Accounting, Finance, Sustainability, Governance & Fraud: Theory and Application

Sezer Bozkuş Kahyaoğlu *Editor*

# The Impact of Artificial Intelligence on Governance, Economics and Finance, Volume 2

Springer

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Sezer Bozkuş Kahyaoğlu
Editor

# The Impact of Artificial Intelligence on Governance, Economics and Finance, Volume 2

Springer

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# Foreword

As the population increases depending on time, and the needs increase, the expectations from technology increase. Developing information technologies are constantly being renewed to meet human needs in all respects and develop application areas with new methodologies.

This book focuses on the effects of human intelligence on governance, finance, and economy by adapting technology. The fact that there are applications as well as theoretical knowledge increases the value of the book even more.

This book will take you into different areas of research and application, depending on the effects of artificial intelligence on governance, finance, and economics:

- An Integrated Model and Application for Smart Building Systems with Artificial Intelligence
- Artificial Intelligence for Smart Cities: Locational Planning and Dynamic Routing of Emergency Vehicles
- How Blockchain and Artificial Intelligence will Affect Cloud-based Accounting Information Systems?
- A machine learning framework for data-driven CRM
- Practices of natural language processing in the finance sector
- Is It Possible to Create Robo-Sapiens for Better Investment Decisions
- The Effects of Artificial Intelligence on the Insurance Sector: Emergence, Applications, Challenges, and Opportunities
- Higher Education and Labor Market Transformation in the Era of Industry 4.0 in a Developing Country: The Case for Turkey
- The Importance of Graph Databases in Detection of Organized Financial Crimes
- Machine learning applications for fraud detection in the finance sector
- The Role of Artificial Intelligence in Healthcare
- The "Transformative" Effect of Artificial Intelligence Systems in Entrepreneurship
- An Overview of New Generation Bio-Inspired Algorithms for Portfolio Optimization

The articles show that artificial intelligence and its sub-branches have unlimited research and application possibilities, especially in social fields. As long as technology perceives it as a tool that facilitates human life, its contribution to every sector will be great. If the concepts of efficiency, effectiveness and effectiveness are used as a measure in every field where it is applied, technological structuring will come to life.

Artificial Intelligence, which recreates education, production, industry, entertainment world, and social life, and technologies such as Machine Learning and Deep Learning that develop based on it, bring a new face to every area they touch.

The concept of artificial intelligence has been used by computer science and technology researchers for a long time. However, with the concept of Industry 4.0, the concept of artificial intelligence in the sectors has gained a different dimension. It is emerging from managing a simple process in computers and production platforms to structures that can continuously implement decision-making processes depending on the conditions.

While Artificial Intelligence is rapidly recreating the present and the future, it must be used and managed correctly. The research presented here offers options to apply new perspectives to the field within this framework. They put forward different perspectives on how and in what form the technological structuring that will shape the future should be.

This book will take you to the cutting edge and beyond with innovations that show how to use artificial intelligence in different areas. Development still remains critical for artificial intelligence projects. In the Management Information Systems community, it can be said that such studies have a great contribution to the field. Every work that develops artificial intelligence methodology and deepens different applications will provide a safer and more accurate look at the future.

While I congratulate all the authors who contributed to this study, I would like to express my greatest thanks to editor Dr. Sezer Bozkuş Kahyaoğlu. It is a magnificent achievement to come up with an extraordinary background and bring together different researchers in this field by touching on an unexpected subject. I believe that this publication, which reveals different dimensions of sectoral studies in the field of artificial intelligence with a scientific, researcher, innovative, and practitioner perspective, will be useful for researchers and practitioners.

November 2020

Vahap Tecim
Dokuz Eylül University
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# Editor and Contributors

## About the Editor

**Sezer Bozkuş Kahyaoğlu** graduated from Bosporus University, Management, Istanbul, Turkey in 1993; received the master's degree in Money Banking and Finance from Sheffield University, UK in 1997, and Ph.D. degree in Econometrics from Dokuz Eylul University, Izmir, Turkey in 2015. She authored 15 articles, 2 books, and 4 book chapters in Turkish and English.

Sezer started her career in the Banking sector as Broker & Dealer and later worked as an Inspector at the Board of Inspectors, and then she became Financial Control Manager in a bank. Afterward Sezer worked as the head of Audit and Investigations Department at Turkish Derivatives Exchange. Besides these, Sezer worked as the project leader of various national and international projects in Risk Consulting Services at KPMG. Sezer worked at Turk Telekom Internal Audit Department as Director responsible for Investigations and Regulations. Sezer worked at SMM Technology ERP Risk Consulting Company as General Manager and Head of the Risk Management Department.

Sezer is a Financial Risk Management expert responsible for making financial business decisions and strategic alignment to supervise duties such as monitoring business performance, handling budgets, controlling accounts, analyzing competitors, developing financial models, supply chain management, procurement process, and monitoring cash flow. Highly qualified in business models in various sectors, internal auditing, fraud investigations, and workflow analysis with excellent communication and interpersonal skills, problem-solving orientation, leadership, management abilities, and computer proficiency. With a display of a degree in business, finance, and econometrics and certifications in CIA, CFSA, CRMA, CFE, CICP, and CPA. To demonstrate thought leadership skills, work as part-time Lecturer at Istanbul Bilgi University at Accounting and Auditing Program for eight semesters (2008–2014) and Ankara University Faculty of Political Science at Internal Control and Internal Audit Program (2015–2018). Sezer is currently a full-time academic

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Professional interests mainly include Financial Markets and Instruments, Applied Econometrics, Time Series Analysis, Corporate Governance, Risk Management, Fraud, ERM, Internal Control, and Internal Auditing. Sezer is a member of the following organizations: Izmir High Technology Institute (IYTE) Foundation, Audit Committee Member, Institute of Internal Auditors (IIA), USA, Committee Member of Research and Education Advisors, USA, Member of IIA Turkey Chapter, Member of Association of Certified Fraud Examiners (ACFE)—Turkish Chapter, Advisory Board Member of Association of Certified Fraud Examiners (ACFE), USA, Board Member of Association of Young Eigen Businessman (EGIAD -12th Period), Member of ISACA, Member of EMCC Turkey.

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# Introduction

# Chapter 1
# Introduction


**Sezer Bozkuş Kahyaoğlu**

**Abstract** In this study, it is planned that the Volume-2 will provide technical information on thematic issues related to artificial intelligence. In particular, the impact of artificial intelligence and advanced technologies on different sectors is presented with examples. In this context, dramatically changing business model approaches are presented. In addition, it is explained how the change in the value creation approaches of enterprises is shaped by artificial intelligence implementations. There are sections that include intelligent systems developed with artificial intelligence, the use of these systems in terms of accounting, finance and fraud prevention, and different applications with specialized topics on AI. Human resources and ethical issues, which are important in the realization of all these, are also mentioned. Thus, while examining the areas where artificial intelligence can provide added value for the future, risk factors are also explained. Accordingly, it is aimed to contribute to the literature by presenting solutions and policy recommendations.

**Keywords** Artificial Intelligence · AI-based systems · AI tools · FinTech (Finance + Technology) · RegTech (Regulation + Technology) · GreenTech (Sustainability · Green + Technology) · EduTech (Education + Technology) · WealthTech (Wealth + Technology) · PropTech (Property + Technology) · InsurTech (Insurance + Technology)

## 1.1 Introduction

The form of competition varies in the business world. Now, a competition starts over the value offered to the customer instead of just a competition on quality and/or price. The prerequisite for realizing these goals is to update the "business model" of companies and make them compatible with AI applications. AI-based systems are defined as different tools and novel technologies, which can be connected in

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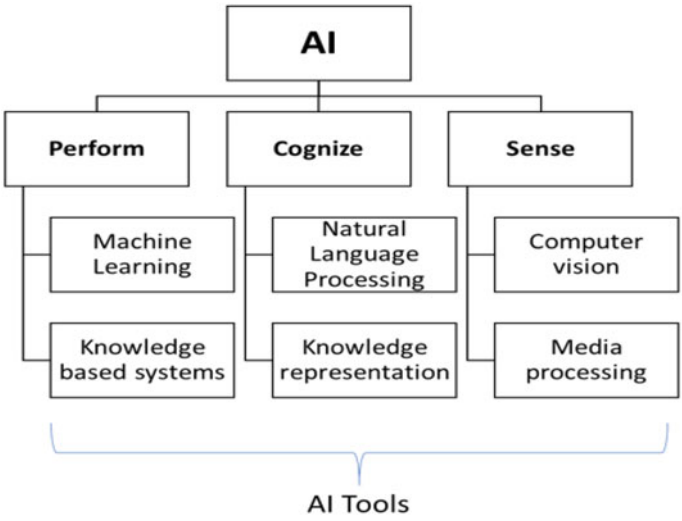


**Fig. 1.1** AI-based system. *Source* Akerkar (2019)

various methods to "sense," "cognize," and "perform" with the capability to learn from observations and adapt over time, as shown in Fig. 1.1.

There is the potential to use AI-based applications in almost every industry and hence, AI promises to notably change existing business models while concurrently generating new business models, i.e., digital business model. The usage of digital products and parts, such as sensors, communication infrastructure means, operating systems, data storage systems, analytical tools, etc. is increasing in the global economy. Thus, companies have significant competitive advantages by using smart systems via AI implementations. Their highlights are the opportunity to produce more, lower costs and savings, the opportunity to sell more, and in summary, the opportunity to make more profit. Business models are changing to make things faster, cheaper, and easier. In order to adapt to this change, it is critical to harmonize the organizational structure and employee competencies. Therefore, although artificial intelligence has its benefits, it also has risks and threats arising from uncertainty about the product ownership model, internal control weaknesses, and lack of regulatory environment (McKinsey Global Institute, 2017).

Over time, it is a fact that the infrastructure has been developed that will enable fast and easy integration of AI applications with each other. This situation requires businesses to make certain decisions from the very beginning. For example, is it more appropriate to produce the relevant parts of a product within the company or to supply it from outside? In this case, there are two basic options: The first is to buy the most affordable and fast parts from the outside. The second is to make products within the company by undertaking research and development activities. This decision contains its own contradiction for digital products. Wodechi (2019) proposes that research and development activities for the solution of this problem

should be carried out in different formats. The author offers an approach that plans to collaborate with outside service providers and R&D teams within the company. This action is called "Development and External Provider Team -Dev-ExP."

Artificial intelligence applications have important effects on the functioning of the global markets. Especially, institutions that provide brokerage and/or intermediation services may not be needed in the future. Instead, platforms are created. This transformation is accelerating with the effect of developments in the communication sector and technological innovations. An example of its implications is the impact of financial markets and digitized products and services. Therefore, the way the world trade and economic units do business begins to change in every aspect. Even companies competing in this renewed market structure must cooperate with each other. With the renewal of the business model, the emergence of new business ideas, and the changing areas of expertise of employees, the position of artificial intelligence in strategic business management is strengthening to achieve more intelligent ecosystem in the future than today.

It is a fact that AI implementations are useful and inevitable in the new digital markets and everyday life. On the other hand, regarding the unsolved ethical issues in AI implementation process, the AI concept may generate an immense threat to mankind. This immense threat has been discussed in the literature such as Nick Bostrom's book namely "Superintelligence: Paths, Dangers, Strategies" (Bostrom, 2014). In addition, Stephen Hawking et al. (2014) have asked the question to warn the society, namely "are we taking AI seriously enough?" (Hawking et al., 2014). For this reason, it is recommended that studies should be carried out systematically through research centers and institutes in order to take firm steps and make the right decisions about AI implementations everywhere to prevent harm. An example of this type of research center is "Machine Intelligence Research Institute- MIRI" (Soares & Fallenstein, 2014). MIRI focuses on two major perspectives in designing AI systems to achieve transparency.[1] The first one is "high reliability focus," and the second one is "error tolerance focus."

Bostrom and Yudkowsky (2019) argue that the concept of transparency is not the only expected characteristic of AI implementations. Another important issue becoming more and more prominent is the fact that AI implementations and specifically algorithms should be robust against any kind of manipulation. In this respect, it is essential to achieve AI algorithms which are used in various social functions to be foreseeable for those they guide.

In today's business world, we request executives to obey the corporate governance principles to monitor the segregation of duties and manage any conflict of interest within an organization. In this respect, considering the digitally transforming organizations workflows are changing their shapes toward AI implementations. This brings another issue for discussion on the AI.

[1] MIRI relies on AI approaches to become more transparent. For instance, they use "precisely specified decision algorithms," "not genetic algorithms." In this way, people can easily recognize the difference and why AI systems are behaving as they are.

It is related to defining the social criterion for dealing with organizations to determine the person responsible for "doing assignments right." If we talk about this issue as an example; imagine that an AI system has failed at its assigned work, then whom can we blame for this situation at work? Will it be the end-users at work or AI programmers? Even if a typical AI algorithm aims to override users, we still need to consider the worst-case scenario for preventing any harm and to maintain the risk management purposes. Some researchers are proposing a career incentive for the person who will take responsibility when we face a negative outcome. Considering the responsibility context; there is no "one size fits all" solution for AI-based systems. It is recommended in the literature to rely on a specific design methodology namely value-sensitive design (VSD) that most suits what we believe to be an all containing, resilient, and talented one (Baum, 2016; Friedman, et al., 2013; Muehlhauser & Bostrom, 2014; Soares & Fallenstein, 2014). It is generally accepted that the current AI systems have no moral status at all. This means that we can do whatever we want in any computer programs such as copying, deleting, editing, or using other commands. Thus, the moral limitations are only relevant to our obligations to other human beings, do not involve any commitment to the AI systems themselves.

It is expected that the major impact of AI in relation to the increased distribution, blockchain based business models leading to decentralization in financial services and products will create an opportunity for more advisory services (Tashea, 2018). With the effect of artificial intelligence and digital transformation, businesses are obliged to receive consultancy services in order to transform their infrastructure and business models faster. In this respect, "technology family" is defined as shown in Fig. 1.2 such as FinTech (Finance + Technology), RegTech (Regulation + Technology), GreenTech (Sustainability, Green + Technology), EduTech (Education + Technology), WealthTech (Wealth + Technology), PropTech (Property + Technology), InsurTech (Insurance + Technology), etc., the basic areas of expertise that correspond to the consultancy needs, have emerged.

The foundation and evolution of AI is based on a blend of several disciplines which is summarized in Fig. 1.3. AI-enabled systems can resolve sophisticated issues with more integrity and accuracy. For instance, in the finance field, computational finance is a part of applied computer science that is related to practical problems in financial markets. In this respect, computational finance is defined as the analytics of data and algorithms in finance. This is an interdisciplinary field that synthesizes quantitative methods, mathematics, and finance. It should be noted that we can call an AI-based system "intelligent" only if we have enough suitable data to learn from. Therefore, the greater the volume of information the AI-based system can derive from its analysis, the better and more accurate the reply it gives will be. Due to the large number and high frequency of data in the financial markets, artificial intelligence-based applications are the most popular practices in this sector. However, the protection of personal data is considered a sensitive issue in regulated[2] markets such as the financial sector. On

[2] In this context, the new European Union data protection regulations (General Data Protection Regulation-GDPR) which has been operative since May 2018 should be noted with attention. Visit https://gdpr.eu/ for more information on General Data Protection Regulation—GDPR.

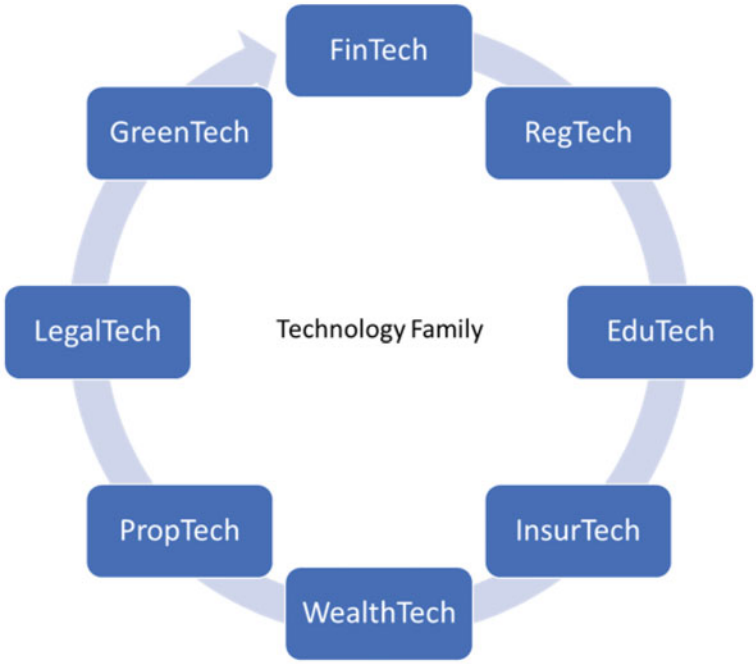


**Fig. 1.2** Technology family. *Source* Prepared by the Editor

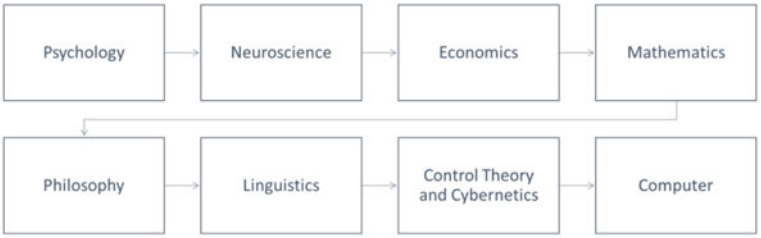


**Fig. 1.3** The foundation and evolution of AI. *Source* Mondal (2020)

the one hand, this regulation will strengthen the privacy rights, on the other hand, it will be raising the claims from those processing such data. Inevitably, most the organizations will assume more liability for handling private data in accordance with the related rules, regulation, and transparency expectations will be tighter.

It should be noted that the AI-based systems are likely to increase the efficiency in business world by generating new occasions to speed up the growth of current global economic systems. This efficiency increase is possible based on the rise in labor efficiency and the development of advanced goods and services, which will meet consumers' needs and expectations. On the other hand, such a digital transformation may produce resistance to change and risks for both the business world

and society. Such risks mostly have cultural characteristics and hence, they need to be predetermined by the specifics of the domestic economy and cultural factors in each country (Filippov et al., 2019) In this respect, it is recommended to manage these risks at the national level through applying AI-based systems to modernize the organizational, cultural, and managerial practices.

Financial markets are among the sectors where artificial intelligence is used most effectively and widely. In this context, high-frequency time series data is analyzed instantaneously. In addition, financial institutions and investors change their major trading policies and strategic portfolio management approaches to products. One of the most important developments in this process is digitalization. In other words, the start of digital banking, the spread of digital money, and the adoption of blockchain technologies should be regarded as the crucial developments toward the infrastructure in this field. Artificial intelligence applications developed especially for the financial sector require that financial institutions upgrade their current management processes, audit and risk management methods, and organizational infrastructure. According to McKinsey (2017), financial institutions will have significant benefits from improved accuracy and speed in "AI-optimized fraud detection systems," which are forecasted to bring a $3B market potential in 2020.

In this book, the impacts of artificial intelligence on governance, finance, and economy, in general, are investigated and major findings are discussed within the framework of the expertise areas of the contributing authors.

In Chapter 2, the authors propose an integrated model and application for smart building systems with artificial intelligence. Particularly, the integrated model is composed of six sub-models in order to improve productivity, effectiveness, and efficiency levels of some administrative activities. These sub-models are defined as follows: First, the intelligent evacuation subsystem in smart buildings based on the AHP method. Second, a smart guest guidance subsystem suitable for complex buildings enables guests or people who come to the building for some processes such as business meetings, to easily find the locations they want. Third, the smart media system works in an integrated structure with the sound and imaging devices inside the smart building. This model is convenient for announcements, video and radio broadcasting, and announcing current news. The fourth model is the intelligent staff monitoring system which can be used actively, especially during staff entry-exit times in the smart building. The authors recommend a cost-effective approach by using open source Computer Imaging libraries such as OpenCV. Fifth, the Intelligent Survey System has been developed specifically to measure customer, staff, student, and guest satisfaction and to take necessary measures in line with the objectives. Sixth, the Intelligent Building Information System based on augmented reality and the other one is the method performed with iBeacons. In summary, the authors recommend heuristic algorithms based on artificial intelligence as a solution for many problems that may occur in smart buildings.

In Chapter 3, the author proposes AI solutions, which could be used for locational planning and dynamic routing of emergency vehicles for smart cities. The author presents a novel perspective for the use of artificial intelligence and optimization in sustainable healthcare logistics within a smart city. It is a fact that the usage of

advanced communication and data flow tools in smart cities can highly contribute to increasing effectiveness of emergency services planning. Considering the COVID-19 pandemic, it is necessary for the urban information systems to integrate the capability of sensor devices in IoT networks such as adaptive traffic management systems having advanced artificial learning features with cloud-based (such as Amazon, Google, IBM, or similar), or local computing services to improve real-time optimization performance much further.

In Chapter 4, the author analyzes the role of artificial intelligence and blockchain technologies in cloud-based accounting information systems. The author provides a wide range of discussions in order to respond to the question of how to benefit from the power of artificial intelligence and blockchain technologies in the operation of cloud-based accounting information systems, all aspects of cloud-based accounting, artificial intelligence and blockchain technologies were discussed.

In Chapter 5, the authors provide a holistic framework for the implementation of machine learning methods in data-driven CRM applications. They propose a framework that relies on past transactional data of customers and employs state-of-the-art machine learning techniques. In this respect, this chapter serves as a foundation for future studies on data-driven CRM applications utilizing machine learning techniques.

In Chapter 6, the authors synthesize the current literature using NLP methods in financial tasks to provide the state of current knowledge and implications for future studies. In this context, the authors analyze the usage of NLP methods in two main sections: In the first section, NLP analysis models are given in detail to determine financial market dynamics using news and user comments in the digital platforms. In the second section, NLP methods to detect sensitive user data (e.g., identity number, credit card number, telephone number) in the financial documents are discussed.

In Chapter 7, the authors synthesize the current literature using NLP methods in financial tasks to provide the state of current knowledge and implications for future studies. In this context, the authors analyze the usage of NLP methods in two main sections: In the first section, NLP analysis models are given in detail to determine financial market dynamics using news and user comments on the digital platforms. In the second section, NLP methods to detect sensitive user data (e.g., identity number, credit card number, telephone number) in the financial documents are discussed.

In Chapter 8, the author states the fact that a machine is not a human. Hence, an investor can beat biases by making decisions considering a robo-advisor. The author argues that the input of an AI is "data," and its output is defined as "prediction." In this respect, the quality of the data is important for determining the power of the prediction and it reduces the uncertainty in the process of decision-making.

In Chapter 9, the author explores the AI innovations and their effects on the insurance sector. In this context, the author provides useful cases of global and Turkish insurance in the best practice of AI. The AI technologies in the insurance industry are expected to be more obvious in the near future. Balasubramanian et al (2018) state that AI technologies are critical for improving the simulation capabilities useful for modeling the perception, reasoning, learning and problem-solving abilities implemented by the human mind, which will turn the direction of the insurance sector

from "perception and repair" to "learning and prevention" (Balasubramanian et al, 2018: 2).

In Chapter 10, the authors analyze to what extent the adjustment in education policy and the labor market develops in the era of Industry 4.0. In this respect, the authors employ the TURKSTAT Household Labor Force Survey data (2009–2018) to evaluate the impact of Industry 4.0 with the synthetic control method. In their empirical work, the authors evaluate the change in the sectoral employment rates and analyze whether the share of the workers who graduated from departments varies in this era. Based on the synthetic control method, they discuss the empirical findings and conclude that while Industry 4.0 positively affects the Industry 4.0 related education ratio of the furniture sector, the impact occurs negatively in the automotive, textiles, and transport equipment sectors. In addition, they state that there is no effect of Industry 4.0 on the food sector.

In conclusion, the major impacts of AI to achieve a high business outlook can be summarized as follows:

- "**Economics of Predictive Learning**" leads to better analysis based on AI algorithms (McKinsey Global Institute, 2017).
- "**Change in Amortization**" leads to an increase in the value of products and services. It should be noted that this is just the opposite case of traditional systems (Porter & Heppelmann, 2015).
- "**Increase in Quality of Assessment and Evaluation**" leads to experience-based learning system that ensures the strength of business model and decision-making process (Ransbotham et al., 2017).
- "**Increase in Synergy Effects**" by integrating human soft skills with the AI practices to achieve better end-user experiences (Ross, 2017).
- "**Ethical Decision-Making**" is needed more because of conflicting needs and expectations arising from AI-based smart systems to identify the complete understanding of the meaning of being "fair" (Wilson et al., 2017).

It is important to use artificial intelligence applications for the well-being and happiness of humanity with very accurate and expert hands. In this context, instead of a future guided by machines developed based on artificial intelligence practices, we should be in the expectation of a life that increases effectiveness and efficiency, using them. In this way, there will be some more time to achieve sustainability by acting more humanely.

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# Part II
# The Impact of AI on Smart Systems

# Chapter 2
# An Integrated Model and Application for Smart Building Systems with Artificial Intelligence

**Emre Karagöz and Vahap Tecim**

**Abstract** The intelligent evacuation subsystem has great importance for all intelligent buildings. In addition to natural disasters such as tornados, floods, human hazard situations such as terrorist attacks, electrical leaks, and fires reveal the necessity of emergency evacuation systems. The model proposed in this study suggests a model in which users, depending on their location, can see the exit routes from the smart screens which are placed in the smart building. This model uses instantaneous data obtained by evaluating the distance of the relevant location to the exits, the width of the exit doors, and the crowdedness in front of the exit doors. This data then proposes a method that shows the best result from smart screens by using the Analytical Hierarchical Process technique, which is a multi-criteria decision-making method. This study demonstrates the establishment and design of an integrated smart building management system that combines smart survey systems and Augmented Reality-based smart building promotion systems that use different types of technological tools and collect different types of data. Intelligent evacuation systems, smart guest guidance systems, smart voice, music, announcement and video usage systems, computer vision-based smart face recognition, and personnel tracking systems are some of the technologies used. *For what purposes, particularly in terms of management, how these tools can be used, what hardware and software tools are utilized to create this system, and the procedures to be carried out in the application process* are the subjects of the study. The importance of emergency evacuation systems, especially in feature buildings such as hospitals and educational institutions, is increasingly being managed by intelligent systems that will work at any time, not just on paper and at the initiative of some people, but also independent of individuals. This study demonstrates with an example how an integrated model can be designed and implemented. The technological system that is able to think like people and make the right decisions will spread from houses to buildings, from buildings to campuses, from campuses to regions, from regions to provinces, and from provinces to countries.

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With the right approach, the societies that use human intelligence and experience with the philosophy of Industry 4.0 at every point of life will increase their welfare as they will increase productivity. If artificial intelligence is used as suggested in this study, it will continue to affect lives positively and open new horizons.

**Keywords** Artificial intelligence · Smart buildings · Smart evacuation systems · Learning systems · Media tools

## 2.1 Introduction

The development of technology has transformed traditional structures into technological formats. Many of the traditional methods and processes that used to be utilized especially in management tools have been replaced by digitalization processes and structures. This is because technology-based new structures are more productive, more efficient, and more competent. Industry 4.0, which is regarded as the fourth industrial revolution, refers to many processes where internet usage is particularly effective.

The new production and life model brought about by Industry 4.0, the internet of things, a component of Industry 4.0, and augmented reality technologies also provide new features and uses for different complex structures such as houses, workplaces, buildings and campuses. Today, smart buildings and workplaces that are heavily powered by technology have made many elements necessary for productivity and efficiency. Intelligent building systems, in general, include computer and internet systems based heavily on media tools and artificial intelligence techniques. Thanks to smartphones, it has become possible to control almost all the functions of living spaces. Nowadays, it is possible to offer many technology-based methods and solutions on smartphones or tablets to solve different types of problems and needs. These methods, in particular, enable computer technologies and scientific advances to be integrated and implemented. Due to this and many other reasons, it has become impossible to act independently from the information technologies.

Intelligent buildings represent the spaces in which different technological and scientific approaches are applied according to different needs. These technologies are technologies that use the computer and internet intensely and are equipped and strengthened with scientific methods. Smart alarm systems, media systems, and smart face recognition systems are the basic instruments of this type of smart buildings. The usage styles of smart buildings play an important role in determining the needs within. For example, the needs of a smart building used in education and a smart building used in sales and marketing or production differ. This study focuses on the basic subsystems of a smart building that can be used especially for education and training and what functions these subsystems can perform. Some needs are indispensable and important for all smart buildings. For instance, an intelligent evacuation subsystem developed in order to evacuate the building in case of any danger is of great importance for all smart buildings regardless of its purpose. In addition, the

smart survey system, which enables the prevention from potential problems that arise or may arise with the information it receives from the users and takes the necessary measures, may not be important for all smart buildings. In the model proposed in this study, the issues of a smart evacuation subsystem, smart guest guiding subsystem, smart media and announcement system, intelligent staff monitoring subsystem, smart survey subsystem, and intelligent building information subsystem were discussed.

The intelligent evacuation subsystem has great importance for all intelligent buildings as stated. In addition to natural disasters such as tornados, floods, human hazard situations such as terrorist attacks, electrical leaks, fires reveal the necessity of the emergency evacuation systems. When the literature is examined, it is seen that there are different types of evacuation models. These models are generally based on different simulations which determine the factors and scenarios that may occur in the event of a possible danger before the actual danger arises by determining the evacuation models formed according to the results. However, it is imperative to develop a simultaneous building evacuation model for the emergence of situations not taken into account at the time of evacuation. The model proposed in this study suggests a model in which users, depending on their location, can see the exit routes from the smart screens which are placed in the smart building.

This model uses instantaneous data obtained by evaluating the distance of the relevant location to the exits, the width of the exit doors, and the crowdedness in front of the exit doors. This data then proposes a method that shows the best result from smart screens by using the Analytical Hierarchical Process technique, which is a multi-criteria decision-making method.

An intelligent guest guiding subsystem has been developed in order to allow the guests visiting the intelligent building to find the people they are looking for easily. When the incoming guest informs the smart monitor at the entrance of the smart building about whom he wants to see, the system is able to lead the visitor to the address, provided that the person is in the building. In addition, the system takes a photo of the caller, sends this photo to the person requested as an email, and informs the person about the visitor with the taken photograph. The system also provides an opportunity for the caller to leave a note if the person being called is not in the building and thus enables communication.

The smart media subsystem allows the administrator or other authorized users in the smart building to broadcast any content from the internet, music, or video sources through smart screens, amp, and speaker systems in the building. In addition, the system allows notifications, even warnings such as an announcement or emergency alarm. With the help of the sensors on the Raspberry Pi minicomputer, which is one of the hardware tools in the system, the system also enables broadcasting music according to the weather conditions. It is also possible to activate music, news, and video broadcasts during certain hours during the day. The intelligent personnel tracking subsystem provides tracking of the entry-exit hours of the people working in the building, and it reminds them of the daily tasks to carry out. It then allows these transactions to be reported to the required management units on a daily, weekly, or monthly basis. The developed model is structured based on web programming tools and computer vision principles.

The smart survey subsystem has been developed to investigate the ideas of users in the building on any subject or to measure their satisfaction status. The system enables the preparation of research questions in such cases, storing the data obtained and then presenting it to the managers as a report. The smart building presentation subsystem enables the transfer of various media contents to the guests or other users about the facilities such as saloon, room, laboratory, and lounge in the building with augmented reality or iBeacon technology.

This study, demonstrates the establishment and design of an integrated smart building management system that combines smart survey systems and Augmented Reality-based smart building promotion systems that use different types of technological tools and collect different types of data. Intelligent evacuation systems, smart guest guidance systems, smart voice, music, announcement and video usage systems, computer vision-based smart face recognition, and personnel tracking systems are some of the technologies used.

*For what purposes, particularly in terms of management, how these tools can be used, what hardware and software tools are utilized to create this system, and the procedures to be carried out in the application process* are the subjects of the study.

In addition to the hardware and software elements used in smart building system design, short information about the methods used will be included in the study. First, hardware screens, smart screens, Raspberry Pi, and iBeacon technologies and their innovations and usage areas within the Industry 4.0 philosophy will be briefly explained. Since server, web camera, minicomputer, mobile tablet, and other hardware elements used in system design such as mobile phone, amp, and speaker are widely known, these are not emphasized. In general, the software elements will be mentioned in web programming tools such as HTML, CSS, Javascript, PHP, and MySQL, and then Matlab, Python, JAVA, Unity, and Vuforia topics will be briefly discussed. Brief information will be given about Computer Vision (CV), text to speech and Augmented Reality (AR), Analytical Hierarchical Process (AHP), which is one of the multi-criteria decision-making techniques on the technologies used. How artificial intelligence logic is used in an integrated system will be explained with the application process of the model.

Smart buildings that produce their own energy and do their outdoor cleaning using nanotechnologies, provide dozens of features with smart technologies that make life easier without the human element. This situation eliminates subjective decision-making due to human-related factors such as illness, fatigue, incompatibility, and emotionality. The purpose of this study is to create systems that prioritize personal and social benefits in the economic sense, use resources efficiently and effectively, and make clear and correct decisions in the face of events. In addition to how smart systems can be modeled in such situations, important elements of the established system have been implemented and tested. It should be known that the smart technologies to be used are an imperative, not a choice, especially in places where there are crowded groups such as hospitals, educational institutions, public buildings, and shopping malls. The importance of emergency evacuation systems, especially in feature buildings such as hospitals and educational institutions, is increasingly being managed by intelligent systems that will work at any time, not just on

paper and at the initiative of some people, but also independent of individuals. This study demonstrates with an example how an integrated model can be designed and implemented.

The technological system that is able to think like people and make the right decisions will spread from houses to buildings, from buildings to campuses, from campuses to regions, from regions to provinces, from provinces to countries. With the right approach, the societies that use human intelligence and experience with the philosophy of Industry 4.0 at every point of life will increase their welfare as they will increase productivity. If artificial intelligence is used as suggested in this study, it will continue to affect life positively and open new horizons.

## 2.2 Literature Review

The new technological approach brought by Industry 4.0 shows itself in traditional buildings as well as in many areas of life, and many academic studies are carried out on this subject. Lan and Yan (2020) proposed a multi-protocol parsing and configuration system in order to facilitate the integration of many subsystems with TCP and IP protocols, in parallel with the development of smart buildings. The database created for this process is organized according to the protocol parsing components and the protocol data formats configured in the received data packets (Lan & Yan, 2020). Pereira et al. (2020) developed a model for energy consumption in smart buildings. In this model, they developed an executive program using the fuzzy logic technique that adjusts the temperature inside the building. The artificial neural networks technique was used for temperature estimation (Pereira et al., 2020). Pan et al. (2019) designed a smart building fire system based on the internet of things approach. Thanks to the system they developed, they also designed an interface that can monitor the fire conditions of the entire building in real time (Pan et al., 2019). Schneider et al. (2020) developed a person detection model to be used in smart buildings and then compared their findings with the outputs of the Horn-Schunck algorithm. They performed their tests on 12 floors in the building they determined (Schneider et al., 2020). Novak et al. (2018) designed a control system that can communicate with the help of sensors over smart buildings and Ethernet connection and analyze the measured values (Novak et al., 2018). Maryasin (2019) talked about a problem-solving approach in various modes of operation using a multi-agent control system with smart agents. With this approach, they conducted simulation studies on how to solve the problems related to decision-making in case of any danger in the building, determining their preferences and meeting the needs of people. When the results of the simulation study were analyzed, they stated that the building management approach they suggested was effective (Maryasin, 2019). Naqvi et al. (2019) proposed a Fuzzy Inference System (FIS) that coordinates natural ventilation with the HVAC system and occupancy mode of users according to temperature, humidity level, and optimum setpoints (Naqvi et al., 2019). In their work, Vesselényi et al. (2014), Oradea University, and Debrecen University described their research on what applications can be implemented with

software and equipment used in a laboratory platform containing research equipment and software to support research in the field of Intelligent Building (Vesselényi et al., 2014). Li and Cao (2020) worked on Building Information System (BIM) used in smart buildings. This system is a digital representation of the physical and functional characteristics of a facility. It can be used as a shared information source for facility information. They stated that the facility life cycle has become a reliable basis for the decision-making process (Li & Cao, 2020).

## 2.3 Brief Information About Some Software, Hardware, and Techniques

In the next section, brief information about some software, hardware, and techniques used in the proposed model is given.

### *2.3.1 Smart Screens*

Smart screens are used in integrated or separate digital screens used for running applications such as information, advertisement, video playback in closed or open places such as subways, train stations, or shopping centers. Smart screens, especially in touch structure, allow users to interact with the application on the smart screen. But every smart screen may not be touch-sensitive. This feature is preferred according to the purpose of use. While integrated computers can be found in smart screens, digital screens can be turned into smart screens with Raspberry Pi or mini computers of different structures. With smart screens; video, music broadcasting, live camera viewing, url viewing, taking photos, and many more digital operations can be performed. It is an important hardware element used in almost all of the smart subsystems used in smart building systems.

### *2.3.2 Raspberry Pi*

Raspberry Pi is a credit card-sized computer offered by the UK-based Raspberry Pi foundation for the use of students and other users. This computer consists of a single board. It has been developed by the Raspberry Pi Foundation since 2009. Two models, A and B, have been launched. Model B has more equipment than model A. It has been offered to users as open-source since April 20, 2012. Below are some technical features of Raspberry Pi.

- Broadcom BCM2835 (700 MHz, ARM1176JZF-S based) Processor
- Broadcom VideoCore IV (OpenGL ES 2.0, 1080p supported) Graphics Processor

- 256 MB on Model A, 512 MB Ram on Model B
- USB 2.0 (Model B has 2, Model A has 1)
- HDMI port
- SD card reader
- 3.5 mm audio jack
- RCA video output
- CSI connection
- 10/100 Ethernet (available on Model B)
- Operating system: Debian GNU/Linux, Fedora, Arch Linux and derivatives
- Low-level peripherals: 8 GPIO, UART, $I^2C$ bus, two Chip Select with SPI bus, + 3.3 V, +5 V, ground
- Weighs 45 g
- Model A consumes 1.5 W, Model B consumes 3.5 W
- Working voltage: +5 V DC (Raspberry PI Foundation, n.d.).

The fourth version is now on the market.

### *2.3.3 IBeacon*

iBeacon is a technology developed by Apple Company and was first introduced at Apple Worldwide Developers Conference in 2013. A beacon is a small wireless device that broadcasts radio signals to nearby smartphones and mobile devices such as tablets (Business insider, 2014). The main working principle is to trigger applications on mobile devices with BLE (Bluetooth Low Energy) signals. It is mainly used in indoor shopping malls to send product advertisements to customers' mobile phones. Some usage areas of iBeacons are shown in the list below.

- Store advertising
- Monitoring activity
- School and education
- Automation
- Indoor applications
- Zoo applications
- Museum applications.

In some specific trade areas, information related to the path of store-customer behavior is useful to improve customer relationship management (Oosterlinck et al., 2017). After Apple introduced Beacon technology, many companies started to produce their own Beacons. Companies such as Estimote, Bluecats, Bluesense, Gelo, Glimworm, and Kontact are known as major Beacon producers in the market (nodes, 2014).

The Beacon working process proceeds as follows. First, a Beacon is placed in any location. It periodically transmits BLE signals to external receivers. These signaling

intervals are determined by the user. This value determined by the user is the "interval", which is another parameter of the Beacon. If the user has set the interval value as 5 s, the Beacon will send BLE signals every five seconds. The farthest point that the signals can reach is determined by the THEX value which is another parameter of the Beacon. For example, if this value is set as a small value, the signals only act up to 1 m away. In other cases, large-signal ranges such as 100 m can be achieved. For example, suppose that the THEX value is set to be 50 m and the interval value to be 5 s. In this scenario, BLE signals are received by anyone within 50 m of a Beacon application by their mobile phone. The signal reports the UUID, major and minor values sent by the Beacon to the mobile phone. The event that matches these values in the application on the mobile phone is triggered, and the process takes place. Using Beacons can be considered a good option, especially in cases where GPS (Global Positioning System) is not able to be located indoors. One of the tools used in the developed smart evacuation system application is Beacon.

### *2.3.4 Web Programming Tools*

The rapid spread of internet usage, especially after 1995, led to the emergence of new versions of many applications realized with traditional programming that can reach more users via the internet. New Internet-based programs are called web-based applications. Web-based applications refer to the structure that an application running on a server can run on the user's internet browsers. The user can access web-based applications from anywhere on the internet (Coresolutions, 2015). Languages such as HTML5, CSS, PHP, Javascript, MySQL are especially used in web programming processes.

HTML is the official programming language of the World Wide Web (WWW) and was created in 1992 by Tim Berners-Lee (The World Wide Web Consortium, n.d.). HTML can be defined as a product of SGML (Standard Generalized Markup Language), which is a complex, technical definition that specifically defines markup languages used in electronic document exchange, document management, and document publishing. It was originally created to allow non-experts in SGML to publish and modify scientific and other technical documents. HTML got this name because it has the ability to electronically link documents using link hyperlinks (Ironspider, 2017).

CSS determines the features of HTML elements such as color, size, and location on the page, either individually or in classes. While these properties are written separately for each of the elements in HTML pages before CSS, the same properties can be added to many elements quickly with CSS. It is known as one of the easiest languages to learn and can be added to HTML elements in 3 different ways. With style files on a completely different page, CSS can be used as <style> .. < /style> class and id tokens between the <Head> .. < /Head> tags or by opening the style directly next to the element.

PHP Language started to be created in 1994 by Rasmus Lerdorf. In June 1995, PHP source codes were made public. Php codes are used by hundreds of millions of domains worldwide. It is one of the most used programming languages worldwide. It provides data exchange by providing a connection to the most common usage databases. Today, it can be said that there is almost no web application where php language is not used. Below are some advantages of PHP.

- Open to everyone (Open Source)
- Use of system resources is very reasonable
- Easy to use
- It works stably
- Has powerful library support
- Database connection skills are pretty good
- Can be used platform independently in Windows, Mac or Linux (Techstrikers, 2017).

The Javascript was created in 10 days in May 1995 by Brendan Eich. Javascript was not always called Javascript. It was first designated as Mocha by Marc Anderson, founder of Netscape. Its name was changed to LiveScript in September 1995. Its name was changed to Javascript in December of the same year after Sun received a commercial license (The World Wide Web Consortium, n.d.). It is specified as a dynamic programming language that is widely used in web browsers. It is also widely used on the server-side thanks to platforms such as Node.js. Javascript is a prototype-based programming language with dynamic types and first-class functions. The list below lists the advantages of Javascript.

- Javascript is run on the client-side
- Javascript is an easy-to-learn language
- Javascript runs pretty fast
- Adds extended functionality to web pages
- They have very large libraries (Jscripters, 2017).

### *2.3.5 Matlab*

Used by millions of engineers and scientists around the world, MATLAB is used for system analysis and design. It is actively used in many projects such as automobile security systems, interplanetary spacecraft, health monitoring vehicles, and smart electric grids. In addition, it is used in machine learning, signal processing, image processing, computer vision, communication, robotics and many more. It is used for solving processes and problems with very strong graphical display features and numerous iterations (Mathworks, 2017). Although being a commercial software is a negative feature, it is a fact that it is an extremely powerful platform.

### 2.3.6 Python

The Python programming language was developed in 1990 to replace a language called ABC. It is Guido van Rossum, who works at Stiching Mathematisch Centrum, who develops the language. In 1995, Guido continued his studies on Python at the Corporation for National Research Initiatives. In May 2000, Guido and the Python team continued their work by moving to BeOpen.com (Python.org, 2017). Python is offered to users as open source. Features such as being easy to learn, supporting many platforms, being object-oriented, providing more work with less code, and being free, made it possible to use Python language intensively. Web programming can also be performed with frameworks like Django. The Python language has quite a lot of libraries. Libraries such as NumPy, Scippy, Pytest, Matplot are widely used in many areas.

### 2.3.7 Java

According to their definition, Java is a technology used to develop applications that make the web experience more fun and useful. A very confusing fact is that it is not the same as Javascript, which is used specifically to create web pages and can only be run in internet browsers. Java allows you to play games, upload photos, chat online, take virtual tours and use services such as online education, online banking, and interactive maps. More than 9 million developers around the world use Java. Java has been tested by a dedicated community of developers, Java architects, and volunteers. It enables applications developed to be used on computer platforms and to be developed with high performance in the widest scope possible (Java.com, 2019).

### 2.3.8 Unity

The Unity platform is mainly a graphics engine used in 2D and 3D game production. It is a highly developed platform with many libraries, especially used by professional game developers. It is frequently preferred by developers who have libraries ready in Augmented Reality (AR) and Virtual Reality (VR), which are among the recently popular technologies, and who want to implement applications with these technologies. Unity makes its platform available free of charge for non-commercial users. For users who develop games or applications for commercial purposes, they are charged according to different memberships. Unity platform allows development in C #, JavaScript/UnityScript or Boo languages.

### 2.3.9 *Vuforia*

Vuforia is a cross-platform Augmented Reality (AR) and Mixed Reality (MR) application development platform with powerful monitoring and performance on various hardware. Vuforia integration allows you to create visual apps and games for Android and iOS using the drag and drop development workflow. A Vuforia AR + VR sample pack is available in the Unity Asset Store along with a few useful examples showing the most important features of the platform. Vuforia, which is very easy to use, can be used effectively in 3D visualization of contents to be developed especially for human anatomy, plant structure, or industrial applications. Figure 2.1 shows a sample Vuforia application.

## 2.4 Analytical Hierarchical Process (AHP)

AHP (Analytical Hierarchical Process) is a decision-making method and was developed by Thomas L. Saaty. It is especially used in the analysis and construction of complex decision problems (Hanine et al., 2016). The AHP method is based on human perceptions. Key inputs in AHP are variables, projects (decision points), and variable significance values. Ho stated in his study in 2008 that the AHP method has been used in most of the studies on multi-criteria decision-making in recent years (Supçiller & Cross, 2011). AHP is a method that can be modeled in a hierarchical structure, showing the relationship between the main objectives, criteria, sub-criteria,

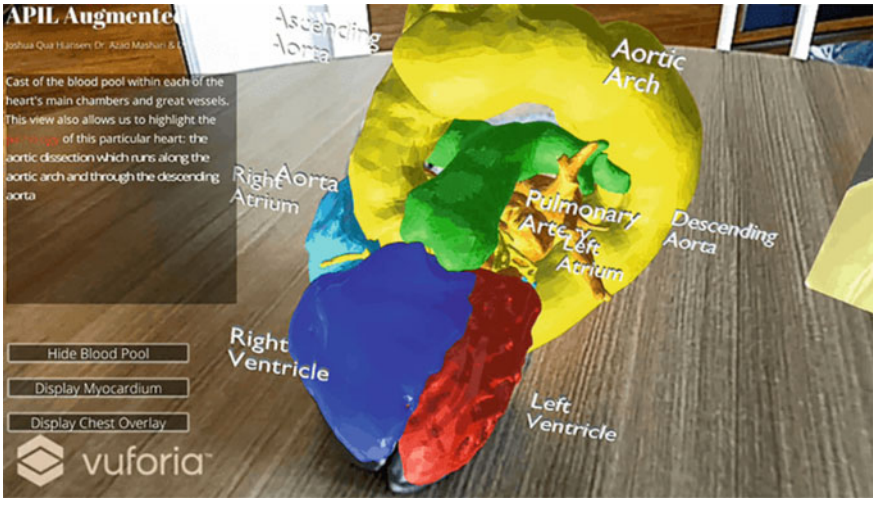


**Fig. 2.1** Sample Vuforia application screenshot. *Source* Circuitstream (2021). Ultimate AR Comparison Guide: ARKit vs ARCore vs Vuforia vs AR Foundation. https://circuitstream.com/blog/augmented-reality-guide/ (Accessed on January 6, 2022)

and alternatives of multi-criteria decision-making problems (Ömürbek et al., 2015). The most important advantages of the AHP method are that it is easy to use and it can be used in complex decision problems that may require subjective as well as objective judgments. AHP ensures that multidimensional problems are reduced to one dimension by determining the importance values of criteria and sub-criteria (Yıldırım & Önder, 2015).

Saaty (2008) states that the AHP process consists of the following 4 steps.

- Defining the problem and determining the information
- Ranking of variables from lowest to highest, depending on the main purpose
- Creating binary comparison matrices
- Determining variable importance levels and priorities.

### *2.4.1 Computer Vision (CV)*

Computer Vision (CV) is known as an interdisciplinary concept related to artificial intelligence, machine learning, robotics, signal processing, and geometry. Computer Imaging provides information about the properties of an object or image. Another definition is that images and videos are automatically analyzed by computers (Dawson-Howe, 2014). Computer Vision systems allow to renew processes in production, reduce production costs, increase product quality, guarantee human safety, and minimize the harmful effects on the environment during production (Klancnik et al., 2015). It can be shared in many methods and topics such as Computer Imaging, image processing, and machine vision. Computer Vision is divided into subcategories.

These categories are listed below.

- Datasets
- Software (Software)
- Digital geometry
- Commercial systems (Commercial Systems)
- Feature Detection
- Geometric Image Sensor Technology
- Learning
- Morphology
- Motion Analysis
- Noise Reduction Techniques
- Recognition and Categorization
- Research Infrastructure
- Researches
- Segmentation.

### 2.4.2 Text to Speech

Text to Speech is the process of converting textual data obtained by computer or mobile devices into voice and speech format. It is known that the main purpose of development is to provide support to visually impaired individuals. It uses a different technology than voice response systems. Voice response systems are shaped according to the answers presented to the user as a result of comparing previously recorded words with other phrases or sentences stored in the database. For this reason, only words previously determined by the administrator or system developer are used (Beal, 2002).

### 2.4.3 Augmented Reality

Augmented Reality (AR) can be mentioned as one of the popular computing topics of recent years. In general, it is the representation of non-real objects in real environments. Another definition, it can be defined as the display of computer graphics in the real world (Silva et al., 2018). Augmented reality provides the creation of a level of depth by mixing with the virtualized real world at different rates (Zlatonova, 2002). Tools such as mobile phones, tablets, or smart glasses are needed to perform this process. Figure 2.2 shows AR technology visualization. It is ensured that AR technology is used successfully in many different areas. Some of them are listed below.

- Education
- Decoration
- Shopping
- Museum Tours
- Tourism
- Cinema and Television
- Sales and Marketing
- Computer games.

## 2.5 Information About the Developed Model

The next section contains information about the developed model.


**Fig. 2.2** AR technology visualization. *Source* Instabug (2019)

### *2.5.1 System Design*

The proposed model consists of 6 different structures. These 6 different structures represent subsystems that are thought to be in a smart building. These systems consist of intelligent evacuation systems, smart guest guidance systems, smart media (sound, music, announcement, and video) systems, smart face recognition and personnel tracking systems, smart survey systems, and intelligent building information systems. Each of these systems has different types of technologies and software tools. In addition, in each of these subsystems to be established, it is ensured that these subsystems are effective and efficient both within themselves and within the structure that complements the main system by making use of the system development life cycle steps, planning, analysis, design, development, implementation, and evaluation. Table 2.1 shows the hardware, software, and technology requirements used for each system.

### *2.5.2 Intelligent Evacuation System (IES)*

Intelligent Evacuation System refers to a smart system that suggests how to evacuate the existing building or location in different types of dangerous situations with

**Table 2.1** Intelligent building subsystems requirement

| IES | SGGS | SMS | ISMS | SSS | IBIS |
|---|---|---|---|---|---|
| *Hardware* | | | | | |
| Server<br>Webcam<br>iBeacon<br>Smart Screens<br>Raspberry Pi | Server<br>Smart Screens<br>Webcam<br>Raspberry Pi | Server<br>Computer<br>Raspberry Pi<br>Amfi<br>Audio System | Server<br>Smart Screens<br>Webcam<br>Mini Computer | Server<br>Tablet<br>Computer<br>iBeacon | Mobile Phone<br>Tablet Computer<br>iBeacon |
| *Software* | | | | | |
| HTML5<br>PHP<br>Javascript<br>MySQL<br>Matlab<br>JAVA | HTML5<br>PHP<br>Javascript<br>MySQL | HTML5<br>PHP<br>Javascript<br>MySQL<br>Python | HTML5<br>PHP<br>Javascript<br>MySQL<br>Matlab | HTML5<br>PHP<br>Javascript<br>MySQL<br>JAVA | Unity<br>Vuforia<br>JAVA |
| *Technique* | | | | | |
| Web Programming<br>Multi-Criteria Decision-Making Techniques<br>Computer Vision | Web Programming<br>Text to Speech | Web Programming | Web Programming<br>Computer Vision<br>Text to Speech | Web Programming | Augmented Reality |

**IES**: Intelligent Evacuation System; **SGGS**: SMART Guest Guidance System; **SMS**: Smart Media System; **ISMS**: Intelligent Staff Monitoring System; **SSS**: Smart Survey System; **IBIS**: Intelligent Building Information System

the easiest and optimum efficiency. When the literature is examined, it is seen that evacuation systems are using different techniques. In particular, optimization techniques have methods to be used in solving the situation encountered at the time of evacuation. In the smart evacuation model developed, the Analytical Hierarchical Process (AHP) approach, one of the multi-criteria decision-making techniques, is used. Briefly, AHP suggests an optimum selection of decision points with the help of certain criteria, which are determined according to various levels of importance. Therefore, during a certain evacuation, it is necessary to find a route through which individuals in the building or any location can leave the building as quickly and safely as possible. This route can be drawn with simulation applications before the evacuation occurs, but the existence of some variables that cannot be determined in advance at the time of evacuation can give rise to problems of a different nature. For this reason, an information-based system that can guide people according to the current variable values that occur at the time of evacuation can bring a more successful result. As mentioned before, the AHP method is used in the developed smart evacuation model. Thanks to this method, the smart screens positioned inside the building enable a structure that shows the person in the relevant location the best route to use at that moment and presents this route to the user according to the AHP

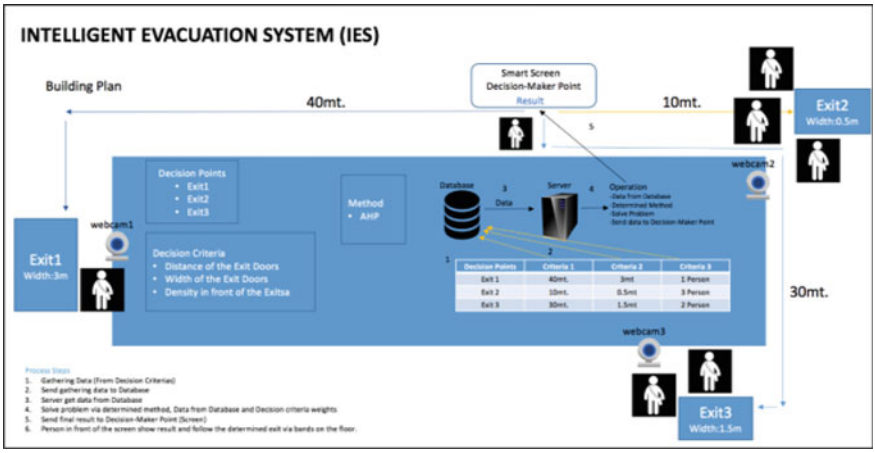


**Fig. 2.3** Intelligent evacuation system basic structure

method. According to the working logic of the developed model, all doors in the building that will allow evacuation are decision points, the distance of the doors to the relevant positions, the width of the doors, and the human density in front of the doors also decision criteria. The decision criterion, which constantly changes during an evacuation, is the crowd value in front of the door. Other decision criteria can be determined in advance. Figure 2.3 shows the basic structure of the developed model and the technologies used.

The smart evacuation system works according to the following steps.

- Data are collected according to the criteria of the decision-making problem.
- These data are sent to the database.
- It pulls data from the server database.
- According to the AHP method, the problem is solved by using the weight values of decision variables and data from the database.
- The best result achieved is transmitted to the Decision-Making Point and displayed on the smart screen.
- A person in front of the smart screen sees the door that is best for him and leaves the building following the doorway lanes on the ground.
- In case the smart screens do not work, the beacon at the decision-making point sends a signal to the mobile phone of the person at the location. And the same result is seen on the mobile phone and the evacuation process is performed.

In system design, HTML5, CSS, PHP, JAVASCRIPT, MySQL, JAVA, and MATLAB were used as programming languages. Smart screens, Raspberry Pi, Webcam, iBeacon, and Server were used as system hardware. The most important subsystem in the smart building system is the smart evacuation system. Because no other factor is as important as human life. Therefore, it is a necessity for a smart building system to have a robust evacuation system.

### 2.5.3 Smart Guest Guidance System (SGGS)

Another subsystem in the developed Smart Building System Model is the smart guest guidance system. The purpose of this subsystem is to use the system as a healthy communication tool as well as effective guidance with kiosk-based computers or tablets placed at different points in the building. In the development of the system, HTML5, PHP, Javascript, and CSS were used as web programming languages, JAVA language, and Android Studio platform were used for the mobile application and MySQL as the database. Regarded as a new technology, iBeacon technology has been integrated into the system and made ready for use on mobile devices. In this way, not only the kiosks in the building but also the mobile application developed makes it possible to direct people from their current location to their destination and communicate. Due to the limited use of GPS, especially in indoor areas such as buildings, iBeacon technology was used. The operating logic of the system is shown in Fig. 2.4.

When the visitor calls a person, the system takes a photo of the person who is calling and sends the person's picture and the time they called to the email address defined in the system. In this way, the person called is informed by the system. An iBeacon has been placed in the rooms of the academic staff in the building and made ready for use. These iBeacons send BLE signals to the mobile phones of visitors who come to the location directed by the main system and provide some information about this location and the person called. In addition, if the person being called is not in the building, the guest can leave a message to the person they are calling, thanks to this application. With this developed system, guests visiting the smart building will be able to easily find the location or person they want. The ability of incoming

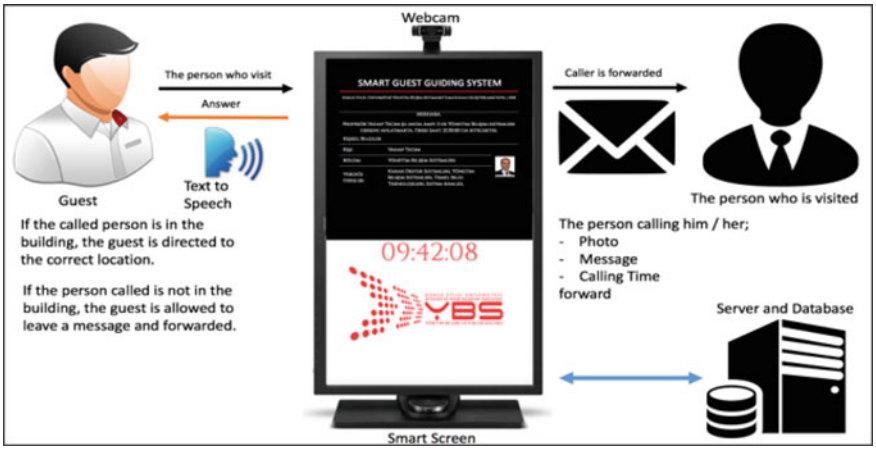


**Fig. 2.4** Smart guest guiding system basic structure

guests to leave messages about the people they are looking for and the transmission of pictures and related messages to the person called will contribute to an efficient communication process.

### *2.5.4 Smart Media System (SMS)*

Another subsystem that should be in smart building systems is the smart media system that allows the display of media tools such as music, announcements, news, and videos. The smart media system is ready for use with speakers and smart screens in the smart building. Within this structure, users can activate the music and video broadcasts they want in the whole building or their area. Likewise, they can transmit their announcement and warning messages to the whole building with the help of loudspeakers in the smart building. The system works with smart screens placed in the smart building, integrated speaker and amplifier system, and raspberry pi computers are integrated into them. Media elements such as Video, News or URL can be played on any smart screen within the smart building. Warning notifications such as music, radio broadcast, call announcement, or emergency announcement can be used with the help of the speaker system in the smart building. These operations can be performed easily from a smart mobile device or any computer. In addition, another raspberry pi device integrated into the exterior of the smart building can broadcast different types of music to users in the smart building, depending on the daily weather and temperature elements. In this way, while listening to slower music in overcast weather, more active music can be broadcast in clearer weather. All these adjustments can be made easily from the admin screen. Activities such as music broadcast and video broadcasting can be planned to work at desired times of the day. In particular, a planned media program can be carried out at conferences or various organizations in the building. Figure 2.5 shows the operating logic of the system.

### *2.5.5 Intelligent Staff Monitoring System (ISMS)*

Another subsystem in the smart building system is the intelligent staff monitoring system. The intelligent personnel tracking model is a model developed for building managers who want to track activities such as personnel entry-exit and daily tasks, especially in places such as universities or workplaces. This model is realized with a smart screen positioned at the entrance of the smart building, a minicomputer, and a web camera. Computer vision techniques and web programming are used as methods. MATLAB Computer Vision library is used for computer vision. HTML5, PHP, Javascript, CSS, and MySQL languages are used in web programming. In addition, texts related to the text to speech method are voiced and the information is transmitted to the user by voice. Also, the exit times of the personnel can be followed through this system. The daily tasks that the personnel need to do are transmitted

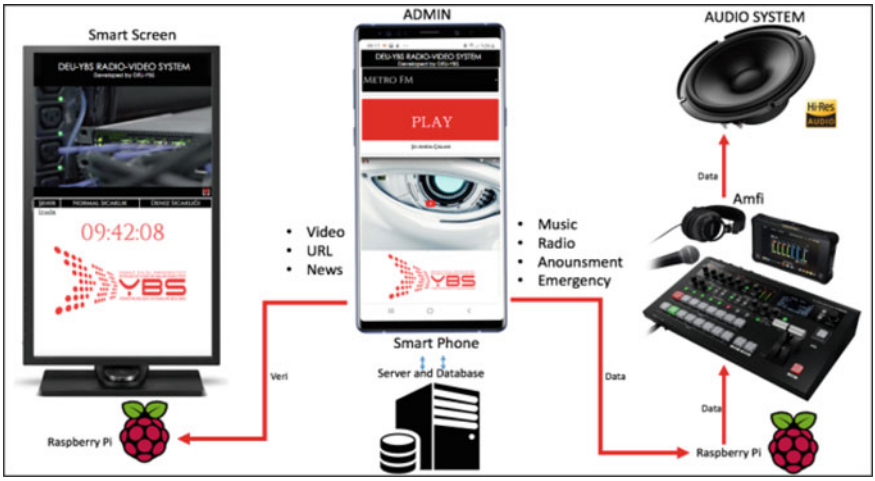


**Fig. 2.5** Smart media system basic structure

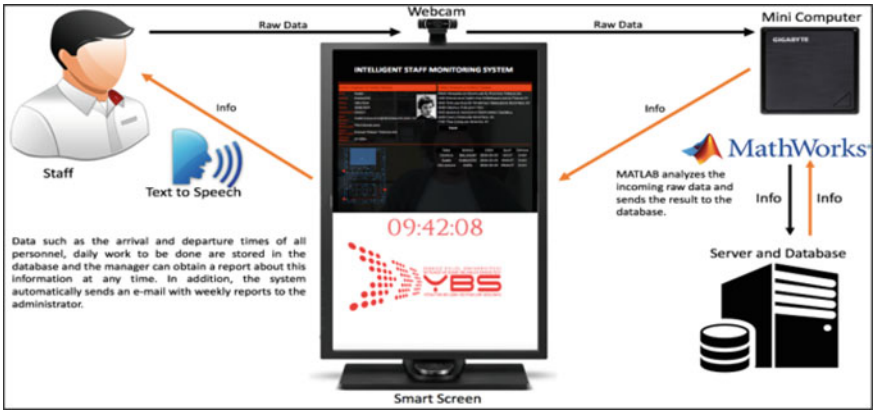


**Fig. 2.6** Intelligent staff monitoring system basic structure

audibly and visually by the smart screen when they first enter the smart building. The working logic and screenshots of the system are shown in Fig. 2.6.

First, the staff comes to the smart building at a certain time in the morning. Then, the web camera on the smart screen at the entrance of the smart building captures the face data of the person. This data is transmitted to the Matlab program on the computer as raw data input. Matlab analyzes this raw data and sends the result to the database. Thus, the entry time of the staff is recorded. Then, the work that the person concerned has to do is accessed from the database. Subsequently, this information is

transferred to the smart screen and transmitted to the personnel visually and audially through text to speech method. All data stored in the database can be reported daily or monthly, at the request of the manager. In addition, a report is sent to the manager by the system every week or at specified time intervals.

### *2.5.6 Smart Survey System (SSS)*

Another subsystem of the Intelligent Building System is the smart survey system. The smart survey system developed is used to obtain all kinds of information from users in buildings, especially in educational institutions and institutions operating in the service sector, and to provide efficient effects on business processes by producing meaningful results from these data. The system developed is web-based making it extremely easy to integrate into any building. The structure to be used for data collection consists of a tablet computer, a physical platform in which this tablet computer is located, and software running the system. 3-point and 5-point Likert scales were used for data collection. HTML5, PHP, Javascript, and CSS are used as web programming languages. JAVA language and Android Studio platform are used for the mobile application. MySQL has been chosen as the database. Considering a relatively new technology, iBeacon technology has been integrated into the system and made ready for use on mobile devices. The operating logic of the system is shown in Fig. 2.7. The functioning of the system is based on the preparation of survey questions, then assigning these questions to digital surveys in the relevant location, and then determining what actions are required or not as a result of the collected answers. Survey responses are first stored in the database and the administrator can review these survey results based on the relevant location and question. The system


**Fig. 2.7** Smart survey system basic structure

automatically transmits reports to the manager via email at the end of the survey period. Thanks to iBeacon technology, another tool used in the system, the same questions are sent to the phone of the guest, staff, or anyone in the building at any location in the building, and the person can view the questions on their mobile phones. In this way, survey questions are answered without the need for any physical smart survey signboard.

### *2.5.7 Intelligent Building Information System (IBIS)*

The last subsystem of the smart building system is the intelligent building information system. The intelligent building information system informs visitors or residents about any location, place, room, or person in the building. For example, when a person comes to the front of the conference hall, he/she gets information in 2 ways. The first one is the use of augmented reality technology and the other is the method using iBeacons. In order to use the augmented reality technology, firstly, pictures of the current locations within the smart building should be taken and these pictures should be classified. Then, for each of the pictures taken, media content with a different structure should be prepared and then these 2 elements should be matched. To do these operations, Vuforia, an open-source Unity library, is used. After these mappings are made from within Vuforia, a database must be exported and then this database must be imported to the Unity Platform. Later, the pictures in the library must be matched with the content to be displayed via the Unity Platform. After all these pairing processes are completed, they should be printed out in Android or IOS format and made ready for use on mobile devices. The process is visualized in Fig. 2.8. The guest coming into the smart building for the first time can easily benefit

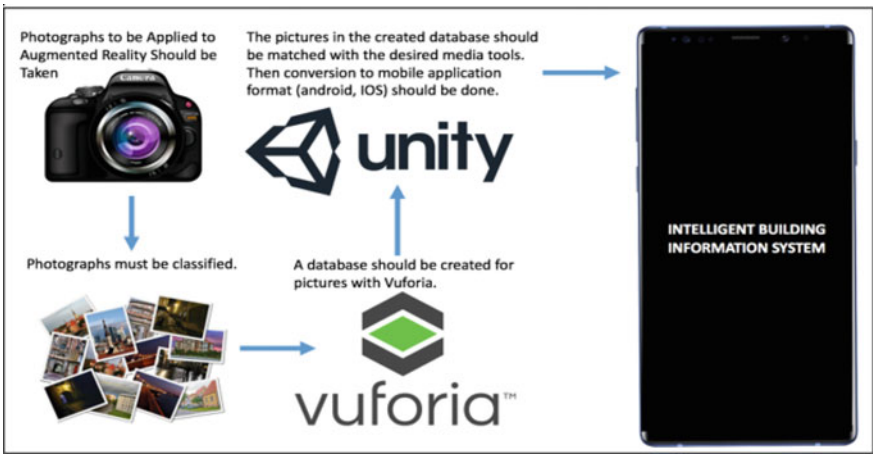


**Fig. 2.8** Intelligent building information system (augmented reality model)


**Fig. 2.9** Intelligent building information system (iBeacon model)

from the system by downloading the application obtained from the door. In this way, more detailed information about any location or person in the smart building can be accessed in the form of video, audio, 3D animation, URL, or textual augmented reality contents.

The second model in the system is the one created with iBeacon devices. The process is visualized in Fig. 2.9.

This system model is provided by placing the iBeacon devices in front of the objects, halls, or rooms determined in the building and then sending signals to the smartphones of the guests. For example, while passing in front of the conference hall inside the building, the iBeacon positioned in front of the conference hall sends a signal to your mobile phone and says "This is the conference hall. Please click for more detailed information!" When you click on this message, you can reach the contents (video, audio, URL, etc.) prepared in different structures related to the conference room. The hardware elements required for using this model are iBeacon and smart mobile phones, smartwatches, or tablet computers. For the mobile application of the model, JAVA languages are used on Android devices and Objective C languages are used on IOS devices.

## 2.6 Conclusion and Recommendations

The developed system proposes the use of 6 sub-models that can be integrated into smart building systems. The design of this model has been carried out to contribute to the productivity, effectiveness, and efficiency levels of some administrative activities. All subsystems in this developed system have been tested and usability has been tested in the building used by Dokuz Eylül University Management Information Systems

Department. The establishment of all subsystems brings a certain commercial cost, but it has been found to be in an extremely advantageous position compared to alternative commercial models. Intelligent building technologies should be updated in parallel with other scientific innovations and developments that are constantly developing.

A smart building must have an evacuation system. The intelligent evacuation subsystem used in this model has been prepared in a structure based on the AHP method. The integration of other multi-criteria decision-making methods such as Topsis, Electre, Promethee, Vikor, Aras into the system can make a positive contribution to the system. Or at least, a model in which all these models are compared in certain scenarios and the best result is transferred to the user may also provide positive contributions in terms of system efficiency. Creating a stronger structure by integrating different types of variable data in the smart building into the decision process is also recommended. The developed model was used only in Dokuz Eylül University Management Information Systems Department and the efficiency of the system was evaluated only based on this building. For this reason, it is necessary to investigate the validity and efficiency levels of this model in buildings with different structures.

The smart guest guidance subsystem has been developed to enable guests in a smart building or people who come to the building for some processes such as business meetings to easily find the locations they want. It is thought that this model can be useful especially for complex buildings. The developed model has been put into use at the Dokuz Eylül University Management Information Systems Department building and it has been observed that it has positive results. It was observed that students looking for instructors' rooms especially benefited from the system.

The smart media system works in an integrated structure with the sound and imaging devices inside the building. It has been actively used in Dokuz Eylül University Management Information Systems Department building, especially for announcements, video and radio broadcasting, and announcing current news. One of the most important advantages of the system is that media activities are programmable. The low cost of Raspberry Pi mini computers, which is one of the hardware elements, provides an advantage in terms of efficiency.

The intelligent staff monitoring system can be used actively, especially during staff entry-exit times or during student attendance. This subsystem, which is integrated according to the purpose, can be used for different goals. Matlab Computer Vision library was used in the study. This is a commercial application and has been preferred due to its robust structure. However, a cost advantage can be achieved by using open source Computer Imaging libraries such as OpenCV.

The Intelligent Survey System has been developed specifically to measure customer, staff, student, and guest satisfaction and to take necessary measures in line with the results. Thanks to this system integrated into smart buildings, it can be ensured that data are collected and some results are achieved in complex organizations within the building.

Two different methods have been applied in the smart building information subsystem. One of them is augmented reality and the other is the method performed

with iBeacons. In particular, the augmented reality technology attracts the visual attention of incoming guests or smart building users and it appears to be extremely attractive with the use of different media tools. The hardware units used while extremely low cost, have an extremely high level of satisfaction. The important thing here is to be meticulous and careful in the creation of augmented reality and iBeacon content and to create highly attractive content.

The model suggested in this study is what subsystems with only 6 different structures can be and with which instruments and methods these structures can be created. Of course, many stronger structures can be created by integrating many different methods into smart building systems. In the solution of many problems that occur or are likely to occur in smart buildings, heuristic algorithms based on artificial intelligence can be used. In the next study, possible models to be created by these methods will be considered and different structures will be examined.

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# Chapter 3
# Artificial Intelligence for Smart Cities: Locational Planning and Dynamic Routing of Emergency Vehicles


**Ugur Eliiyi**

**Abstract** To enhance the efficiency and effectiveness of essential emergency services such as ambulances, fire brigades, and police, one of the most important problems to tackle is to minimize the response times of these emergency vehicles. As well as attaining optimal waiting sites and deployment strategies for the emergency vehicles, the optimal routing and traffic preemption of the vehicles are also crucial in minimizing response times and maximizing coverage. As locational planning and dynamic routing of the emergency vehicles relate to many different situations with varying emergency levels, they are a crucial part of the smart city concept. In this chapter, we present a perspective for the use of artificial intelligence and optimization in sustainable healthcare logistics within a smart city. We provide a survey of literature and identify many applications from around the globe. Related mathematical models and solution approaches are also presented, as necessary.

**Keywords** Healthcare logistics · Artificial intelligence · Smart cities · Optimization · Emergency services planning · Vehicle routing · Location/relocation problems · Ambulance deployment · Dynamic routing · Mathematical modeling

## 3.1 Introduction

In December 2019, the Chinese city of Wuhan contracted with Huawei to install infrastructure to improve its security and information services, and convert the city into a "smart city" (Liu & Li, 2020). The contract also incorporated procedures for rapid emergency response, which could, in principle, aid in containing the city's epidemic of the coronavirus disease COVID-19. This recent and crucial emergency problem pertains to many large cities around the globe, and an imminent problem of embracing parallel practices for timely prevention and control of infectious-disease

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outbreaks, as well as regular health services, is of major concern. Artificial intelligence techniques and data analytics in big data ecosystems of smart cities alert authorities to any irregularities (e.g., in population mobility, traffic flow, weather conditions, etc.) in real time.

The rational utilization of limited resources is critical in smart cities for effective management. In order to improve timeliness, utilization, and sustainability of emergency services, the allocation of the resources and the emergency vehicle routes need to be optimized. With increasing urbanization and traffic, the frequency and impact of traffic accidents also intensify. For this reason, the research on emergency rescue and emergency services planning is getting ever more attention. When an emergency occurs (e.g., a traffic accident), timely arrival is key for emergency rescue. Efficient and effective planning of emergency vehicle paths depends on optimized travel times and maximizes emergency logistics service quality. Thus, the problem of route planning for the emergency vehicles also attracts attention by the researchers.

In Turkey, recent major enhancements in the domestic health infrastructure resulted in the formation of large-scale city hospitals. The consolidation of health services in such large hubs brings an operational efficiency in services within facilities. This approach also facilitates the pooling of critical resources, and in turn conveys cost efficiency. However, the operational planning of emergency logistics for such large facilities can be quite challenging. Traffic congestion within the city limits affect timely access to emergency conditions, as well as the placement of ambulance hubs and the dispatching of the vehicles in a timely manner. Sequential or concurrent optimization of these decisions and other related logistics decisions require the use of artificial intelligence techniques and data analytics.

This chapter aims to present a perspective for the use of artificial intelligence methods in sustainable health logistics in a smart city context. For this purpose, a broad survey of optimization literature is conducted, and many applications are identified and discussed. As locational planning and dynamic routing of emergency vehicles relate to different situations with varying emergency levels, they are a crucial part of the smart city design. We identify various problems and solution methods applied for different variants of these problems. Mathematical models and solution approaches are presented wherever necessary, and different applications from around the globe are provided.

The rest of this chapter is organized as follows. As the routing of emergency vehicles is a critical concept in emergency services planning, the routing problems and their characteristics are presented in the next section, along with related mathematical models and solution approaches. As another critical decision-making problem in health logistics, the ambulance location and redeployment problems are reviewed in Sect. 3.3. Several applications and real-life implementations of locational planning and dynamic routing of emergency vehicles using the technological advances of smart cities are discussed in Sect. 3.4, together with open research areas. Finally, Sect. 3.5 concludes this chapter.

## 3.2 Routing Problems

Dantzig and Ramser (1959) introduced the Truck Dispatching Problem more than 60 years ago, which came to be known as The Vehicle Routing Problem (VRP); one of the most popular problems in the field of operations research and management science. The authors define a real-world problem between a main depot and many vendors in terms of dispatching gasoline delivery trucks. The problem concerned with determining the least-cost vehicle fleet routes from given depot(s) to a set of geographically dispersed locations. In their problem, the truck capacities were also regarded, hence the problem was in fact a Capacitated VRP (CVRP).

In general, the CVRP tries to minimize the total transportation cost while meeting the demands of a set of customers on a network with a fleet of identical or heterogeneous fleet of capacitated vehicles. As the CVRP model is the basis for almost every VRP model in literature, we provide its mathematical model in the next section.

### *3.2.1 The CVRP Model*

A basic integer programming model of single depot CVRP by Fisher and Jaikumar (1981) is provided below.

*Problem Parameters*:

$K$ Number of vehicles
$n$ Number of all customer nodes. All customers are indexed from 1 to $n$ and the single depot is denoted with index 0
$b_k$ Capacity of vehicle $k$
$a_i$ Weight or volume of shipment to node/customer $i$
$c_{ij}$ Cost of travel from node $i$ to node $j$.

*Decision variables*

$y_{ik}$ equals 1 if demand of node $i$ is delivered by vehicle $k$, equals 0 otherwise
$x_{ijk}$ equals 1 if vehicle $k$ travels from node $i$ to node $j$, equals 0 otherwise.

Based on the definitions above, the integer programming formulation is as follows.

$$\min \sum_{ijk} c_{ij} x_{ijk} \tag{3.1}$$

subject to

$$\sum_{i} a_i y_{ik} \leq b_k, k = 1, \ldots, K \tag{3.2}$$

$$\sum_{k} y_{0k} = K \tag{3.3}$$

$$\sum\nolimits_k y_{ik} = 1, i = 1, \ldots, n \tag{3.4}$$

$$\sum\nolimits_i x_{ijk} = y_{jk}, j = 0, \ldots, n, k = 1, \ldots, K \tag{3.5}$$

$$\sum\nolimits_j x_{ijk} = y_{jk}, i = 0, \ldots, n, k = 1, \ldots, K \tag{3.6}$$

$$\sum\nolimits_{ij \in S \times S} x_{ijk} \leq |S| - 1, S \subseteq \{1, \ldots, n\}; 2 \leq |S| \leq n - 1; k = 1, \ldots, K \tag{3.7}$$

$$x_{ijk}, y_{jk} \in \{0, 1\}, i = 0, \ldots, n; j = 0, \ldots, n; k = 1, \ldots, K \tag{3.8}$$

The objective function in (3.1) aims at minimizing the total cost of transportation. Constraints in (3.2) are the capacity constraints for each vehicle. Note that the formulation allows vehicle capacities to be different from one another. Constraints in (3.3) ensure that each vehicle starts and ends its tour at the depot. The guarantee for each customer to be visited by a vehicle is established via the constraints in (3.4). Constraints (3.5) and (3.6) define the relationship between the two decision variables, whereas the constraints in (3.7) impose the subtour elimination constraints for the vehicles. In other words, this constraint set implies that a vehicle cannot make disconnected tours within the planning horizon, it must start and end its tour at the depot while visiting all its assigned nodes within a single tour. Finally, the last constraint set (3.8) defines the variable domains.

### *3.2.2 Vehicle Routing Problem Extensions*

As it is very critical in logistics and distribution management, and must be routinely solved by carriers, VRP gained immense attention from researchers since it was first introduced. Several variants of the problem emerged due to diverse operating rules and a large range of side constraints from practice. For this reason, VRP is now known as a class of problems rather than a single problem (Laporte, 2009). The considerable amount of VRP research over time also led to breakthrough in the general field of exact solution methodologies and heuristics in optimization. Cutting-edge exact algorithms and effective metaheuristics developed for the problem have paved new application avenues for studies in other problems, as well.

Additional features or limitations that tend to properly consider the details of real-life applications form the attributes or the variants of VRP. A well-developed literature, including a wide variety of heuristics, supports the variants thus produced. The key classes of attributes were analyzed in a thorough analytical survey that included heuristics and metaheuristics for the Multi-Attribute Vehicle Routing Problems (MAVRP) (Vidal et al., 2013). The authors reviewed 64 outstanding metaheuristics, critically selected for their success on 15 classic MAVRP with distinct attributes.

They also came up with effective strategies for designing successful heuristics for MAVRP through a cross-analysis among the reviewed literature and the identified attributes. Tasar et al. (2019) provided another novel taxonomic framework for the MAVRP using six main fields of notation with respect to attributes and constraints describing operational policy, problem objective, vehicle fleet characteristics, product characteristics, depot structure, and time period properties.

As one of the attributes reviewed by Vidal et al. (2013), the Multi-Depot VRP deals with more than one depot. One depot is allocated to each vehicle, which is usually both the origin and the destination of the route of the vehicle. The vehicle fleet may contain vehicles with different characteristics in terms of capacity, maximum route times, fixed costs, and variable costs. The problem is generally referred as the Vehicle Fleet Mix Problem when the number of vehicles is not limited, whereas the more complicated form is called the Heterogeneous VRP.

In Periodic VRP, a time dimension is included as the planning of routes is done over many periods of time. A few services are needed by each customer according to some pattern of visit times in this variant. Notable attention was paid to the issue of service consistency within the context of this problem, i.e., visiting frequent customers at the same time during each cycle and with the same driver. If more than one vehicle delivers partial loads to a customer, this variant of the problem is called the VRP with Split Deliveries. In the case where service is optional for many clients, but compensated with a prize, the problem is known as the Prize Collecting VRP. In this variant, the customers must be split into two subsets based on whether their service is omitted or performed.

Certainly, the most thoroughly researched VRP variant to date is the VRP with Time Windows (VRPTW). Time windows are predetermined for customer visits and depots with a time duration characterizing each arc. Waiting times are allowed at customer locations upon early arrivals, whereas late arrivals are prohibited. The mathematical model of the VRPTW, as introduced by Ioannou et al. (2001), is provided below.

*Problem Parameters:*

| | |
|---|---|
| $V$ | Set of available identical vehicles |
| $C$ | Capacity of vehicle (identical for all vehicles) |
| $L$ | Set of nodes including the depot. $i = 1$ refers to the depot, while indices $i$, $j$, and $u$ valued between 2 and $n$ denote the customer nodes |
| $q_i$ | Demand at node $i$ |
| $[e_i, l_i]$ | Time window requested by node $i$, where $e_i$ represents the earliest and $l_i$ refers to the latest service start time |
| $s_i$ | Service time of node $i$ |
| $t_{ij}$ | Travel time from node $i$ to node $j$ |
| $c_{ij}$ | Travel cost from node $i$ to node $j$ |
| $w_k$ | Fixed cost of using vehicle $k$. |

*Decision variables*

$a_i$ Arrival time to node $i$ (continuous variable)
$p_i$ Departure time from node $i$ (continuous variable)
$z_k z_k$ equals 1 if vehicle $k$ is activated (used), equals 0 otherwise
$x_{ijk}$ equals 1 if vehicle $k$ travels from node $i$ to node $j$, equals 0 otherwise.

Based on the definitions above, the mixed-integer programming formulation is as follows.

$$\min \sum_{ijk} c_{ij} x_{ijk} + \sum_{k} w_k z_k \tag{3.9}$$

subject to

$$\sum_{ik} x_{ijk} = 1,\ j = 2, \ldots, n \tag{3.10}$$

$$\sum_{jk} x_{ijk} = 1,\ j = 2, \ldots, n \tag{3.11}$$

$$x_{ijk} \leq z_k 1,\ i = 1, \ldots, n;\ j = 1, \ldots, n. \tag{3.12}$$

$$\sum_{j=2}^{n} x_{1jk} \leq 1,\ k = 1, \ldots, |V| \tag{3.13}$$

$$\sum_{i=2}^{n} x_{i1k} \leq 1,\ k = 1, \ldots, |V| \tag{3.14}$$

$$\sum_{i=2}^{n} x_{iuk} - \sum_{j=2}^{n} x_{ujk} = 0,\ k = 1, \ldots, |V|;\ u = 1, \ldots, n \tag{3.15}$$

$$\sum_{ij \in S \times S} x_{ijk} \leq \sum_{ij \in S \times L} x_{ijk} - 1,\ S \subseteq L;\ 2 \leq |S| \leq \sum_{ij \in L \times L} x_{ijk};\ \forall k \in V \tag{3.16}$$

$$\sum_{i} q_i \left( \sum_{j} x_{ijk} \right) \leq C,\ k = 1, \ldots, |V| \tag{3.17}$$

$$a_j \geq p_i + t_{ij} - \left(1 - x_{ijk}\right) M,\ i = 1, \ldots, n;\ j = 1, \ldots, n;\ k = 1, \ldots, |V| \tag{3.18}$$

$$a_j \leq p_i + t_{ij} - \left(1 - x_{ijk}\right) M,\ i = 1, \ldots, n;\ j = 1, \ldots, n;\ k = 1, \ldots, |V| \tag{3.19}$$

$$a_i \leq p_i - s_i,\ i = 1, \ldots, n \tag{3.20}$$

$$e_i \leq p_i \leq l_i,\ i = 1, \ldots, n \tag{3.21}$$

$$a_1 = 0 \tag{3.22}$$

$$x_{ijk}, z_k \in \{0, 1\}, i = 0, \ldots, n; j = 0, \ldots, n; k = 1, \ldots, |V| \tag{3.23}$$

The objective function in (3.9) addresses the trade-off between transportation and vehicle usage costs via taking the total cost as the fixed cost of usage plus the variable transportation cost. Constraints in (3.10) and (3.11) guarantee that every node is served by one vehicle. Unused or inactive vehicles are banned from serving nodes by constraint set (3.12). The constraints in (3.13) through (3.15) are the flow conservation constraints, while constraint (3.16) eliminates the subtours. Identical vehicle capacities are imposed by constraint set (3.17). Constraints in (3.18) and (3.19) determine the service start times of subsequent nodes in the tour sequence. Constraints in (3.20) and (3.21) relate the arrival time and departure time variables by using service time parameters, while also safeguarding the service time windows for each node. The departure time from the depot is set to zero through constraint (3.22). Finally, constraint set (3.23) defines the domains of the decision variables.

In realistic environments, the travel times on arcs may depend on the vehicle departure times, e.g., when facing network congestion. In this case, the problem becomes a Time-Dependent VRP. In the literature, several other time attributes on routes have been studied, such as speed options, waiting time limits, various time frames, time-dependent service costs, or the minimization of the average time to meet customer demands, known as the Cumulative VRP. Also, long-distance transportation laws place specific rules on travel time and driver breaks. Incorporating break scheduling into VRP brings an additional challenge to the problem.

The operations in less-than-truckload routing lead to a broad range of constraints related to the packing of 2D and 3D packing of items. Such problems incorporate both Multi-Capacity Bin Packing and VRP (Gendreau et al., 2008). As another important variant, in the Open VRP, the return to the depot is not included in freight costs in relation to the invoicing practices of road transport suppliers. Vidal et al. (2013) identified some key metaheuristic approaches successfully used in solving the above variants of VRP. These approaches included Tabu Search, Genetic or Evolutionary Algorithms, Iterated Local Search, Ant Colony Optimization, Variable Neighborhood Search, Scatter Search, Adaptive Large Neighborhood Search, Path Relinking, Simulated Annealing, and Particle Swarm Optimization.

Routing problem extensions have also been studied in humanitarian contexts. For example, Özdemirel et al. (2012) addressed a need-based real-life assignment-routing problem from Turkey, which can be applicable for most underdeveloped or developing countries. For identifying and meeting the basic needs of indigent residents, the municipal authorities collect and distribute donations and funds, which require the matching of donations and needs and efficient distribution planning for timely pick-ups and deliveries. The authors tackled this essential problem by developing a novel and integrated assignment-routing mathematical model with time windows and a humanitarian objective of maximizing utility. Multiple criteria were considered for the assignment of donations and recipients such as the travel times, income

level, age, previous usage, etc., and the priorities among the criteria were set through pairwise comparisons.

As one of the latest trends in logistics and supply chain management, the concept of Green Logistics has arisen. To mitigate system-wide costs related to economic and environmental problems, the conventional goal of distribution management has been upgraded with this new concept. The value of Green Logistics is driven by the fact that conventional logistics solutions for production and distribution are not viable in the long term in terms of sustainability. In addition to the traditional economic costs, financial, ecological, and social impacts should also be taken into account when developing logistics policies in this new paradigm. Green Transportation has a wide range of concerns, such as the promotion of renewable fuels, electronic vehicles of the next decade, electric intelligent transport systems, and other eco-friendly infrastructure. The class of VRP incorporating these concerns is known as Green Vehicle Routing Problem (GVRP) in literature.

Koç et al. (2014) addressed the problem of fleet size and pollution-routing, which expanded the issue of pollution-routing in GVRP, by considering a heterogeneous fleet of capacitated vehicles. Their main objective was to minimize the sum of fixed costs and the routing costs of the vehicles, where the latter can be specified in terms of fuel costs, $CO_2$ emissions, and the driver cost. All customers were to be served within their predefined time windows without allowing for any split deliveries. Moreover, as an interesting extension to the problem, the speed of each vehicle on each arc was also a decision variable. As well as modeling this complex green VRPTW, the authors developed a hybrid evolutionary metaheuristic algorithm, and implemented it on benchmark problem instances. Lin et al. (2014) provided a comprehensive review on GVRP that reflected environmental issues. The authors included a GVRP classification categorizing GVRP into many subcategories and addressed several research gaps.

The dynamic routing of vehicles, which is closely associated with healthcare and emergency logistics, was also addressed in literature. In static and deterministic problems all problem parameters are predetermined, and the optimal routes are not expected to change once they are set. However, in dynamic routing, the customer visits must be explicitly sequenced along the routes, which requires real-time communication between the vehicles and the dispatching center, as is the case for emergency services. Figure 3.1 illustrates this real-time communication (Pillac et al., 2013). The environment applies to the physical world while the person supplying the vehicles with orders is the dispatcher. The dispatcher decides on the route and instructs the ready vehicle to fulfill request *A* (shown by a double-headed arrow). The vehicle notifies the dispatcher every time it starts and ends service at a service point. The dispatcher makes the necessary updates through these communications and incoming demand. Then, the dispatcher instructs the vehicle to its next request *B*. The procedure is repeated at every new visited node.

Pillac et al. (2013) provided a nice review on dynamic routing. One application provided in their survey was the French non-profit organization SOS Médecins, which works with a crew of doctors who, via a call center organized with other emergency services, are called into action. The seriousness of a case is determined when a patient

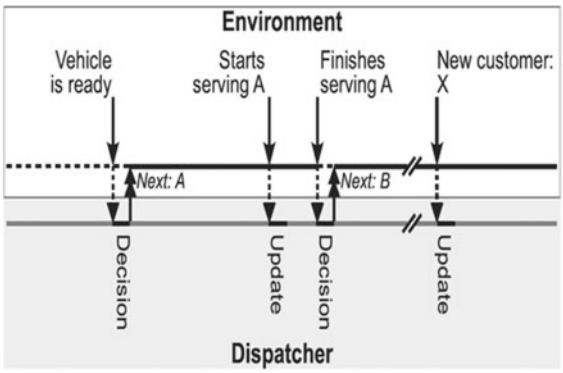


**Fig. 3.1** Timeline of events for dynamic routing of a single vehicle. *Source* Pillac et al. (2013, p. 3)

calls, and a visit by a doctor is scheduled accordingly. Having an effective dispatching system decreases the response time, thus enhancing the quality of service to society. It is also necessary to dynamically determine whether or not to send a physician, so that a sufficient quality of care could be assured. Other applications of dynamic routing in the humanitarian context include the transportation of children, the elderly, the disabled people, or patients from one point to another, i.e., home to school, medical center, or place of work. Such routing problems that involve moving people between locations are referred to as Dial-A-Ride-Problems (DARPs). Ho et al. (2018) very recently provided an extensive review for this class of problems.

## 3.3 Ambulance Location/Relocation Problems

Location problems in the general field of operations research and management science is a highly active research field, drawing the attention of many researchers and practitioners. This class of optimization problems are concerned with deciding the optimal location of a facility, facilities, or equipment to support a collection of demand points. The optimal location depends on the essence of the handled problem in terms of constraints and parameters. As location problems constitute a very rich class of problems, research carried out on them has led to considerable theoretical and practical contributions in many different fields. The engagement with fields such as economics, geography, regional science, and logistics has supported the popularity and growth of location science. Many effective implementations of location problems show that comprehension in detail is needed for developing good solutions to problems coming from different fields. In this section, we focus on the location problem of ambulances, or emergency vehicles in general, and the use of optimization and artificial intelligence techniques for this important area.

Ambulance location planning incorporates features from classical location models, multi-period location models, and location models under uncertainty. The

effect of local administrative legislation on problem constraints and objective functions is also significant for these models. Defining this problem as one of the three key location issues arising in the healthcare context, Güneş and Nickel (2015) addressed the ambulance location problem, which entails emergency vehicle location and relocation decisions. A common objective of ambulance location problems is to find ambulance parking or station locations that reduce the size of necessary ambulance fleets or the number of stations while meeting a certain level of demand. Another objective is to optimize the coverage with a given ambulance fleet. The key feature of coverage models is that, within a given time limit, all demand points must be served by the determined locations. There exists a wide variety of literature reviews on ambulance planning (Brotcorne et al., 2003; Li et al., 2011; Owen & Daskin, 1998).

Ambulance planning is usually carried out at three different decision-making levels: strategic, tactical, and operational. Strategic level decisions involve finding positions of emergency stations that have a long-term influence for several decades in emergency medical services, whereas tactical level models cover evaluating the number of ambulances per site and the movable positions. Short-term operational ambulance planning deals with ambulance dispatching for allocating and reallocating to emergency sites and stations (Güneş & Nickel, 2015). A classical approach for determining ambulance base locations at the strategic level is to use the Location Set Covering Model (LSCM) due to Toregas et al. (1971). When determining where to locate emergency points where an ambulance can wait for a call, it happens very frequently that patients will only access this service if they are within a certain distance from the nearest facility (e.g., the ambulance will arrive at the home of this individual in less than 9 min). The location problems with this property are referred to as covering problems, and it is said that the patient is covered if a predetermined response time can be achieved. The mathematical formulation for LSCM is provided below.

*Problem Parameters*:

$J$ Set of demand nodes and potential locations for the ambulances
$TT$ The maximum response time
$t_{ij}$ Driving time between node $i$ and node $j$
$J_j$ Set of all nodes that can cover an emergency in node $j$. A node $i$ can cover node $j$ if and only if the driving time $t_{ij}$ between the two nodes is less than or equal to $T$, i.e., $J_j = \{i \in J | t_{ij} \leq T\}$.

*Decision variables*

$x_j$ equals 1 if an ambulance is located at site $j$, equals 0 otherwise.

Based on the definitions above, the binary programming formulation for LSCM is as follows.

$$\min \sum_{j \in J} x_j \tag{3.24}$$

subject to

$$\sum_{j \in J_j} x_i \geq 1, \forall j \in J \tag{3.25}$$

$$x_j \in \{0, 1\}, \forall j \in J \tag{3.26}$$

The objective function in (3.24) tries to minimize the number of ambulances. The constraints in (3.25) guarantee that each demand node is covered, i.e., each node can be reached within the given response time by at least one ambulance. Hence, the covering model minimizes the number of ambulance stations required to fulfill all possible demand. The last constraint set defines the decision variables to be binary. Figure 3.2 illustrates an example and a feasible solution to this covering problem.

While LSCM only enforces accessibility to all demand points within a specific time, it does not allow answering an emergency call from different EV sites. This was addressed by a Tactical Level Double Standard Model (Gendreau et al., 1997), which extended LSCM by incorporating split deliveries and two different response time limits instead of one, which was called as double coverage for the demand points. Moreover, the size of the overall ambulance fleet was predetermined in their model in contrast with LSCM. In real-life emergency situations, the vehicles might not be always available. Therefore, strategic and tactical decisions should also consider the utilization levels of the vehicles evaluated via aggregated data from operational service level. Daskin (1983) formulated the maximum expected location covering problem (MEXCLP) for maximizing expected demand coverage defined for each service area as follows.

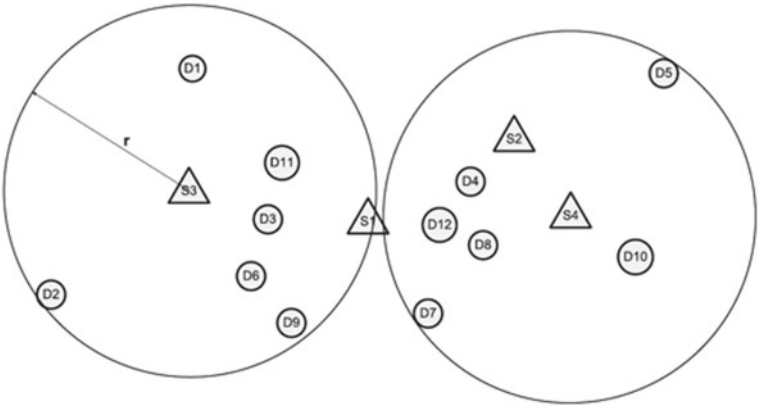


**Fig. 3.2** An illustration of the LSCM. *Source* Li et al. (2011, p. 285). D1–D12 are demand nodes and S1–S4 are ambulance locations. The maximum response time is denoted by r. A feasible solution is illustrated by determining S3 and S4 as ambulance locations, which cover all demand points

*Problem Parameters:*

$J$ Set of demand nodes
$d_j$ Demand of node $j$
$T$ The maximum response time
$t_{ij}$ Driving time between node $i$ and node $j$
$II$ Set of potential location sites for the ambulances ($I$ may be equal to $J$)
$p$ Maximum number of ambulance sites to be located
$P$ The probability that an ambulance is occupied
$P^k$ The probability that $k$ ambulances are concurrently busy
$K$ Set for defining the number of times a node is covered, $K = \{1, \ldots, n\}$.
$\gamma_{ij}$ equals 1 if an ambulance at site $i$ covers demands at node $j$ ($t_{ij} \leq T$), equals 0 otherwise.

*Decision variables*

$x_{jk}$ equals 1 if node $j$ is covered $k$ times, equals 0 otherwise ($k \in K$).
$y_i$ Number of ambulances located at site $i$.

Based on the definitions above, the integer programming formulation for MEXCLP is as follows.

$$\max \sum_{k \in K} \sum_{j \in J} d_j (1 - P) P^{k-1} x_{jk} \tag{3.27}$$

subject to

$$\sum_{k \in K} x_{jk} \leq \sum_{i \in I} \gamma_{ij} y_i, \forall j \in J \tag{3.28}$$

$$\sum_{i \in I} y_i \leq p \tag{3.29}$$

$$y_i \in \{0, 1, \ldots, p\}, \forall i \in I \tag{3.30}$$

$$\forall j \in J; \forall k \in K x_{jk} \in \{0, 1\} \tag{3.31}$$

The objective function in (3.27) maximizes the expected covered demand. Note that, if node $j \in J$ is covered by $k$ ambulances, $E_k^j = d_j\left(1 - P^k\right)$ gives the corresponding expected covered demand. To this expected value, the marginal contribution of the $k$th ambulance can be computed by $E_k^j - E_{k-1}^j = d_j (1 - P) P^{k-1}$. The objective function therefore sums these marginal contributions to expected coverage over all possible numbers of ambulances. The constraints in (3.28) warrant that the number of ambulances used to cover demand node $j$ is less than the number of ambulances within the coverage area for that node. The coverage area is defined by nodes located not farther away than the response time threshold $T$ from $j$. Constraints in (3.29) bound the number of located ambulance sites by $p$. Constraints in (3.30) and (3.31) define variable domains. Daskin (1983) also developed a heuristic for this problem.

Based on these earlier versions, many extensions of covering models were adapted by researchers for solving complex emergency response problems. Li et al. (2011) surveyed these covering models and optimization techniques for emergency response facility location and planning. The reviewed models included LSCM, Maximal Covering Location, Double Coverage, MEXCLP, and Maximum Availability Location. The developments on hypercube queuing models, dynamic allocation models, and many others were also identified by the authors, as well as optimization techniques including heuristic algorithms, simulation, and exact methods. The authors stated that Genetic Algorithms and Tabu Search are the main metaheuristic approaches used to tackle this class of problems. Simulation was also used by many researchers either to gain insight into the implementation of optimal policies, or to assess the performance of optimization and hybridize solution methods to yield better results. The authors stressed the need to integrate data from geographic information systems (GIS) and other tools such as smartphones into the models for visualization and effective solutions.

For decision making at an operational level, the allocation of vehicles to emergency services and their relocation to stations after service completion are considered. Vehicle relocations can be made within a specified time horizon such as daily, either determined in advance or dynamically in that decision horizon (Brotcorne et al., 2003; Güneş & Nickel, 2015). Markov chain or approximate dynamic programming models were proposed in literature for solving relocation problems (Alanis et al., 2013; Maxwell et al., 2013; Schmid, 2012), as well as a parallel tabu search for the dynamic version of the problem (Gendreau et al., 2001). Due to several requirements faced in real-life situations, studies on ambulance relocation concentrated mostly on heuristic solution approaches. For example, Andersson and Värbrand (2007) developed a tree search algorithm for minimizing the maximum travel time of emergency vehicles while also taking preparedness levels of vehicles into consideration. They assigned vehicle demand weights to zones that were defined for the covered emergency service area.

## 3.4 Applications in Healthcare Logistics for Smart Cities

An important way to enhance essential services such as ambulances, fire, and police is to reduce the travel times of the emergency vehicles (EVs). Optimal routing and preemption are effective strategies used to minimize EV response time. An EV's response time is defined as the interval from the receipt of an emergency call to the arrival of the EV at the emergency site. The response time is determined by several static parameters such as distance and number of (signalized/unsignalized) route intersections, and by dynamic parameters such as flow, average velocity, and the number of stops. The existence of these parameters makes it complicated to minimize EV travel times (Humagain et al., 2020). An irreparable loss of life and property may result in the presence of increased EV response time. Any 1-min delay in response time causes mortality rates to rise by 1% in medical emergencies such as

cardiac arrest and contributes $7 billion increase in healthcare spending each year in the United States alone. Other emergencies, such as building fires, usually increase by 20% per minute, causing additional damage of an average $4000 per fire (RapidSOS, 2015). To achieve the shortest EV travel times, route optimization tries to select the best path. Preemption of the routes, also referred to as "traffic signal prioritization" adjusts traffic control to give special vehicles such as EVs priority.

To locate, dispatch and route EVs, emergency management systems in smart cities usually use dedicated software. The EVs have installed applications such as Sygic and Infoware that use personalized traffic information to direct the driver toward the emergency spot using route optimization (Humagain et al., 2020). In recommending optimized paths, knowing the location of an EV is important. For this reason, Global Positioning System (GPS) technology is used in most studies and applications. Different cost functions are allocated as weights to edges of the graph representing the traffic network, such as distances along usable travel routes, travel times along parts of the network, or fuel costs. The cost function is then optimized by an algorithm.

Preemption requires enabling the EVs at intersections to take priority. Manually operated sirens accompanied with blinking lights are the most conventional and widely used preemption devices. Manual priorities such as intersection monitoring and use of sirens, vibration, and the flashing lights by the police officers have limitations in assessing the presence and path of the EV. To allow EVs travel more quickly, technology has developed to provide automatic preemption, as well.

In a very recent study, Humagain et al. (2020) provided a systematic literature review for routing EVs. The authors use path-based optimization and time-based optimization for computing the cost of transportation and review the literature accordingly. The arrival time to the emergency site is far more important for EV routing than distance, cost, or fuel cost. Therefore, time-based optimization makes more sense. Along with a critical review and discussion, the authors presented a thorough classification of current optimization and preemption techniques. They identified the Shortest Path Algorithm as the most common choice in terms of algorithms, but different algorithms have also been implemented, such as Ant Colony, Linear Regression, and Simulated Annealing. The authors also identified three key categories of tasks carried out by the current preemption techniques: deciding when to enable preemption, determining the location of an EV for preemption triggering, and preemption execution through the use of communication technologies between an EV and the infrastructure/other vehicles.

For an efficient execution of preemption in EV routing, determining when to enable preemption is crucial. This decision depends on either preemption for a specific traffic signal or an entire route is carried out. The presence of an EV can be detected via installed sensors in a specific area, where preemption can be performed to make the associated traffic signals go green as necessary (Barthwal & Menghani, 2017; Kodire et al., 2016). Another solution to preemption activation is to establish a "green wave" in traffic on the EV path. Primarily, the emergency response EV path, lane, and route are specified, and entire set of traffic lights on the route are arranged to go green as the EV approaches (Pighin & Fierens, 2015). Preemption can

be controlled via vehicle-mounted devices or emergency control centers remotely. Emergency dispatchers assess variables such as the level of emergency in remote triggering and monitor the position of EVs to enable preemption over the upcoming intersections. Vehicle-mounted preemption systems are normally incorporated with warning lights on the EV that can, when necessary, be turned on and off. For preemption activation, acoustic sensors, radio sensors, or GPS are utilized. An additional light known as a confirmation beacon near a traffic light indicates whether that light is preempted, and alerts drivers for an approaching EV. A blinking confirmation beacon in some countries signals to a vehicle that an EV approaches from the opposite direction, whereas a solid light signals that the EV is behind (Huang et al., 2015). OPTICOM, EMTRAC, and Transmax are EV preemption devices currently used in various cities in the USA, the UK, Canada and Australia.

Identifying the constraints of existing routing studies and their shortcomings in real-world implementations, a range of interesting and substantial application gaps were also identified in (Humagain et al., 2020). The study claimed that researchers deliver efficient route optimization and preemption methods that deliver excellent solutions. However, the commercial EV routing software do not make use of these advanced methods and instead rely on elementary heuristics. Instead of designing a time-consuming solution for a particular EV routing problem, it is more efficient for the software developers to develop simple optimization methods that suit also different cases such as carrier logistics. Another implementation challenge is that much of the literature suggests real-time optimization that involves costly computational resources and time. In the case of EV routing, as it is a niche market with relatively few customers, the industry is not too interested in spending more in computing capital. Either vehicle-mounted devices or traffic control systems are triggered by existing preemption techniques. Hence, there is also an unresolved issue of determining priorities when multiple EVs seek concurrent preemption.

Most of the stochastic and real-time information needed for the implementation of real-time dynamic optimization and preemption for EVs will be collected from various linked sensors and Internet of Things (IoT) networks in smart cities, which are not readily available. Although the importance of dynamic real-time optimization for EVs has been well established, the comparison of results from these approaches is therefore still problematic. As smart cities develop and state-of-the-art IoT network grow, more data will be at hand for coming up with more sophisticated and efficient approaches. However, as current studies use artificial data generated based on real-world applications, most findings are still predictive in this respect. As wireless communication systems such as cooperative vehicle infrastructure systems become more advanced, there will be an opportunity to provide effective preemption using real-time GPS and traffic data as well as the timing of traffic signals. There has been limited research on the use of intelligent preemptions using advanced technologies that utilize real-time traffic data to reduce EV delays. In addition, it is a challenge to reduce the detrimental effects of EVs on traffic flow.

As theoretical models in literature do not address complex parameters such as increased congestion, halt on a lane, pedestrian traffic, or actual and adaptive velocity, there is a discrepancy between the real travel times and the theoretical travel times of

EVs. Dynamic optimization and effective preemption would involve an acceptable approach to enhance the established techniques for minimal disruption on traffic flow. The performance of integrated and complex systems of optimization and preemption depends on the availability of dynamic traffic data in real time. The connected environments supporting Vehicle-to-X (V2X: car, road, person, infrastructure, internet) communication through multiple communication protocols are called the Vehicular ad hoc Networks (VANETs). It is straightforward to detect the location of an EV in a connected world, as they too often exchange location information among themselves. Humagain et al. (2020) proposed that emergency management services researchers would concentrate on making preemption and optimization more dynamic by using traffic data in real time utilizing advanced tools such as VANET and taking time as a crucial optimization parameter. Jose and Grace (2020) very recently suggested a dynamic route planning scheme for EV routing. They simulated VANET and a dynamic route planning was carried out after emergency services have arrived. Two phases were included in their proposed dynamic route planning as travel-time estimation and bimodal routing. Travel time forecasts were obtained via machine learning using Support Vector Regression and a bimodal routing model was used to optimally route EV.

The advances in technology in sensors, communication and networking technologies and GIS enable fleet operators to be aware of unexpected changes in fleet activity almost at the time of occurrence, thus allowing for increased levels of dynamicity in operational decisions. Billhardt et al. (2014) proposed an ambulance fleet coordination in the city of Madrid through an event-based fleet management system architecture. The proposed system utilized many different artificial intelligence tools for allocation optimization, demand and traffic prediction, and dynamic waiting positions of the ambulances. As new prototypes of autonomous vehicles are tested daily, the authors also proposed a smart, cyber-physical system (cyber fleet) made of cyber vehicles and drivers with cyber interfaces. Another dynamic routing study focused on a method intermittently reconstructing the vehicle routes by collecting real-time road conditions via VANET (Katsuma & Yoshida, 2018).

Operations research scientists, planners, and healthcare professionals have recognized the relevance and importance of optimization for emergency medical services (EMS). As shown by numerous review papers that have appeared in recent years, the location decision for EMS vehicles has been widely studied. For example, a review on ambulance positioning and relocation problems was presented by Brotcorne et al. (2003), and existing models in literature were divided into three categories as static and deterministic, probabilistic and dynamic models. Goldberg (2004) reviewed different models from literature for EMS vehicle deployment, with an emphasis on characteristics of modeling and expectations. The problems introduced via implementations from practice, possible research gaps, and emerging trends were discussed. A taxonomy for the EMS location problem was proposed by Başar et al. (2012). The authors built their classification based on problem type, model, and methodology. They divided models into four general classes for problem types based on type of emergency, model structure (deterministic or stochastic), time variance (static or dynamic), and problem objectives. They considered 5 main model

subclasses that varied in parameters, form of mathematical programming (integer, nonlinear, dynamic programming, etc.), and the objective function. They grouped the methodologies into exact methods, heuristics, metaheuristics, and simulation.

Aringhieri et al. (2017) recently claimed that, a crucial issue to be addressed is the consistency between the current direction of research and the main objectives in EMS systems. The complexity of modeling increasingly complex EMS logistics systems may cause a potential divergence of research from practice. The authors conducted a thorough review on EMS, based on the concept of emergency care pathway (ECP), inspired from the clinical pathways (CP) defined for healthcare systems, which shifted the attention from distinct departments to the entire healthcare chain. As many decision problems are linked to each other in EMS management, the decisions taken in one step of the ECP can have an impact on decisions in subsequent steps. Figure 3.2 shows an example ECP consisting of five steps and the relations with associated management problems (Aringhieri et al., 2017). The ECP is initiated via an emergency application received by the EMS. An ambulance is dispatched after determining the urgency of the incident and it must arrive to the emergency scene urgently for first-aid and transfer of the patient to the emergency department of a nearby health facility. The ECP finishes once the patient is discharged from the hospital.

Ambulance location and relocation problems are one of the optimization problems addressed in Fig. 3.3. In addition, the management and optimal routing of the ambulance fleet is another problem presented earlier in this section. This problem handles dispatch policy and vehicle routing as well as preemption. The communication with national health services or ministry of health is rather crucial, as data flow in the entire health network is critical to prevent the overcrowding of the emergency service in a particular hospital. This will directly affect the length or duration of the ECP. Accurate forecasts for demand, travel times, and workloads are also

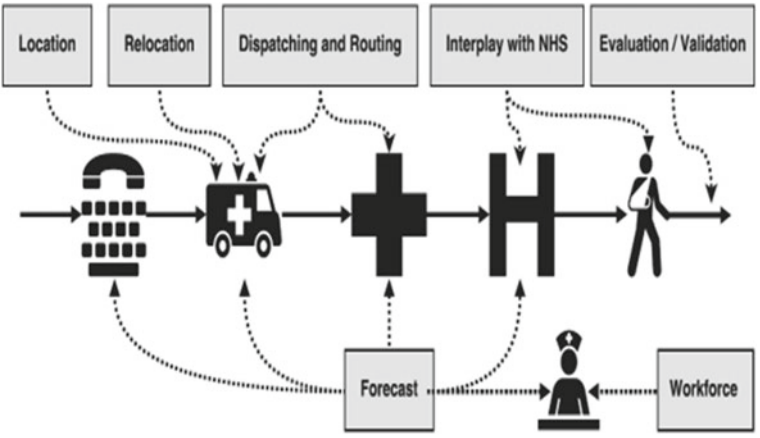


**Fig. 3.3** Emergency care pathway and related problems. *Source* Aringhieri et al. (2017, p. 350)

vital to ensure that sufficient resources are available to meet emergency demands. The said resources include EV, facilities, and the workforce including paramedics and medical doctors. To provide high-quality health care, it is essential to plan and schedule adequate workforce and to determine appropriate rosters as needed. And finally, for evaluating the performance of the entire ECP, good evaluation metrics in terms of efficiency, effectiveness, and fairness are necessary. In literature, these interconnected components through the ECP are mostly handled separately, as even the individual optimization problems are challenging.

In dealing with the ambulance or EV location and relocation problems, one of the main humanitarian concerns, unlike other location/relocation problems in other sectors, is the concept of equity or fairness. Equity is a measure of fairness in resource allocation among patients in different geographical locations within the service area, and is generally measured in terms of response time. For example, McLay and Mayorga (2010) considered equity in their EV location models via an objective function that corresponded to the ratio of rural demand at each node. They tested their model with real data from a county EMS in Virginia, USA. A nine-minute response time goal is the most common performance metric currently employed in the country, and the study justified this implicit consideration of equity through their experimental results. On the other hand, EMS planners might not be very apprehensive of service equity. Erkut et al. (2008) pointed out that, the presence of gaps between the realized response times and the response time standards in rural and urban areas supports the argument that EMS system administrators are opposed to equal access provision. Due to the confusion and research-practice gap in this metric, Aringhieri et al. (2017) stated that the future research should concentrate on various aspects of equity and some generally agreed assessment criteria for it.

As another critical concern in the location/relocation problems of ambulances or EVs, uncertainty as to the amount and location of demand, travel times, incident intensity, and other problem parameters play a big role in planning activities. Amid these complexities, it is important to make expensive decisions with long-term consequences, which can be a difficult job for both researchers and practitioners in this area. To compensate for the lack of coverage due to busy ambulances, the relocation/redeployment problems deals with the complex relocation of available ambulances. Excessive workload may be introduced by unsystematic redeployment and result in excessive exhaustion for the EMS staff. The current literature adopts one of the following methods to address this problem of ambiguity in literature: Probabilistic models, stochastic programming, simulation, and fuzzy approaches. For example, Enayati et al. (2018) employed a real-time redeployment approach to maximize the service coverage of emergency vehicles within minimum possible total travel time, considering the workload restrictions for personnel. The authors proposed a computationally efficient solution to the problem, which needed only data regarding the current state of the system. Discrete-event simulation was utilized to assess the efficiency of the developed solutions.

For reducing emergency response times, the dynamic reassignment of ambulance deployment locations to balance availability can also be effective. Via GIS-based analysis and mathematical programming, Lam et al. (2015) handled the problem

of dynamic ambulance allocation planning in Singapore and evaluated the resulting plans through simulation. The authors claimed that the developed strategies resulted in superior response times and coverage performances compared to static reallocation policies even when the dynamic plans were not strictly followed. Bélanger et al. (2016) focused on assessing several relocation strategies and reported their performances under different levels of workload through simulation experiments. Their empirical study also confirmed that dynamic strategies dominated static ones, but at a cost of substantial relocation expenses. When selecting an appropriate response plan, the nature of ambiguity as well as the type of available data should be considered. Applying a combination of approaches for various sources of uncertainty might help executives come up with more practical models in which the system's complexity is captured and a clearer overview of the entire system is given. Further research is needed combining optimization with other quantitative methodologies to gain further insights into these potential hybridizations.

The existing studies in literature on other components of ECP are rather scarce (Aringhieri et al., 2017). The gathering of information about incidents affecting the patient before, during, and after the emergency action is one of the key challenges. Typically, a vast amount of data is gathered by the information systems, yet this data excludes information on the events before and after an EV is involved. Thus, whole ECP cannot be optimized effectively due to this lack of information. Within a smart city infrastructure, the data gathered from different interconnected systems pertinent to emergency planning can be quite valuable. Consider the implementation of a new dispatching decision support system. The first decision is to send an EV capable of reaching the patient on time with a minimal effect on the region's coverage. Locational models may be fruitfully used to support this decision if reliable data is available through the correct data channels. The second is to choose the proper emergency service to transfer the patient. For example, based on the urgency of an incoming request, the dispatcher may quickly pick the least-crowded emergency department based on real-time data. In the case of urgent requests, picking departments having less workload would be better. After servicing an emergency, the EV should be relocated based on real-time data. In this respect, accurate forecasts on the expected emergency demand together with locational analysis is important for determining the least-covered regions. When deciding the collection of the most accessible or nearest EVs or emergency services, the utilization of real-time traffic information is also essential.

Noteworthy studies from the literature using real data for EV planning include small-scale cases such as a town from Buenos Aires provincial area (Pighin & Fierens, 2015), Argentina, or a county from Virginia, US (McLay & Mayorga, 2010); regional examples like Edmonton (Erkut et al., 2008), Ontario (Almehdawe et al., 2016), and Waterloo in Canada (Naoum-Sawaya & Elhedhli, 2013); Wales, UK (Knight et al., 2012); and finally large metropolitan cases from Utrecht, Netherlands (Jagtenberg et al., 2015), Madrid (Billhardt et al., 2014), and Singapore (Lam et al., 2015). Su et al. (2015) incorporated a cost of delayed services definition and reduced the total cost of operating an ambulance service in Shanghai even when more stations and ambulances are added. Jagtenberg et al. (2015) reduced the expected late arrival

ratio while maintaining the current fleet by using a dynamic MEXCLP approach. One study focused on EMS operations optimization for the highway connecting Rio de Janeiro to Sao Paulo (Iannoni et al., 2011), expanding the service range of the problem even more.

## 3.5 Conclusion

The COVID-19 pandemic recently drew attention to healthcare systems. Any country around the globe started to reconsider or reform health care in many dimensions, ranging from actions to strengthen the existing healthcare system to deal with pandemics, to reorganization of health logistics planning activities for efficient response. Using fewer emergency vehicles with dynamic dispatching and redeployment policies can attain a comparable efficiency to the increase in the ambulance fleet size (Bélanger et al., 2016). However, dynamic methods often produce large increases in the overall traveled distance and ultimately, the number of relocations. The development of strategies to minimize or manage the costs of systemic dynamic redeployment may be of great practical importance and can contribute to forming hybrid policies.

The results of a study by Griffin and McGwin (2013) suggested that, factors having the highest effects on emergency response times are the ones that could be changed relatively easily, such as in-vehicle technologies. The use of advanced communication and data flow tools in smart cities can highly contribute to effective emergency services planning. The urban information systems should integrate the capability of sensor devices in IoT networks such as adaptive traffic management systems having advanced artificial learning features with cloud-based (such as Amazon, Google, IBM, or similar), or local computing services improving real-time optimization performance further. This will allow the designed/developed automated algorithms to reduce the stochasticity of critical data for reaching even more critical solutions in faster and more efficient ways regarding all types of costs involved. Connecting the big data readily available within the smart city infrastructure may help the decision makers to view the big picture and make more informed and efficient decisions in emergency planning.

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# Chapter 4
# The "Transformative" Effect of Artificial Intelligence Systems (AIS) in Entrepreneurship


**Umut Sanem Çitçi**

**Abstract** In this chapter, one of the scholars working on entrepreneurship shares her ideas about how the field of entrepreneurship meets artificial intelligence systems and what this meeting can mean for the field of entrepreneurship today and in the future, with a supple wording as possible. Entrepreneurship is an important phenomenon that increases individuals' and countries' welfare and plays a role in social transformation. Its importance appeals to a large number of researchers. What makes these studies possible to stand out from the research crowd depends on their design as modern, contemporary, and preliminary studies. The author also wanted to reveal the possibilities of artificial intelligence systems, which offer the opportunity to conduct innovative research, in the field of entrepreneurship.

The chapter titled "The 'Transformative' Effect of Artificial Intelligence Systems (AIS) in Entrepreneurship" primarily targets researchers who are interested in entrepreneurship research and want to gain general information about the intersections with artificial intelligence. As it is known, artificial intelligence systems have highly specialized literature. This situation causes most researchers to develop a perception of the difficulty of the field. The author promises to transform this perception positively and discover artificial intelligence, which we inevitably have to dive into and learn, from the perspective of entrepreneurship, when the development of technology is considered. For this purpose, in the content design of the chapter, how artificial intelligence will affect the entrepreneurship classification and the way entrepreneurs do business; how artificial intelligence will transform the big picture through entrepreneurship; what can be the usage of artificial intelligence for entrepreneurs; how artificial intelligence will affect entrepreneurship education; how will artificial intelligence affect entrepreneurship research with the use of new technologies for data gathering and data analyzing are included. It can be said that the chapter has a guiding quality, especially for graduate students who want to do entrepreneurship research but have not yet determined the research subject. For example, the subject of postgraduate research may be how artificial intelligence

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systems will transform the gender-based problems faced by women entrepreneurs. The steps in the literature regarding this subject can be found in the chapter.

This book, in which artificial intelligence is evaluated from various perspectives, could be said to be incomplete if it did not include a discussion in terms of entrepreneurship. With this awareness, the author endeavored to offer her readers a good reading and knowledge acquisition experience by referencing as many sources as possible and sharing different ideas.

**Keywords** Entrepreneurship · AIS · Entrepreneurship classification · Digital entrepreneurship · Social entrepreneurship · Business model · Entrepreneurial intention · Entrepreneurial opportunity · Entrepreneurial behavior · Entrepreneurship education · Entrepreneurship research

## 4.1 Introduction

Human beings make their decisions under "uncertainty" since they do not possess complete information on what is going around them. Furthermore, they are classified as a "bounded rational" creature due to their tendency to include their experiences, prejudices, and intuition in the decision-making process. Deciding on a situation by completing the missing information in multiple ways instead of starting from the data alone complicates matters, in effect saying "this is the best decision" for both the decision-maker and those affected by the decision. One of the main features that distinguish human beings from other living things is that they do not accept their situation as "given" yet they struggle for a solution. That is why human beings have long been pondering what kind of tools and techniques they need to make better decisions. AI studies, which began in the 1960s and started to achieve extremely successful results in the recent period, are perhaps the greatest step that human beings have taken to defeat the lack of bounded rationality. Still, it may be naive to believe that increasing the quality of decisions will create good results for humanity. Because the use of AIS, which includes machines that can think as if they were human, may create unexpected consequences, just like many studies that were sources of pride in human history and later turned into a source of shame, such as the fragmentation of the atom and the atomic bomb. So, what is AI?

Just as steam was the driving force behind Industry 1.0, the driving force of Industry 4.0 is accepted to be AIS (Schwab, 2017). The systems that are comprised of machine-based learning results from this learning process, techniques that involve solutions to problems. Fundamentally, what AISs do can be summed up as developing algorithms for circumstances in which human intelligence has trouble making decisions and processing large volumes of unformatted and diverse data that are not possible for human analysis with these algorithms (Choudhury et al., 2018; Kaplan & Haenlein, 2019).

John McCarthy, who initiated the work that formed his AIS' basis almost 60 years ago, describes AI as "the science and engineering of making intelligent machines."

Since then, AI studies have continued, and the scope of the definition has expanded with developments as "intelligence demonstrated by machines—or, in terms of an academic field (typically seen as a sub-discipline of computer science), the examination of how digital computers and algorithms perform tasks and solve complex problems that would normally require (or exceed) human intelligence, reasoning, and prediction power needed to adapt to changing circumstances" (Obschonka & Audretsch, 2019). Based on the literature's definitions, AIS stand on three pillars: The first pillar is the "domain structure," and it involves drawing the boundaries of the area produced by engineers and other relevant experts, almost determining the rules of the game. The second pillar involves "the identification and aggregation of data groups" that will feed the learning algorithms. The last pillar is "the substantiation of machine learning." The last pillar is the rationale for the need for AIS. At this stage, patterns in the research area make it possible to predict its emergence (Taddy, 2018). Regarding these three pillars, it is possible to see the AI as an umbrella concept since there is a relationship between them as summarized by Obschonka and Audretsch (2019) as "an often used categorization is that machine learning is a subset of AI and deep learning (e.g., deep neural networks) a subset of machine learning. Big data can mean a large volume of structured, semi-structured, or unstructured data, and a way to collect/produce, process, and analyze these data sets using non-traditional methods."

AI, which is a great tool to reshape the costs of acquiring information and estimating in the Industry 4.0 layout, is on the way to becoming an indispensable tool for companies in terms of making the identification, acquisition, sorting, and processing of information faster, cheaper, and more effective (Desai, 2019) and concerning these properties, it is considered the new type of intellectual capital of today's companies (Popkova & Sergi, 2020). Regarding the use of AI and its development potential, it can be claimed that its popularity as intellectual capital for companies will increase more in the future. Maybe what needs to be clarified here is why AI is considered the intellectual capital, not a technology owned by companies. According to Davenport & Ronanki's article published in HBR in 2018, AI is more of a business capability for companies than a technology. This is because companies have different success potentials in terms of automating business processes using AI, developing insight with data analysis, and establishing cognitive engagement with the customer/employee. Still, it should be remembered that what AI can do for a company depends on its managers and employees, that is, the capacity of the existing intellectual capital to use this tool. At least for now, this claim remains valid. According to Davenport & Ronanki, the areas expected to benefit from AI are to "enhance the features, functions, and performance of products," "make a better decision," "optimize internal business operations," and "free up workers to be more creative by automating tasks." In other words, the last benefit mentioned is that in the future, there is a possibility that predominantly human-based intellectual capital will turn into AI-based intellectual capital.

Indeed, what needs to be considered here is whether using AI in areas predicted to be beneficial will bring "guaranteed" success or not. Maybe success can be measured to some extent when speaking at the company level. Yet, when the success

in question is estimated at the company founder's level, that is, when considered at the individual level, it is not easy to evaluate it. Because success is the individual's evaluation according to the degree to which he/she reaches his/her goals determined within his/her context. In this case, it can be claimed that being a successful entrepreneur is contextual (Çitçi et al., 2018). According to Sternberg (2004), successful entrepreneurship is the result of the combination of "analytical, creative and practical intelligence." Sternberg calls it "successful intelligence." Successful intelligence makes it possible for entrepreneurs to accurately evaluate these ideas for products and services by identifying that all the ideas they confront are unequal and the right combination of triple intelligence (Sternberg, 1999). When studying AI types, it can be argued that significant progress has been made from past to present and that it facilitates a step-by-step approach to the right combination of successful intelligence required for entrepreneurship (Fig. 4.1).

When the AI development summarized by Kaplan and Haenlein (2019) above is examined, it is observed that AI can behave almost like a human and exhibit cognitive-emotional-social intelligence features. Thus, it can be said that entrepreneurs can receive AI support in the analytical intelligence and even partially creative and practical intelligence they need to be successful. It is partly because even though AI uses emotional and social intelligence, it still lacks artistic creativity.

This chapter precisely places the reason for its existence here while revealing whether AIS cause a transformation in the field of entrepreneurship. Particularly in recent years, special issues related to AI have been published in major journals in entrepreneurship, and conferences are organized. This situation motivated the author to research what kind of developments AI has generated and will lead to in entrepreneurship. In the chapter, firstly, the possible effect of AIS on entrepreneurship classifications and what developments can be experienced at the macro level within

| | Expert Systems | Analytical AI | Human-Inspired AI | Humanized AI | Human Beings |
|---|---|---|---|---|---|
| Cognitive Intelligence | x | ✓ | ✓ | ✓ | ✓ |
| Emotional Intelligence | x | x | ✓ | ✓ | ✓ |
| Social Intelligence | x | x | x | ✓ | ✓ |
| Artistic Creativity | x | x | x | x | ✓ |
| | | Supervised Learning, Unsupervised Learning, Reinforcement Learning | | | |

**Fig. 4.1** Types of AIS (Kaplan & Haenlein, 2019: 18)

entrepreneurship have been examined. Then, how entrepreneurs benefit from AIS in the entrepreneurial process, and the kind of a course entrepreneurship education will follow in the light of these developments have been evaluated. Eventually, the transformation points in entrepreneurship research and new research topics that bring the two fields together have been mentioned.

## 4.2 How Will AIS Affect the Entrepreneurship Classification and the Way Entrepreneurs Do Business?

With Industry 4.0, the digitalization trend that has spread to all areas of life also affects entrepreneurship. Today, the rapid increase in the number of entrepreneurs entering the market by developing digital business models has led to the emergence of a new entrepreneur class who are now defined as "digital entrepreneurs."

"Digital entrepreneurship" refers to entrepreneurship where the use of digital technologies creates the service. The word digital has been employed in the business model to cover entrepreneurs who have recently included AIS such as big data, machine learning, deep learning, and neural network. In other words, the term is used not only for the e-commerce entrepreneur who offers the product or service via the internet but also for those who manage to integrate their AIS into the business model. Digital entrepreneurs are quite different from entrepreneurs in the traditional sense. In their field research, Chae and Goh (2020) stated that digital entrepreneurs' characteristics such as being extroverted and open-minded and active and influential on social media platforms are more prominent, and they found that this particular group showed more effort to benefit from open innovation (Yoo et al., 2012). However, Chae and Goh's (2020) work has an assumption that will attract criticism. Their studies divided digital entrepreneurs into two groups as digital and non-digital in order to examine them in terms of personality, demographics, and social media presence. They also defined sectors such as construction and machine manufacturing as a group with relatively less digital potential. However, in the CB Insights 2020 data, it is seen that companies from the construction sector take first and second place in the list of top 100 AI-based startups. Furthermore, there are four companies from the manufacturing sector on the same list. It would then not be wrong to say that AIS use depends on the entrepreneur's openness to this and the business needs, and that the traditional sector-digitalized sector distinction is gradually becoming meaningless. In the National Venture Capital Association (2020) report, it was confirmed that 285 AI-based startups in the US collected $ 6.9 billion in the first quarter of 2020. While the world struggles with the COVID-19 epidemic and almost all economies are contracting, AI-based startups receive investment, which gives a clue that AI-based startups will gain increasing popularity in many varied sectors.

It would be wrong to say that the concept of "digital entrepreneurship" is the only one representing the industry 4.0 entrepreneur. A group calls the entrepreneurs of the current period "Information entrepreneurs" (Coulson-Thomas, 2003; Kabir,

2018). Entrepreneurs are viewed as the growth dynamics, social change catalyst, and triggers of personal wealth increase in the information economy. Based on this role, the information entrepreneur's primary goal is to create an economic and social value of existing information sources and information asymmetry (Kabir, 2018). When the purpose is defined so, indeed, the most potent tools of recent years are AIS. Primarily in innovation and business model testing, information entrepreneurs can avoid wasting resources by using AIS and can place themselves in a strong position against others through asymmetric power as long as they maintain their ability to use AI. It is stipulated that information entrepreneurs should be distinguished from other entrepreneurs with some features, as in digital entrepreneurs. Kabir (2018) classified the prominent features in his research as agility, flexibility, and the ability to cause disruption.

Another classification made for entrepreneurs in the current period is SMART entrepreneurs. SMART is used both in the literal meaning of the word and as an acronym for Specific, Measurable, Attainable, Relevant, and Time-based words. For instance, Sauer (2012) claims that Smart Cities will create Smart entrepreneurs, while Damian and Manea (2019) emphasizes that with Fintech developments, freelancers are transformed into smart entrepreneurs who spend smartly, save money and make use of venture opportunities. Whatever entrepreneurs of the era may be given, they differ contextually from traditional entrepreneurs. Therefore, a new type of entrepreneurship that emerges should be accepted.

Herein, AIS, the driving force of industry 4.0, will be instrumental in the emergence of a new type of entrepreneur. Besides, it is predicted that there will be many effects on existing entrepreneurship types such as commercial entrepreneurs, social entrepreneurs, women entrepreneurs, internal entrepreneurs, innovative entrepreneurs, etc. These include reducing process costs, expanding market share, and shortening the time to introduce new products. For instance, the impact of AIS will be evident in social entrepreneurship, a type of entrepreneurship that focuses on the social purpose and requires professional management understanding and strategies to survive such as non-profit organizations (Hoogendoorn et al., 2011).

AIS's topics that may affect social entrepreneurship can be summarized as follows: (i) Although social entrepreneurs do not seek profit, they attempt to create business models with low cost and high impact power to survive and perform sustainable impact. Since social entrepreneurs do not have a high income, they often need to find volunteers or low-paying staff. Thanks to AI, the number of personnel they require can be reduced or they benefit from existing personnel more efficiently. (ii) AI can mediate social entrepreneurs to identify their target audience and give them the service/product they want to deliver at a minimum cost. Traditionally, most social entrepreneurship activities focus on specific problems. The addressees of this problem are waiting for their similar needs to be met in various parts of the world. AI can identify these groups' deployment and the optimum solution for how they should receive the service. In another study, Muñoz and Kibler (2016) defined the configurations of local institutional elements that create social entrepreneurship with AI and determined under what conditions social entrepreneurship activities emerge.

Up to this point, the facilitating and productivity-enhancing effect of AI for social entrepreneurship has been mentioned. But AI is also the source of a new difficulty for social entrepreneurship that needs to be solved. The digitalization process, which has accelerated with Industry 4.0, may also cause mass unemployment (Korinek & Stiglitz, 2017) by the 2050s. The unemployed group that emerges in this condition will turn into a disadvantaged group that social entrepreneurs would want to find solutions for. Perhaps, the prospective social entrepreneurs will solve this difficulty with social innovations they will create using their AIS.

## 4.3 How Will AIS Transform the Big Picture Through Entrepreneurship?

Entrepreneurship is one of the rare areas desired to be developed in almost every sector globally in the world economy. How digitalization, which gained speed with Industry 4.0, caused entrepreneurship development in terms of entrepreneurship types has been discussed in the previous sub-heading. What happens at the macro level, that is, the big picture, will be discussed. Still, before going into detail on this subject, it should be emphasized what digital infrastructure means for today's entrepreneurship. Digital infrastructure involves digital technology tools and systems such as cloud computing, data analysis, online communities, social media, 3D printing, digital production areas that provide communication, collaboration, and/or computing. According to Aldrich (2014), digital infrastructure has led to the entrepreneurship process's democratization due to its capacity to support innovation and entrepreneurship. With the opportunities it offers, the participation of more and more diverse people with different backgrounds in the entrepreneurship process has been ensured. It has been possible to search for opportunities, test product–customer compatibility more efficiently and in a shorter time, and finance and announce initiatives (Hatch, 2013). The alleged democratization is based on assuming that implementing an entrepreneurial project is now much more comfortable and cheaper for everyone. So, is this really the case? So, what is intriguing is whether digital infrastructure opportunities create democratization and equality in entrepreneurship.

When you look at the list of CB Insights 2020 AI companies, it is noticed that although there are companies based in Europe and Asia, USA-based companies dominate the list and make up about 65% of them. This table alone shows that some of them have benefited more from digital infrastructure opportunities in this process.

Indeed, the widespread use of big data opportunities in a region and the increasing interest in taking advantage of these opportunities will transform into a business culture. Thus, new entrepreneurs in that region will have the opportunity to differentiate as a more successful generation than previous entrepreneurs, namely with the uncertainty and relatively increasing rationality that is partially eliminated compared to other generations (Obschonka & Audretsch, 2019). Such advancement can make

it possible to be competitive at the meso and macro level in matters of not wasting country resources, applying them in priority areas, creating clusters, and developing dynamic capabilities. In fact, disrupted entrepreneurship, which expresses a model stemming from the entrepreneurial business system, has started to bring about more comprehensive partnerships with digitization and AIS that develop accordingly. Disrupted entrepreneurship is a model highlighting that the entrepreneurial process is not built on a single person or company and that this process takes place with a natural division of labor among many institutions. Briefly, it emphasizes the distributed dimension of entrepreneurship by citing the role of formal alliances, informal relations, and public institutions surrounding and assisting the entrepreneur. Still, there is no precise decision on this concept to describe the circumstance. It is known that more than one concept is used to reinforce the conceptual contradiction (such as distributed, dispersed, collective, or diffused entrepreneurship) (Bureth et al., 2006).

In summary, it can be assumed that thanks to tools such as AI, entrepreneurship with various suppliers and infrastructure elements conveys a new turn and takes a very different form by shifting from the isolated or one-man-oriented perspective. Indeed, in order to talk about real democratization in a distributed operation, the parts of the whole should not consist of the same actors, but the actors suitable for the context and which even have managed to develop in that context. Nevertheless, it is known that there are major world countries and companies in the construction of domain structures that AIS focus on, and the preparation of algorithms that enable the recording, classification, and processing of big data. Then, although AIS allow positive results at the micro-level, it is not known whether it will increase the development level of countries in the big picture in the long term, but an increase in dependency levels can be predicted. Davenport and Ronanki (2018) argue that the technology used in AI also determines which supplier and infrastructure will be used. Countries that started the first studies on AI and continue their progress systematically in this field and these countries' companies thus gain an essential competitive advantage. It can be claimed that an injustice caused by AI will develop in this direction and will encourage dependency relationships unilaterally (Cheng, 2018).

Indeed, the problem that AIS can cause in the big picture is not only the asymmetric dependency relationships between countries. Another problematic area is ethics. For instance, AI applications are known to make predictions regarding the solution to a problem. So, whose interest is optimized by trying to solve this problem? If entrepreneurs do this to create a business, offer products, and gain customers, the data they use belong to potential and existing customers. Does the use of these data solve the problem by optimizing what customers or governments will gain at least as much as the gains of entrepreneurs? This point raises a major ethical debate (Agrawal et al., 2017). Another ethical problem is that AI can be employed as a pressure and social control tool (Whittaker et al., 2018). Entrepreneurs who develop and apply this technology can take social engineering initiatives and transform from "anticipating behavior to an engineering understanding that holds power to create a mass that moves as desired" (Morozov, 2019). The robust capabilities and potential for abuse of AI technologies that are continually being improved should be considered and their use should be ethically regulated. There are some initiatives in this respect. In

2018, Montréal University announced a statement recommended to be followed in the development of its AIS. While preparing the announced declaration, care was taken to bring together all the influencers and affected stakeholders, and ten basic principles to be followed were accepted (Montréal Declaration for Responsible Development of Artificial Intelligence, 2018).[1] The drafters of the declaration also developed eight recommendations. The proposal that directly concerns entrepreneurship and is directly related to the troubling developments mentioned for the big picture is presented as follows: "*International development of AI*: A non-predatory model of international development should be adopted that aims to include the various regions of the globe without abusing low- and middle-income countries (LMICs)."

Another difficulty AIS will cause is mass unemployment, as mentioned earlier. In their study, Davenport and Ronanki (2018) argued that AIS are useful in three steps, and each step will have varying outcomes in terms of employment. They claim that AI will have adverse consequences for employment by automating processes by designing robotic processes, mainly in industries where offshore outsourcing is widespread, but administrative workers will not be unemployed. But matters not provided for or overlooked is that some of the entrepreneurial activities of developing and less developed countries are based on offshore-based B2B businesses. Then, it can be predicted that these countries will be deprived of not only in terms of employment but also the initiatives that will increase welfare of these countries. The second claim is related to cognitive insights, which is the other usage area of AI, and it is claimed that employment will not be affected negatively since, at this stage, in practice, something beyond human capabilities is already performed by computers. The last claim is cognitive engagement. The requirement to cooperate with humans is evident since it is emphasized that AI's meeting the expectations is very low in interactive decisions. Consequently, according to Davenport and Ronanki, there will be no significant employment loss, and those affected do not need to be taken into account.

Eventually, the problem is that firm-level exit strategies are likely to miss out on macro-level returns. Traditionally, startups appear before investors on the world scale

[1] (1) *Well-being*: The development and use of artificial intelligence systems (AIS) must permit the growth of the well-being of all sentient beings. (2) *Respect for autonomy*: AIS must be developed and used with respect for people's autonomy, and with the goal of increasing people's control over their lives and their surroundings. (3) *Protection of privacy and intimacy*: Privacy and intimacy must be protected from intrusion by AIS and by data-acquisition and archiving systems. (4) *Solidarity*: The development of AIS must be compatible with maintaining the bonds of solidarity among people and generations. (5). *Democratic participation*: AIS must meet intelligibility, justifiability and accessibility criteria, and must be subjected to democratic scrutiny, debate and control. (6) *Equity*: The development and use of AIS must contribute to the creation of a just and equitable society. (7) *Diversity inclusion*: The development and use of AIS must be compatible with maintaining social and cultural diversity, and must not restrict the scope of lifestyle choices and personal experience. (8) *Prudence*: Every person involved in AIS development must exercise caution by anticipating, as far as possible, the potential adverse consequences of AIS use, and by taking appropriate measures to avoid them. (9) *Responsibility*: The development and use of AIS must not contribute to diminishing the responsibility of human beings when decisions must be made. (10) *Sustainable development*: The development and use of AIS must be carried out so as to ensure strong environmental sustainability of the planet.

as they enter the growth phase. A company's valuation increase is a source of income and prestige for both the entrepreneur and the host country. With the use of qualified data sets and AI, investors can have basic patterns concerning the futures of startups to buy startups before they reach high valuations and push entrepreneurs out of the game in a short time. Thus, firm-level strategies may have negative consequences at the macro level.

But for the humanity—AIS relationship, these unfortunate scenarios can be put aside, and "not running out of hope" may be an option. With the measures to be taken, AI and humanity can meet at a common ground that will make it possible to benefit more efficiently from what the world and its institutions offer. For instance, it can be in a country itself or in a region that involves different countries; macro policies can be produced at the country's level and the region with research on entrepreneurial opportunity potential. Sustainable development can be encouraged by using world resources effectively.

## 4.4 What Can Be the Usage Areas of AIS for Entrepreneurs?

Entrepreneurship's three crucial research issues can be stated as entrepreneurial opportunity, entrepreneurial intention, and entrepreneurial behavior. *Entrepreneurial intention* is described as the belief or wish of a potential entrepreneur candidate to engage in entrepreneurial behavior one day. On the other hand, entrepreneurial opportunity is the driving or attractive force that transforms entrepreneurial intention into behavior. *Entrepreneurial opportunity* mainly refers to more attractive and sustainable business opportunities favorable to entrepreneurship. It relates to circumstances where new products, new services, new raw materials, and new organizational methods can be sold at a higher price than the cost (Miao, 2020). In addition to the view that the entrepreneurial opportunity is related to the entrepreneur's perception and arises depending on it, it is also understood that its existence is considered ontologically independent of the entrepreneur, waiting to be discovered at some point (Araslanov & Zelinskaya, 2018). Both perspectives nourish AI's instrumental power in entrepreneurship. From the first perspective, it can take part in the entrepreneur's opportunity by applying AIS to solve a problem. In the second perspective, an existing opportunity is explored with AIS—e.g., trend analysis with AIS to reveal the opportunity—and the strength of the emerging patterns and the potential can be evaluated. For example, suppose there is an enthusiastic startup to open up to the world and be born global with product x. In that case, various trade data—which may be related to similar or complementary products—can be included in the analysis and provide an idea regarding the right place, time, and sustainability for product x. It will also reduce the risk of failure in entrepreneurial behavior. When increased success rates with AI are shared with the public, entrepreneurial intention development will also be indirectly positively influenced.

Behind the vital role that AI plays in the creation or discovery of entrepreneurial opportunities (Kabir, 2018) lies: i) its ability to be applied in any field from which systematic, standard, and analytical data are obtained, from automotive to the agricultural sector; ii) the fact that most of the machine learning algorithms and many of the source codes of AI agents are open-source; iii) that some AI agents and tools developed for one industry can apply to other areas as well.

*Entrepreneurial behavior*, one of the entrepreneurship issues mentioned above, emerges when entrepreneurial intent meets entrepreneurial opportunity and enters the market as an active player. AIS are effective not only in terms of entrepreneurial intent and opportunity but also in the creation of entrepreneurial behavior. Davidsson et al. (2018) therefore qualify AIS as "external enablement" for entrepreneurship.

With the realization of entrepreneurial behavior, that is, from the startup stage, entrepreneurs have to struggle with uncertainty and move between stages of the process under conditions of uncertainty (McKelvie et al., 2011). In the process in question, the organization's appropriate organizational form, the business model, being agile, the customers' reaction to existing and new products, the establishment of the price-product feature balance, etc. require focus and all data-based steps in the works on this subject can be more effective with AIS (Chalmers et al., 2020). For example, ensuring product–customer balance is essential to entrepreneurial success (Barringer & Ireland, 2019). Based on this claim, an entrepreneur following his/her sales activities with AI-powered automation can identify customers with hot potential, identify them, and then connect them with the right salespeople as soon as they are ready to purchase goods or services (Chalmers et al., 2020). Yet another example can be given for enterprises with more than one customer segment. AI can identify thousands of customers (Kosinski et al., 2013) and create thousands of message/ad variations that emphasize things that meet their expectations. Of course, what AI can do is not limited to the startup phase, which is the first stop of entrepreneurial behavior. It can also be used at the scale-up stage. For example, AI-based solutions are used for the legal regulations and requirements in financial accounting, which are needed for growth, production and delivery of products in large capacities, providing expanding customer services with growth, recruiting personnel, etc. And these have a mitigating effect on the difficulties entrepreneurs encounter in capturing economies of scale and scope (Chalmers et al., 2020) (Fig. 4.2).

Maybe at this point, giving a more specific example of how AIS are applied in the entrepreneurial process can facilitate understanding of the subject. For this purpose, the business model Ng modeled as above can be examined. The business model explains "how to make money" in the entrepreneurial process. The business model adjusts to the changing nature of the business, depending on the growth stages. According to Ng, if you desire to develop an AI-based business model, you should start with an area that can be successful with AI. Proving that successful results can be achieved with the pilot application instead of making the whole business model based on AI positively affects the stakeholders' acceptance. At this stage, the requirements of AIS can be met by outsourcing, but as the number of works done will increase, and the strategic significance will change over time, an AI team should be established within the company.

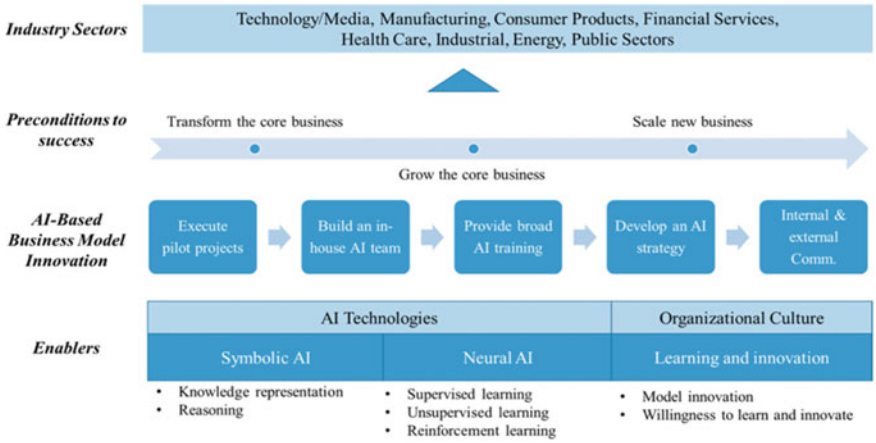


**Fig. 4.2** Developing an AI-Based Business Model (Lee et al., 2019: 7)

In the AI-based way of working, organizing training, and raising awareness to increase the alignment of those within the organization with AI should be done as things related to AI will be too important to be left to the AI department alone. From this point on, an organization-inclusive AI strategy is developed. According to some, this should happen much earlier. However, which point of the business model will have strategic importance at what stage may vary from one organization to another. Therefore, time should be given to identify strategic points and develop strategies that can make a difference with AI. Eventually, when an AI-based business model is applied, potential changes and development areas should be distinguished and notified for each stakeholder group that will be affected. Following such a path in developing an AI-based business model will also serve the robust data infrastructure that AIS will require because individuals will comprehend the data's outcomes in the big picture and more readily accept it as a part of the system. In particular, the areas where stakeholders will remain legally and ethically reserved should be disclosed and revealed individually for each stakeholder (Lee et al., 2019; Ng, 2018).

## 4.5 How Will AISs Affect Entrepreneurship Education?

Entrepreneurship education is one of the other discussion topics in the entrepreneurship literature. While a group of researchers examined personality traits' effects on being an entrepreneur and the entrepreneurial process, assuming that personality traits are determinants in becoming an entrepreneur, some other researchers claim that talents and skills gained later are as essential as personality traits. This second group claim prompted entrepreneurship lessons to start almost at the primary school level and made entrepreneurship education one of the countries' macro policies. The

debate whether one is born an entrepreneur, or it is an acquired skill has not lost its heat until today. The fact that entrepreneurship transformed by AIS, which are a product of Industry 4.0, requires expert knowledge can be interpreted as the second camp will gain power.

At this stage, the curriculum should be revised to increase the ability to use AIS in almost all areas, especially in business/management schools. However, the curriculum change in question depends on the preparation of the academic staff for AIS. University management should encourage entrepreneurship research with AI and allow them to develop themselves in this field (Lévesque et al., 2020).

As it is known, companies have intellectual capital. Intellectual capital increases the potential to be creative, but those who increase intellectual capital power are also a group with managerial costs—workforce motivation and promotion, time for leisure, etc. It is claimed that firms will utilize AI opportunities instead of individuals soon to reduce their costs (Daugherty et al., 2019). Indeed, some researchers make their claims to the point that, over time, AI can completely deduct human intelligence from all equations (Popkova & Sergi, 2020). Looking at the event from a slightly more optimistic perspective, it can be predicted that at least the startup founders will come together as a team, but will build adaptive processes using their AIS in routine work. Potential and existing entrepreneurs' ability to evaluate AI integration's appropriateness with the nature of their business depends on their knowledge and experience in this area. It should be ensured that AI's most preferred application areas, process automation, cognitive insights, and engagement, must be accepted as dynamic capabilities (Davenport & Ronanki, 2018), and which one should be focused on within the scope of the business model must also be decided. Nevertheless, as mentioned earlier, this adaptation depends on the innovation process, business model, and the "AI-based entrepreneurship education" that can combine AI in the operation process.

## 4.6 How Will AIS Affect Entrepreneurship Research?

*Investigations that show how entrepreneurs benefit from AIS in practice*:

The transformation of entrepreneurship practices with AI is, of course, a new beginning for researchers in this field. Researchers have started to include "AI usage" and AI variables in their models while searching the entrepreneurial events. In studies on AI and entrepreneurship, it has been questioned how AI plays a role in solving the uncertainty problem (Dubey et al., 2020; Park et al., 2020). As it is known, making decisions and taking risks under uncertainty is the basic assumption for entrepreneurship. Thus, the tools utilized by entrepreneurs to overcome uncertainty and reduce risks have always attracted attention. It is also impressive how AI is applied to overcome uncertainty in financing and innovation processes (Corea, 2019; Montull, 2020). It is envisaged that this interest will continue in the upcoming periods, and other AI effects in the entrepreneurial process will be researched. These studies not only concern academics interested in entrepreneurship, but at the same time, it can

be assumed that entrepreneurs will benefit from the before-mentioned studies' results. For instance, researches are carried out on what venture capitalists and crowdfunding campaigns pay attention to most (Kaminski & Hopp, 2019; Liebregts et al., 2019) and which areas they are directed through the social media footprint, and the conclusions of these studies are of a nature to attract entrepreneurs.

*Researchers' use of AIS to understand and explain entrepreneurs and entrepreneurship practices*:

As in all social science fields, understanding or explaining a phenomenon/case in entrepreneurship is unfortunately not straightforward due to several causes and consequences. Researchers, accordingly, often need to diversify data while working on a phenomenon/case. At this point, AI enables a researcher to access many data sources and types of data that cannot be obtained due to his/her limited nature. Hence, it can be assumed that AI enables more reliable assumptions concerning entrepreneurship (Maula & Stam, 2019). Besides, the inclusion of AIS in the research processes will make it possible to understand entrepreneurship practices across the country, region, and the world and lead entrepreneurship research with relatively strong explanatory power (Fig. 4.3).

For instance, in their study, Bloh et al. (2020) established a relationship between entrepreneurial activities and media with rich data generation features as in the model given above. According to the model, it is aimed to measure entrepreneurial activities by utilizing techniques such as sample-based surveys, case studies, and process-based data.

The most logical point to benefit from AI in entrepreneurial research is the instrumentalization of AI in ensuring the balance of the research subject and research design emphasized by Maula and Stam (2019). As it is known, in the research concerning entrepreneurship, it is observed that researchers generally start with quite ambitious research questions, except those published in journals that are accepted as "good" in the field, but that over time they tend to be oriented toward a research design from which they can obtain data. This situation has evolved into a chronic problem, especially for researchers in developing countries experiencing serious problems in obtaining data. Researchers can overcome the question-design discord by using AI's feature of using a large amount and variety of data. It also enables us to fulfill the triangulation requirement, which provides a factual basis for explaining claims and contributes to the research's validity and reliability (Lévesque et al., 2020).

For the reasons outlined above, AI can increase the number of quality research, but it can also plague entrepreneurship research. This situation manifests itself as a question mark, mainly in terms of theoretical discussions. It is questioned whether we will demand the theories put forward to generalize based on a small or limited number of observations and increase predictability about the unknown after AI (Lévesque et al., 2020). This is because AI stipulates a solution based on data for a specific domain structure. In this situation, it is more sensible to evaluate the "unique" situation as much as possible instead of making generalizations. Furthermore, developing theories to predict another area may be a futile effort, since unique patterns can be revealed for each situation. In the future, theories will be developed for areas that are perhaps only inherently impossible to obtain data. Haveman et al. (2019) argue that

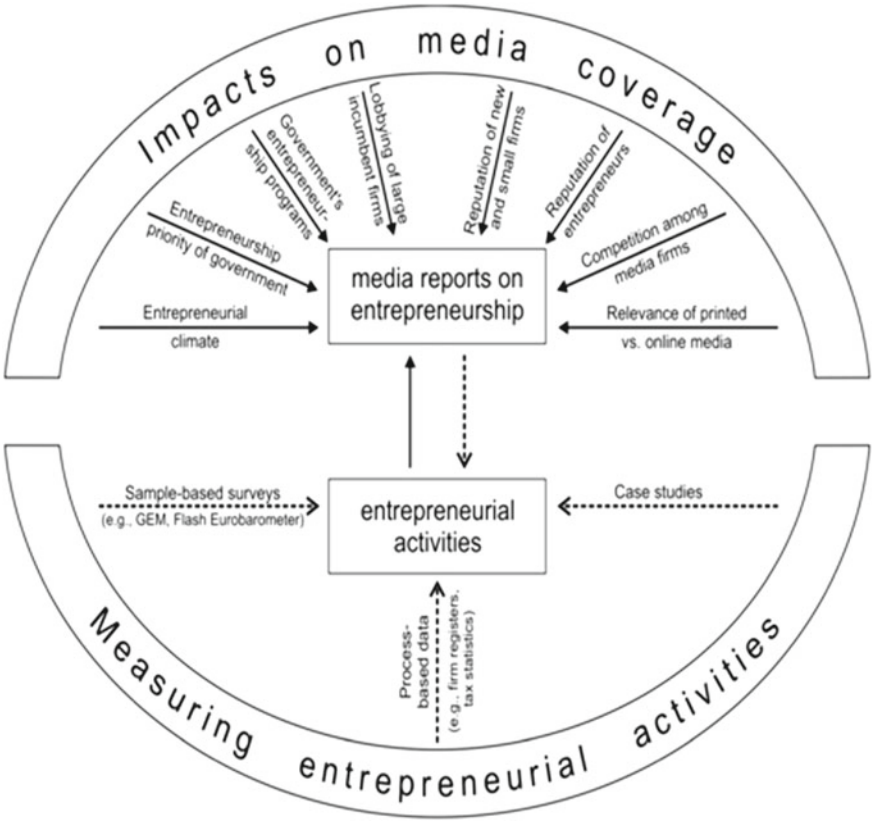


**Fig. 4.3** The relationship between media coverage and entrepreneurial activities (Bloh et al., 2020: 676)

even though we have had the opportunity to carry out serious experiments, models, and empirical researches thanks to AI, advancing without theory is not attractive in terms of science; hence, acceptance of AI at the scientific level will be a little slower than in practice. Indeed, these should be considered speculative opinions for now, and step by step, what the time will bring should be followed.

Entrepreneurship researchers can also benefit from AI for their own benefit (Lévesque et al., 2020). Patterns can be determined by analyzing which subjects primarily "good" journals focus on from time to time, what is on the agenda in entrepreneurship, and publications with a higher probability of publication can be produced.

In brief, two main contributions of the research made using AIS to the field can be mentioned: (i) The use of new information and data sources emerging with AI and thus *advancing the data frontier*, (ii) Applying new techniques to existing data

and/or problems thanks to AI and thus *advancing the knowledge frontier* (Prüfer & Prüfer, 2019). In other words, smart machines and algorithms will not only transform the entrepreneurial phenomenon but also affect both the research subjects and the way they are studied.

## 4.7 What Will AIS and Entrepreneurship-Based Research Questions Be? Curious Topics…

Entrepreneurship is one of the most popular fields in the social sciences. Lately, journals in entrepreneurship have been publishing special issues and cover studies where AIS and entrepreneurship meet. It is not difficult to guess that the studies, which have never lost their popularity with AIS, the popular subject of today, and where entrepreneurship intersects the leading actor institution of capitalism, will be on the agenda for a long time. Considering the points of curiosity, the research topics of the immediate future can be predicted as follows:

- Women entrepreneurship and AIS: There is curiosity regarding how Industry 4.0, digitalization, and use of AIS will change the position of "women" in entrepreneurship. As it is known, the concept of "entrepreneur" is masculine in the field of traditional entrepreneurship. When women tackle this job, they are subjected to a particular classification as "woman entrepreneur" (Çitçi & Sağır, 2017). Several positive discrimination policies are applied to women entrepreneurs worldwide for them to attain a place in the system, and thus an effort is made to "lead the way for women." Still, it is hard to say that expected development in women's entrepreneurship has been achieved. One of the critical reasons for this is that women's role in social culture has not changed. Thus, it is a matter of curiosity about whether industry 4.0 and its tools will lead to a change in entrepreneurship in terms of gender. In their research, Chae and Goh (2020) found no transformation in digital entrepreneurship in favor of women yet. Perhaps, when a similar study is repeated 5–10 years later, the indicator may change in favor of women.
- Entrepreneurial process and AIS: As mentioned above, there are determinations and predictions that AIS can be used in various fields of entrepreneurship. Although it is claimed that AIS have serious potential in achieving efficiency in entrepreneurship, the number of studies revealing at what level and stage entrepreneurs use their AIS in reality/practice is relatively low. For instance, what AIS practices are used and effective in creating/exploring entrepreneurial opportunities in the product, technical, and market innovation (Miao, 2020) can be investigated.
- Scaling and AIS: Could the inadequate or high cost of the expert labor force in AI make startup and scaling activities challenging? Or can the cost incurred in this regard be considered a bearable one since it increases the possibility of opening to large markets with big data analyses? Field studies can be performed to get the answers to these questions and contribute to the entrepreneurship literature.

- Entrepreneurial potential and AIS: It is suggested in the literature that AI can be used as a tool to determine entrepreneurial potential (Lévesque et al., 2020). By analyzing data sets across the country, region, and the world, entrepreneurship areas can be determined, and the probability of success can be increased by producing appropriate resource policies. However, questions like "How can the characteristics, background and contextual data of individuals be determined completely and comprehensively," "Even if determined, is it possible to access them as a regular data set," and "Does the high entrepreneurial potential constitute a guarantee that the individual will be a successful entrepreneur?" still exist. Yet, the reality is that if robust entrepreneurship data from around the world are compiled, efficient use of macro-level resources and the simultaneous evolution of economies may be possible.
- Entrepreneurial context and AIS: What kind of contexts AI is suitable for can also be one of the research topics. Context includes industry, size and age of the firm, and many elements that shape the venture. Research may be conducted to identify contexts in which it is advantageous to meet with AI as early as possible. In this way, it will be possible to develop more consistent and result-producing intra-organizational and macro policies.
- Entrepreneurial ecosystem and AIS: It is predicted that the digital infrastructures that entered our lives with Industry 4.0 and the new socio-technical processes developing with them will create new practices and institutional arrangements in the field of entrepreneurship (Nambisan, 2017). The increase in the number of digital entrepreneurs and the increased use of AI as a result of the big data in the digital economy order will transform the existing entrepreneurship ecosystem and generate new concepts that explain its context and new actors of the context. In the future, institutions that are included in the ecosystem based on institutional theory can be scrutinized. Sussan and Acs (2017) took the first step in this matter. In their study, in which they investigated the digital ecosystem and the intersection cluster of the entrepreneurial ecosystem, they suggested that the digital entrepreneurial ecosystem can now be mentioned. They stated that the four important actors of this ecosystem are digital user citizenship, digital marketplace, digital infrastructure governance, and digital entrepreneurship. This study can be accepted as an introductory study, and other actors and institutions of the digital entrepreneurial ecosystem can be determined.
- The relationship between uncertainty and entrepreneurship and AIS: Depending on the use of AIS, the uncertainty becomes specific (Obschonka & Audretsch, 2019). In this case, the definition of the concept of entrepreneurship, which has been defined as "taking risks and entering the market under uncertainty conditions" for more than a hundred years, may change. It will be beneficial for researchers to conduct interviews with entrepreneurs to investigate the uncertainty dynamics and effects after AIS in order for the theory meets the practice.
- Disruptive creative entrepreneurs and AIS: This section focuses on how AIS transform entrepreneurship. However, entrepreneurs who are valued as one of society's transformative forces and even described as destructive creators (Schumpeter, 1934) can create a similar effect in the field of AI over time. In the coming years,

entrepreneurs' transformative activities on this subject may also be the subject of research.

- Entrepreneurship research and AIS: What types of AIS can be developed to be used in studies investigating the entrepreneurs of the future, how inductive and deductive entrepreneurship research will be affected by AIS can also be the subject of the research (Obschonka & Audretsch, 2019).

## 4.8 Should We Call It the End or the Beginning…?

As a result of the studies that could and could not find a place for themselves above, what can be said about AI is that AI can be the magic mirror as stated in the studies of Kaplan and Haenlein (2019). When the evil queen in the fairy tale of Snow White and the Seven Dwarfs asks, "Mirror, mirror on the wall, who is the fairest of them all?", what the mirror does is no more than scan a distant data set according to the beauty criteria coded for it (i.e., white skin like cotton, red lips like cherry and black hair like ebony according to the beauty understanding of the period). The mirror does not do anything wrong in this tale; what is done is a detailed scan in line with the commands entered into it. But what matters here is who has the mirror. Likewise, the outcomes of using AI in entrepreneurship depend on who uses it for what purpose. Since AI-supported applications will not create equal opportunities and results for all parties, the power balance between developed-developing countries, business entrepreneurs-investors, women entrepreneurs, social entrepreneurs, and commercial entrepreneurs should be monitored. In cases where the same side continually wins, progresses, and writes the tale's continuation, asymmetric power relations will be permanent, and even AIS will be the source of new inequalities.

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# Chapter 5
# A Machine Learning Framework for Data-Driven CRM


**Serhat Peker and Özge Kart**

**Abstract** In today's digital world, enterprises accumulate large quantiles of customer data which drives firms to implement data-driven CRM strategies to manage customer relationships. In CRM, machine learning techniques are widely used as a tool for using customer data and thereby acquiring knowledge from such data. In this context, this research presents a holistic framework for the implementation of machine learning methods in data-driven CRM applications. The proposed framework relies on past transactional data of customers and employs state-of-art machine learning techniques. This research serves as a foundation for future studies on data-driven CRM applications utilizing machine learning techniques.

**Keywords** Machine learning · Artificial intelligence · Data mining · CRM · KDD · Clustering · Classification · Association analysis · Regression · Customer attraction · Customer retention

## 5.1 Introduction

In today's business, companies are faced to more intense competition than ever before. With advances in online shopping and e-commerce, many new firms can easily enter into the market. This not only drives costs down, but also the alternatives of customers are more diversified. This environment makes customer experience extremely important, and so customers' shopping preferences are based on their experience they receive. Thus, businesses are under immense pressure to maintain close relationships with their customers, and enterprises building an excellent relationship with customers can gain customer loyalty and thereby increase competitive advantage and overall business profits (Saarijärvi et al., 2013). In this manner, customer

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relationship management (CRM) which is a broadly recognized strategy can assist firms in managing their customer relations.

With the explosive growth of internet and mobile technologies, businesses have increasingly been adopting CRM. CRM is an approach to identify and understand its markets and customers to achieve customer acquisition, customer retention, customer loyalty, and customer profitability (Swift, 2001). It also aims to form closer and long-lasting interactions with its customers and to maximize their lifetime value to the business as well (Peppers et al., 1999). CRM covers many components and activities, but customer information is the essential asset in its all operative and analytical processes. In this context, customer surveys and transactional data in databases are key sources to obtain customer information.

With the digital transformation, massive databases and data warehouse with big data technologies have enabled easily storing and managing massive amount of data about customers' transaction records. This is an incredible goldmine of intelligence that could be used to design data-driven CRM strategies and create a unique customer experience. However, big data has no value without obtaining insights into customer behavior. In this manner, mining transactional data is a critical task, and CRM needs tools and techniques for analyzing large amounts of complex data. Big data analytics, artificial intelligence, and machine learning, therefore, can help to accomplish such an objective by acquiring implicit customer characteristics and behaviors from large datasets.

Machine learning (ML) has gained impressive momentum in recent years, and its techniques have been transforming the way firms interact with their customers (Rodrigues Chagas et al., 2019). Using machine learning provides businesses with deep insights into their customers and gives ideas about their future behaviors. However, there are numerous machine learning techniques available, and in practice, it is not an easy task to pick an appropriate technique which requires understanding the business requirements and data characteristics as well. Further, employing and implementing ML techniques require significant expertise and know-how in the fields of data science and artificial intelligence (AI) because of their requirements that need to be addressed and their steps that are performed in a systematic manner. Hence, this paper aims to propose a framework for the implementation of machine learning techniques in data-driven CRM applications through utilization of past transactional data of customers. This proposed framework can enable both researchers and practitioners to easily incorporate machine learning techniques into their data-driven solutions for CRM activities.

## 5.2 Literature Review

This section reviews the relevant literature concerning customer relationship management, and machine learning techniques.

### 5.2.1 CRM

CRM is a key strategy to build close and long-term relationships with customers in the competitive business environment through understanding and fulfilling the needs of customers (Brown & Coopers, 1999). It involves all activities related to customers which are integrated in different functions of organization including marketing, sales, and technical support. Information technologies are usually employed in CRM to implement customer-centric approaches, which assists businesses in improving relationships with customers and thereby can enhance their loyalty.

CRM consists of four dimensions: customer identification, customer attraction, customer retention, and customer development (Parvatiyar & Sheth, 2001; Swift, 2001). These four dimensions can be seen as a cycle and they are crucial to gain insight on the behaviors of customers (Ling & Yen, 2001).

- *Customer identification*: This phase involves analyzing of customers in terms of their relationship with the company. The main elements of this phase are customer segmentation and profiling. Based on these applications, companies identify the most profitable customers and the ones who are almost being lost.
- *Customer attraction*: This phase involves attraction of the target customer segments. Customer-centric classification and forecasting are key elements for analyzing, detecting, and predicting changes in customer behaviors. With these applications customized strategies can be implemented effectively to attract target customers.
- *Customer retention*: This phase involves maintaining the close and effective relationship with the customers by satisfying their needs. The main elements of this phase are customer-centric classification and forecasting which enables companies to understand and analyze the characteristics of their customers. Using these applications, they can increase the loyalty of customers.
- *Customer development*: This phase focuses on consistently increasing individual customer profitability through the expansion of transaction intensity and transaction value. The main element of this phase is market-basket analysis which reveals associated or closely related services. Therefore, customer transaction intensity and value can be maximized by utilizing this application.

### 5.2.2 Machine Learning Techniques

Machine Learning is broadly divided into two main categories which are supervised and unsupervised machine learning. The following subsections introduce these techniques and their CRM applications.

#### 5.2.2.1 Unsupervised Learning

Unsupervised machine learning techniques are fed with data that has no human predefined labels. It is mainly categorized as cluster analysis and association analysis techniques.

Clustering Analysis

In cluster analysis, data is divided into disjoint groups. Data points that share similar characteristics are grouped under the same cluster. Cluster analysis are the most popular and widely used tool for customer segmentation and profiling (Sarstedt & Mooi, 2014; Wedel & Kamakura, 2000). There are many clustering algorithms employed, and among them K-means is the most commonly used one for various customer segmentation applications (Cheng & Chen, 2009; Guney et al., 2020; Hosseini et al., 2010; Khobzi et al., 2014; Nikumanesh & Albadvi, 2014; Peker et al., 2017a). In addition to this algorithm SOM and Ward's hierarchical method are the other widely used ones for this purpose. However, these two algorithms have been usually employed with K-means algorithm together in a two-stage clustering concept. For example, a number of studies (Dursun & Caber, 2016; Kao et al., 2011; Wei et al., 2013) have implemented two-stage approach by using K-means and SOM algorithms, whereas a couple of studies (Li et al., 2011; Peker et al., 2017b) have utilized that approach which employs K-means and Ward's hierarchical methods.

Association Analysis

Association analysis builds relationships between items which exist together in a dataset. Market basket analysis and cross-selling programs are classic examples of association analysis. Mustakim et al. (2018) determined the layout and planning of goods availability by employing market basket analysis using FP-Growth algorithm. They showed that FP-Growth algorithm has been effectively generated informative association rules to discover customer consumption pattern at a local minimarket. Kapadia and Kalyandurgmath (2015) analyzed customer buying behavior patterns of items of a lifestyle store. They developed a software which gives valuable insights about the formation of the basket to the retailers. It could be useful for product variety, replenishment of stocks for possible products to be sold, make promotions based on possible products to be sold in a specific category.

#### 5.2.2.2 Supervised Learning

Supervised learning is generally categorized into classification and regression. In supervised learning, an algorithm is used to learn the mapping function from the input variable (called features, X) to the output variable (y); that is $y = f(X)$. The

major difference between classification and regression is that the output variable in regression is numerical (or continuous), whereas it is categorical (or discrete) for classification (Kelleher et al., 2015).

### Classification

Classification techniques have been widely used for various CRM purposes. Customer churn is a prominent problem which affects industry and business. Kirui et al. (2013) applied decision tree, naïve Bayes, and Bayesian network algorithms on a European telecom company dataset to predict customer churn. Cao and Shao (2008) implemented support vector machine on a CRM dataset from Duke University for churn prediction. Burez and Van den Poel (2009) applied Random Forest and Logistic regression models on several real-world European churn datasets. Vafeiadis et al. (2015) presented a comprehensive comparison of classification algorithms namely, Artificial Neural Network, Support Vector Machine, Decision Tree, Regression Analysis, Naïve Bayes, boosting on Telecom Dataset from UCI machine learning repository for churn prediction purpose.

The behavior of customers were aimed to be predicted to retain valued customers by improving the decision-making processes (Femina & Sudheep, 2015). They applied Naïve Bayes and Neural Networks on a dataset containing some features about a direct bank marketing campaign and a target feature with two possible labels. These labels denote if the customer approved the long-term deposit or not. Chen et al. (2016) proposed new collaborative ensemble learning based multi-kernel support tensor machine to classify cross-selling recommendations utilizing multi-type and multiway customer behavioral data. Ogwueleka et al. (2015) applied neural network classification approach for predicting behavior of customers of an international bank. Wang et al. (2015) aimed to find out the predictive power of customers' social media checkins on business failure of restaurants by using some classifiers, such as K-nearest neighbor, Logit model, and Neural Network.

### Regression

Regression problems involve forecasting quantities or sizes. Rathi (2010), proposed a regression model for CRM in order to retain customers of organization. Their proposed model predicts the continuous values using regression technique. Chang and Ijose (2016) showed how to measure customer lifetime value (CLV) by considering individual heterogeneity using linear regression and offered an application in the credit card industry. Çavdar and Ferhatosmanoğlu (2018) developed a model for airline industry to estimate the CLV. They integrated customers' flight information and social network. They adopted a regression model to be used for estimating airline customers' CLVs, and presented how to improve the estimations with the integration of social network information to the base model.

## 5.3 Proposed Framework

This paper proposes a generic framework for the implementation of machine learning techniques in data-driven CRM applications. The proposed framework is designed to enable customer segmentation, market-basket analysis, customer-centric classification, and customer-centric forecasting by enabling the use of corresponding supervised or unsupervised machine learning techniques. In this manner, Table 5.1 shows ML-based CRM applications and CRM dimensions for each main category of ML technique.

The proposed generic ML framework consists of the following main steps: (a) problem formulation, (b) data preparation and pre-processing, (c) implementation of ML algorithms, (d) evaluating the results or models based on one or more performance metrics, and (e) interpretation of the results. Each of these steps will be given in greater detail in the following subsections.

Fig. 5.1 provides an overview of the application of our proposed machine learning framework for data-driven CRM. Problem formulation which includes goal identification and understanding domain requirements is the initial step of every machine learning application. The second step of data preparation and preprocessing involves processing, cleaning, and transforming the raw data, selecting important features, etc. for constructing models and evaluating them. If the determined problem requires a supervised learning approach, model building is a prominent step in which a predictive model to meet the business requirements is built. Model evaluation measures the effectiveness of the model. If the determined problem involves discovering unknown patterns in data or doing exploratory analysis and automatically identifying structure in data, unsupervised ML algorithms are implemented, and the obtained outcomes are interpreted.

### *5.3.1 Problem Formulation and Machine Learning Technique Selection*

As a first step, it is essential to formulate the problem which gives direction for the future steps. In this context, the aim should be identified in the scope of CRM policies

**Table 5.1** ML-based CRM applications and CRM dimensions

| ML techniques | ML-based CRM application | CRM dimension |
|---|---|---|
| Cluster analysis | Customer segmentation/profiling | Customer identification |
| Association analysis | Market-basket analysis | Customer development |
| Classification | Customer-centric classification | Customer attraction, customer retention |
| Regression | Customer-centric forecasting | Customer attraction, customer retention |

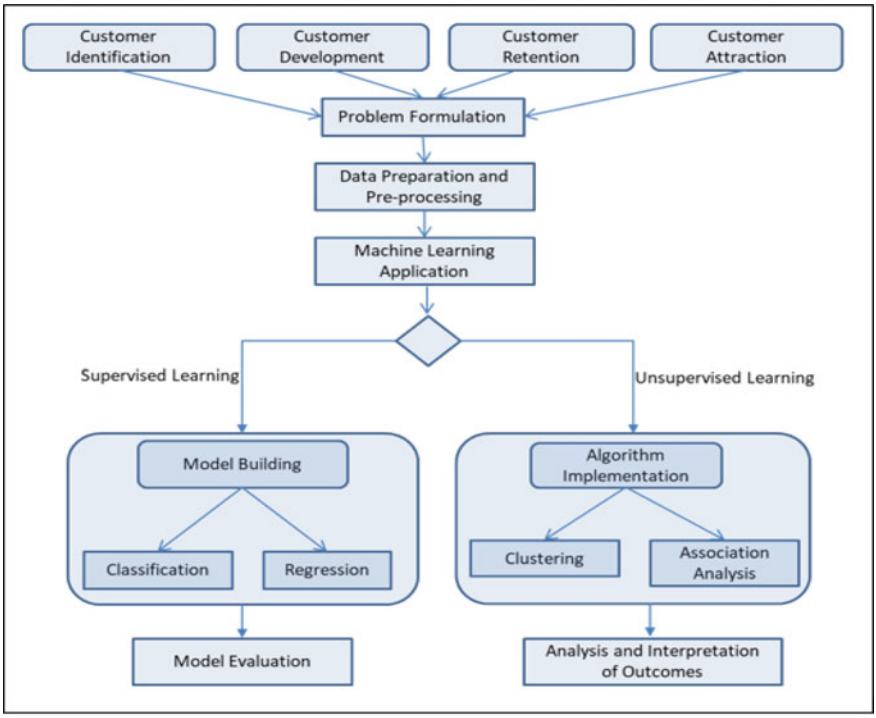


**Fig. 5.1** Machine learning framework for data-driven CRM

and strategies, and companies should decide what to do for that objective. Afterwards, the corresponding machine learning method and certain algorithms are determined according to the selected CRM application. For example, a company that wants to profile customers and determine its target group. To meet this purpose, customer segmentation is needed, and this is a typical unsupervised learning problem. For such problems, cluster analysis which is one of the most popular and widely used ML methods in the CRM is applied. Finally, one of the most commonly used clustering algorithms is selected. Another unsupervised problem for a company could be to discover combinations of items that occur together frequently in sale transactions. This is an unsupervised learning problem and requires market-basket analysis by using association rule mining technique.

Other scenarios could be to predict whether a next online shopping session of a certain customer will end in a purchase or not or to predict the number of copies a music album will be sold next month. Both are supervised learning problems. The only difference between these two problems is the types of target to be predicted. The first example requires customer-centric classification, whereas customer-centric forecasting is appropriate for the second one. For the first problem, classification techniques are employed, while regression methods are implemented for the second problem.

### 5.3.2 Data Preparation and Pre-Processing

After formulating problem and identifying appropriate machine learning technique for the problem, next step is understanding data and preparation of it for the application. In this manner, first step is deciding on the granularity/level of the data. Selected problem plays the most important role in this process. For example, the problem of predicting the number of copies a music album will be sold next month requires historical transactional data of all customers in an aggregated manner. On the other hand, the customer's past purchase transactions are needed for the problem of predicting whether a next online shopping session of a customer will end in a purchase or not. This type of data includes individual-level data, which contains a specific customer' behaviors.

The second step is identifying the feature set which is indispensable for the application of the machine learning techniques. This is related with the problem itself, and so involves having some understanding of which features potentially affects the selected problem. Moreover, this process differs across industries and business sectors. One way for this process is taking opinion of domain experts. In this sense, CRM experts can decide on the relevant feature set according to the data in hand. Another way to determine feature set is reviewing the past related literature and investigating commonly used features. In the literature, various feature subsets have been utilized in machine learning techniques for many CRM applications. For example, RFM model features which are recency (R), frequency (F), and monetary (M) are used most effectively in customer segmentation applications (Bauer, 1988; Bult & Wansbeek, 1995). Thus, different versions of RFM model features have been frequently and successfully utilized for understanding and analyzing customer behavior characteristics in the application of customer segmentation in the literature (Peker et al., 2017a).

In order to use machine learning methods effectively, pre-processing of the data is also essential. In CRM domain, a customer identifier feature such as customer membership number is mostly available and obvious in the databases of the organizations, while many of the features are hidden in the transactional data and requires additional pre-processes to be ready for use. Thus, it is impossible to use these features directly. Because of this, such features are generated by combining information from two or more attributes in the database. For example, in the application of customer segmentation using RFM model features, *Recency* is obtained by calculating the time interval (such as days or months) between the last purchase date of the customer and the last observation date, *Frequency* is generated by counting the number of purchases made by the customer during the observation period, and *Monetary* is created by calculating the total amount spent by the customer or the customer's average amount spent per purchase during the observation period.

Moreover, target variable is sometimes needed to be formed and data transformation is required in classification machine learning problems. To exemplify this process, assume that above table in Fig. 5.2 shows customer transaction records of an e-commerce company and this is a partial segment which shows only the purchase

| Date | Customer | Purchased Products | Feature 1 | ... | Feature N |
|---|---|---|---|---|---|
| 1/13 | c1 | p1, p5 | f11 | ... | fN1 |
| 1/18 | c2 | p2, p8 | f11 | ... | fN1 |
| 1/22 | c1 | p3, p5, p8 | f12 | ... | fN2 |
| 1/24 | c2 | p1 | f12 | ... | fN2 |

| Date | Customer | Product | IsPurchase | Feature 1 | ... | Feature N |
|---|---|---|---|---|---|---|
| 1/13 | c1 | p1 | 1 | f11 | ... | fN1 |
| 1/13 | c1 | p3 | 0 | f11 | ... | fN1 |
| 1/13 | c1 | p5 | 1 | f11 | ... | fN1 |
| 1/13 | c1 | p8 | 0 | f11 | ... | fN1 |
| 1/18 | c2 | p1 | 0 | f11 | ... | fN1 |
| 1/18 | c2 | p2 | 1 | f11 | ... | fN1 |
| 1/18 | c2 | p8 | 1 | f11 | ... | fN1 |
| 1/22 | c1 | p1 | 0 | f12 | ... | fN2 |
| 1/22 | c1 | p3 | 1 | f12 | ... | fN2 |
| 1/22 | c1 | p5 | 1 | f12 | ... | fN2 |
| 1/22 | c1 | p8 | 1 | f12 | ... | fN2 |
| 1/24 | c2 | p1 | 1 | f12 | ... | fN2 |
| 1/24 | c2 | p2 | 0 | f12 | ... | fN2 |
| 1/24 | c2 | p8 | 0 | f12 | ... | fN2 |

**Fig. 5.2** Illustration of data transformation

records of customers c1 and c2. Let us say the problem is predicting whether a next online shopping session of a customer will end in a purchase or not. For such a binary classification problem, a boolean target feature called "IsPurchase" is created and the transactions in the first table are transformed into the ones in second table. In this transformation, a new record is formed for each purchased product of customers' shopping occasions and for each record, "IsPurchase" boolean feature is labeled to specify whether the corresponding product is purchased by the customer in that transaction. Consequently, it is clearly seen in that example, data transformation is one of the important processes in data pre-processing in terms of adapting the data for the problem.

Most of the CRM applications based on machine learning techniques needs meaningful and a large amount of data to generate useful strategies and policies. Especially in individual-level data, transactions can have null values for certain features. For example, to calculate *Recency* and *Length* features is impossible in RFM based customer segmentation, when the customer has only one transaction. Thus, transactions of such customers should be excluded before the implementation of cluster analysis. Further, in implementation of predictive models based on individual-level

data, customers with a small amount of previous transactions are considered useless or inefficient in terms of obtaining a high prediction accuracy. As a result, it is important to leave out these transactions from the model.

In addition to these, transactions with missing values and duplicate records are highly possible in databases and so another data pre-processing step is removing these records before machine learning based CRM applications. Note that before execution of some classification algorithms such as NN and SVM, categorical features are converted into a new form through one-hot encoding. With this method the categorical features are replaced by new binary dummy ones, which take value 0 or 1, to indicate whether or not a certain label of the feature is present for that record. Figure 5.3 illustrates this method with an example. Assume that above table in Fig. 5.3 shows sample of data with three categorical variables. Features "Gender" and "Martial" has two labels, whereas "Education" has three labels. This method generates n-1 new binary dummy features for a categorical feature with n labels. Thus, a new dummy feature for each "Gender" and "Martial," and two new dummy features for "Education" are created, and all these features are populated with values of 0 or 1 as shown in below table in Fig. 5.3. Moreover, another important data pre-processing step is that all features except for target one in classification problems are standardized to a zero mean and one standard deviation to reduce the scale effects, before feeding data into algorithms.

| ID | Gender | Martial | Education |
|---|---|---|---|
| 1 | Male | No | Undergraduate |
| 2 | Female | Yes | Graduate |
| 3 | Male | Yes | Undergraduate |
| 4 | Female | No | Undergraduate |
| 5 | Male | Yes | High School |

| ID | Gender_male | Martial_yes | Education_highSchool | Education_undergraduate |
|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 | 0 |
| 3 | 1 | 1 | 0 | 1 |
| 4 | 0 | 0 | 0 | 1 |
| 5 | 1 | 1 | 1 | 0 |

**Fig. 5.3** Illustration of one-hot encoding

### *5.3.3 Application of Machine Learning Algorithms*

The type of machine learning algorithm (unsupervised/supervised) to be implemented on the final dataset after data preparation and pre-processing steps must be decided in accordance with the CRM purpose determined in Sect. 5.3.1.

#### 5.3.3.1 Unsupervised Machine Learning Algorithms

When the CRM goal is customer segmentation/profiling, clustering techniques can be implemented. Association analysis is generally performed for market basket analysis and cross-selling programs.

A. Cluster Analysis
As an unsupervised approach, clustering techniques have been prominent in numerous real-life customer segmentation applications (Nilashi et al., 2015; Wu & Chou, 2011). The customers in a same group have similar characteristics. Clustering algorithms can be applied for clustering the customers of company on the basis of their data such as their purchase behavior. Hence, the profitable customers can be recognized.

Self-organizing Maps, Support Vector Clustering, and KMeans algorithm with various extensions are clustering algorithms that have been widely used in customer segmentation problems (Ahani et al., 2019; Albuquerque et al., 2015; Khalili-Damghani et al., 2018). These algorithms have been generally implemented for target market discovery, market segmentation, and find out the customer groups having similar value, demands, and preferences (Ahani et al., 2019).

As a result of the clustering process, customers are divided into K groups according to their similarity and each is labeled with the cluster information it belongs to. Number of clusters (K) can be hyper parameter (given by the user) or determined by the algorithm itself. It depends on the selected clustering algorithm.

B. Association Analysis
The aim of association analysis is to build relationships between items which exist together in a given record (Mustakim et al. 2018). Common approaches for association modeling are statistics, apriori algorithms, and fp-growth algorithms (Mustakim et al. 2018; Nengsih, 2015). As a result of association analysis, a set of association rules hidden in databases are extracted. These rules are about discovering important association relationships that are greater than a significant threshold. The threshold indicates how powerful the pattern is and how likely it is to occur again (Berson et al., 1999).

#### 5.3.3.2 Supervised Machine Learning Algorithms

When the CRM goal is customer-centric prediction or forecasting, supervised machine learning algorithms are implemented.

A. Customer-centric classification
Classification is one of the mainly used machine learning techniques (Linoff & Berry, 2011). Classification algorithms build a model to predict future customer behaviors. The model learns from the historical customer data which have been categorized into predefined classes (labels) based on certain criteria. Then, the model aims to make an accurate prediction on new customer data, which is not seen by the model before (Ogwueleka et al., 2015).

B. Customer-centric forecasting
Forecasting algorithms build a model to estimate a future value about a customer. Unlike classification, they deal with continuous outcome values instead of categorical class labels (Linoff & Berry, 2011). Demand forecasting is a classic example of customer-centric forecasting (Sigauke & Chikobvu, 2016).

### *5.3.4 Evaluation*

The performance of the created models should be evaluated. The purposes of evaluation are three-fold: to determine which model is the most suitable for our goal, to estimate how accurately the model will perform, to be convinced that the model will meet the CRM needs.

Since clustering and association analysis are unsupervised approaches, which do not include ground-truth labels, evaluation process is only practicable for customer-centric classification and forecasting. As unsupervised approaches give descriptive insights about the customer data, outcomes of unsupervised learning algorithms can be interpreted with some descriptive analysis.

The basic evaluation process of a supervised model is as follows. The dataset is split into training and test sets. A machine-learning model is trained by using the training set. Then, the instances in the test set are presented to the trained model, and record the predictions that the model makes. These predictions can then be compared to the expected outputs. Based on this comparison, a performance measure can be used to determine, numerically, how well the predictions made by the model fit those that were expected.

k-fold cross validation is a commonly used sampling method. The dataset is separated into k equal parts (folds) and k-number of evaluation experiments are conducted. Firstly, the 1st fold is taken as the test set, and all the other folds are used as the training set. A model is trained using the training set, and the relevant performance measures on the test set are recorded. This process goes on until k evaluation experiments have been performed and k sets of performance measures

have been recorded. At last, the k sets of performance measures are averaged to give one total set of performance measures (Kohavi, 1995).

### *5.3.5 Analysis of Results*

The performances of customer-centric classification and customer-centric forecasting models can be evaluated using some performance measures. These performance measures can be divided into two categories according to the type of target (categorical targets and continuous targets).

#### 5.3.5.1 Categorical Targets (Customer-Centric Classification)

A. Binary targets

Binary classification problems have two levels of targets (for example: yes/no). There are 4 possible outcomes for binary classification:
True Positive (TP) means the model correctly predicted the instance in the test set having a positive target feature value.
True Negative (TN) means the model correctly predicted the instance in the test set having a negative target feature value.
False Positive (FP): means the model *incorrectly* predicted the instance in the test set having a negative target feature value.
False Negative (FN) means the model *incorrectly* predicted the instance in the test set having a positive target feature value.
Common performance measures to evaluate performance of the machine learning models are following (Kelleher et al., 2015). Larger numerical values of these measures indicate better model performance.

$$\begin{aligned} \text{Accuracy} &= (\text{TP} + \text{TN}) / (\text{TP} + \text{TN} + \text{FP} + \text{FN}) \\ \text{Precision} &= \text{TP} / (\text{TP} + \text{FP}) \\ \text{Recall} &= \text{TP} / (\text{TP} + \text{FN}) \end{aligned}$$

B. Multinomial Targets

Multinomial target means there are more than two levels in the target column of the dataset. The performance measures described in the previous section are suitable for the prediction problems having two target levels. However, some of the prediction problems are multinomial, that is, there are multiple target levels. If it is the case, performance measures are calculated for each target level *l*.

$$\begin{aligned}\text{Accuracy}\ (l) &= (\text{TP}(l) + \text{TN}(l))/\,(\text{TP}(l) + \text{TN}(l) + \text{FP}(l) + \text{FN}(l))\\ \text{Precision} &= \text{TP}(l)/\,(\text{TP}(l) + \text{FP}(l))\\ \text{Recall} &= \text{TP}(l)/\,(\text{TP}(l) + \text{FN}(l))\end{aligned}$$

#### 5.3.5.2 Continuous Targets (Customer-Centric Forecasting)

All the performance measures given in previous section are on prediction problems with categorical targets. In this section the most popular performance measures used for continuous targets are described. The basic process is the same as for categorical targets. There is a test set containing instances with correct target values, and there is a set of corresponding predictions made by a model. It is aimed to measure how accurately the predicted values fit the correct target values. The most common performance measure for continuous targets is sum of squared errors (SSE). The SSE, for a set of predictions made by a model M, is given as follows,

$$SSE = \frac{1}{2}\sum_{i=1}^{n}(t_i - M(d_i))^2$$

where $\{t_i \ldots t_n\}$ is the set of expected target values in the test set, and $M(d_i)$ is the prediction of the model for the $i$th instance in the test set.

Mean squared error (MSE) is another common performance measure that takes the average of the difference between the target values in the test set and the values estimated by the model (Kelleher et al., 2015). Smaller values of these error measures denote better model performance.

## 5.4 Conclusion

To stand out among competitors in the current digital world, companies strive to better understand their customers' behavior, cater more accurately to their needs, and interact with them in a more targeted way. Machine learning provides powerful tools to achieve these goals. In this context, usage of machine learning methods in CRM gained more and more importance with the recent increase in accumulation of large quantiles of customer data.

The main goal of the current study is to provide a holistic CRM-machine learning framework, which can be the basic direction of design and guidelines of development for data-driven applications on various dimensions of CRM. The proposed framework requires customer data such as past purchase histories, surveys, and demographics, etc. as input, and systematically address all stages of a classic ML technique implementation including problem formulation, data preparation, algorithm implementation, and evaluation/interpretation. It could assist researchers and practitioners in employing ML techniques for data-driven CRM applications.

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# Part III
# The Impact of AI on Accounting, Finance and Fraud

# Chapter 6
# How Blockchain and Artificial Intelligence Will Effect the Cloud-Based Accounting Information Systems?


**Betül Şeyma Alkan**

**Abstract** Digitalization reduces unnecessary workload by accelerating and diversifying business processes and enables it to focus on more useful areas. In this context, the transformation of accounting in the digital age aims to ensure efficiency in accounting transactions with real-time accounting information system integration. In terms of real-time accounting, it is important to benefit from the power of new technologies by connecting all current technologies to every stage of financial accounting processes and to establish a solid integrated system. The contribution of every new technology to the process is inevitable within the scope of cloud-based accounting information systems. In order to find an answer to the question of how artificial intelligence and blockchain technologies will affect cloud-based accounting systems, a detailed literature review has been conducted and discussed conceptually. In this context, the study focuses on the advantages of cloud-based accounting systems unlike traditional accounting systems, the effectiveness of blockchain and artificial intelligence technologies in accounting processes, and the synergy of blockchain and artificial intelligence. Today, accounting basic functions have been significantly integrated into artificial intelligence technology. Decentralized artificial intelligence emerging as a combination of artificial intelligence and blockchain allows the processing of reliable, digitally signed, and secure shared data that is stored on a decentralized and distributed blockchain without trusted third parties or intermediaries. The basic understanding of this decentralized, reliable, and secrecy system is based on the reliability and credibility of information. Central data storage can be highly sensitive in terms of security and privacy when it contains personal and private data about users, operations, and financial information. Artificial intelligence applications can expose the capacity and scaling issues of the centralized infrastructure that needs to process, transform, and store big data sets. Blockchain-based decentralized storage infrastructure will simplify cryptographically secure data storage across participatory networks. Thus, technology integration will offer benefits such as enhanced data security, collective decisions making, decentralized intelligence,

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and high efficiency. Multi-user accounting processes involving stakeholders such as business management, regulators, financial institutions, or government are inherently inefficient by reason for the multilateral authorization of business transactions. The integration of artificial intelligence and blockchain will enable automatic and rapid verification of data-asset-value transfers between different stakeholders. Thus, it is clear that the stakeholders involved in the process (financial advisors, auditors, public and fiscal authorities, shareholders, creditors) will also provide practical solutions to all their needs.

**Keywords** Accounting information system · Cloud accounting · Artificial intelligence · Blockchain

## 6.1 Introduction

Accounting is commonly characterized as "the language of business." The language is a communication tool. Accordingly, the accounting language serves as a tool to communicate matters concerning to different aspects of business operations. In other words, the role of accounting is that of communicating the operating results of a business. The accounting definition of the American Accounting Association (AAA) emphasizes the communication aspect of accounting for decision-making by various information users. The users-oriented definition of accounting as an information system refers to the process of identifying, measuring, and communicating financial information to permit in formed judgements and decisions by the information users. According to Robert Sterling, accounting symbolizes a measurement communication process. The financial information as an output of the accounting system are the inputs to decision theories (Maharshi Dayanand University, 1975: 5). To the definition of the American Institute of Certified Public Accountants (AICPA): "Accounting is the art of recording, classifying and summarising in a significant manner and in terms of money, transactions and events which are a financial character, interpreting the results thereof." In the literature, the common point of different accounting definitions is that accounting is an information system with certain functions. Today, the function of recording, classifying, summarizing, reporting, and analyzing, which are the basic functions of accounting, have been significantly integrated in artificial intelligence (AI) technology.

The accounting process is characterized by various interconnected processes. Although new technologies have been invented that are useful at every stage of the accounting process, their integration is still limited. At the same time, the potentials of these technologies are still little used. It is necessary to use a cloud system to create an integrated system by connecting all technologies to each stage of the financial accounting cycle. It is important to emphasize that a cloud-based system should be inserted in the midst of the overall system. The basic understanding of the system, which is guarantees decentralized, secured and reliable, is based on the credibility and reliability of the information.

Companies' financial statements involve entrusted information of all corporate shareholders. Reliable and timely information is essential for decision makers. Developing information technologies have enabled information to become an indispensable element for users by equipping the world with a network system and removing time and border barriers.

In this context, AI is an integral part of the decision-making process. AI is the ability of learning a program. Algorithms can solve problems and analyze external data inputs without taking commands from people and using big data sets. The information obtained from the data is used to achieve certain goals. Accordingly, the purpose of AI is to allow to learn and apply the information collected from big data streams to make machines smarter.

Big data management is potentially revolutionary in terms of information systems and management, as it is considered one of the groundbreaking technological advances in the digital age. The positive aspect of the usability of big data is above all the ability to connect different topics together. It is also the ability to make real-time predictions and allow incredible developments in the analysis of any phenomenon. Thanks to new technologies, the huge amount of data and the ability to analyze them is a very important development. In this context, new technologies rely on big data, especially data sharing.

The purpose of this study is to investigate the role of artificial intelligence and blockchain technologies in cloud-based accounting information systems. In order to find an answer to the question of how to benefit from the power of artificial intelligence and blockchain technologies in the operation of cloud-based accounting information systems, all aspects of cloud-based accounting, artificial intelligence, and blockchain technologies were discussed.

### *6.1.1 Cloud-Based Accounting*

Most of the changes in accounting information systems have occurred in the light of developments in information and communication technologies. Information and communication technologies, which form the basis of all systems today, provide great advantages in terms of speed, time, and quality from past to present. Developments at the level of information and communication technology; digitized accounting processes, revealed the concept of cloud accounting, electronic accounting applications (e-invoice, e-ledger), and updated accounting programs used by professional accountants as web-based systems that can also be defined as a new generation.

The concept of cloud accounting has emerged with the use of cloud computing in accounting information systems. Cloud Computing is based on the logic that an application or system can be accessed and used on the internet without the need to install the programs required to access it on a computer. As a real-time system, it is expressed as "a technology that can solve the problems in business life very cheaply and quickly with advanced cloud and service models" (Molen, 2010: 4). The term cloud refers to the location of shared files on the information network.

Cloud computing applications have offered advantages to businesses in terms of cost and speed by bringing alternative solutions to basic business functions.

The cloud-based accounting system, which was introduced by Oracle for the first time in 1998, can be defined as software in which all transactions of the accounting processes can be performed completely through a web browser. Using this system is economically very advantageous. Because instead of paying high fees for hardware and software, users pay only monthly rental fees and perform their accounting business processes at low cost. (www.asaresearch.com, History of Web-based Accounting).

Compared to traditional accounting applications, cloud accounting offers significant convenience and advantages to businesses. Cloud computing, which has three basic elements, namely software, platform, and infrastructure, uses the possibilities offered by systematic and scalable information technologies. Software as a Service (SaaS) refers to the most up-to-date versions of all web-based software, from electronic mail service to all business functions including accounting and office applications. Platform as a Service (PaaS) refers to the informatics environment that enables users to develop new applications. Infrastructure as a Service (IaaS) is a tool that enables all information transactions on the network (Buyya et al., 2009.

In cloud computing, the location of the servers and the users who access these servers can use different distribution models such as public cloud, private cloud, community cloud, and hybrid cloud. Thus, businesses can either design the cloud computing they can use in e-services, specifically for the business as well as by choosing a cloud system leasing method with common features. Institutions can choose the public or private cloud model according to the materiality of the privacy and/or process security level of the information processing. Institutions and certain organizations that cooperate in the community cloud model can access the data and applications of the system by sharing the informatics infrastructure of the model. In the hybrid cloud model, public and private clouds can be used together according to the needs and priorities of the information processing (Jamsa, 2012: 6). With the system possibilities and time/cost advantages offered by cloud computing, traditional accounting software has been replaced by cloud computing-based accounting software.

Cloud-based accounting programs have features that can meet all the needs of businesses and accounting departments (Elitaş & Özdemir, 2014: 103). The cloud-based accounting system, which has unique features and emerges with the adaptation of e-transactions to accounting, is the accounting software where the software components can be installed on the central computer and users can perform the accounting operations by logging into the system via a web browser (Çeviker et al., 2012: 134).

The software used with cloud accounting is entitled to use based on a subscription system with a certain fee and contract, and the data obtained by the transactions on the system are stored in an external database, not the user. System setup and updates are performed with remote access by the software company. Backup takes place on cloud system or local server. Legal changes related to the profession are followed through the cloud information system Declarations are prepared and sent automatically. The preparation and delivery of invoices and other official documents takes

place on a web-based basis. It is possible for business decision makers to access financial data with remote access at any time. With cloud-based accounting, Financial Reporting Standards with the creation of a suitable infrastructure is provided to the regulation of the report without experiencing any problems. Financial statements are easily organized by creating an infrastructure compatible with Financial Reporting Standards. Due to its flexible structure, it is easy to add to the needs of the users. Hybrid cloud structure emerges with the integration of cloud-based accounting systems used in the form of private cloud due to security concerns, into the cloud systems of banks and public institutions (Öz, 2016: 75–76). In the studies, it is stated that cloud technology has a positive effect on the accounting information system and reduces the purchasing cost of the business management. It is clear that cloud accounting application increases the economic gains of businesses (Sugahara et al., 2017: 136).

In cloud-based accounting systems, all documents are prepared by a web-based program in order to improve the adaptation between documents 'formats (improving adoption between documents' formats) in one machine to match others and are accepted by the same program on another machine. In cloud-based accounting systems, all documents are prepared by a web-based program and accepted by the same program on another machine to match documents prepared on one machine to others in order to improve adaptation between formats of documents. In this context, XBRL, the reporting language that enables the use of a common language in the cloud-based accounting system, translates financial reports into a digital language. It enables businesses to produce the necessary reporting information directly from their financial data. Owing to XBRL, continuous auditing of financial transactions and real-time information can be provided to business managers in the decision-making process. The most important features of XBRL are that external reporting is single and reliable enough to meet the data requirement and does not allow manipulation during the processing of records.

In addition to the advantages of cloud-based accounting systems to users, there are some disadvantages and risky aspects in the operation or use of the system. Data privacy and security, problems in internet connection, software system and firm dependency, legal problems, and contractual problems are the limitations of cloud-based accounting software (Öz, 2016: 71–73). The most risky factor threatening the security of cloud-based systems seems to be cyber attacks. Today's developing technologies, artificial intelligence and blockchain technologies, have features that can eliminate these problems.

### *6.1.2 Artificial Intelligence*

Companies are filled with large amounts of data, and it is simply impossible to manage with operating staffs or professionals. The data to be processed and stored in the accounting and bookkeeping processes are too many to be managed only by

people. For this reason, technologies that can collect and process these data quickly, reliably, and securely should be adopted.

The concept of AI, first improved by John McCarthy in 1956, describes a range of factors and technologies from automation to robotics. The main purpose of AI is to deal with the complex tasks carried out by people using computers capable of using the features of human intelligence. The designing of AI technology encompasses its versatility, velocity, veracity, and connectivity features. AI penetrates all technologies and affects today's business processes. Today, AI is used for data quality assessment, regulatory compliance, surveillance, fraud detection in both private and public institutions (FSB, 2017).

AI is highly effective in accounting systems because it has the power to implement self-management, self-healing, self-diagnosis, self-adjustment, and self-structuring methods. In the studies, it is stated that the development of cloud-based software and the modern AI tools significantly improves the accounting process and performance from the point of speed and accuracy, reduces paper usage, increases flexibility and efficiency, and improves reporting and database management system (Francis, 2013). However, information will be accessed more quickly and transparently in the accounting information system; It was also stated that the accounting process would be managed more efficiently (Tutar, 2019).

The main purpose of accounting is first of all to produce information (Yücel & Adiloğlu, 2019: 55). Accounting as an information system is defined as recording, classifying, summarizing and reporting, analysis, and interpretation of financial events that are capable of being measured in monetary terms. Professional accountants keep taxpayers' records, classify, summarize, analyze and interpret them and prepare the legal notifications and declarations required by the legislation and submit them to the relevant authorities. Therefore, the functions of recording, classifying, summarizing, and analyzing by reporting, which are the basic functions of accounting, can be reconsidered in terms of artificial intelligence.

- Recording Function: The recording function, which is the first function of accounting, is still performed with manual entries today. Accounting records can be performed with artificial intelligence technologies. Scanning invoices and transferring them to accounting records is a technological development that can be possible with artificial intelligence. In addition, the power of blockchain technology can be used to transfer financial transactions to the records.
- Classification Function: It has been completely automated by transferring transactions from journal to general ledger through cloud-based accounting software.
- Summarizing-Reporting Function: It is understood that the adjusted trial balance is created with the summary function of the accounting, and the financial statements with the reporting function. This function can also be fulfilled through software.
- Analysis-Reporting Function: Financial statements can be analyzed using a variety of techniques (ratio analysis, horizontal, vertical and trend analysis) by means of computers and therefore artificial intelligence technology. However, there is no development in the field of artificial intelligence regarding the interpretation of the analyzed financial statements.

Artificial intelligence is currently useful to classify each accounting transaction and transfer it to financial statements and tax returns (Biryukov & Antonova, 2018: 111). Technological tools with artificial intelligence provide advantages in terms of not losing valuable information, and improving and conducting business processes (Tarmidi et al., 2018: 1116). It reveals that as AI technology is developed, some jobs in accounting applications will be eliminated and some business areas will be born (Greenman, 2017). Studies show that AI will reduce the repetitive, rigorous, and boring nature of the accounting profession, and increase productivity as a consulting tool.

### *6.1.3 Triple-Entry Accounting Based on Blockchain*

With the widespread use of information technologies in accounting, it is clear that the concept of cloud accounting will leave its place to the concept of real-time accounting. Accounting applications on the basis of blockchain offer real-time reporting to relevant parties. The blockchain is a public digital ledger of all transactions carried out and shared with multiple parties in a distributed database. It is a platform where every transaction in the ledger is unanimously verified by the majority of the participants in the system (Crosby et al., 2016).

The blockchain is a distributed database in which records are linked together by cryptographic elements. Therefore, blockchain technology is defined as distributed ledger technology (DLT). It refers to the technology in which activities such as execution, approval, or authorization of transactions are held in nodes, with the approval of all participants on an independent network without the need for a central authority (Blockchain Platform of Turkey 2019: 15).

The blockchain accounting system proposed by Rückeshäuser is a system that performs monetary transactions on a peer-to-peer network between companies using blockchain based on accounting in their practices, and allows all transactions to be recorded and verified on the network. The system is also assumed to provide complete transparency to regulators and shareholders, allowing external audit of accounting entries. Proof of Work verification means transactions are verified through an implicit mining process (Rückeshäuser, 2017: 24) (Fig. 6.1).

Blockchain systems are classified into three separate categories as general, private, and consortium blockchain in line with the access permission decisions of the relevant parties. Since blockchain systems are configured on a peer-to-peer network, a cryptographic method is used as the trust mechanism for recording transactions.

In the cloud accounting system, records and financial reports are stored in a central place, such as the database of accounting software applications. The business owner and regulators or auditors can have direct access to relevant information. However, accounting information is a very valuable tool not only for management and shareholders, but also for government and tax offices (Özkul & Alkan, 2020). The entry or ledger shared in blockchain technology is distributed to all participants in the network in order to verify transactions and thus eliminate the need for intermediation

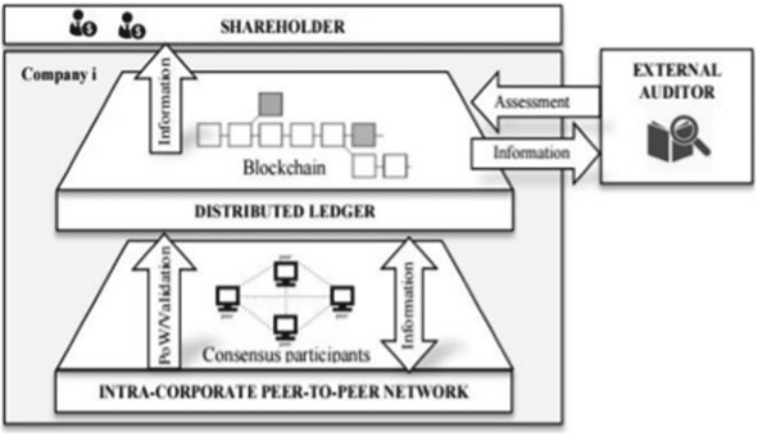


**Fig. 6.1** A concept of blockchain accounting system. *Source* Rückeshäuser (2017: 24)

by third parties (Tysiac, 2018). Therefore, in the blockchain system, records are entered and stored in a distributed or shared ledger that is accessible by all parties involved.

The accounting system based on blockchain proposes a triple-entry accounting system,[1] a third layer of blockchain embedded in the double-entry accounting system (Dai & Vasarhelyi, 2017: 11). In the traditional double-entry accounting system, the accounting records of each financial event that occurs are recorded independently in the ledger of both parties (buyer and seller). Relevant records can only be seen by the buyer and seller parties.

However, the triple-entry accounting system ensures a third entry to be journalized in a blockchain in addition to the accounting records journalized by the buyer and seller regarding the financial event in the traditional accounting system. Accordingly, in the blockchain-based accounting system, distributed and public records will be created instead of central accounting records, and records will be placed at three separate points due to the third accounting record, which is decentralized and open to parties, in the blockchain together with the buyer–seller. On the basis of the blockchain, the parties in the same transaction are located in the blockchain as a set of linked accounting records in the same ledger, not separately (Uysal & Kurt, 2018: 474). The records at the blockchain layer will be maintained by linking each blockchain account to the corresponding double-entry account in the traditional cloud accounting system. Hence, records in the blockchain-based accounting system will become accessible to all parties. In this case, regulators, auditors, and clients will each have an identical copy of the ledger.

[1] This system, proposed by Ian Grigg (2005) as the recording system of digital documents based on cryptographic transactions between different parties, was introduced three years before blockchain technology was discovered.

**Table 6.1** Differences between cloud-based ERP and Blockchain

| Cloud-based ERP | Blockchain |
|---|---|
| Centralized | Decentralized and distributed |
| High tampering risk | Low tampering risk |
| Many data operations | Append only |
| Relational database | Linear transactional database |
| Human labor-intensive | Non labor-intensive |
| Currently do not have self-enforcing contracts | Easier to create self-enforcing smart contracts |
| Controls are specially designed and in place | Controls could be set through smart contracts–smart controls |
| Accounting-specific modules | Currently no accounting-specific modules |

The important point is that the accounting systems based on blockchain technology will form a complementary function, not by replacing cloud-based accounting systems, but by moving them to the blockchain database with an integrated operation. A comparison between cloud-based ERP and Blockchain accounting can be found in Table 6.1 (Dai & Vasarhelyi, 2017).

Integrating blockchain technology into cloud-based accounting systems will form a highly secure collaboration platform where the recording system can be freely shared with trusted users or parties. For this reason, blockchain technology will ensure a non labor-intensive system with ease of access to distributed data in decentralized system.

This system will prevent unauthorized data changes. In this regard, control mechanisms will be created through smart contracts and will ensure the protection of company data against cyber attacks.

## 6.2 The Synergy of AI and Blockchain

In accounting information systems, data has become a valuable entity that must not only be securely stored but also shared. AI systems rely largely on data, and data can also be stored on blockchains with very high levels of reliability. At its core, a blockchain is a secure, distributed database shared by all participants in the network. Thus the decentralized AI method is a combination of AI and Blockchain; It is used to share information in a cryptographically signed, secure, and reliable manner without the use of third parties. Data is journalized in blocks, and each block is linked to the hash value of the preceding block. Thus, it is extremely difficult to change the stored data.

Distributed ledgers sacrifice efficiency for immutability and censorship resistance. In this context, AI can offer a high level of efficiency in optimizing energy consumption. Particularly, AI can also optimize the storage needs of blockchains. Since the

transaction history is kept in all nodes, the distributed ledger can reach large sizes quickly. If the storage needs are high, the entrance barrier is also high. This could potentially reduce the decentralization of the network. AI can provide a database that will make the blockchain smaller and enable data to be stored on the chain more efficiently. Decentralization feature for automatic and rapid verification of data in blockchain networks, solves a single point of failure in a cloud server with the help of AI for big data analysis. Artificial Intelligence (AI) plays an important role as a powerful analytical tool for analyzing big data and provides a scalable and accurate data analysis in real time.

Ben Goertzel, one of the leading researchers in the field of artificial intelligence, thinks that the advancement of artificial intelligence technology in a way that benefits users can only be possible when it is developed with a decentralized and democratic blockchain infrastructure. By developing an anti-centripetal artificial intelligence platform, it plans to create a blockchain-based infrastructure that can effectively run many artificial intelligence algorithms from image identification to natural language processing.

In the operation of the cloud-based accounting information system, it is crucial to provide a valid accounting system which can integrate all technologies and show a common way to software owners, governments, and policy makers to make the most of big data potential and the power of artificial intelligence and blockchain technologies. An advanced financial accounting model that highlights all opportunities and benefits offered by combining new technologies and finds the ideal technologic combination in a consistent and systematic process, will provide various advantages to all information users.

A model was proposed by Faccia et al. (2019). The proposed model is based on a blockchain technology that is approved by the public authorities of participating parties who want to be included in the cloud platform, provided by a specialized and trusted organization. The aim is to decrease or eliminate significant problems affecting modern society, such as corruption, tax evasion, business fraud, and the presentation of fraudulent or misleading information in financial statements. (Faccia et al., 2019: 33) (Fig. 6.2).

The advantages of blockchain are linked to decentralized management system, that permits most transparency as well as maximum security and invariance of the data to be involved in the blocks. Blockchain technology is based on a distributed ledger structure where users are given the authority to approve or disapprove certain transactions. A transaction is included in the block only when it is approved by all users with that authority. Therefore, blockchain is a system that is not only connected to a single central organization, but also reduces the possibility of data exchange or corruption, guaranteeing higher transparency and more security owing to the sharing of transaction confirmation selection. Basically, while blockchain is concerned with accurate records, authentication, and execution, AI ultimately causes autonomous interaction in decision-making, evaluating, and understanding specific patterns and datasets. In this context, a technology integration that takes into account all the needs of the accounting information system users will offer a revolutionary system

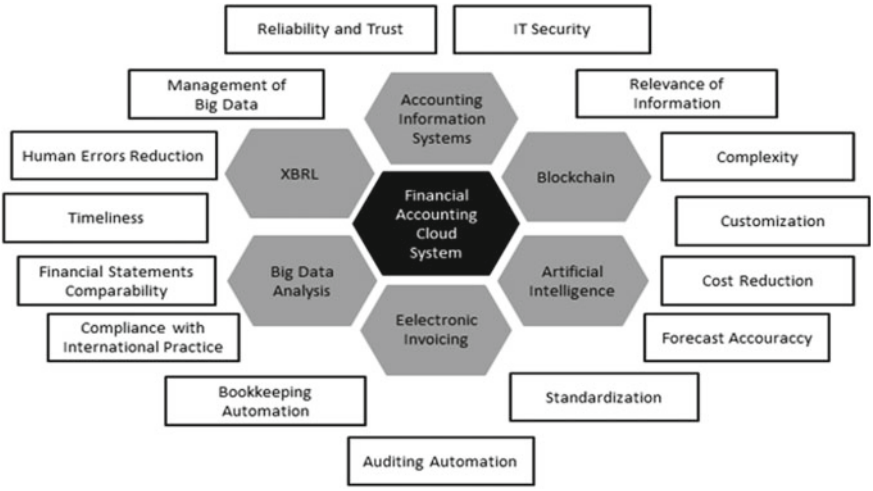


**Fig. 6.2** The investigation of new technologies. *Source* Faccia et al. (2019: 33)

infrastructure that can combine data in a single homogeneous system and solve many simultaneous challenges and existing system vulnerabilities.

Ultimately, it is clear that an artificial intelligence developed as open source on a decentralized blockchain will be more successful and in every sense more reliable than an artificial intelligence developed by any company.

## 6.3 Conclusion

The use of computerized accounting has been replaced by cloud-based accounting systems. It will not be a surprise to integrate all technologies in a single panel in order to meet the needs of all stakeholders and to eliminate the security, privacy, and storage gaps of the current system.

By nature of accounting information, it increases the usefulness of accounting information in order to establish modern accounting information systems by using modern information technology tools. In this context, it will be important to use modern information technologies to structure the traditional accounting model and to establish accounting integration in the restructuring of the modern accounting model by deepening the development and widespread use of cloud-based accounting systems.

Integration of information technologies based on modern accounting will provide a high degree of automation of business processes, a high degree of information sharing, and real-time accounting information reporting by fully utilizing modern information technologies and network systems. Highly automated systems

in accounting processes will seamlessly connect business processes with real-time transactions.

The accounting cycle is characterized by a large number of interconnected processes. Developing a model that can integrate all information technologies will ensure that the current limits of accounting are exceeded in regards to credibility and reliability of accounting information. Therefore, it is possible to attain an integrated system that can solve many difficulties at the same time and work together by combining XBRL reporting language, big data, artificial intelligence, blockchain technologies in a joint homogeneous system. This system can be designed to meet the needs of information users in the fastest way possible. It can also make serious progress in funding accounting and big data management. It can represent an effective accounting model to solve a variety of challenges, such as accounting frauds and errors, difficult reconciliations, costly audit, data collection, and analysis. In this context, the convergence of AI and blockchain on the system will also solve problems such as accuracy, privacy, and security.

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# Chapter 7
# Machine Learning Applications for Fraud Detection in Finance Sector


**Pelin Yıldırım Taşer and Fatma Bozyiğit**

**Abstract** Due to advances in information technology, instantaneous accessibility to financial services through digital channels has increased. *Although* digital platforms' usage makes an individual's life more comfortable, it may also cause some critical consequences like financial fraud which causes critical losses for companies in the industrial sector, investors, and governments. Identification of frauds can be challenging task for a human because it may be necessary to analyse high volume data during long time periods. An alternative is to use financial data as a fraud detection tool to automatically classify fraudulent activities. Currently, there are many practical solutions for automatically detect frauds in the finance domain. In this chapter, we examined on three different fraud types (bank fraud, insurance fraud, and corporate fraud) in finance sector and reviewed the studies using machine learning methods to detect financial fraud in a detailed manner. The findings from this review show that most commonly applied algorithms for financial fraud detection are Decision Tree, Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Random Forest and most of machine learning-based studies were performed in bank fraud field. This chapter also reveals that deep learning and ensemble-based machine learning applications has been frequently preferred in recent years to improve detection performance of the frauds in finance sector.

**Keywords** Financial fraud · Machine learning · Bank fraud · Insurance fraud · Financial statement fraud · Mass marketing fraud · Securities fraud · Supervised learning · Unsupervised learning · Ensemble learning · Deep learning

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## 7.1 Introduction

The World Wide Web (www) has drastically increased the amount of electronically exchanged information. These changes bring new forms to the supply–demand model in the finance sector. Along with the extensive application of information technologies, there has been increased usage of online banking and financial services to transfer money, invest, manage payments, and so on. Although online platforms provide internet users access to financial services more comfortable, some security issues like financial fraud reveal as a major problem to be handled. The problem of fraud, including insurance fraud, bank fraud, and corporate fraud has a significant impact on the finance industry, corporate organizations, and government. Fraud detection using traditional methods is based on manual analysis and interpretation. Since manual data analysis is time-consuming, costing, and highly subjective, there is a need to scale up human analysis capabilities to deal with a large number of user data (Kılınç, 2019). Therefore, business organizations focus on artificial intelligence technologies to overcome financial fraud problems in recent times.

*Artificial Intelligence* is a computer system consisting of various algorithms that simulate human intelligence. *Machine learning* is a sub-branch of artificial intelligence which gains systems the learning ability using some experiences continuously without any human interference. The learning ability of the system is provided by discovering hidden and potentially useful patterns from the raw data using machine learning algorithms, including mathematical and statistical methods. Machine learning techniques have been frequently used in the finance sector for various issues such as credit scoring, risk management, and fraud detection. There are two conventional machine learning approaches to address fraud detection problem; supervised and unsupervised learning. In this chapter, supervised and unsupervised machine learning applications for financial fraud detection are reviewed.

In recent years, ensemble learning has become increasingly popular research focus in machine learning because of the high accuracy ability it provides. *Ensemble learning* is a paradigm which trains multiple machine learning models (learners) and then combines them to make final output decision using a voting process. In this approach, it is aimed to get a strong learner by using multiple models instead of using a single model. Many studies in the literature revealed that ensemble learners give more successful results than the traditional individual learner. Therefore, ensemble-based machine learning models has commenced to be used in financial fraud detection area nowadays.

*Deep learning* is a subtype of supervised learning that aims to describe complex data representations using simpler hierarchized structures defined from a specific feature set (Wang et al., 2019). Due to the advent of powerful parallel computing hardware and the big data technologies, deep learning has also become a widely preferred technique in financial problems, and it shows great promise for fraud detection. It commonly includes convolutional neural network (CNN), long short-term memory neural network (LSTM), and autoencoders.

This chapter focuses on presenting an overview of the studies using machine learning methods to detect financial fraud. It also proposes an insight into researchers for their future applications in this field. In this study, the machine learning techniques that were used in current fraud detection studies are described in a detailed manner. Finally, the advantages and some drawbacks of the usage of machine learning methods in financial fraud detection area are expressed.

This chapter is divided into four sections. The first section gives a brief overview of the financial fraud problem and solving approaches in the current studies. The second section addresses a financial fraud problem in three subsections: bank fraud, insurance fraud, and corporate fraud. In the third section, the machine learning methods used in financial fraud detection studies are described in a detailed manner. This section also analyzes the existing studies and highlights improvable points. The next section illustrates the statistics of machine learning-based fraud detection systems.

## 7.2 Financial Fraud

The financial fraud problem has risen due to the increasing usage of online banking and financial services in recent years. It causes critical losses for companies in the industrial sector, investors, and governments. In this section, we address this problem under three categories: bank fraud, insurance fraud, securities/commodities fraud, and mass marketing fraud.

### *7.2.1 Bank Fraud*

In recent years, it is seen that there has been a significant increase in the number of customers working with banks due to the expansive use of digital banking channels. Accordingly, fraudsters have taken malicious actions seriously and focused on bank customers. In this section, the fraud types threatening individuals through the banking sector (i.e., credit card fraud, money laundering, and mortgage fraud) are analyzed.

**Credit card fraud**

In addition to providing people the opportunity to spend money without carrying cash, credit cards also enable payment of their expenses in the following months. Especially with the widespread use of the internet, people have started to shop more comfortably on e-commerce platforms using their credit cards. Thus, credit cards providing people with advantages in their lives become objects that people do not separate from them. Credit cards are one of the most famous fraud targets but not the only one; fraud can occur with any credit products, such as personal loans, home loans, and retail. It is necessary to take precautions during credit card transactions. In cases where the precautions are insufficient, people exposed to credit card fraud

may have critical losses. In recent years, it is seen that various researches have been conducted in the literature to detect credit card fraud.

**Money laundering**
Money laundering is the illegal manner of getting large amounts of money generated by criminal activity, such as terrorist funding, which appears related to a legitimate source. This money injected into the economy causes negative social, economic, and political impacts on countries. Empirical studies in finance show that current solutions have limitations to detect money laundering and they can only save a very small amount of money laundered.

**Mortgage Fraud**
Mortgage fraud is a criminal act that involves obtaining a mortgage by making false pretenses such as using fraudulent identifications. Mortgage fraud may leave people with inflated property values, costlier taxes, an inability to sell their homes, or damaged credit scores. Considering the researches in the literature, it is seen that mortgage fraud detection is one of the emerging topics in the finance domain.

### *7.2.2 Insurance Fraud*

Insurance fraud relates to any misuse of insurance policies or applications to obtain some benefits illegally. It may occur at many steps in the insurance procedure (e.g., application, rating, billing) and realized by consumers, agents, healthcare providers, and technical services (Ngai et al., 2011). In this study, insurance fraud is researched in three categories; automobile, health care, and crop insurance frauds.

**Automobile insurance fraud**
Automobile insurance fraud comprises a set of fraudulent activities (e.g., exaggerating damages/losses, unreal claims about accident) to gain funds from insurance company. Fraud investigation is usually done by hand by the domain expert. However, detection of automobile insurance fraud is challenging task because of dealing with inappropriate representation of data (Šubelj et al., 2011). In recent times, it is seen that researchers benefit from the advantages of data science approaches to automatically reveal false accident reports.

**Healthcare insurance fraud**
In this type of fraud, purposeful deception is committed against a health insurance company to have them pay unauthorized benefits to the policy holder. It is perpetrated by the casualties or the provider of healthcare services.

**Crop insurance fraud**
Crop insurance provides protection to the farmers against financial loss resulting from a drop in agriculture commodities prices or natural disasters. Crop insurance

fraud is committed by agricultural producers who deliberately give false information to the insurer when damaged crops do not exist.

### *7.2.3 Corporate Fraud*

Corporate fraud refers to provide misleading information about the financial activities of a company to increase its profit. It may result in serious financial losses and damage to the overall economy (Dong et al., 2018). We overview corporate under three subsections: Financial statement fraud, securities and commodities fraud, and mass marketing fraud.

**Financial statement fraud**
The accuracy and reliability of financial information significantly affect the economy. The formation of efficient capital markets depends on trust and equal opportunity principles. In recent years, it is observed that behaviors in the markets are contrary to these principles. Some market participants mislead the investors by causing unexpected market fluctuations to gain unfair profit from them.

**Securities and Commodities fraud**
Securities (also called as commodities) fraud is defined as misrepresenting information in order to make unfair profit in the financial market. This fraud type is one of the major challenges to be dealt since misrepresenting the information causes serious financial losses in case of significant investment strategies.

**Mass marketing fraud**
Mass marketing refers presenting of a product in large quantities without considering customer needs. Mass marketing fraud benefits from mass communication techniques using digital channels to target victims for financial profit.

## 7.3 Machine Learning Applications for Financial Fraud Detection

Fraud continues to be the major issue for the governments around the world and they undertake regulatory initiatives to prevent fraud with policies, regulations, and laws. The main authority in charge of fraud identification and prevention in public companies is the Securities and Exchange Commission (CCIIndia, 2020). In this commission, fraud detection is based on manual analysis and interpretation. Since manual data analysis is time-consuming, expensive, and highly subjective, there is a need to scale up human analysis capabilities to deal with a large number of user data. Therefore, financial institutions have turned to automated fraud detection systems

using intelligent computational methods with the recent advances in data science (West & Bhattacharya, 2016).

Findings of the recent studies show that machine learning plays a critical role to deal with financial tasks such as fraud detection. Since performing machine learning to classify patterns increase the accuracy of the proposed systems, many researchers have introduced learning methods to specify fraudulent behaviors in financial activities. Deep learning, also known as subtype of machine learning, has the ability to efficiently extract high-dimensional complex nonlinear features using simpler hierarchized structures. In addition to traditional ML approaches, deep learning has been widely proposed in finance domain so far. In this chapter, we review the researches, which utilizing fraud detection using machine learning approaches, in order to establish a boundary in the scope.

### *7.3.1 Machine Learning*

Machine learning, a subfield of artificial intelligence, enables systems to learn automatically from the experiences (training data) without any human interference. Machine learning algorithms generate a mathematical or statistical model from the training set and this model makes decisions from the observations by identifying hidden patterns. In the literature, machine learning is divided into two main types: supervised learning and unsupervised learning.

#### 7.3.1.1 Supervised Learning

The supervised learning algorithms train the system using observation data which is already tagged with correct labels. This type of learning focuses on predicting outputs of unlabeled samples using labeled data. The supervised learning is divided into two main tasks: classification and regression. In this chapter, the classification studies of supervised learning in financial fraud detection field were reviewed.

Classification

Classification is one of the commonly applied machine learning method which categorizes new objects into predefined classes. In this task, the classification algorithms try to reveal relationships between attributes of samples in the training dataset and

estimate unknown target output based on a given input. The broadly used classification methods to detect financial fraud are Naive Bayes, Decision Tree, Artificial Neural Network, Bayesian Network, KNN, SVM, and Logistic Regression.

**Bayesian Network**

Bayesian Network, also known as Bayesian Belief Networks, is a type of probabilistic graphical model that consists of nodes and directed links among them. The nodes and the links in this graph structure represent random variables in the Bayesian sense and the probabilistic dependency between two variables, respectively. It is preferred in machine learning applications for the ability to represent relations between variables.

Bayesian Network is one of the preferred classification algorithms for detecting bank (Khan et al., 2013; Sá et al., 2018) and corporate frauds (Kirkos et al., 2007). Sá et al. (2018) proposed a novel customized Bayesian Network Classifier (BNC) algorithm, named Fraud-BNC, to solve a real credit card fraud detection problem. The Fraud-BNC method was tested on a dataset supplied by PagSeguro, which is a Brazilian online payment service and improves the company's economic efficiency at the rate of 72.64%. Another study by Khan et al. (2013) also introduced a Bayesian network-based fraud detector which analysis the transactions of customers in a financial institution to prevent money laundering. In financial statement fraud detection domain, Kirkos et al. (2007) applied Bayesian Network, Decision Tree, and Neural Network model on a publicly available financial data for detecting fraudulent financial statements. The obtained performance results indicated that the Bayesian Network algorithm achieved 90.3% accuracy rate using tenfold cross validation technique.

**Logistic Regression**

Logistic regression is a supervised learning algorithm that assigns a new sample to one of the predefined discrete classes using a logistic function with independent variables. The logistic regression algorithm is generally used in binary classification problems, but it also produces successful solutions to multiple classification problems.

Logistic Regression is another preferred supervised learning algorithm in bank (Shen, Tong & Deng, 2007) and corporate fraud (Spathis, 2002) detection area. Shen, Tong and Deng (2007) developed a framework consisting of decision tree, neural networks, and logistic regression algorithms for detecting external card fraud. The algorithms were tested on a real-time credit card transaction dataset and Logistic regression and neural networks provided more accurate predictions than the decision tree. In another study, a false financial statement (FFS) detection model was generated by using logistic regression method (Spathis, 2002). The proposed approach was applied on a publicly available financial dataset and predicted FFS and non-FFS firms in this dataset successfully.

**Naive Bayes**

Naive Bayes is a well-known classification algorithm which uses Bayes Theorem as defined in Eq. (7.1).

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \tag{7.1}$$

where *P(A)* and *P(B)* are prior probabilities and *P(B|A)* and *P(A|B)* are posterior probabilities of event *A* and *B*, respectively. The attributes in the training set are considered independently in this approach and the conditional probabilities of the attributes are evaluated for categorizing a new sample as one of the predefined classes.

There are some studies (Humpherys et al., 2011; Kiran et al., 2018; Peng et al., 2007) in the literature that implements Naive Bayes algorithm for predicting financial frauds with high accuracy. For example, Kiran et al. (2018) combined Naive Bayes algorithm with k-NN to detect credit card frauds using a dataset which includes the records of the European cardholders in September 2013. Humpherys et al. (2011) analyzed the linguistic cues of 202 financial disclosures using Naive Bayes and Decision Tree algorithms to detect fraudulent financial statements. Lastly, Peng et al. (2007) applied Naive Bayes, Decision Tree, and Multiple Criteria Linear Programming (MCLP) classifiers on health insurance data for predicting insurance fraud. According to experimental results, the highest insurance fraud prediction performance was provided by Naive Bayes algorithm.

**k-Nearest Neighbor (k-NN)**

k-Nearest Neighbor (k-NN), proposed by Thomas Cover, is an instance-based classifier that predicts a new sample's class label as a majority vote of its k neighbors' target labels. To specify the k nearest neighbors of the new sample, the distance metrics are utilized, including Euclidean, Manhattan, Minkowski, Hamming, and so on.

The k-NN algorithm detects credit card frauds in a short time and with high accuracy (Khodabakhshi & Fartash, 2016; Malini & Pushpa, 2017; Vardhani et al., 2019). Khodabakhshi & Fartash (2016) and Malini and Pushpa (2017) proposed the application of k-NN algorithm for predicting fraudulent credit card transactions. In the first study, the researchers implemented k-NN algorithm with association rules to improve prediction performance. The other study presented the usage of KNN algorithm and outlier detection methods as the best solution for the fraud detection problem. Vardhani et al. (2019) introduced an improved k-NN called condensed nearest neighbor (CNN) algorithm which eliminates unrelated and irrelevant instances to enhance learning stage.

**Support Vector Machine (SVM)**

Support Vector Machine (SVM) is a non-parametric supervised learning algorithm proposed for binary classification and regression problems. Each record in the dataset is placed on *n* (number of attributes) dimensional space, a hyperplane is drawn to split two different classes with the largest margin for preventing overfitting problem.

In the fraud detection literature, SVM algorithm has widespread usage in discovering bank frauds (Abdelhamid et al., 2014; Gyamfi & Abdulai, 2018; Hejazi & Singh, 2012; Keyan & Tingting, 2011; Sahin & Duman, 2011; Tang & Yin, 2005). Hejazi and Singh (2012) applied different kernel methods using Sequential Minimal

Optimization (SMO), *C*-Support Vector Classification (*C*-SVC), and *v*-Support Vector Classification (*v*-SVC) for detecting fraudulent credit card transactions. In another study (Gyamfi & Abdulai, 2018), a novel fraud detection system, named SVM-S, which combines SVM algorithm with Spark. Lastly, Sahin and Duman (2011) compared SVM models with different kernels (Radial Bases Function (RBF), Polynomial, Sigmoid, and Linear) and Decision Tree classifiers (C5.0, CART, Chi-squared Automatic Interaction Detector [CHAID]) for detecting fraudulent credit card usages over virtual POS terminals or mail orders. In all of these studies, experimental results provided that SVM algorithm outperforms the other classifiers in terms of fraud detection ability.

Two different SVM-based approaches (Keyan & Tingting, 2011; Tang & Yin, 2005) are proposed for solving anti-money laundering problem. Tang and Yin (2005) introduced SVM algorithm using an improved RBF kernel with Heterogeneous Value Difference Metric (HVDM) on a real-world transactional dataset obtained from Wuhan Branch of Agriculture Bank. On the same dataset, Keyan and Tingting (2011) applied a SVM model with the optimal parameters that will provide the highest accuracy rate. These parameters were determined by using a cross validation technique.

Besides these studies, Abdelhamid et al. (2014) introduced a general bank fraud detection system which uses a hybrid version of SVM for credit card frauds, money laundering, and mortgage frauds. The hybrid version of the SVM consists of single class and binary SVM methods and it was applied on the GeneralLedger, PayablesData, and RevenueData datasets for card fraud, money laundering, and mortgage fraud, respectively.

**Artificial Neural Network (ANN)**

Artificial neural network was developed inspiring by the biological structure and information processing ability of the human brain. The structures in the biological nervous system such as neuron, dendrite, nucleus, axon, and synapse are modeled as input, sum function, activation function, output, and weight, in the artificial neural network approach, respectively.

The general structure of the ANN is given in Fig. 7.1. To classify a new sample, each attribute of the sample is given as an input to the ANN system. These inputs are multiplied by the specific weight values and the obtained values are summed into the sum function. The summed value is sent to the activation function and the value obtained from the activation function is determined as the output of the sample.

In the literature, there are several ANN models, including perceptron, single layer perceptron, multilayer perceptron, backpropagation, and feedforward neural network. The radial basis function (RBF) and multilayer perceptron (MLP) algorithms were used for predicting the fraud in the finance sector.

- **Radial Basis Function (RBF):** Radial Basis Function (RBF) model is a feedforward neural network consisting of three layers: input, hidden, and output layers.

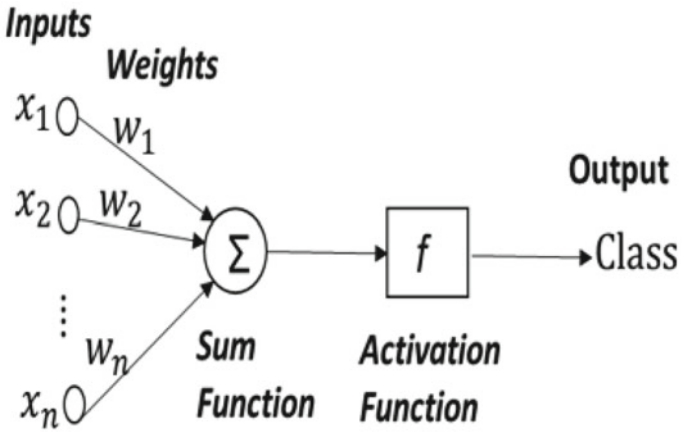


**Fig. 7.1** An illustration of a basic NN model

The hidden layer of the network includes a number of RBF nonlinear activation units. In RBF models, Gaussian function is generally used as an activation function.

RBF algorith2008m is one of the preferred ANN models for credit card (Brause et al., 1999; Gosh & Reilly, 1994) and money laundering (Lv et al., 2008) detection field. Brause et al. (1999) and Gosh & Reilly (1994) used RBF for predicting credit card frauds. The researchers tested the RBF algorithm on real-world credit card data and the algorithm showed successful prediction performances. Lv et al. (2008) proposed a hybrid approach that merges RBF model with APC-III clustering algorithm and recursive least square (RLS) algorithm for detecting money laundering. The proposed approach was compared with SVM and outlier detection methods and it achieved the highest accuracy in detection.

- **Multilayer Perceptron (MLP):** Multilayer perceptron (MLP) algorithm, first emerged to solve the XOR problem, classifies new samples that are not linearly separable successfully. The MLP structure consists of fully connected layers, such as an input layer, an output layer, and an intermediate layer which contains one or more layers of hidden neurons. The input layer transfers input data to the intermediate layer. The information is transmitted between hidden layers and finally reaches the output layer.

  Although RBF offers reasonably good solutions for bank fraud detection problems, researchers (He et al., 1997; Patidar & Sharma, 2011) have also tried using the MLP algorithm. Patidar and Sharma (2011) proposed a new architecture, namely GANN, which is the combination of MLP model with a genetic algorithm for credit card fraud detection. The proposed approach improved the detection ability of the traditional MLP model. The other study (He et al., 1997) implemented MLP model with Self Organizing Maps (SOM) algorithm for the purpose of medical fraud detection. The proposed method achieved 80.93% accuracy rate in the test set.

**Decision Tree**

Decision tree is one of the commonly applied supervised learning technique which classifies a new sample using a tree containing conjunction of rules. The decision tree branches from the root node using a depth-first strategy. Like the traditional tree structure, decision trees are made up of nodes, branches, and leaves and these structures represent attributes, attribute values, and classes in the dataset, respectively. There are various studies which implement Iterative Dichotomiser 3 (ID3), C4.5, and Classification and Regression Tree (CART) algorithms for the detection of financial fraud.

**Iterative Dichotomiser 3 (ID3):** Iterative Dichotomiser 3 (ID3) algorithm, introduced by J. Ross Quinlan, is used to construct a decision tree from a training set. In each iteration, the ID3 algorithm calculates information gain values of each attribute in the training set for the construction of the tree. Then, it chooses the attribute that has maximum information gain value to place on the tree. The ID3 algorithm is only used for classifying categorical attributes with no missing values.

Wang and Yang (2007) examined customer profiles of a commercial bank in China using ID3 algorithm for anti-money laundering. As a result of the empirical experiments, it was observed that 12% customers were considered as high anti-money laundering risk.

**C4.5:** C4.5 decision tree algorithm is proposed by J. Ross Quinlan to extent Quinlan's earlier ID3 algorithm. It also benefits from information gain metric to construct a decision tree like ID3. C4.5 algorithm handles continuous valued target attributes and missing values. It also converts the output of ID3 algorithm to if–then rules.

There are some studies (Bhowmik, 2011; Perez et al., 2005) that apply C4.5 decision tree algorithm in automobile insurance fraud detection systems. Bhowmik (2011) analyzed fraud patterns in a real-world credit card dataset using C4.5 algorithm with Naive Bayes classifier. According to observed experimental results, the proposed approach predicted legal and fraud transactions with high accuracy. Perez et al. (2005) used consolidated trees including C4.5 decision trees that constructed from multiple subsamples. The proposed approach was tested on a car insurance data and it was predicted fraudulent data accurately.

**Classification and Regression Tree (CART):** Classification and Regression Tree (CART) algorithm, another algorithm used to create a decision tree, is a binary tree in which each node has at most two child nodes. In this approach, a maximum tree is constructed by using GINI and Towing criteria and then, the depth of the tree is determined. One of the most important advantages of the CART algorithm is its fast and flexible structure.

The CART algorithm is as widely used as the C4.5 algorithm in financial fraud detection systems. Chen (2016) proposed a novel financial statement detection model which analysis financial statements between the years 2002 and 2013 using CART and the Chi-squared automatic interaction detector (CHAID). The detection performance of the proposed approach was obtained as 87.97% from

the experiments. In the other study (Bai et al., 2008), used CART algorithm for detecting seriousness of financial data manipulation in China. The applied algorithm presented high accuracy in identifying fraud cases.

Besides these well-known decision tree algorithms, different tree-based detection systems (Sahin et al., 2013; Save et al., 2017) were proposed for credit card frauds. Sahin et al. (2013) developed a novel cost-sensitive decision tree method that minimizes the sum of misclassification costs. The proposed method was applied on a real-world credit card data and it presented high accurate fraud detection rate. In other study (Save et al., 2017), a new decision tree approach combining Luhn's and Hunt's algorithms was introduced. The approach successfully determined whether an incoming transaction is fraud or genuine.

### *7.3.2 Unsupervised Learning*

In unsupervised learning, the system is trained by using unlabeled data which has not any prior information about the output value and finds hidden patterns from it. It consists of two main techniques: clustering and association rule mining.

#### 7.3.2.1 Clustering

Clustering is used for grouping object sets into clusters by considering the similarity between these objects. In the grouping process, the similarity between the objects is evaluated by using similarity measures including Manhattan, Minkowski, and Euclidean distances for numerical data and Jaccard's distance for categorical data. The most commonly applied clustering algorithms in the financial fraud literature are K-Means, Fuzzy C-Means, and Self Organizing Maps (SOM).

**K-Means**
K-Means is a distance-based clustering algorithm which divides the dataset into predefined $k$ clusters. First, user-defined number of cluster $k$ is determined and the initial centroids of these $k$ clusters are randomly selected. Then, each object in the data set is assigned to the cluster whose centroid is the closest to it. Finally, in each iteration, the centroids of the clusters are recomputed and the objects are re-clustered until the objects in the clusters do not change. In this approach, each object in the dataset belongs to only one cluster.

K-Means clustering algorithm is utilized in credit card fraud detection studies (Chougule et al., 2015; Singh & Raheja, 2014). In the first study (Chougule et al., 2015), K-means algorithm was combined with genetic algorithm to reach high detection rate in credit card frauds. It was also understood from the experimental results,

that the execution time of the proposed method is less than the simple genetic algorithm. The last study (Singh & Raheja, 2014) developed an improved K-means algorithm which is a combination of Luhn and K-Means algorithms for validating the credit card numbers.

**Fuzzy C-Means**

Fuzzy C-Means is another algorithm in the clustering literature which calculates the distances between each object in the data set and the cluster centers, and assigns a membership to each object corresponding to the cluster center according to the distances. The membership value of an object to a cluster is inversely proportional to its distance from that cluster. It minimizes the objective function defined in Eq. 7.2.

$$\sum_{i=1}^{N}\sum_{j=1}^{C} u_{i,j}^{m}\left(x_i - c_j\right)^2 \tag{7.2}$$

where $m$ is the fuzzifier that is a real number greater than 1, $u_{i,j}$ is the membership value of $x_i$ in the cluster $j$, $x_i$ is the i$^{\text{th}}$ object in the dataset $D$ with $n$ objects, $c_j$ is the center of the cluster.

Fuzzy C-Means algorithm was preferred in one of the insurance fraud detection study (Majhi, 2019). Researcher proposed a Fuzzy C-Means algorithm based on modified whale optimization (MWOA) for automobile insurance fraud detection in his study (Majhi, 2019). The proposed technique was compared with some advanced supervised learning algorithms such as CATBoost, XGBoost, Random Forest, LightGBM, and Decision Tree in terms of accuracy and it was achieved 86.38% detection rate.

**Self Organizing Maps (SOM)**

Self Organizing Maps (SOM), also called Kohonen map, is an artificial neural network-based unsupervised learning algorithm that is proposed by Teuvo Kohonen in the 1980s. In this algorithm, first, the weight vectors are initialized and the random sample vector is chosen from the training set. Then, the best matching unit whose weight value is the closest to the sample vector's weight value is determined. Finally, the neighborhood of the BMU is evaluated and the winning weight's chance of being the sample vector is increased. So, the neighbor of the BMU learns better. These steps are repeated for the number of iterations.

There are several detection studies that utilizes SOM algorithm for credit card (Olszewski, 2014; Quah & Sriganesh, 2008; Zaslavsky & Strizhak, 2006) and automobile insurance frauds (Brockett et al., 1998). Zaslavsky and Strizhak (2006) used SOM algorithm for monitoring transactions and discovering credit card frauds in their study. Researcher in another study (Olszewski, 2014) also applied SOM algorithm to visualize accounts and detect threshold types. Quah and Sriganesh (2008) proposed a cost-effective and real-time fraud detection system that uses SOM algorithm for analyzing spending patterns. In automobile insurance fraud detection study (Brockett et al., 1998), the frauds about bodily injury claims were detected by using SOM algorithm.

#### 7.3.2.2 Association Rule Mining

Association rule mining (ARM), a rule-based unsupervised learning method, is a well-researched machine learning technique which is proposed for discovering interesting correlations and frequent patterns among large datasets. To discover hidden patterns from the raw data, two main measures that are user-defined thresholds used such as support and confidence.

In the literature, there is a financial fraud detection study (Sánchez et al., 2009) that uses ARM as unsupervised learning technique. Sánchez et al. (2009) discovered patterns of unlawful transactions from transactional credit card dataset using association rules. The developed model was applied on the credit card data of a retail company in Chile.

## 7.4 Ensemble Learning

Ensemble learning combines several learners instead of using a single classifier to make final output decision using a voting process as shown in Fig. 7.2. In this approach, it is aimed to get a strong learner by using multiple models. Many studies in the literature revealed that ensemble learners give more successful results than the traditional individual learner. Ensemble learning can be grouped into four classes: bagging, boosting, voting, and stacking.

### *7.4.1 Bagging*

Bagging (Bootstrap Aggregating) is a commonly applied ensemble method that creates multiple subsets from the original training dataset. Multiple classification

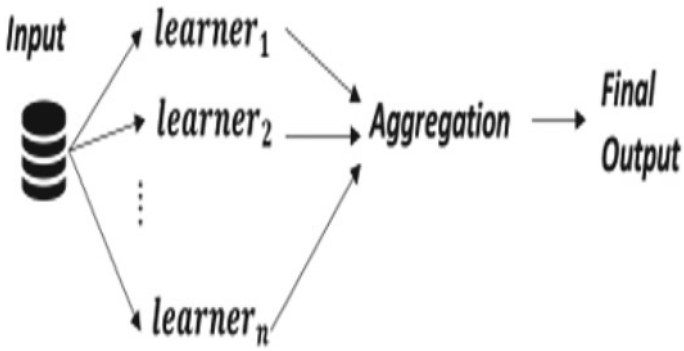


**Fig. 7.2** Voting in ensemble learning

models are obtained by training a single algorithm with different subsets. The final class label is selected by the majority vote of each classifier's output.

For the credit card fraud detection field, Zareapoor and Shamsolmoali (2015) introduced a novel bagging-based ensemble classification method using decision tree algorithms. They concluded that their novel method predicts credit card frauds with high accuracy in a short time.

#### 7.4.1.1 Random Forest

Random Forest algorithm builds a multitude of individual decision trees using different training subsets. Each tree in the forest gives an output and the final class is determined by the majority vote of them.

As a well-established ensemble learning classifier, the Random Forest algorithm has been preferred to overcome detection problems in credit card (Bhattacharyya et al., 2011; Carneiro et al., 2017; Xuan et al., 2018) and automobile insurance frauds (Harjai et al., 2019; Li et al., 2016, 2018). Carneiro et al. (2017) and Bhattacharyya et al. (2011) both applied Random Forest, SVM, and Logistic Regression algorithms for the detection of credit card frauds in a large e-tail merchant and transactions from an international credit card operation, respectively. In both studies, the Random Forest algorithm outperformed SVM and Logistic Regression algorithms in terms of fraud prediction ability. In another credit card fraud detection study (Xuan et al., 2018), researchers compared two different Random Forests based on Random Tree and CART algorithms on a real-world dataset obtained from an e-commerce company in China. In the experiments, Random Tree and CART based Random Forests presented successful prediction performances at 91.96% and 96.77% accuracy rates, respectively.

In one of the automobile insurance fraud detection study, Li et al. (2016) implemented Random Forest algorithm on a dataset of a vehicle insurance company in 2011. The same researchers (Li et al., 2018) also introduced a novel ensemble structure based on Random Forest, Principle Component Analysis (PCA), and Potential Nearest Neighbor (PNN) to detect automobile insurance fraud in another study. In addition to these studies, Harjai, Khatri, and Singh (2019) applied Synthetic Minority Oversampling Technique (SMOTE) on an automobile insurance dataset of over 15,420 car-claim records for transforming it into a balanced dataset at first. Then, they used Random Forest algorithm to classify records in the dataset as normal and fraud. In the experimental study, the Random Forest algorithm was compared with SVM, MLP, and Decision Tree algorithms and it showed the highest accuracy rate with 94.33%.

### 7.4.2 Boosting

The Boosting method aims to reduce bias and variance by training the classifiers incrementally. Initially, each sample in the dataset has the same weight value, then samples are reweighted according to their error rate in each iteration.

#### 7.4.2.1 AdaBoost

AdaBoost, also known as Adaptive Boosting, is the most known boosting algorithm that earned Gödel Prize in 2013. This algorithm combines weak learners to get a strong classifier. It boosts the performance of the classifier by increasing the misclassified samples' chance of being selected for the training set in each iteration. Thus, the ensemble structure learns better and more sample is classified correctly.

Viaene et al. (2004) proposed an application of Adaboosted Naive Bayes on a dataset including closed personal injury protection (PIP) automobile insurance claims to detect frauds. In the experiments, the performance of the proposed approach was evaluated using Percentage Correctly Classified (PCC), Receiver Operating Characteristic (ROC) Curve, Area under the ROC (AUROC), Logarithmic Score, Brier Inaccuracy, and Calibration Plot metrics and the ensemble method detected automobile insurance frauds accurately.

### 7.4.3 Stacking

Stacking (Stacked generalization) is another ensemble method that obtains the predictions of each weak classifier in the ensemble structure and gives them to a meta classifier as an input. The output of the meta classifier is considered as a final decision. In this type of ensemble, different classification algorithms can be used for the construction of multiple models.

There is a stacking-based financial statement fraud detection study (Kotsiantis et al., 2006) in the literature. They developed an ensemble decision support system which combines C4.5, RBF, Bayesian Network, k-NN ($k = 3$), Ripper, and Sequential Minimal Optimization (SMO) algorithms using a stacking methodology. The proposed approach was tested on a dataset including 164 fraud and non-fraud Greek firms in the recent period 2001–2002 and was compared with other ensemble structures such as Voting, BestCV, and Grading. It was seen from the obtained results that the proposed stacking-based system achieved 95.1% accuracy rate.

### 7.4.4 Voting

In the voting method, the outputs obtained from multiple classifiers are aggregated and the class label that received more than half of the output votes cast is determined as a final output. As in the stacking method, different classification algorithms can be used in the voting method.

In one of the ensemble-based fraud detection study, Randhawa et al. (2018) presented a comparative analysis of AdaBoost and majority voting methods for credit card fraud detection. They applied these ensemble methods on a publicly available credit card dataset that consists of 284,807 transactions made in September 2013 by European cardholders. The ensemble techniques were compared in terms of Matthews Correlation Coefficient (MCC) metric and the highest MCC value was achieved by majority voting method.

## 7.5 Deep Learning

Deep learning is a sub-branch of machine learning which constructs multi-layered artificial neural networks to imitate the human brain. Differently from conventional machine learning techniques, in a deep learning approach, the computational models including a large number of processing layers learn representations for sets of data. The main advantage of deep learning architectures is training a huge amount of data in a short time under the favor of high computing power it has. The deep learning methods presents state-of-the-art solutions in various fields such as object detection, speech recognition, natural language processing, and computer vision. In recent years, deep learning technology has been widely used in the financial sector for processing large amounts of data. Convolutional Neural Network (CNN) and Deep Autoencoder architectures were used in the deep learning studies reviewed in this chapter.

### 7.5.1 Convolutional Neural Network (CNN)

Convolutional Neural Network (CNN) is a deep feed-forward neural network type that includes multiple hidden layers consisting of convolutional layer sets. The CNN architecture has multiple convolutional and subsampling layers followed by a fully connected layer. The CNN model builds new features from the training set by reducing the network parameters. Even though the CNN architecture is originally developed for image processing, it is also one of the frequently preferred algorithms for training a large volume of non-image datasets.

Fu et al. (2016) proposed a credit card fraud detection framework which implements CNN algorithm on a real-world dataset which is represented by a feature

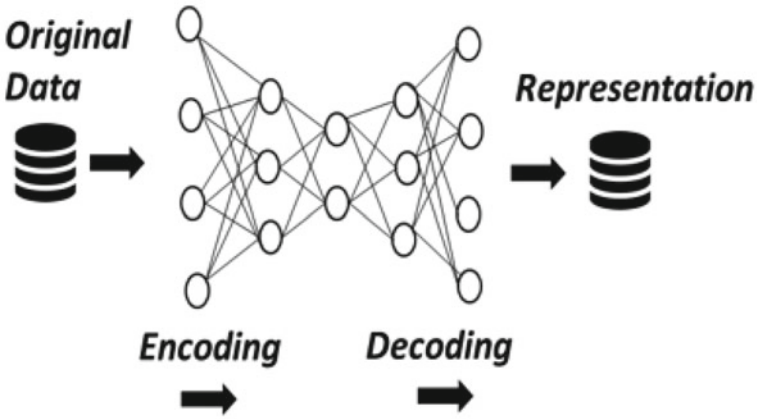


**Fig. 7.3** General structure of the autoencoder

matrix including transactions of a major commercial bank. The proposed model was compared with SVM, Random Forest, and Neural Network in terms of F1 score. In the experiments, the CNN model gave the best performance among the applied algorithms.

### *7.5.2 Autoencoder*

Autoencoder is an unsupervised neural network architecture that learns dataset representation for reducing high dimensionality. It compresses multidimensional data using an encoder in hidden space to get a bottleneck. Then, the decoder reconstructs the bottleneck's dimension as the same as the number of neurons in the input layer. The general structure of the autoencoder architecture is shown in Fig. 7.3.

The Autoencoder model is generally used in bank fraud detection problems, including credit card (Pumsirirat & Yan, 2018; Rushin et al., 2017) and money laundering (Paula et al., 2016) frauds. Rushin et al. (2017) applied Autoencoder, Logistic Regression, and Gradient Boosted Tree approaches individually on a bank dataset consists of approximately 80 million transactions to reveal credit card frauds. In this study, Autoencoder model outperforms the other implemented algorithms in terms of forecasting credit card fraud ability. In another study, Pumsirirat and Yan (2018) proposed an Autoencoder model with Restricted Boltzmann Machine consisting of an input layer, 6 hidden layers (3 encoders and 3 decoders), and an output layer. The model was tested on three different datasets including credit card transactions and the fraud prediction performance of the proposed model was evaluated by using AUC, Mean Square Error (MSE), and Root Mean Square Error (RMSE) metrics. To detect money laundering in exports of goods and products in Brazil in 2014, Paula

et al. (2016) used an Autoencoder model with selecting hidden layer size as 6–3-6. The proposed model presented lower MSE value when compared with PCA.

## 7.6 Statistics of Machine Learning-Based Fraud Detection Studies

In this study, 51 different machine learning-based fraud detection studies were examined. Table 7.1 gives information about the number of studies for each method according to three different fraud types. The findings of this review show that the most frequently used classifiers are logistic models, ANN, SVM, Random Forest, and decision trees to provide primary solutions to classification of fraudulent data. Other techniques are used alone or some of them are combined to construct robust learning model. In some studies, a classifier is hybridized with clustering algorithms. For example, Lv et al. (2008) propose a hybrid approach that merges the RBF with APC-III clustering algorithm which enables fast and adaptive learning. Recently,

**Table 7.1** Statistics of the reviewed studies for each method according to three different fraud types

| | FRAUD TYPES | | |
|---|---|---|---|
| Applied Methods | Bank Fraud | Corporate Fraud | Insurance Fraud |
| Bayesian Network | 2 | 1 | – |
| Logistic Regression | 1 | 1 | – |
| NB | 1 | 1 | 1 |
| kNN | 3 | – | – |
| SVM | 6 | – | – |
| ANN | 4 | – | 1 |
| Decision Tree | 3 | 2 | 2 |
| K-Means | 2 | – | – |
| Fuzzy C-Means | | – | 1 |
| SOM | 3 | – | 1 |
| ARM | 1 | – | – |
| Bagging | 1 | – | – |
| RF | 3 | – | 3 |
| Voting | 1 | – | – |
| Stacking | – | 1 | – |
| AdaBoost | – | – | 1 |
| CNN | 1 | – | – |
| Autoencoder | 3 | – | – |

researchers have increased their scrutiny of developing multiple classifiers also known as ensemble learning. Ensemble systems are widely used to address different machine learning problems, such as feature selection, confidence estimation, missing features, incremental learning, error correction, and imbalanced and heterogeneous data (Polikar, 2012). The analysis of current approaches point to ensemble learning being a superior method than traditional individual learner (see Sect. 3.2). The other considerable point is that majority of studies performing ensemble learning, propose Random Forest classifier to detect fraudulent activities. This finding validates the usefulness of Random Forest algorithm in financial fraud tasks since it is robust to noisy data and prevents overfitting.

With the experiments to strengthen the neural networks in the 2000s, deep learning has become an extremely active area of research (Buduma and Lacassio, 2017). For example, it is a widely used approach in finance sector to address critical tasks like fraud detection in recent times. In this chapter, we review four studies utilizing deep learning methods to detect financial frauds. According to analyses of these studies, it is concluded that autoencoders is the most preferred deep learning approach in the reviewed studies and they generally have high performance scores compared to baseline machine learning approaches.

Figure 7.4 presents the distribution of machine learning-based fraud detection studies in terms of supervised and unsupervised learning techniques. Considering this figure, it is concluded that most of the proposed fraud detection techniques are based on supervised learning and few are based on unsupervised learning.

Financial fraud can be categorized into three types: bank fraud, corporate fraud, and insurance fraud. The bar chart in Fig. 7.5 compares the number of fraud types

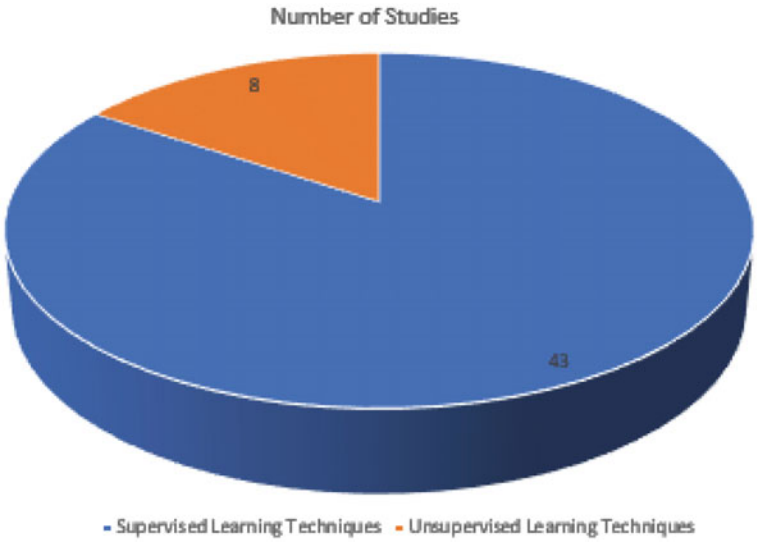


**Fig. 7.4** Distribution of the reviewed studies by machine learning techniques

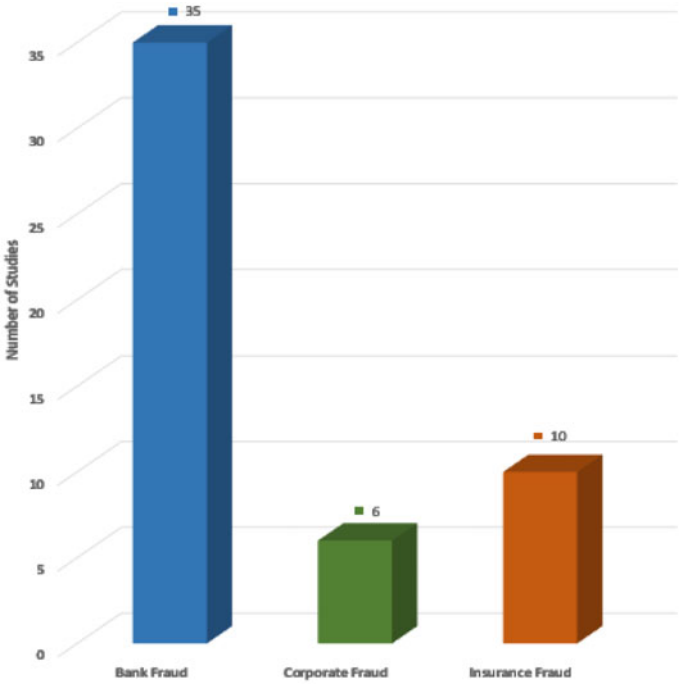


**Fig. 7.5** Classification of the reviewed studies by the categories of financial fraud

examined. We can see that the number of studies dealing with bank fraud is greater than others examining on insurance and corporate frauds. The results confirm that bank fraud is a major threat in finance domain due to extensive use of credit cards and increased usage of online banking and financial services to transfer money, invest, manage payments, and so on.

Table 7.2 shows the distribution of the reviewed studies according to year of publication.

Looking at the number of studies, it is noticeable that financial fraud problem has continuously been an important and valuable topic for researchers over the period between 1994 and 2019. Overall, it can be concluded that the financial fraud has increased dramatically during the last few decades as technologies have changed and developed.

**Table 7.2** Distribution of the reviewed studies according to years

| | Fraud Types | | | | |
|---|---|---|---|---|---|
| Publication Years | Bank Fraud | | Insurance Fraud | | Corporate Fraud |
| | Credit Card | Money Laundering | Automobile | Health care | Financial Statement |
| 1994 | 1 | | | | |
| 1997 | 1 | | | | |
| 1998 | | | 1 | | |
| 1999 | 1 | | | | |
| 2002 | | | | | 1 |
| 2004 | | | 1 | | |
| 2005 | | 1 | 1 | | |
| 2006 | 1 | | | | 1 |
| 2007 | 1 | 1 | | 1 | 1 |
| 2008 | | 1 | 1 | | 1 |
| 2009 | 1 | | | | |
| 2011 | 3 | 1 | 1 | | 1 |
| 2012 | 1 | | | | |
| 2013 | 1 | | | | 1 |
| 2014 | 3 | | | | |
| 2015 | 2 | | | | |
| 2016 | 2 | 1 | 1 | | 1 |
| 2017 | 4 | | | | |
| 2018 | 6 | | | | 1 |
| 2019 | 1 | | 2 | | |

## 7.7 Conclusion

Financial fraud is a crime and civil law violation that involves any deliberate or unfair acts of deception on financial transactions. In general, the financial frauds are divided into three categories: bank, insurance, and corporate. Because financial fraud is a very crucial issue for finance industry, corporate organizations, and government, detection of financial frauds accurately is essential. Considering this motivation, machine learning techniques has been commenced to be used to deal with fraud detection problems where traditional methods (manual analysis and interpretation) are inadequate. In this chapter, machine learning studies, including ensemble learning and deep learning algorithms, implemented in financial fraud detection field were explained in detail. This study also provides an insight into researchers for their future applications in this area. The evaluation of the current studies clearly indicates that the supervised learning algorithms have been more widely used for the detection

of financial fraud than the unsupervised learning algorithms. It is also seen from this chapter that deep learning and ensemble-based machine learning applications has been frequently preferred in recent years to improve detection performance of the frauds in finance sector. The most commonly applied algorithms for financial fraud detection are decision tree, SVM, ANN, and Random Forest. When the fraud detection studies examined in general, it is possible to say that most of these studies were performed in bank fraud field.

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# Chapter 8
# The Importance of Graph Databases in Detection of Organized Financial Crimes


**Buket Doğan**

**Abstract** This paper aims to reveal how important and irreplaceable graph databases are in discovering and preventing organized financial crimes, with their reasons. In order to find out organized financial crime, its perpetrators, and victims, it is necessary to uncover the multi-layered and hidden relationships between different entities. It is almost impossible to achieve this by developing a software solution on a relational database due to the large volume of data and intricate multi-layered relationships, and it is insufficient at many points. In this paper, we propose to overcome this by visualizing these complex relationships on graph databases. Graph databases have much more natural analytical power for social networks than relational databases. Graph databases are designed to model, store and query social networks with multiple complex relationships. Each entity in the social network can act as an individual entity and interact with other entities. While there are several different ways to reveal these illegal relationships, the most obvious, most used, and most effective method is to track money transfers between different entities. In this paper, we will display money transfers between different entities in a graphical database.

**Keywords** Fraud · Financial crime · Link analysis · Visual analytics · Graph database

## 8.1 Introduction

On Wikipedia, a financial crime is depicted as a crime against property that involves the illegal conversion of another person's property for one or more persons' personal use and benefit (Wikipedia, 2020). The most prominent feature of financial crimes is the illegal flows of money resulting from "money laundering," "bribery" and "corruption" that cause human abuses, including "modern slavery," "drug trafficking" and "prostitution" (Refinitiv, 2018).

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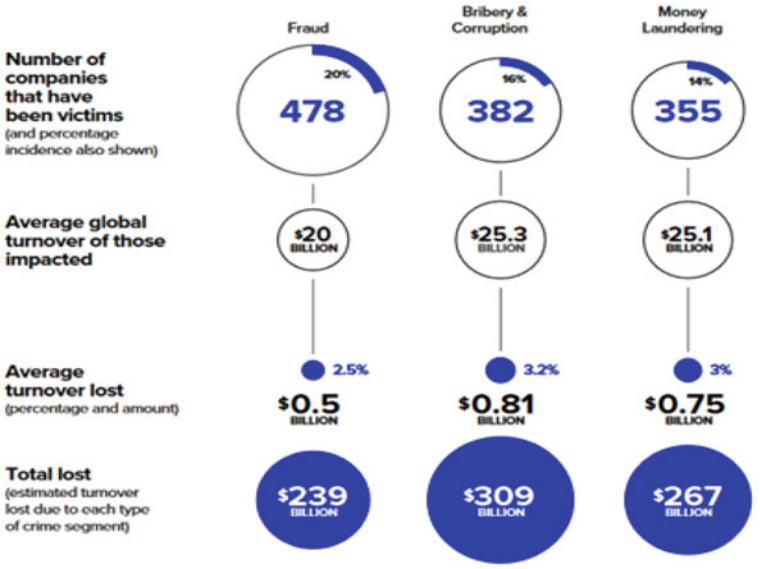


**Fig. 8.1** Estimating the business cost of financial crime (Refinitiv, 2018)

Considering that an estimated 40 million people suffer from modern slavery, the human and economic costs are apparent. In a 2014 report by the ILO, this cost was $150 billion, but the actual numbers are likely to be much higher (Refinitiv, 2018) (Fig. 8.1).

A study of the total economic cost of organized crime in the EU revealed that slavery/human trafficking cost is €30 billion. Assuming that the EU represents about 20% of the global economy and other parts of the world have a similar prevalence, the global cost is 150 billion Euros (Refinitiv, 2018).

The most apparent difference between organized crime and other forms of criminal behavior is that the crime is committed in an organized way. Organized crime generally does not include random, unplanned, individual criminal acts. Instead, it focuses only on planned, rational actions that reflect the efforts of groups of individuals. Various efforts have been made to reveal common elements to more precisely describe and define the organized crime (UNODC Justice Education, 2020).

Organized crime groups make large sums of money through drug trafficking, arms smuggling, racketeering, theft, and financial crime. This large amount of illegally earned money is of no use to criminals unless injected into the financial system. The methods used to transform dirty money into clean assets, that is, to inject it into the financial system, trigger corruption.

As the number of perpetrators and victims of organized financial crimes increases, revealing their relationships between them becomes problematic. However, uncovering all the perpetrators and victims is crucial to stopping organized crime gangs. Otherwise, those who remain may continue to commit crimes.

Graph databases are an excellent solution for uncovering explicit and implicit relationships between entities and have more inherent analytical power for social networks than relational databases.

Graph databases are designed to model, store and query social networks.

## 8.2 Literature Review

### *8.2.1 Comparison of Relational and Graph Databases in Terms of Revealing the Relationships Between Different Entities*

Relational databases were first described by Edgar Codd in June 1970. He was one of the computer scientists of IBM's San Jose Research Laboratory.

Relational databases are traditional databases that deal only with structured data and are based on the relational model and are managed with Relational Database Management System (RDBMS) software. There are specific rules for a database to be the perfect RDBMS. Codd developed these rules to define a perfect RDBMS.

Most relational database systems use SQL (Structured Query Language) for querying and maintaining the database. The relational model organizes data into more tables (or relationships) of columns and rows with a unique key (primary key) that identifies each row. Tables usually represent one type of relationship. The tables are linked together via a foreign key. And, this key is the primary key of another table. The database management system (DBMS) must have ACID operations (Atomicity, Consistency, Isolation and Durability) in order to work effectively and correctly. Relational databases only provide vertical scalability, meaning new records can be added at runtime. However, horizontal scalability is not allowed, that is, new fields cannot be added while running (Ramzan et al., 2019).

Non-relational databases are NoSQL databases. In 1998, Strozzi Carlo defined his SQL-free relational database solution as NoSQL. And these databases rivaled relational databases in that they either had a dynamic schema or did not have a schema and provided horizontal scalability. NoSQL databases have been the best choice for big data requiring cloud computing and horizontal scalability. NoSQL databases have become indispensable for big enterprises and web services due to their high availability, efficient performance, and linear scalability. Because of these features, Google, Twitter, Facebook, and Amazon use NoSQL databases widely. NoSQL databases have no structured query language interface. NoSQL databases are the only databases that allow data distribution and persistence between different computing nodes. NoSQL databases are classified based on their storage type; "key-value store," "document store," "column-oriented database," and "graph database" (Ramzan et al., 2019) (Table 8.1).

Graph database is based on graph theory and it consists of a set of objects, which can be a node or an edge.

**Table 8.1** Comparison between Graph DB and RDBMS (Unique Computer Systems, 2017)

| RDBMS | GraphDB |
|---|---|
| Tabular form | Graph form |
| Stores highly structured data | Maintains semi-structured data |
| Depends on key constrains | Relationships are first-class citizens of the Graph database model – Constrains can be represented using relationships |
| Data is normalized, meaning lots of joins, affecting speed | Better performance |
| Expensive with join operations | Eliminates the need for an expensive search/match computation |
| Does not scale horizontally | High scalability |

Graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. Within this scope, a graph comprises vertices, nodes, or points that are connected by edges, arcs, or lines. If there is no distinction between the two vertices associated with each edge in a graph, or its edges may be directed from one vertex to another, it is an undirected graph.

In discrete mathematics, graphs are one of the main areas of study.

- Conceptually, a graph is formed by vertices and edges connecting the vertices.
- In appearance, a graph is a pair of sets (V,E), where V is the set of vertices and E is the set of edges, formed by pairs of vertices. E is a multiset; in other sayings, its elements can occur more than once. The vertices can be labeled with letters (for example: a, b, c,... or v1, v2,...) or numbers 1, 2,...
- For the vertices, V = {v1,..., v5}. For the edges, E = {(v1, v2), (v2, v5), (v5, v5), (v5, v4), (v5, v4)}.

Graphs provide us with a very useful data structure and can help us find the structure within our data. With machine learning and the advent of big data, we can gain as much information as possible about the relevant data.

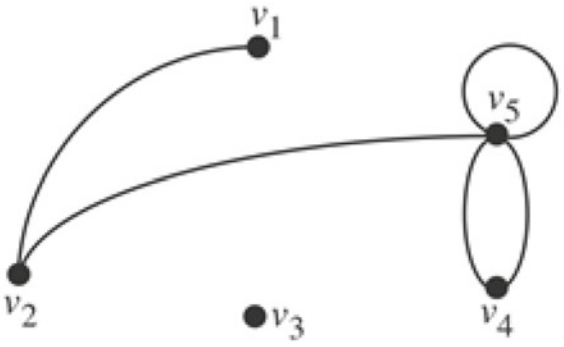


**Fig. 8.2** Graph

A graph database stores data in a graph. It is a data structure that is capable of representing any kind of data for storage and accessibility. A graph database is a non-relational database and provides a powerful and highly productive solution for information storage in environments where data is very strongly connected. (Guia et al, 2017).

Graph databases have more inherent analytical power for social networks than relational databases. Graph databases provide an excellent environment for modeling, storing, and querying social networks. Social network entities and relationships can be represented by graphs. Each person in the social network can act as an individual entity and interact with other entities (Chaudhary et al., 2016).

- Social network queries are based on relationships. Example; A query to find "friends of friend and their liked pages."
  - Relations in a relational database are managed by join between tables. Performing many joins between several tables are costly work. Relations are not stored.
  - In graph databases, it is easy to perform such queries because relations are stored inside a node.
- As a nature of SNs, we have to perform queries to find from many to many relations.
  - Relational Database performance is poor in many to many relations.
  - As every node in the Graph database stores relations that are pre-processed doesn't require to perform join. It requires traversal through nodes, and we should look at every node until it finds the correct one.
- Social network size is scalable. It can have new entities and relationships.
  - New entities and relationships require to change schema in relational databases.
  - Some graph databases are schema-less which makes them highly scalable.
- There is a need for concurrency low latency reading and writing due to the multiple relationships between multiple entities in the social network.
  - Relational databases will perform a concurrency control and it is used to ensure ACID (Atomicity, Consistency, Isolation, and Durability) properties which will increase the latency.
  - No need to perform concurrency control if we write to each node in Graph database.
- Faster query performance
  - Query performance of Graph databases is 1000 times faster than relational database (source IMDB and Neo4j) in Graph like structures.

– Find the answer in SN

  - In a graph database, you can bundle up a query in a traversal object and, this object will scan multiple connected nodes entirely to find the answer in the social networks.
  - It will recurrently request for one row of a traditional database, then use that information to search for a new row over and over.
  - Conversely, a traditional database would require a separate query for each step over the search. And, this will cause increasing the traffic of data.

– Dynamic network size

  - Since the network size is not static in social networks, it may sometimes need to be re-indexed if any change occurs in the network (Chaudhary et al., 2016).

### *8.2.2 Case Study*

Despite advances in technology and strict regulations, fraud attacks cause huge damages each year, especially in the financial sector; millions of dollars are lost. It also causes significant erosion in the reputations of these companies.

Traditional fraud detection methods fall short of preventing or significantly reducing these crimes as scammers take devious ways to hide track of money.

It is necessary to use other methods to detect grift and multi-layered relationships. Graph databases offer new ways to detect fraud networks and other sophisticated frauds, such that they can stop these attacks in real-time.

Example: First-Party Bank Fraud (Sadowksi & Rathle, 2015).

First-party fraud is where a person, or group, knowingly misrepresent their identity or give false information to gain financial. In this type of fraud, fraudsters apply for a loan or credit line with no intention of repayment.

The details of first-party fraudulent collusion may differ in each case, but still, you can understand how fraud rings generally work from the following example:

1. A group of at least two people get together to form a fraud ring.
2. The fraud ring generates fake identities using legitimate contact information such as phone numbers and addresses.
3. People in the fraud ring use these fake identities to open accounts.
4. The accounts are used for casual purchases to avoid attention and payments are made on time.
5. Since there is no suspicious behavior and payments are made on time, banks increase the credit limits of these accounts after a while.
6. One day members of fraud use up all of their credit limits and disappear.
7. Collections processes start, but agents cannot reach the fraudsters.
8. The debt cannot be collected and written off.

We will exemplify the scenario with a ring of two people colluding to create fake identities:

| Name and Surname | Address | Phone |
|---|---|---|
| Tony Bee | 123 NW 1st Street, San Francisco, CA 94,101 (his actual address) | gets a prepaid phone, 415–123-4567 |
| Paul Favre | 987 SW 1st Ave, San Francisco, CA 94,102 (his actual address) | gets a prepaid phone, 415–987-6543 |

They can combine these two phone numbers and two addresses to create four fake identities with fake names.

While John Smith and Frank Vero share the phone number, 415-123-4567, Mike Grat and Vincent Pourcent share the other phone number (Fig. 8.3).

If each fake person opens a 4–5 bank account, there can be 18 bank accounts in total. If we suppose an average of $4,000 in credit risk per account, the bank's loss could be around $72 K. Just before investigators raid the addresses, the phones are destroyed. Tony and Paul will undoubtedly say that they know nothing about these four people (John, Frank, Mike and Vincent), nor have they even heard of their names. Catching and stopping fraud networks before they do harm is a real challenge. However, standard methods such as anomaly detection use discrete data

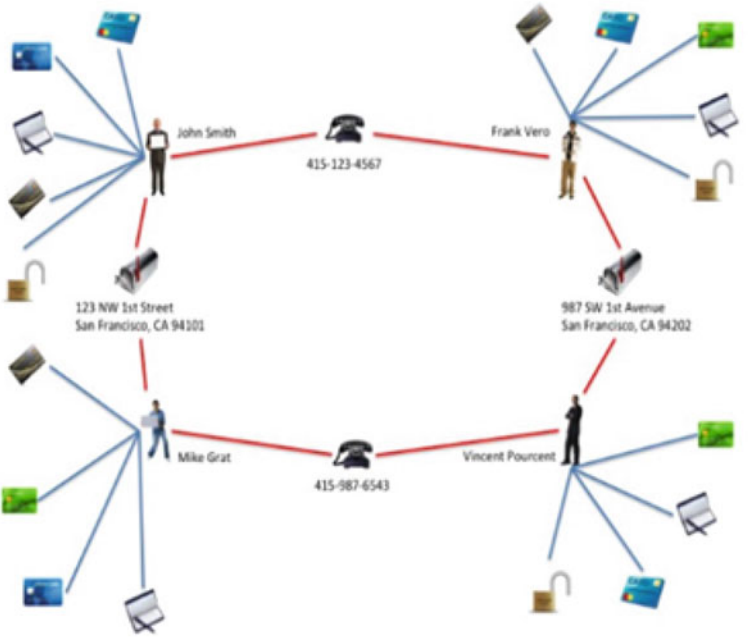


**Fig. 8.3** Two people sharing two pieces of data and creating four fake identities (Sadowksi & Rathle, 2015)

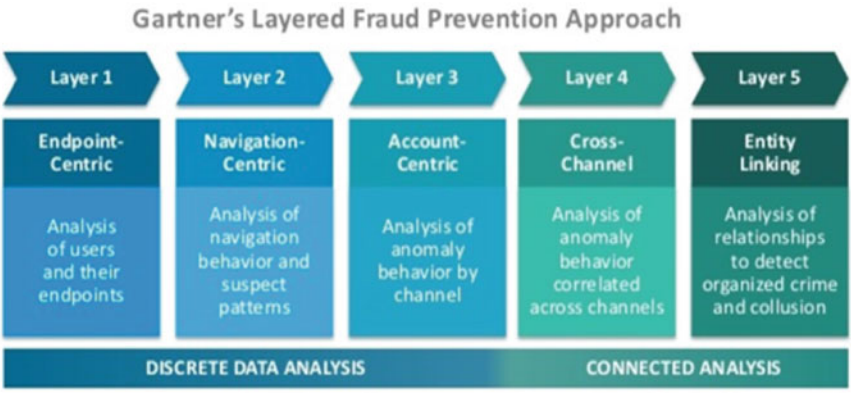


**Fig. 8.4** Gartner's layered fraud prevention approach

and are therefore they are much more useful for catching fraudsters acting alone. To detect fraud networks, it is necessary to focus on the relationships between entities. Gartner offers a layered anti-fraud model which is given below (Fig. 8.4).

It begins with customary discrete strategies and advances to progressively expound the "big picture" sorts of examination. "Entity Link Analysis" uses associated information to discover illegal relationships and fraud rings. Intrigues of the kind mentioned here can be effectively uncovered with a high certainty using a graph database and interface.

It is almost impossible to uncover fraudulent networks with traditional relational database technologies. To perform this, we need to model the graph that shows the complex relationships between entities as a series of tables and columns and then perform a complex series of joins and self-joins. However, running such queries is very complicated and costly. Also, scaling them to support real-time access will become more difficult as relationships become more complex and the dataset grows. And performance will worsen exponentially, too. Graph databases have appeared as a magical tool to overcome these obstacles. Languages such as Cypher, the Graph query language, provide simple semantics for detecting networks in the graph, navigating over links in memory in real-time (Sadowksi & Rathle, 2015).

## 8.3 Conclusion

Our main goal is to prevent crime. However, since we cannot eliminate the crime, our second goal is to identify the crime, the perpetrators, and the victims as soon as possible. The value of relationship analysis in the detection of organized crimes is indisputable. Using advanced methods, criminals have found out how to break systems they consider fragile. Unfortunately, while appropriate and necessary for some known types of frauds, traditional technologies are not designed to discover

fraud networks and hidden relationships. In other words, it is not successful enough in detecting organized crime. This is where graph databases can make a tremendous difference. Graph databases, including fraud networks, collusion groups, and independently worked criminals, provide unique possibilities to uncover complex fraud patterns in real-time. Consider a dataset with complex connections between entities. With the help of real-time graph queries, a powerful tool for discovering highly complex fraud scenarios, we can look for suspicious links with a system designed to work on such datasets. Then we will see that we can find illegal cooperation that went unnoticed before.

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# Chapter 9
# Practices of Natural Language Processing in the Finance Sector


**Fatma Bozyiğit and Deniz Kılınç**

**Abstract** Natural language processing (NLP) is a subfield of artificial intelligence that focuses on extracting meaning from unstructured data. It has become widely used due to advances in information technology and so increasing textual data in recent years. Since a large portion of the available information in the finance domain is in textual form (e.g., reports, contracts, agreements), researchers have increased their scrutiny of using NLP that is necessary to obtain insight from such collections. This chapter synthesizes the recent literature using NLP methods in financial tasks to demonstrate the state of current knowledge and its implications for future studies. Accordingly, we examine the usage of NLP methods under two sections. In the first section, we focus on NLP analysis models to determine financial market dynamics using news and user comments in the digital platforms. In the second section, we discuss NLP methods to detect sensitive user data (e.g., identity number, credit card number, telephone number) in the financial documents.

**Keywords** Artificial intelligence · Natural language processing · Finance sector · Financial organization · Financial market forecasting · Portfolio selection · Lexical analysis · Syntactic analysis · Semantic analysis

## 9.1 Introduction

Natural Language Processing (NLP) is one of the emerging research areas in Artificial Intelligence (AI) that explores how intelligent systems can be used to analyze textual data. The primary task of the NLP is to process the input text and construct a representation of its meaning. This representation is stored in a relevant knowledge-base and can be used for various tasks. Applications of NLP include many fields from

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different disciplines where qualitative data is available to be processed. Utilizing NLP tasks on textual data to improve modeling of the financial market dynamics has long been the customs of trading practice. The increasing volume of financial sources (e.g., papers, reports) also galvanize to perform this analysis to gain an advantage in the competitive market. For example, since having an insight into what people think about is valuable to financial traders, NLP is used to track user comments on social media and then incorporated into a trading algorithm to generate massive profits. Consequently, we address the issue of information extraction in the financial domain within the framework of NLP systems in this chapter. We direct the researches that implement NLP techniques to model the financial market dynamics using financial reports, news, and user comments in the digital platforms.

In the first section of this chapter, we direct the researches that implement NLP techniques to model the financial market dynamics using financial reports, news, and user comments in the digital platforms. Due to its wide digital accessibility, news media has been increasingly becoming a critical source of information that assists internet users in investment decision-making. The existence of financial contents on the regular press of media companies (e.g., Financial Times, Thomson Reuters, Bloomberg, Forbes), social media platforms like Twitter, and digital sources (e.g., Yahoo Finance, Google Finance, Raging Bull) affect investors' attitudes and consciousness of the finance market. Since a large portion of the available information is in textual (unstructured) form, primary techniques operating on textual data become necessary to extract data from such kinds of collections. These techniques are collected under the NLP to handle the implicit structure of the texts. Consequently, we review the technical aspects and limitations of the natural language-based financial forecasting studies. It is observed that current researches benefit to using widely known NLP analysis models (e.g., lexical analysis, syntactic analysis, semantic analysis) to get semantics from financial contents. Lexical analysis identifies the structure of words and phrases in the sentences. It consists of some steps, such as tokenization, stemming, and part of speech (POS) tagging. Tokenization facilitates information retrieval by separating words, abbreviations, punctuations, and number groups in the sentence (Kılınç et al., 2017). Stemming or lemmatization derives a base form of a word by reducing all inflectional forms. POS tagging enables the identification of words in a sentence according to the linguistic properties such as noun, verb, and adjective (Bozyiğit et al., 2019). Syntactic analysis determines whether the sentence structure is correct according to the grammar, and it is used to reduce the number of irrelevant and rare terms in the sentences. Semantic analysis figures out the meaning of linguistic input. The basis of this type of analysis is to interpret the semantic aspects of the analyzed sets.

In the context of the second part of the chapter, we aim to address NLP methods to detect and prevent unintended distribution of sensitive content outside the organization. The protection of personal data has recently become even more significant with growing attention from legislators, entrepreneurs, developers, and authorities. As in many sectors, personal information security is an essential concern for all institutions in the finance sector. Financial organizations must have valid and reliable systems to authenticate users following the General Data Protection Regulation (GDPR),

which is a broad-based privacy regulation, arranges restrictions to protect personal information throughout the European Union. An authentication system should keep customers' data safe, preclude terrorist financing, prevent fraud, inhibit identity theft, and promote the legal enforceability of the contracts on electronic transactions. Providing the security of online transactions is one of the notable difficulties that banking systems manage. The security systems developed for banking transactions perform intelligent data analysis not only for the maximization of customer benefit but also for the optimization of processes and internal infrastructure. Considering the literature, it is seen that the major of the current studies constitute morphologic analysis to detect information hidden in textual documents like identity number, address, contact details, and so on. Morphological analyzer provides the lexical form of an input word and specifies the amount, case, tense (for the verbs), aspect, and modularity. To perform better analysis, a more generic representation can be achieved by using Name Entity Recognition (NER), which allows the identification and generalization of some aspects of a sentence. Moreover, some studies benefit ontology to label personal sensitive data. An ontology for NLP is a body of knowledge about a domain that is a repository of conceptual terms mapping a class. It also organizes these terms in a relative hierarchy and further set interconnections between them using semantic and discourse-pragmatic relations defined. Since financial organizations use words for concepts having specific meaning relevant to organizations' operations, well-designed ontologies become a computational resource for solving ambiguity and reference resolution.

We organize the structure of this chapter as follows; Sect. 9.2 defines some helpful terms used in explaining and evaluating NLP analysis methods on financial news media. We examine the previous studies that perform natural language-based financial market forecasts considering used NLP analysis models. Section 9.3 provides a formal definition of NLP methods used to detect sensitive user data in the finance sector and reviews various aspects of this problem. Finally, a conclusion about the advantage of existing approaches and open issues on financial market forecasting and sensitive data detection are provided in Sect. 9.4.

## 9.2 Financial Forecasting Using NLP Methods

Due to instantaneous accessibility to financial news, digital channels have become a critical source of information that is very influential in shaping investment decisions. Textual data collected from various sources can be used to forecast market dynamics and give information investment. Besides well-known financial data sources like Bloomberg, social media is also used to follow recent information about news analytic solutions. In this respect, more researchers recently investigate the impacts of investors' sentiment on the financial market. Since social media data to be analyzed is in unstructured form, NLP techniques form a basis of sentiment analysis to forecast financial market dynamics. The typical analysis process includes pre-processing

textual data through NLP techniques and training models with machine learning algorithms. The primary objective is to develop better methods to process textual data for improved forecast accuracy. Typically, there are three steps in the pre-processing stage: feature selection, dimensionality reduction, and feature representation. To get semantics from social media contents, most of the current research first assigns feature selection and feature representation tasks using widely known NLP analysis models such as lexical analysis and syntactic analysis followed by bag-of-words. The main problem with the bag-of-words approach is that it considers only individual words and their frequencies during feature vector creation. Consequently, the relationship between the keywords are missed out. Researchers have become to add semantics while extracting feature vectors from the textual data to overcome this problem. This section reviews research that performs NLP analysis models to get information about financial market dynamics from financial reports, news, and user comments in the digital platforms.

### *9.2.1 Lexical Analysis*

Lexical Analysis is performed as the first step of textual data analysis. This task's main purpose is to convert a text into a list of tokens (discrete string objects) and extraction of feature sets. The punctuation marks and spaces are considered separators to implement this process, and the sentences are separated into their components. After tokenized words are cleaned from the inflectional morphemes through the stemming process, POS tagging, which categorizes word-groups considering their function in a sentence, is applied.

In order to simplify information retrieval from requirements, the tokenization is applied first, and word sequences are obtained. These features include the words of the text blocks, their POS tags, and a set of topological features (see Fig. 9.1).

Lexical Analysis has widespread usage in discovering semantics from user-generated content or news in financial forums and social media platforms. For example, Das and Chen (2007) conduct a study for investor sentiment extraction from stock message boards in Yahoo finance's forum. The proposed model is formed using an ensemble learning approach to classify messages into three categories: optimistic, pessimistic, and neutral. First input data, including investor comments, is pre-processed using text mining and NLP analysis methods. Adjectives and adverbs are extracted by implementing lexical Analysis since the classifier assumes that using adjectives and adverbs as features facilitates sentiment analysis. In another study, Pagoli et al. (2016) analyze the relationship between investor opinions shared on Twitter and companies' stock prices. Two different representations of input data, Word2vec and N-gram, are inputted to the classifier. Evaluation results prove that tweets tagged as optimistic about a company motivate other people to invest in the stocks, and accordingly, the stock price of that company increases. Nguyen and Shirai (2015) also propose an approach to predict stock price movement by discovering topics and sentiments in social media data. The study's main contribution is

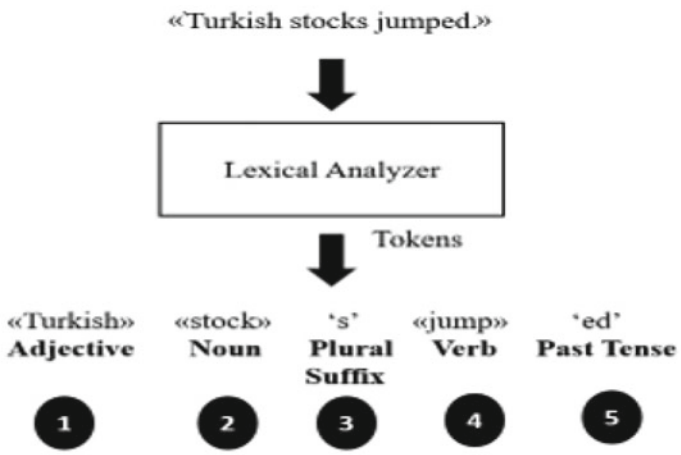


**Fig. 9.1** General framework of Lexical Analysis

stated as adding "topic-sentiment" as a feature to the learning model. It is also made large-scale evaluation for five market stocks (i.e., Exxon Mobil Corporation, Dell In, eBay Inc, International Business Machines Corporation (IBM), and the Coca Cola Company) in Yahoo Finance. Since it is concluded that topics are in the form of nouns and opinion words are adjectives or adverbs, the first task in the development process is to determine POS tags. The accuracy of the proposed model is measured as 56%.

### *9.2.2 Syntactic Analysis*

Syntactic Analysis is the process of determining whether a string of tokens can be generated by the grammar. The most fundamental point in the Syntactic Analysis should be the mathematical modeling of the language. Context-Free Grammar (CFG) proposed by Noam Chomsky (1957) is one of the models used in this context. The way to formulate information about the structure of the language in this concept is to create dynamic rules that will form the language's sentences. For example, the statement "a sentence consists of nouns and verbs" is one of the general rules used for all languages in the world. Figure 9.2 shows a basic syntax analysis mechanism in Syntactic Analysis.

As the Fig. 9.2 shows, tokenized inputs are inputted for the lexical analyzer which tries to locate the boundaries and the spans of the phrases. Then, syntactic class tags of the word sequences are predicted. To identify the recursive phrasal structure, the $i_{th}$ token is then fed back to the Lexical Analyzer for processing at the $(i + 1)_{th}$ level. This iteration continues until a complete parse tree is constructed. Both the phrases and syntactic class tags acquire the knowledge encoded in treebanks and benefit from

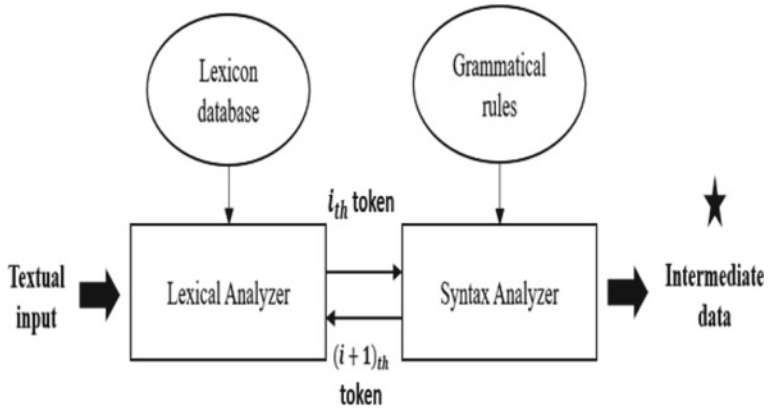


**Fig. 9.2** Syntactic analysis of textual input

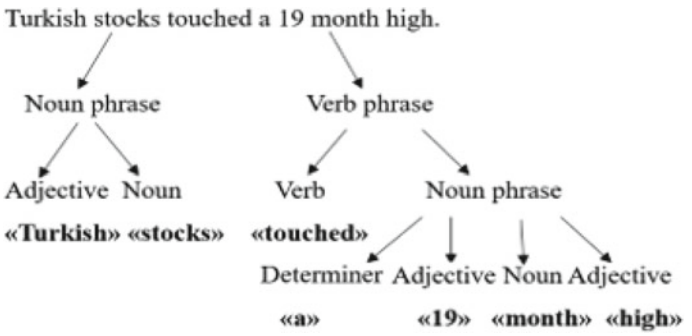


**Fig. 9.3** An example of a parse tree for the sentence: "Turkish stocks touched a 19-month high"

a machine learning technique for the chunking and prediction. For example, input sentence "Turkish stocks jumped and touched a 19-month high this week." has the elements, "Turkish," "stocks," "touched," "a," "19," "month," "high" with their POS tags "adjective," "noun plural," "verb, past participle," "determiner," "adjective," "noun," "adjective" respectively in the parse tree (see Fig. 9.3).

Syntactic Analysis is one of the preferred approaches to forecast stock price movements. Chan and Chong (2017) conduct a study to extract sentiments from textual data about financial markets' trends using Syntactic Analysis. This research's primary purpose is to establish grounds for the hypothesis that the sentiments expressed through textual content help analyze the stock market trends. Another study by Schumaker and Chen (2009) presents three textual representations: bag-of-words, noun phrases, and named entities to extract necessary information from financial news. This first process involves the elimination of stop words such as conjunctions and declarations from the text. Then, Lexical Analysis, which finds named entities (e.g., proper nouns), and Syntactic Analysis, which specifies noun phrases, are applied

to the pre-processed textual representation. The method used to filter data is more abstract, and it provides a better generalization of unprecedented terms before.

### 9.2.3 Text Representation Approaches: Bag of Words (BoW)

Most of the previous work primarily used the bag-of-words (BoW) as text representation that are incorporated into the prediction model. BoW model is a way of representation of text which specifies occurrence (E.g. counts, frequencies) of terms in a document. In this model, order and the sequence of words are not considered. Vector Space Model (VSM) is the improved version of BoW where each text document is represented as a vector, and each dimension corresponds to a separate term (word). If a term occurs in the document, then its value becomes non-zero in the vector.

The problem with counting term frequencies is that the frequently used terms become dominant in the document and begin to represent the document. Even if these terms are not very informative, they probably passivate other terms in the feature set. To solve this problem another scoring model *"tf x idf,"* which stands for "*Term Frequency x Inverse Document Frequency*" is commonly used. Model uses two metrics in its computation: term frequency (*tf*) and inverse document frequency (*idf*).

- *Term frequency (tf):* A term that appears several times in a document is weighted more heavily than a term that appears only once.
- *Inverse document frequency (idf):* A term that occurs in a few documents is likely to be a better discriminator that a term that appears in most or all documents.

In this model the objective is assigning a *tf x idf* weight ($w_{ik}$) to each term in each document as follows.

$$w_{ik} = tf_{ik} * idf_k$$

where,

- $T_k$ is the term k in Document $D_i$,
- $tf_{ik}$ is the frequency of term $T_k$ in Document $D_i$,
- $idf_k$ is the inverse Document frequency of term $T_k$ in $C$,
- N is the total number of documents in the collection $C$,
- $n_k$ is the number of documents in C that contain $T_k$,
- $idf_k = log(N/n_k)$

The bag-of-words model is one of the most widely used approaches that use single discrete words to represent text. For example, Groth and Muntermann (2011) analyze intraday market risk using German ad-hoc announcements represented in bag-of-words. After the feature selection process by Chi Square method, four different learning algorithms (k-Nearest Neighbours (kNN), Naive Bayes (NB),

Neural Network (NN), and Support Vector Machine (SVM)) are employed to measure the effects of the announcements on the stock price. In another study, Li (2010) performs NB classifier on internet stock message postings to forecast market volatility and stock return. He represents the US corporate filings as bag-of-words and employs several pre-defined dictionaries for feature selection. Tetlock et al. (2008) analyze US financial news (in *Wall Street Journal* (WSJ) and Dow Jones News Service (DJNS)) to predict firms' daily price of a firm's stock. They use bag-of-words model to represent the textual data. The ratio of negative terms in a widely read news column about the stock market is calculated.

### *9.2.4 Semantic Analysis*

Semantic Analysis extracts the meaning from linguistic input. This task's primary purpose is understanding what the view is to be expressed in a sentence. The source of baseline rules used in Semantic Analysis are divided into two as grammar and conceptual relations. The grammar of a language includes the vocabularies and syntactic rules such as verb tenses, articles, and adjectives (and their proper order). Dictionaries provide to find the meanings of the words and to establish the relationships between them. For example, WordNet (Miller, 1995), a dictionary of word meanings/concepts in English, is widely used to find the semantic distance between the textual inputs. Exploring semantic relationships between words can be done through WordNet's synsets, which are sets of cognitive synonyms expressing a particular concept.

Semantic Analysis is one of the widely used tasks in sentiment analysis for market stock market movements. Since it enables adding semantics of the words into feature vectors, the relationship between the terms is considered during the forecasting process, so the proposed system's accuracy is increased. For example, Atan and Çınar (2019) perform Lexical Analysis and Semantic Analysis to observe the relations between companies' market capitalization in Borsa Istanbul and financial news about them. They create a dataset, including 14.108 news from 313 different financial information providers. Then, they translate a sentiment dictionary into Turkish to be used in Semantic Analysis. As a result, the relationship between the intermediate data obtained from the companies' textual content and market capitalization values are determined. In another study, Bollen et al. (2011) analyze the streams in Twitter by mood tracking tool named as OpinionFinder to explore users' views about the stock market. The proposed model based on Semantic Analysis and Self-Organizing Fuzzy Neural Network tries to determine Twitter users' moods like calm, alert, sure, vital, kind, and happy.

Overall, these results imply that what investors think about stock market data. It is stated that the proposed model has an accuracy of 86.7% in predicting the daily up and down changes in Dow Jones Industrial Average. Mehtab and Sen (2019) also propose a hybrid approach for stock price movement using natural language processing and supervised learning methods. First, they experiment with a regression method on a dataset, including the daily price movement of NIFTY 50 index values of the National

Stock Exchange (NSE) of India to predict the closing value of NIFTY50. They also perform Long and Short-Term Memory (LSTM) by integrating a sentiment analysis module on Twitter data to correlate the public sentiment of stock prices with a market. Another study by Xie et al. (2013) presents a novel tree representation based on a semantic frame parser to analyze financial news sentiments. An experimental dataset is created by manually annotating financial news collected from Yahoo Finance. The semantic features in the textual data are determined by Lexical Analyse and Semantic Analyse and used in the proposed model. The researchers claim that the semantic features encoded as syntactic trees perform remarkably better than bag-of-words vectors and supervised learning approaches.

## 9.3 Detecting Sensitive Information Using NLP Methods

Due to advances in information technology, instantaneous accessibility to financial services through digital channels has increased. Along with the extensive application of information technologies, there has been increased usage of online banking and financial services to transfer money, invest, manage payments, etc. Although digital platforms' use makes an individual's life more comfortable, it may also cause some security issues, causing critical losses for companies in the industrial sector, investors, and governments. Personal information security is an essential concern for all finance sector institutions, as in many sectors. Financial organizations must have valid and reliable systems to authenticate users following the General Data Protection Regulation (GDPR). This broad-based privacy regulation arranges restrictions to protect personal information throughout the European Union. An authentication system should keep customers' data safe, preclude terrorist financing, prevent fraud, inhibit identity theft, and promote the contracts' legal enforceability on electronic transactions. Providing the security of online transactions is one of the considerable difficulties that banking systems manage. The security systems developed for banking transactions perform intelligent data analysis to maximize customer benefit and optimize processes and internal infrastructure.

Companies keep many different data in their systems, such as identity information, call number, address, etc. The most significant problem is that these data need to be protected or require sensitivity in transactions. In the past, sensitive data detection has been generally realized with human interference by governments and companies. Since manual data analysis is expensive, time-consuming, prone to errors, sensitive data detection has become an increasingly popular research focus in information retrieval tasks. Considering the literature, it is seen that most of the current studies utilize Named Entity Recognition (NER), which categorizes critical information (entities) in text. A more generic representation can be achieved using an ontology that is a repository of conceptual terms mapping a class. Since financial organizations use words for concepts having specific meaning relevant to organizations' operations, well-designed ontologies become a resource for defining a semantic model of the data combined with the associated domain knowledge.

### *9.3.1 Named Entity Recognition (NER)*

Named entities are collections of elements that are essential for text understanding. Named Entity Recognition (NER) is a process to extract names, organizations, locations, quantities, monetary values, and percentages, etc. NER is used in many fields in NLP, and it can help answering many real-world problems. There are three widely known approaches to recognize entities in the textual data, such as lexicon-based recognition (see Fig. 9.4), rule-based recognition, learning-based recognition (machine learning). Lexicon-based recognition uses the ontology framework, including a set of concepts for a particular domain. The disadvantage of this approach is that it cannot find entities that are not in the lexicon. In the rule-based approach, linguistic patterns and grammatical structures are used to extract identity numbers and contact information (email, telephone, address, etc.). Although using this approach to extract specific entities from the textual documents can improve the proposed model's accuracy, building a set of linguistic patterns and rules can be time-consuming and challenging. Moreover, they only work for the purpose they have been created, and it is not easy to modify them. In recent years, machine learning has become an increasingly popular research focus on NER because of the high accuracy ability it provides. To develop a learning-based entity recognition, the model must be trained with a large volume of historical data.

We analyze the following sentence from a R&D project agreement to label the entities.

**R&D PROJECT AGREEMENT**

Within the framework of the regulations made within the scope of the Law No. 4691 and 6170 on the Technology Development Zones, this agreement (dated as of September 27, 2020) is signed by Dr. Fatma Bozyigit and KalybeAI Inc., on the following terms

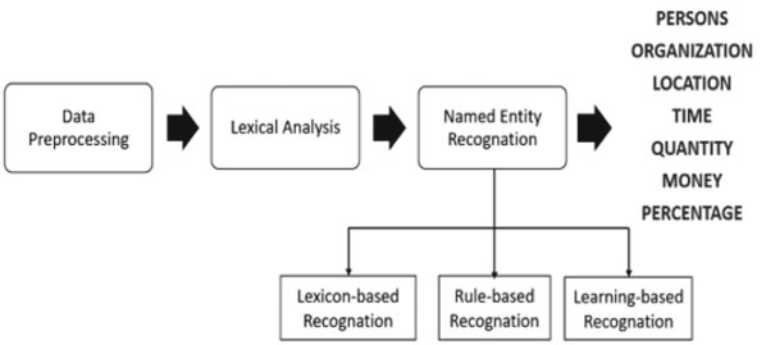


**Fig. 9.4** Illustration of NER process

In this document, (September 27, 2020), ("Fatma Bozyigit"), and ("KalybeAI") are tagged as TIME, PERSON, and COMPANY, respectively.

There are many different documents that financial organizations keep in their systems, like contracts, customer information forms, application forms, etc. The preservation of sensitive data (e.g., location, name, identity number) in these documents is a critical task to be observed under the General Data Protection Regulations. Therefore, banks and financial institutions have to establish internal control and audit mechanisms to protect personal data. In case of non-compliance with the legislation, they face severe sanctions. Traditionally, companies have relied on domain experts to capture this information which is time-consuming. However, recent trends suggest that specialized tools and algorithms are being used to extract key data points from documents to augment and reduce human effort.

Nayak et al. (2019) develop a deep learning-based NER model to extract sensitive data from the financial documents. They experiment bi-directional long short-term memory (Bi-LSTM) model, which works well on low resource datasets. The researchers add a novel domain-specific Bi-LSTM layer into the proposed learning model to improve NER performance. They also perform transfer learning trained with the out-of-domain dataset. It is stated proposed model outperforms the reported state-of-the-art results on the Financial NER dataset and obtains 87.48% accuracy score in terms of F-measure. Wang et al. (2014) develop an approach to recognize stock names and specific financial terms from financial news using a domain ontology. The experiments on a Chinese financial dataset state that Conditional Random Fields achieve 91.02% precision and 92.77% recall. Researchers also utilize Levenshtein algorithm, a similarity calculating method, to identify the abbreviations in Financial Named Entities.

### *9.3.2 Domain Ontologies for Sensitive Data Detection*

One of the most critical problems in knowledge-based systems is that the obtained information may contain uncertainty. Ontologies are descriptions of terms in particular knowledge domains, which incorporate sets of concepts and relations between them (Petrova et al., 2017). The purpose of using ontology for information extraction is to enable definitions of activities in a domain with the minimum workload. While manual information extraction from documents is time-consuming and costly, automatic document categorization benefits from a domain ontology increases performance and consistency as it decreases costs. The general terms must be considered in the data protection framework can be listed as person (e.g., name, surname, year of birth, address), institution, organizations (e.g. tax number), account (account id, account activities, account type), credit card (e.g., card number, security code, password, expiry date).

Figure 9.5 (Hu et al., 2014) shows an example of the static ontology which includes actors and resources, and represents the static aspect of the financial market. Fed (a3) is a kind of central bank (a2) and the relationship between of them (c6) is stated as a3

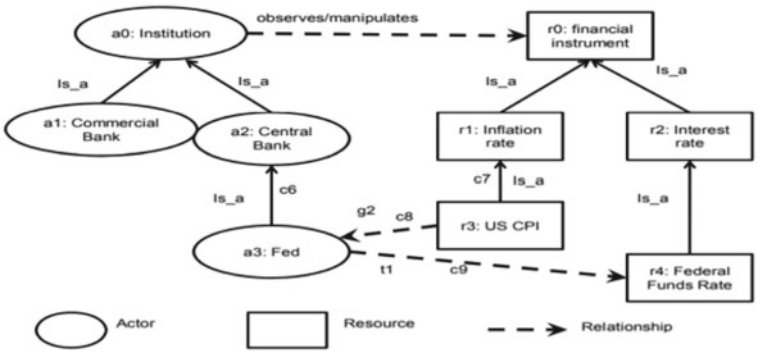


**Fig. 9.5** An example of financial ontology

$\subseteq$ a2. US CPI (r3) is a kind of information rate (r1) and the relationship between of them (c7) is represented as r3 $\subseteq$ r1. Dashed lines (c8 and c9) indicate the behaviors of classes. For example, c8 demonstrate that US CPI.

(r3) triggers the goal of reducing the inflation rate (g2).

The protection of personal data is of critical importance for banks and their customers. This section refers to ontology-based information extraction methods to categorizing documents, including sensitive data. Various academic studies have been carried out using the ontology to find sensitive data in financial documents. Kul and Upadhyaya (2015) employ a methodology to detect insider attacks targeting database systems (user records). The proposed model's main idea is to analyze the chronology of events in sequential order using the predefined ontology in the banking domain. The ontology is mapped onto the Suggested Upper Merged Ontology (SUMO), Friend of a Friend (FOAF), and Finance ontologies. It is integrated into the system, which detects deception, privilege removal, privilege misuse, and cyber-attacks. Can and Olca (2019) present a consent ontology to conduct personal data management. They create concepts concerning General Data Protection Regulation (GDPR). After specific terms are extracted, they represent the feature vector using TF-IDF method. Then, the concepts and relationships between them are matched with the input vector.

## 9.4 Conclusion

Analyzing textual data to improve modeling of the financial market dynamics has become popular in recent years. The growing volume of financial data (e.g., reports, news, social media contents) also increases the importance of systems that automatically retrieve semantic information from textual documents. This chapter addresses

NLP's practices in the finance sector and gives information about recent literature using NLP methods in financial tasks. We categorize the financial tasks under two sections: forecasting financial market dynamics using online news and user comments about the stock markets and detecting sensitive data (e.g., identity number, credit card number, telephone number) in the financial documents.

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# Part IV
# Specialized Topics on AI Implementations

# Chapter 10
# Higher Education and Labor Market Transformation in the Era of Industry 4.0 in a Developing Country: The Case for Turkey

**Aslı Dolu and Hüseyin İkizler**

**Abstract** With Industry 4.0, especially in Germany, as of 2013, the industrial countries started to form their strategy documents. Industry 4.0 is a part of the global megatrends of digitalization in all areas of life and economy. This transformation in Turkey, primarily to the automotive and telecommunications companies have started by the end of 2014. In the study, we analyze to what extent the adjustment in education policy and the labor market develops in the era of Industry 4.0. For this purpose, we use the TURKSTAT Household Labor Force Survey data (2009–2018). We evaluate the impact of Industry 4.0 with the synthetic control method, the change in the sectoral employment rates, and analyze whether the share of the workers who graduated from particular departments vary in this era. Using the synthetic control method, we find that while Industry 4.0 positively affects the furniture sector's Industry 4.0 related education ratio, the impact occurs negatively in the automotive, textiles, and transport equipment sectors. Also, we find no effect on the food sector.

**Keywords** Artificial intelligence · Education · Labor market · Synthetic control · Industry 4.0 · Employment · Manufacturing sector · Technology · Education policy · The industrial revolution · Furniture sector · Automotive industry · Food industry · Textile industry

**Jel Codes** I21 · I25 · J23 · J24 · N34 · O30 · O52

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## 10.1 Introduction

One of the most important factors underlying modern societies is industrial revolutions. The industrial revolutions are essential because they contribute to economic developments and are the driving force of today's digital and artificial intelligence production system with exponentially growing technologies. Besides, industrial revolutions are cases that shed light on our daily life, and these revolutions have led to significant improvements (Baygin et al., 2016). Throughout human history, there have been four major industrial revolutions as the basis. Each new industrial revolution has brought a different production and consumption pattern than the previous ones and a different social structure. In the late eighteenth century, Industry 1.0 initiated mechanical production with the use of the steam engine. After about one century, Industry 2.0 introduced the use of electrical power. Computerized automation systems were available in mass production with Industry 3.0 in the late twentieth century. Rüßmann. et al. (2015) summarize each industrial revolution as mechanization (Industry 1.0), use of electrical energy (Industry 2.0), and electronics and automation (Industry 3.0).

In addition to the economy's production side, all these industrial revolutions also affect the labor market and the education system. Some professions and jobs disappeared due to these changes (Benešová & Tupa, 2017). Finally, due to digitalization and robotic technology development, we face the last industrial revolution known as Industry 4.0. Industry 4.0 is called the fourth step of industrialization revolutions, expressed with smart systems internet-based solutions. This last industrial revolution involves quite different approaches from the industrial courses that preceded it. This revolutionary process, which aims to equip the existing industrial infrastructure with artificial intelligence and machine-to-machine communication technologies, seeks a new production strategy abstracted from labor using smart machines.

Industry 4.0 was conceptually brought to the agenda for the first time in 2011 at the Hannover Fair. The German government put it forward to ensure the transition from conventional production methods to computer internet-supported automated production methods (Sung, 2018). German industrialists needed a new strategy based on the radical change of work and production spaces and started to use this generic expression. This abstract concept has been included in policy and strategy documents, especially in Germany since 2013. As time progressed, the phenomenon of Industry 4.0, with the contributions of the business world and academic circles, has become a concern of all countries that are planning to establish a new industrial system, not just Germany. Afterward, it spread worldwide and has become one of the most critical digitalization trends in all areas of our lives and economy.

The adoption of Industry 4.0 differs between developed and developing countries. Developed countries, which are more prepared for the process in terms of economic and technological infrastructure, are more ahead in implementing Industry 4.0 than developing countries (Sumer, 2018). Most developing countries prepare themselves for the new industrial era by creating the necessary economic and technological infrastructure. Economies that first complete these preparations will be a few steps

ahead of others. Therefore, they will have a competitive advantage in global trade and will be stronger than others in growing their economies.

In summary, Industry 4.0 provides many threats and opportunities for both developed and developing countries. Like every country that desires to maintain its influence globally and maintain its economic superiority, Turkey has made due diligence and tried to adapt Industry 4.0. In Turkey, the most apparent impact of Industry 4.0 occurred in the automotive sector. The transition to advanced technology and automation aims to increase efficiency and profit for other sectors as in the automotive sector (Yüksekbilgili & Cevik, 2018).

Since the beginning, Industry 4.0 has started to affect almost all economic areas, especially the labor market. As in all industrial revolutions, Industry 4.0, which centers digital transformation, affects many professions and causes some jobs to disappear while it creates new professions. Consequently, we expect Industry 4.0 to affect both education policies and the labor market. In this context, there is a growing literature discussing the potential impact of technologies (robotic technologies, machine learning, algorithms, artificial intelligence, and similar technologies.) developed with Industry 4.0 on the labor market and employment (Dalenogare et al., 2018). However, studies on how recent advances in technology leading up to Industry 4.0 will affect employment are still in their infancy. Also, no reviews presenting conclusive evidence are available (Frey & Osborne, 2017; Horváth & Szabó, 2019).

To our best knowledge, Kagermann et al. (2011) proposed the first study in the literature on Industry 4.0. In this study, they revealed the general framework of Industry 4.0 regarding the internet revolution. Subsequent studies generally discuss the emergence of Industry 4.0 and its development in the process (Alekseev et al., 2018; Bogdanova et al., 2016; Chiu et al., 2017; Moeuf, A. et al., 2018; Popkova et al., 2015; Ragulina et al., 2015). Other studies mostly evaluate Industry 4.0 on countries' economic growth performance (Amaghouss & Ibourk, 2013; Lee & Hong, 2010). Studies are examining the opportunities and challenges provided by the technologies introduced by Industry 4.0 for industrial performance focus on logistics (Ben-Daya et al., 2019; Haddud et al., 2017; Hofmann & Rüsch, 2017; Raj et al., 2020). Studies based on Industry 4.0's effects on the labor market are related to the loss of employment or new jobs due to the changing technology and skills requirements. In these studies, researchers evaluated the relationship between technological employment and skills in the workforce and emphasized that skill-based technological change could lead to a qualitative change in employment with increasing skill demand (Haddud et al., 2017; Schwab, 2017). According to studies that estimate the labor market's effects of Industry 4.0, the labor market essentials will alter, and production will become more efficient. Consequently, the transformation process, labor supply, and demand will adjust wages and prices (Weber, 2016; Wolter et al. 2015, 2016).

However, limited research literature in addressing the issue of Industry 4.0 from Turkey's point about the use of technology literacy and emphasizes the question of regional and sectoral differences (Baltacı et al., 2012; Bulut & Akcacı, 2017; Fırat & Fırat, 2017; Toker, 2018). The current literature lacks a comprehensive approach capable of evaluating Industry 4.0's impact on the labor market and education.

This chapter aims to examine the extent to which the adjustment in education policy and the labor market develops in Industry 4.0. To do so, we define the "Industry 4.0 related education ratio" as the share of workers who graduated from one of the Physical sciences, Mathematics and Statistics, Computer, Engineering, and Manufacturing and processing departments in the total sectoral employment. We expect that development in artificial intelligence will eventually decrease labor demand for workers for whom automation substitutes.

To identify the impacts of Industry 4.0 on Turkey's labor sectors, we exploit from the Synthetic Control Method. We determine nine sub-sectors in the industry sector that Industry 4.0 affected substantially. Repeatedly, we estimate the model for each sector. We find that while Industry 4.0 positively affects the education ratio in the furniture sector, the impact occurs negatively in the automotive, textiles, and transport equipment sectors. Also, we find no effect on the food sector.

The structure of the chapter is as follows. In the second section, we present the data set. We introduce our estimation strategy in Sect. 10.3. Section 10.4 provides the result of our synthetic control method estimations. We also give an overview of the results and relate to education policy. In the last section, we conclude.

## 10.2 Data

In the study, we use the data of the Household Labor Force Survey for the period 2009–2018. We need sectoral data over the years to examine to what extent Industry 4.0 affects the education composition. In this regard, we use the sector information and the department information declared by the survey participants at the sectoral level.

We center attention, particularly in the industrial sector, and include the twenty-seven industry sub-sectors in the analysis.[1] Table 10.1 presents these sub-sectors:

As we explained in the Methodology section, we apply the synthetic control method. To produce synthetic control of the sector in which we measure the impact, we exploit the industrial production index, industrial turnover index, gross-salary wage index, and employment index data. We obtained these data from the database of the Turkey Statistical Institute. Academic studies show that 9 out of these 27 sub-sectors have close relations with Industry 4.0. However, only 5 out of the nine sectors yielded statistically significant results in the analysis.

We associate the following departments with Industry 4.0:

- Physical sciences
- Mathematics and statistics
- Computer

[1] Manufacturing production index data for the "Mining support service activities" subsector and Turnover index data for the "Electricity, gas, steam and air conditioning supply" subsector are not available. Also, Industry 4.0 related education ratio cannot be calculated for some years for the "Extraction of crude petroleum and natural gas" subsector.

**Table 10.1** Economic activity (NACE Rev. 2) sectors

| Code | Sub-sector | Code | Sub-sector |
|---|---|---|---|
| **B.05** | Mining of coal and lignite | **C.21** | Manufacture of basic pharmaceutical products |
| **B.07** | Mining of metal ores | **C.22** | Manufacture of rubber and plastic products |
| **B.08** | Other mining and quarrying | **C.23** | Manufacture of other non-metallic mineral products |
| **C.10** | Manufacture of food products | **C.24** | Manufacture of basic metals |
| **C.11** | Manufacture of beverages | **C.25** | Manufacture of fabricated metal products |
| **C.12** | Manufacture of tobacco products | **C.26** | Manufacture of computer, electronic and optical products |
| **C.13** | Manufacture of textiles | **C.27** | Manufacture of electrical equipment |
| **C.14** | Manufacture of wearing apparel | **C.28** | Manufacture of machinery and equipment |
| **C.15** | Manufacture of leather and related products | **C.29** | Manufacture of motor vehicles |
| **C.16** | Manufacture of wood | **C.30** | Manufacture of other transport equipment |
| **C.17** | Manufacture of paper and paper products | **C.31** | Manufacture of furniture |
| **C.18** | Printing and reproduction of recorded media | **C.32** | Other manufacturing |
| **C.19** | Manufacture of coke and refined petroleum | **C.33** | Repair and installation of machinery and equipment |
| **C.20** | Manufacture of chemicals and chemical products | | |

- Engineering
- Manufacturing and processing

We define the "Industry 4.0 related education ratio" as the share of university graduates who have completed the departments mentioned above in the total sectoral employment. While calculating the ratio, we use frequency weights[2] obtained from the microdata. Formally for each subsector, we calculate the "Industry 4.0 related education ratio" as:

$$\text{Educ\_ratio}_s = \frac{\sum_{i=1}^{5} \text{University Graduates}_{s,i}}{\text{Total Employment}_s} \tag{10.1}$$

[2] Weighting is a method used to obtain parameters from the data set resulting from sampling to represent the universe. In the study, while reaching the final weight, the design weights have been calculated depending on the selection criteria; have been controlled for external distribution and corrected for non-responses. In weighting, age group, gender, NUTS Level 2, urban–rural, and household size are based on external control.

where $s$ takes values 1 … 27, Total Employment$_s$ is the total employment in the sector $s$, and University Graduates$_{s,i}$ is the number of graduates from the department $i$ in the sector $s$.

### *10.2.1 Synthetic Control Method*

To identify the effects of Industry 4.0 on the labor sectors in Turkey, we use the Synthetic Control Method (SCM) developed by Abadie and Gardeazabal (2003) and Abadie et al. (2010, 2015). This method is better suited than the classic regression approach and difference-in-differences methodology to address these case studies.

A synthetic control unit's construction relies on the idea that a weighted average of comparison units is a better control unit than any single unit or the average of all potential units. This control group, formally called the Synthetic control unit in SCM, is defined to assess whether the intervention (policy) impacts outcomes and what will happen in the absence of this intervention. The most critical element for evaluating the intervention effect is that the relevant covariates of control units in pre-intervention periods are as close as possible to those of the treated unit (Ando, 2015). By using weights to balance pre-intervention outcomes for treated and control units, the SCM method imputes post-intervention control outcomes for the treated units by building a synthetic version of the treated units equal to a convex combination of control units (Arkhangelsky et al., 2019). The selection of comparison units is essential since using inappropriate control units may lead to wrong conclusions (Abadie et al., 2015).

Using the notation of Abadie et al. (2010), we first describe the SCM for settings when the intervention group consists of only a single unit. Suppose there are $i = 1, 2, \ldots, J+1$ units and without loss of the generality, suppose only the first unit ($i = 1$), called the "intervention group," was subject to policy treatment, and the potential control group ($i = 2, \ldots, J$) called the "donor pool" (Gerring, 2006; Tarrow, 2010) was not affected by the intervention. Suppose that we observe outcomes for $T = 1, 2, \ldots, T$ periods and the intervention occurs during the period from $T_0 + 1$ to $T$. To evaluate the treatment effect, two outcomes are defined. First of these $Y_{it}(I)$ is the outcome of interest affected by the intervention for unit $i$ in period $t \in 1, 2, \ldots T$ and the other $Y_{it}(N)$ is the potential outcome of interest in the absence of the intervention for $i \in 1, 2, \ldots, J+1$ in period for $t \in 1, 2, \ldots, T$. By definition of outcomes, for the pre-intervention periods ($t \in 1, 2, \ldots, T_0$), $Y_{it}(I) = Y_{it}(N)$. Namely, in this period, the intervention does not affect the outcome. Then, the main goal of SCM is to estimate the intervention effect for unit $i = 1$ at each time $t = T_0 + 1, \ldots, T$, defined as $\alpha_{it} = Y_{it}(I) - Y_{it}(N)$. Since $Y_{1t}(I)$ is an observable value, it will be sufficient to estimate the value of $Y_{1t}(N)$ to predict the value of $\alpha_{1t}$. Let us assume that; Let $Y_{1t}(N)$ be defined as the factor model given below:

$$Y_{1t}(N) = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it} \tag{10.2}$$

where $\delta_t$ is an unknown common factor with constant factor loadings across units, $\lambda_t$ is a vector of common factors; $\mu_i$ is a vector of unknown factor loadings; $\theta_t$ is a vector of an unknown parameter; $Z_i$ is a vector of observed covariates (not affected by the intervention), and the error terms $\varepsilon_{it}$ are unobserved transitory shocks with 0 mean.

A vector of weights $\mathrm{W} = \left(w_2, \ldots, w_{j+1}\right)$, where $j$ indicates units in the donor pool, such that each weight is equal to or greater than 0 for all donor units $\left(1 \geq w_j \geq 0\right)$ and $w_2 + \ldots + w_{j+1} = 1$. Each choice of W gives a set of weights and characterizes a possible synthetic control. Using a vector of some optimal weights $\mathrm{W}* = \left(w_2^*, \ldots, w_{j+1}^*\right)$, $Y_{1t}(N)$ is estimated as the weighted average of $Y_{it}(I)$. We construct the estimator of the counterfactual as the linear combination of the observed outcomes of the potential control units: $\widehat{Y}_{1t}(N) = \sum_{j=2}^{J+1} w_j^* Y_{jt}(I)$.

Then $\widehat{\alpha}_{1t}$ is estimated as given below:

$$\widehat{\alpha}_{1t} = \widehat{Y}_{1t}(I) - \sum_{j=2}^{J+1} w_j^* Y_{jt}(I) \tag{10.3}$$

A vector of optimal weights W* is chosen to minimize the discrepancy in the observed and unobserved confounders measured before the intervention, between the treated unit and the weighted average of predictors for the control units in the donor pool. For more detailed information, see Abadie and Gardeazabal (2003) and Abadie et al. (2010).

In our case, the empirical model's goal is to assess the impact of Industry 4.0 on the education ratio for selected five sectors. We approach this study by comparing the education ratio of the five sectors (affected by Industry 4.0) during Industry 4.0 with that of a weighted combination of the other 18 sectors (not affected by Industry 4.0) chosen to resemble the characteristics of the five sectors before Industry 4.0. In the model described above, the vector W* defines the combination of not affected by Industry 4.0 control sectors, which resembled the effected sectors in education ratio at the outset of Industry 4.0.

## 10.3 Results

Note that we determine nine sectors on which we expect a significant Industry 4.0's impact. In our estimation methodology, we use these sectors individually to constitute the treatment group. The rest of the 18 industries establish the synthetic control unit. We find statistically significant results for 5 out of 9 nine sectors: the manufacture of textiles, manufacture of food products, manufacture of motor vehicles, trailers and semi-trailers, manufacture of other transport equipment, and manufacture furniture sectors.

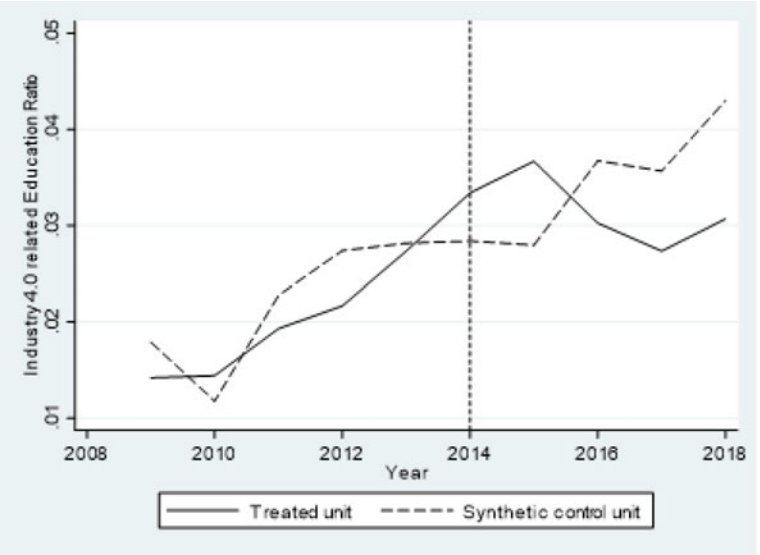


**Fig. 10.1** Treated and synthetic values of the manufacture of textiles

### *10.3.1 Manufacture of Textiles*

Figure 10.1 presents the actual "Industry 4.0 related education ratio" (from now on education ratio) of the textiles sector. Figure 10.1 visibly shows an upward trend in the proportion of those who graduated from specified university departments in the textile industry before Industry 4.0. To the best of our knowledge, during 2008 and 2018, no policy change affects sectors' education level patterns.

However, we do not observe the increase in the textile sector's education ratio indicated by the synthetic control group. We interpret that this effect occurs due to the rise in automation after Industry 4.0. We calculate the approximate value of the impact as 1.2 percent points.

### *10.3.2 Manufacture of Food Products*

As seen in Fig. 10.2, the food sector's education ratio shows an upward trend before Industry 4.0. We notice that the upward trend before 2014 remains afterward. Contrary to our expectations, there exists no change in the education ratio in this sector. This stability may result from the fact that the food sector has already reached a certain automation level. Besides, the low level of the pre-education ratio level consequences a stable ratio. This interpretation indicates that the industry needs a sufficient level of education to implement industry 4.0.

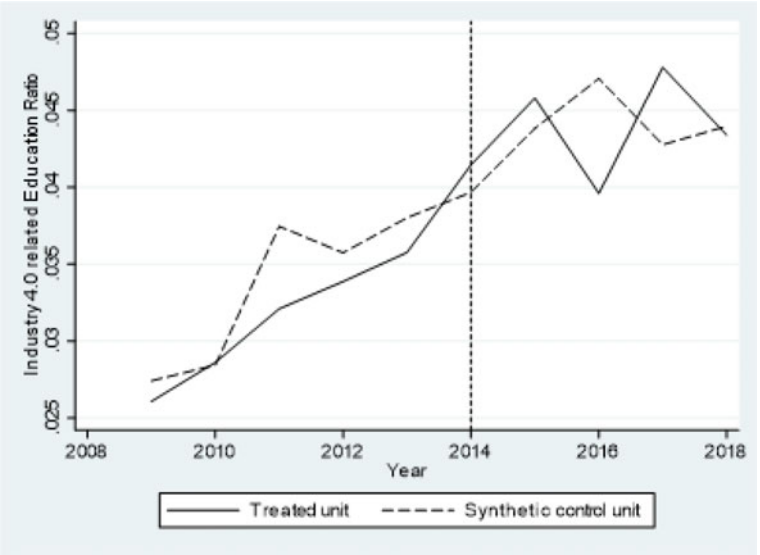


**Fig. 10.2** Treated and synthetic values of the manufacture of food products

### *10.3.3 Manufacture of Motor Vehicles, Trailers, and Semi-Trailers*

Similarly to the textile sector, there is an upward trend in the automotive industry's education ratio before Industry 4.0. The synthetic control group implies an increase in the education ratio in the automotive sector. Nevertheless, the actual education ratio line lies beneath the synthetic dashed line, which means that Industry 4.0 impacts particular university graduates' density in the automotive sector. We calculate the approximate value of the effect as 4.8 percent points (Fig. 10.3).

### *10.3.4 Manufacture of Other Transport Equipment*

Figure 10.4 shows that the effect of Industry 4.0 in the manufacture of other vehicles sector is similar to the automotive industry. The estimation results show that Industry 4.0 decreases the education ratio by approximately 4% in this sector.

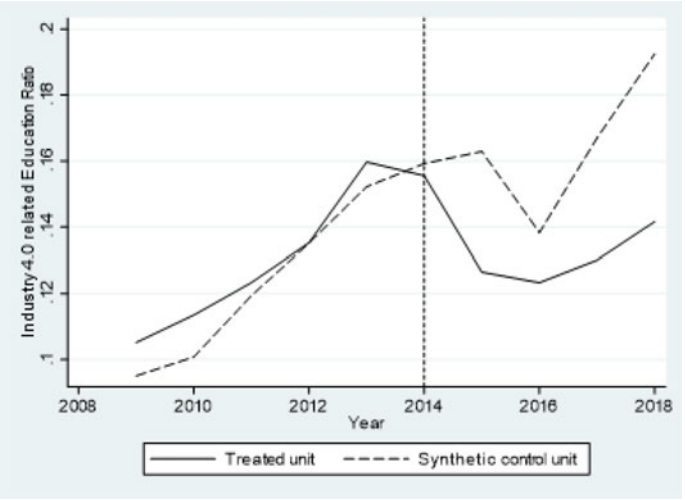


**Fig. 10.3** Treated and synthetic values of the manufacture of motor vehicles, trailers, and semi-trailers

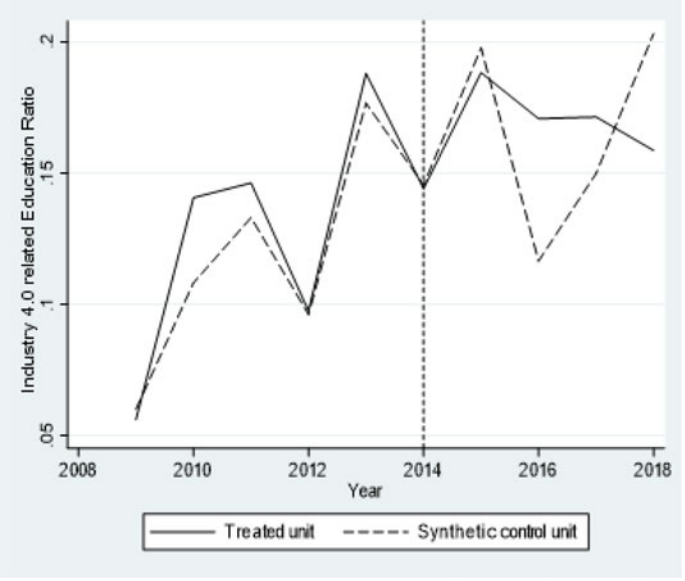


**Fig. 10.4** Treated and synthetic values of the manufacture of other transport equipment

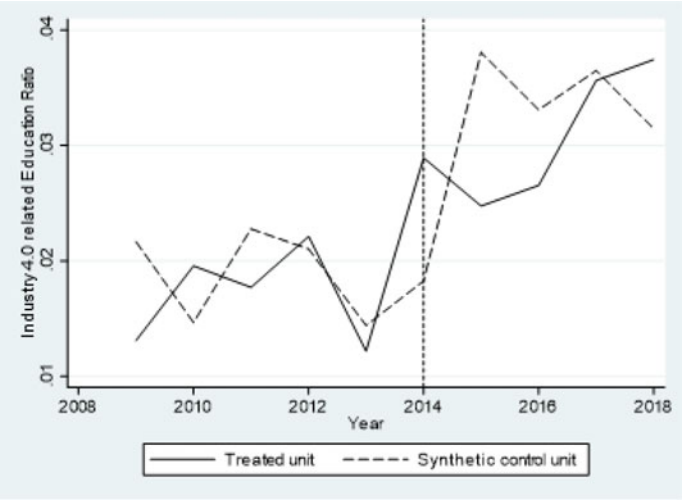


**Fig. 10.5** Treated and synthetic values of the manufacture of furniture

### *10.3.5 Manufacture of Furniture Sectors*

Unlike the other four sectors examined in the furniture sector, we notice a partial increase in the education ratio, contrary to what we expected. Again, this result indicates that the furniture needs more than a 3% share of university graduates from a particular department within the sectoral employment (Fig. 10.5).

### *10.3.6 Overview of the Results and Education Policy*

The results imply that the labor demand for workers who graduated from a particular university department decreases in the era of Industry 4.0. Guiding the qualified workforce required for Industry 4.0 is primarily the duty of education policy (Table 10.2).

For this reason, it is essential to shape the education policy according to the prospects. However, as shown in the table below, the ratio of new enrollments to these departments is gradually increasing. This situation will result in excess supply for graduates of these departments in the future. As a policy implication, we recommend that besides regulating the education policy to meet the demands, the government should prioritize vocational training activities to create employment in new business lines for existing graduates.

**Table 10.2** Industry 4.0-related education ratio in Turkey

| New enrollments | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| **Total** | 576,113 | 607,478 | 676,110 | 440,045 | 448,399 | 463,131 |
| **Technology-related departments** | 78,206 | 86,996 | 92,313 | 81,915 | 87,262 | 89,424 |
| ***Ratio*** | *13.6* | *14.3* | *13.7* | *18.6* | *19.5* | *19.3* |
| Registered | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| **Total** | 3,011,728 | 3,207,612 | 3,422,765 | 2,002,564 | 2,125,366 | 2,229,853 |
| **Technology-related departments** | 365,259 | 396,201 | 425,326 | 439,380 | 457,842 | 472,183 |
| ***Ratio*** | *12.1* | *12.4* | *12.4* | *21.9* | *21.5* | *21.2* |
| **Total** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| **Total** | 3,587,841 | 3,815,090 | 4,098,875 | 2,442,609 | 2,573,765 | 2,692,984 |
| **Technology-related departments** | 443,465 | 483,197 | 517,639 | 521,295 | 545,104 | 561,607 |
| ***Ratio*** | *12.4* | *12.7* | *12.6* | *21.3* | *21.2* | *20.9* |

## 10.4 Conclusion

In this paper, we have investigated the extent to which the adjustment in education policy and the labor market develops in Industry 4.0. First, we have defined the "Industry 4.0 related education ratio" as the share of workers who graduated from one of the Physical sciences, Mathematics and Statistics, Computer, Engineering, and Manufacturing and processing departments in the total sectoral employment.

We have exploited from a synthetic control method. We have determined nine subsectors in the industry sector that Industry 4.0 affected substantially. To construct the synthetic control unit for those sectors, we use the rest of the industry sector.

We have depicted that before Industry 4.0, this share increases in the sectors, except the furniture sector, that we examined. However, while Industry 4.0 positively affects the furniture sector's education ratio, there is a negative impact on the automotive, textiles, and transport equipment sectors. Also, we find no effect on the food sector.

To maintain competitive power, a developing country like Turkey requires a complete Industry 4.0 transformation in all appropriate sectors. Besides, there exists a need to establish transition strategies and methods for each sector. As we noted, this transformation results in a job loss for particular professions. To focus on new professions and new opportunities is of great importance for a developing country. While taking action, governments should simultaneously consider both education and labor market policies.

## Appendix

See Tables 10.3 and 10.4.

**Table 10.3** Treated and synthetic values for sectors

| | Manufacture of textiles | | Manufacture of food products | | Manufacture of motor vehicles, trailers, and semi-trailers | | Manufacture of other transport equipment | | Manufacture of furniture | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Treated | Synthetic | Treated | Synthetic | Treated | Synthetic | Treated | Synthetic | Treated | Synthetic |
| Industry Production Index | 79.6 | 79.1 | 84.8 | 80.0 | 68.1 | 74.2 | 66.3 | 83.8 | 70.4 | 81.1 |
| Turnover Index | 60.1 | 57.9 | 57.9 | 58.6 | 54.1 | 67.6 | 53.7 | 76.9 | 53.2 | 58.8 |
| Labor Hours | 84.9 | 85.1 | 82.4 | 85.7 | 80.2 | 85.7 | 96.1 | 97.3 | 75.0 | 88.4 |
| Gross Wage | 51.4 | 53.8 | 56.9 | 55.3 | 53.5 | 55.2 | 58.9 | 56.6 | 47.2 | 54.5 |
| Education ratio(2009) | 0.01 | 0.02 | 0.03 | 0.03 | 0.1 | 0.1 | 0.1 | 0.1 | 0.01 | 0.02 |
| Education ratio (2010) | 0.01 | 0.01 | 0.03 | 0.03 | 0.1 | 0.1 | 0.1 | 0.1 | 0.02 | 0.01 |
| Education ratio (2013) | 0.03 | 0.03 | 0.04 | 0.04 | 0.2 | 0.2 | 0.2 | 0.2 | 0.01 | 0.01 |
| Education ratio (2014) | 0.03 | 0.03 | 0.04 | 0.04 | 0.2 | 0.2 | 0.1 | 0.1 | 0.03 | 0.02 |

**Table 10.4** Treatment weights using analysis

| | Manufacture of textiles | Manufacture of food products | Manufacture of motor vehicles, trailers, and semi-trailers | Manufacture of other transport equipment | Manufacture of furniture |
|---|---|---|---|---|---|
| B05 | 0 | 0 | 0 | 0.005 | 0 |
| B07 | 0 | 0 | 0 | 0.568 | 0 |
| B08 | 0 | 0.142 | 0 | 0 | 0.279 |
| C15 | 0 | 0 | 0 | 0 | 0 |
| C16 | 0.144 | 0 | 0 | 0 | 0.46 |
| C17 | 0.808 | 0.479 | 0 | 0 | 0.26 |
| C18 | 0.048 | 0 | 0 | 0 | 0 |
| C19 | 0 | 0.113 | 0 | 0 | 0 |
| C20 | 0 | 0 | 0.316 | 0.427 | 0 |
| C23 | 0 | 0 | 0.141 | 0 | 0 |
| C27 | 0 | 0 | 0 | 0 | 0 |
| C28 | 0 | 0.265 | 0 | 0 | 0 |

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# Chapter 11
# The Role of Artificial Intelligence in Health Care


**İpek Deveci Kocakoç**

**Abstract** As the global population ages and longevity increases, health systems around the world are facing significant difficulties in building the workforce required to provide healthcare services due to increasing service demands and increasing innovation costs. The healthcare industry produces large volumes of data, and challenges in cost and patient outcomes are increasing. In order to provide health services in the fastest, most accurate, and highest quality way while also meeting the needs of both patients and healthcare organizations, healthcare professionals must reach the most accurate and up-to-date information and utilize this information by using computerized support systems. For this reason, it is inevitable for healthcare systems to become a structure supported by artificial intelligence that both speeds up and facilitates the way of doing business and provides some basic information and services to patients without being too dependent on the system. Artificial intelligence (AI) aims to mimic human intelligence to perform tasks and can recursively improve itself based on the information it gathers. By increasing the availability of healthcare data and enabling rapid progress in analytical techniques, it brings paradigm changes to healthcare services. Artificial intelligence has been used or tested for a variety of health and research purposes, including management of chronic conditions, workload reduction of doctors and nurses, drug discovery, provision and prevention of health care, diagnosis, treatment of diseases, and patient monitoring. Artificial intelligence has the ability to transform medicine through the role of physicians and nurses and to transform medicine through new science research and delivery models that revolutionize medical practices and enhance person and public health outcomes. Today, artificial intelligence practices are carried out in many private and public health institutions in many countries. In this section, we will discuss in detail the application of artificial intelligence in the modern healthcare system with advantages and possible disadvantages and challenges.

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**Keywords** Artificial intelligence · Healthcare system · Healthcare industry · Machine learning · Optical character recognition (OCR) · Intelligent virtual agent (IVA) · Clinical decision support system (CDSS) · Deep learning · Electronic health records (EHRs) · Robotic surgery

## 11.1 Introduction

Artificial intelligence caused a revolution in our lifestyle; from language and image processing, handwriting recognition, talking and answering human-like robots, weather forecasts, and online search engines to self-driving/driverless cars. The focus of this chapter, "Artificial Intelligence in Health care," is also a massive and maybe one of the core drivers of this revolution. "Artificial Intelligence—AI," in the simplest terms, refers to systems or machines that mimic human intelligence to perform tasks and that can iteratively improve themselves according to the information they collect. It refers to the simulation of human intelligence in computers programmed to think like humans and mimic their behavior. This term can also be adapted to any machine that exhibits features related to the human mind, such as learning and problem-solving.

Artificial intelligence research mainly focuses on the components of human intelligence learning, reasoning, problem-solving, perception, and language use. All methods and technologies that are being developed in order to realize these components in a way that imitates human beings by computers/robots are included in the definition of artificial intelligence. Popular AI techniques include machine learning methods for structured data, such as the classical support vector machine and neural network, the modern deep learning, as well as natural language processing for unstructured data (Jiang et al., 2017).

Artificial Intelligence has been studied by computer scientists for more than 70 years and is one of the most difficult topics in computer science. Although the term "Artificial Intelligence" was invented by John McCarthy in his first workshop at Dartmouth College in 1956, artificial intelligence theory and subjects have a much longer history (Nilsson, 2009).

The healthcare industry produces large volumes of data, and challenges in cost and patient outcomes are increasing. In order to provide health services in the fastest, most accurate, and highest quality way while also meeting the needs of both patients and healthcare organizations, healthcare professionals must reach the most accurate and up-to-date information and utilize this information by using computerized support systems. Artificial intelligence (AI) aims to mimic human intelligence to perform tasks and can recursively improve itself based on the information it gathers. It brings paradigm shifts in medical services by increasing the availability of healthcare data and allowing a quick advance in analytical techniques. A range of health and research uses, including chronic disease management, workload reduction of

physicians and nurses, drug discovery, healthcare provision and prevention, diagnosis, disease management, and patient tracking have been evaluated for artificial intelligence.

Healthcare AI goes back until 1972 with Stanford University's MYCIN, an AI prototype project used to treat blood infections. Early AI research continued to a large extent in the US institutions such as MIT-Tufts, Pittsburgh, Stanford, and Rutgers. In the 1980s, Stanford continued his medical AI studies with the Stanford University Medical Experimental Computer—Artificial Intelligence (SUMEX-AIM) project (IBM Watson Health). Later, applications of AI in health care spread all over the world.

Today, artificial intelligence practices are carried out in many private and public health institutions in many countries. However, global AI in the healthcare market is primarily driven by huge investments by private firms. According to the World Economic Forum, in the year 2018, around 220 artificial Intelligence-based companies mutually invested in AI. Major players in the AI in healthcare market are NVIDIA Corporation (NVIDIA) (US), Intel Corporation (Intel) (US), International Business Machines Corporation (IBM) (US), Google Inc. (Google) (US), Microsoft Corporation (Microsoft) (US), Amazon Web Services (an Amazon.com, Inc. subsidiary) (AWS) (US), General Vision, Inc. (the US), General Electric (GE) Healthcare (US), Siemens Healthineers (Germany), Medtronic plc (US), Johnson & Johnson Services, Inc. (Johnson & Johnson) (US), and Koninklijke Philips N.V. (Netherlands), among others (Marketsandmarkets, 2020).

There are also many organizations for promoting AI in health care. AAIH (The Alliance for Artificial Intelligence in Health care) is one of the biggest organizations in this context. It aims to foster creativity, collaboration, and knowledge sharing to drive AI enabled discovery of novel interventions and product solutions to improve patient outcomes and minimize costs across the entire healthcare spectrum (AAIH, 2020).

As stated in McKinsey & Company's "Transformation of Healthcare with Artificial Intelligence" Report (McKinsey & Company, 2020), as the global population ages and longevity increases, health systems around the world are facing significant difficulties in building the workforce required to provide healthcare services due to increasing service demands and increasing innovation costs. This demographic change, coupled with rapid urbanization, modernization, globalization, and accompanying risk factors and changes in lifestyles, means that chronic conditions will be more common and increasingly the population's demand for healthcare services will increase. Without major structural and transformational changes, health systems will find it difficult to control costs or find the economic support needed to meet increasing demand while maintaining or improving standards of care, access, and patient experience. For this reason, it is inevitable for healthcare systems to become a structure supported by artificial intelligence that both speeds up and facilitates the way of doing business and provides some basic information and services to patients without being too dependent on the system.

Artificial intelligence has the ability to transform medicine through the role of physicians and nurses and to transform medicine through new science research

and delivery models that revolutionize medical practices and enhance person and public health outcomes. It may have some side effects which are improvised in science fiction movies. Robots that harm people, AI forces that conquer the World and enslave people, apocalyptic events caused by AI are all come from human beings' mental image of a human-like, thinking, and—most dangerously—reasoning machine. However, the same human beings are endlessly trying to find ways to train a better thinking and reasoning machine since the potential benefits overcome the potential danger.

AI will encourage improvements in the experience of patients and access to health care. It will improve healthcare professionals' effectiveness and quality of care delivery and allow health systems to offer more and better care to more individuals. Artificial intelligence can enable healthcare practitioners to spend less time directly for the care of the patients which will reduce their burnout by making their work easier. Finally, it can support faster care delivery by speeding up diagnosis time, and helping healthcare systems proactively manage population health, helping allocate resources to where they can have the greatest impact.

In the 2025 global forecast report published by MarketsandMarkets, the market share of artificial intelligence in the global health sector is expected to reach $4.9 billion in 2020 and reach $45.2 billion in 2026. It is foreseen that the largest part of this market share in 2020 will be in the field of machine learning (Marketsansmarkets, 2020).

The general terms and techniques of AI are widely explained through other chapters of this book. In this chapter, the technologies that are related to AI are defined in the context of health care. Then, artificial intelligence applications in health care are explained with some examples. Advantages, possible drawbacks, and potentials in healthcare management are discussed in the last sections.

## 11.2 Key Technologies for AI in Health Care

Artificial intelligence algorithms work with data. The use of advanced technologies to gather the required data from the patient, the environment, the systems, and transfer them to the computer environment by digitizing has enabled great accelerations in AI. Thanks to the technologies that digitize and store the data that human perceives with five sensory organs, the ability of artificial intelligence to imitate human behavior and movements is gradually improving. Data processing, communication, and storage technologies enable more and more resembling the human brain. Many technologies are available in AI, but it is impossible to give every detail in one chapter. Therefore, the most prominent ones will be explained in this subsection.

### 11.2.1 Natural Language Processing (NLP)

Natural Language Processing is a subsection of artificial intelligence that uses natural language to deal with the interaction between humans and computers. NLP's primary aim is to learn, decode, understand, and make sense of human languages in a useful way. NLP is the basis of many cognitive computing applications. Speech recognition, text classification and categorization, named entity recognition (NER), part of speech tagging, paraphrase detection, language generation, semantic parsing and question answering, multi-document summarization, machine translation, character recognition, and spell checking are the main applications of natural language processing among many (Fahad & Yahya, 2018).

In the healthcare context, NLP can be expressed as artificial intelligence applications that understand what computers and clinicians are talking about and what they want. As AI continues to prove itself in more and more areas of the healthcare industry, some of these applications promote NLP.

Due to the ability to scan, evaluate, and interpret vast volumes of patient data sets, the use of NLP in health care is growing. It allows human communication, understanding the intent of voice, text, deciphering different languages, and reacting in a way that imitates human expression, acting like chatbots, and digitizing health records. In order for the source material, such as medical literature, clinical notes or voice dictation records to be automatically transferred to the computer, the computer understands what is written, spoken, or otherwise transmitted. Among healthcare professionals who are fed up with the burden of data entry, speech recognition systems are commonly used to rapidly send voice recordings to the machine. Text-based NLP programs are also beginning to find applications in the clinical field. Static text, such as a PDF picture of a laboratory report or a handwritten clinical note, can be translated into computable data using optical character recognition (OCR) technology. When voice or text data is transferred to the computer in an appropriate format, the algorithm parses the meaning of each item to complete a task, such as translating into a different language, saving or querying the database, summarizing information, or responding to a speech partner.

Companies such as Attivio, Automated Insights, Basis Technology, Cambridge Semantics, Digital Reasoning, Expert System, Coveo, Indico, Knime, Lexalytics, Linguamatics, Lucidworks, Mindbreeze, Narrative Science, NICE, Nuance Communications, OpenText, Sinequa, Stratifyd, Synapsify, SAS, Verint Systems, and Yseop offer NLP-based services such as natural speech recognition and natural language generation.

### 11.2.2 Machine Learning (ML)

ML is a framework that can study and examine the work and creation of algorithms that can make assumptions about data as a structural function. Instead of strictly following static program instructions, these algorithms operate by creating

a model to make data-based decisions and predictions from sample inputs. The key to machine learning is to create algorithms that can take input data and predict an output by using statistical analytics when new data occurs as the output is updated. Machine learning can be examined in three general categories: supervised, unsupervised, and reinforced learning. ML methods include linear regression, least squares method (for numerical data), logistic regression (for binary classification), linear discriminant analysis (for multi-category classification), decision trees (for classification and regression), naive Bayes (for classification and regression), K—nearest neighborhood, K-NN algorithm (for classification and regression), Learning Vector Quantization—LVQ (for classification and regression), support vector machine—SVM (for binary classification), random forests, (for classification and regression) (Digitaltechglobal, 2019), and many more.

The value of machine learning in health care is its ability to process huge datasets beyond the scope of human capability and then reliably convert analysis of that data into clinical insights that aid physicians in planning and providing care, ultimately leading to better outcomes, lower costs of care, and increased patient satisfaction (Corbett, 2017).

Algorithms are readily useful in such fields as radiology, cardiology, and pathology that have broad image data sets and reproducible or structured processes. Machine learning can be trained to improve the accuracy of all these processes in order to display the images and recognize anomalies and point to areas that need attention. The doctor or intern at the bedside can benefit from long-term machine learning. Machine learning can offer an unbiased opinion in order to improve performance, reliability, and precision.

There are many applications of ML in health care. Google has an ML algorithm to help classify cancerous tumors on mammograms through image recognition and classification. Stanford is using a deep learning algorithm to identify skin cancer (Corbett, 2017). ML allows pre-recognition of diseases and personalized treatment strategies to guarantee ideal results. By the help of ML, the determination of possible diseases and possible outcomes to patients, and similar treatment options are easily communicated. In addition, it will positively affect healthcare structures in increasing competence, while reducing costs.

Machine learning platforms are also becoming more popular by providing help on algorithms, APIs (application programming interfaces), training tools, big data, and applications. They are commonly used for categorization and prediction purposes. Some companies that offer machine learning platforms include Adtext, Amazon, Fractal Analytics, Google, H2O AI, Microsoft, SAS, and Skytree (Adext AI, 2019).

### *11.2.3 Virtual Agents*

Virtual agents refer to a computer/machine agent capable of interacting with humans efficiently. A virtual agent (sometimes referred to as an intelligent virtual agent [IVA], virtual rep, digital agent, or chatbot) is a software program that uses scripted rules

and, increasingly, applications of artificial intelligence to provide human beings with automated service or guidance. Virtual agents are most widely used by companies to address regular customer questions, meet standard requests, and/or manage basic issues in their customer service functions. Virtual agents, for example, are mostly used for initial customer encounters with call centers or on websites for click-to-chat functionality.

The healthcare sector primarily uses virtual health agents to enhance clinical workflows and enable medical professionals to handle low-value routine functions such as accessing patient records, providing therapeutic guidance and knowledge, maximizing patient releases, tracking the recovery process, and providing a proper nonclinical service. Meticulous Research® (2020) states that, in 2018, the global healthcare virtual assistants market was valued at $376.8 million. This market is projected to reach $1,767.0 million by 2025, growing at a CAGR of 24.7% during the forecast period of 2018–2025.

Companies that provide virtual healthcare agents are CSS Corp., eGain Corp., idAvatars, Kognito, MedRespond, Microsoft, Next IT Corp., Nuance Communications, True Image Interactive, and Welltok. Companies such as Amazon, Apple, Artificial Solutions, Assist AI, Creative Virtual, Google, IBM, IPsoft, and Satisfi also provide general virtual agent solutions (Adext AI, 2019).

### *11.2.4 Decision Management/Clinical Decision Support Systems (CDSS)*

A clinical decision support system (CDSS) is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information (Osherof et al., 2012). A common use of CDSS is to review data from past, present, and new patients and to detect or recommend user weaknesses, mistakes, safety problems, or changes to the care pathway. The tools of CDSS are capable of reviewing vast quantities of data and recommending the next steps for treatment, flagging possible issues, and improving the performance of the care team. IBM's Watson Health is an example of such a system.

For clinicians and hospital and practice administrators, CDSS may bring several benefits. Doctors and nurses, for example, can introduce or alter rules to help them with the adoption of new rules and procedures. By retaining quick access to vast collections of rare disorders, medications, and complications, CDSS may also offer very useful assistance to nurses and doctors especially in times of pandemics like COVID-19 and Ebola.

CDSS has many functions and advantages for health care (Osherof et al., 2012; Sutton et al., 2020): Patient safety by reducing the occurrence of medication/prescribing mistakes and adverse effects, health management by adhering to clinical guidelines, follow-up and treatment reminders, etc., Cost management by minimizing test and order duplication, recommending cheaper drug or treatment alternatives, automating time-consuming steps to reduce the workload of the provider, etc., administrative function/automation by diagnostic code collection, automated documentation and notice auto-filling, diagnostic help by patient-based diagnostic feedback, automation of test results production, support for decision-making for patients via personal health records (PHR) and other programs, enhanced reporting, and workflow enhancement.

CDSS can be very useful because such systems are consistent and ever-vigilant. They are not susceptible to negligence, fatigue, training lapses, data overload, and/or distractions (Sloane & Silva, 2020). At the same time, we must also discuss the possible drawbacks of CDSS, from the possibility that they simply do not function and waste money to exhaust providers and impact patient quality. The major players in this market include Allscripts Healthcare Solutions, Conifer Health Solutions, VisulaDx, Cerner Corporation, Epic Corporation, Healthagen, Health Catalyst, McKesson Corporation, and Zynx Health.

### *11.2.5 Intelligent Decision Support Systems (IDSS)*

Intelligent decision support is provided by a system that helps in decision-making through a display of intelligent behavior that may include learning and reasoning. Such learning and reasoning can be achieved by implementing rule-based expert systems, knowledge-based systems, or neural network systems (Viademonte & Burstein, 2006).

IDSSs are capable of supporting clinical decision-making at the patient and community level, by routinely interpreting and tracking patient data, supporting chronic disease management through benchmarks and warnings, supporting tracking of public health through pandemic detection or chronic monitoring, ongoing support for decision-making. Another area of use of IDSS is intelligent agents.

### *11.2.6 Deep Learning*

The deep learning mechanism is part of a larger artificial neural networking family of machine learning methods. It unveils enormous amounts of unstructured data that normally take decades to grasp and process. In deep learning, a computer model learns how to classify sound, text, and medical images in particular. Deep learning models, often exceeding human-level efficiency, may achieve state-of-the-art precision. These methods have dramatically improved the latest technology in speech recognition,

visual object recognition, object detection, and many other domains such as drug discovery and genomics (Lecun et al., 2015).

The word "deep" commonly refers to the number of hidden layers in the neural network. Only 2–3 hidden layers are used in conventional neural networks, while deep networks may have as many as 150. In machine learning, sorting images, features, and the classifiers are chosen manually. Feature extraction and modeling phases are automated with deep learning.

Deep learning allows the healthcare industry to interpret data without compromising precision at extraordinary speeds. From cancer and tumor detection to customized medicines developed uniquely for the genome of an individual, many of the largest pharmaceutical and medical companies pay attention to deep learning in the medical field. In health care, sequential deep learning and language technologies power applications within domains such as electronic health records (EHRs) (Estava et al., 2019). In EHR systems, researchers can use data to build deep learning models that predict the probability of certain health-related effects, such as the likelihood that a patient may develop a disease. The fields in which deep learning is shown to be useful include virtual agents, translators, automated cars, chatbots, NLP, face and image recognition, drug discovery, and precision medicine. Some deep learning platform providers include Deep Instinct, Ersatz Labs, Fluid AI, Leverton, MathWorks, Peltarion, Saffron Technology, and Sentient Technologies (Adext AI, 2019).

### *11.2.7 Computer Vision and Image Recognition*

The health sector today relies heavily on precise medical diagnostics. Medical imaging consists of a collection of processes or techniques in clinical surveillance and diagnosis of illness and injury, with which the body's internal regions, such as organs or tissues, are visually represented. Computer vision is basically trying to perform tasks or functions that a person can do visually in a computerized environment. It is the process of making a decision based on the results of digital health images or video images in a way that the human can decide. Computer vision uses the methods of creating, processing, analyzing, and making sense of the digital health images in order to produce information numerically or symbolically on the image.

Some major areas where computer vision and image recognition are utilized are the detection of tumors, cancer, Alzheimer's and Parkinson's diseases, diabetic retinopathy, histological and microscopic elements, gastrointestinal diseases, and cardiac problems (Dutta, 2020) and also surgical planning.

IBM Watson, Butterfly Network, Arterys, Gauss Surgica, Zebra Medical Vision, Sigtuple, Freenome, Enlitic, Caption Health, Behold.ai, Viz.ai, DiA Imaging, RetinAi, Subtle Medical, BrainMiner, and Lunit are among many companies that produce computer vision and digital health imaging solutions.

## 11.3 Applications of AI in Health Care

The growing number of healthcare AI applications enables us to make real a future in which data, research, and creativity work together to assist countless patients and healthcare staff without ever realizing it. Currently, the areas where AI has made the most progress are those with a large amount of standardized knowledge where the problem to be solved is well understood or easy to identify (image recognition, translation of language, etc.). Other application areas are finding their path incrementally by the leverage of the advancements in both algorithms and technology.

### *11.3.1 Identifying Diseases and Diagnosis*

Healthcare systems are rapidly being overburdened, under-resourced, and not prepared for the challenges they face, with rising populations and increased life expectancy. Scientists have been focusing on AI models that forecast the probability of diseases or assist in early disease detection. Researchers mainly focus on the region of major three diseases: cardiovascular disease, nervous system disease, and life-threatening cancer also (Datta et al., 2019).

### *11.3.2 Drug Discovery and Manufacturing*

AI can be used at all stages of new drug development, including the design of drug chemical/protein structures, target validation, drug safety investigation, and clinical trial management. In drug discovery, AI will not only help to drastically reduce the cost of promoting new products but also will make the process of drug discovery quicker and more cost-effective.

### *11.3.3 Medical Imaging Diagnosis*

Possibly the biggest data source in the healthcare industry is medical images. AI algorithms at rapid speeds can process large quantities of medical images. Also, they can be trained to be extremely accurate in recognizing very tiny details in CT scans and MRIs.

AI-based analysis of medical imaging reports has been developed by companies such as Enlitic, Sophia Genetics, and Zebra Medical Vision that can detect malignancies or anomalies with a higher rate of accuracy than healthcare professionals.

### 11.3.4 Precision Medicine

In the field of precision medicine, therapies and prevention are designed specifically for each person by determining which approaches would be successful for patients based on their personal genetic, environmental, and lifestyle factors. In order to help choose the right, personally tailored medical treatment for diseases from cancers to depression, AI systems have been designed to analyze different data sources, such as patient EHR notes and reports, sensor and wearable data, external environmental and lifestyle data, and clinical expertise.

### 11.3.5 Robotic Surgery

AI-based techniques can increase the precision of surgical instruments by integrating real-time data, input from previous successful operations, and data from electronic medical records. This will help minimize human error and assist general surgeons in resource-limited environments lacking experts to conduct complex surgeries. The robot contains 3D cameras and various surgical instruments that mimic the movements of the surgeon. This allows the surgeon to conduct complicated procedures with greater precision and greater control over the instruments. Often the robot's arms can be operated from a computer console, even miles away from the surgery area. Thus, treatments can be performed with surgical robots in places where the physician is not physically present at any time. In case of a wrong move, the robot warns or suggests the surgeon using his previous knowledge.

### 11.3.6 Electronic Health Records—EHR

In the first phase of healthcare information, EHR (e.g., medical records and background history) is collected and checked. The outcomes of clinical and administrative interactions between a physician (doctor, nurse, triage nurse, and others) and a patient occurring during patient care episodes are found in an electronic health record (EHR) or personal health record (PHR). It is an extensive task to maintain up-to-date health records, and while technology has played its part in easing the process of data entry, the fact is that even now, most of the procedures require a lot of time to complete. In health care, the key function of AI is to promote processes to save time, effort, and money. In order to provide quicker, more reliable access to medical data, AI-based robots capture, store, re-format, and trace data stored in EHR. It is beneficial for both patients and doctors. Patients have an always up-to-date, correct, full, and ready to reach health record, while doctors have a reliable data entry and retrieving medium.

Both AI and EHR benefit from each other. Most of the AI applications are being possible by the processing of information in EHRs such as personalized medicine and

imaging diagnosis, while EHRs are being possible by AI technologies such as data extraction from free text, diagnostic, and/or predictive algorithms, digitized clinical documentation and data entry, and CDSS. Governments use AI on EHR for public health. The AI system gathers useful information from a large patient population through the investigation of EHRs to assist in real-time inferences for health risk alert and prediction of health outcomes of the population.

Future EHRs will also be in integration with telehealth technologies, Smart Health Record applications, which are the next step of EHR in mobile phones, smart patient cards, and smart forms.

### *11.3.7 Doing Repetitive Jobs*

Cardiology and radiology are two fields in which it can be difficult and time-consuming to evaluate the volume of data. AI-based algorithms can analyze all examinations, X-Rays, CT scans, and other routine tasks quicker and more accurately. In the future, cardiologists and radiologists, and other specialists can only look at the most difficult cases in which human intuition is beneficial.

### *11.3.8 Telehealth, Telemedicine, and Digital Consultation*

Telehealth is the use of electronic information and telecommunication technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration employing technologies such as video conferencing, the internet, store-and-forward imaging, streaming media, and terrestrial and wireless communications (HRSA, 2020). Telehealth is not a single service, but a set of strategies for improving the quality of patient care and education. Telemedicine/Teleconsultation is a particular form of telehealth that requires a clinician to deliver some kind of medical services remotely in real-time.

Mobile or web applications such as Babylonhealth offer digital medical consultation with the help of AI. Users enter their symptoms to the application by video, voice, or writing and the AI-based decision system equates them with a disease database. The app then provides a suggestion such as treating it at home or going to the hospital, taking the medical history of the consumer into consideration. There are many digital consultation services and symptom checkers available, mostly working subscription-based. American Well, Doc+, Dr Fox Pharmacy, eConsult, and MDLIVE, to name a few.

### 11.3.9 Virtual Nurses and Virtual Medical Assistants

Computer-generated tools that are used to provide care for patients are called virtual nurse avatars, also referred to as relational agents. These avatars are capable of replicating nursing behaviors and performing different nursing activities, such as providing information to patients, evaluating patient health status, and displaying compassion-related behaviors, such as nodding in agreement. Among medical appointments, a virtual nurse helps patients monitor their health and follow-up on treatments. The software uses machine learning, which specializes in chronic diseases, to help patients.

Virtual medical assistants especially support physicians, where they lose a lot of time, with medical writing and documentation. Virtual medical assistants can be examined in three groups: those used to navigate medical records (e.g., Nuance and Suki), those used for medical record-keeping (e.g., Robin Healthcare), and those used for medical information search (e.g., MedWhat).

### 11.3.10 Health Monitoring

Since using AI to monitor patient health remotely is an integral part of diagnostics, the demand is fastly increasing for AI-powered wearables and equipment for remote patient monitoring. Remote health monitoring devices such as activity trackers, watches, smart clothes, heat sensors, smart patches, drug detection and control systems, heart monitors, and respiratory monitors send the data to an AI-based monitoring system to detect, diagnose, and prevent disease or illness.

### 11.3.11 Healthcare System Analysis and Management

Both private and public health enterprises struggle with a huge administrative burden that costs hundreds of billions of dollars a year. Many of these administrative costs result from administrative problems such as fraud, waste and abuse, low value-added business practices, and lack of cooperation among stakeholders. Machine learning and artificial intelligence applications help reduce costly, time-consuming manual processes, and change the cost-quality curve in health care. AI is utilized heavily for a large range of healthcare management applications, including clinical reporting, patient communication and management, payment administration, management of sales cycles, and management of medical records. Here, AI works not only on medical patient data but all clinical data of the healthcare institution including nurse scheduling, appointment schedules, electric consumption, payment and debt reports, etc. AI sifts the data to illustrate medication failures, process inefficiencies, and helps prevent unnecessary hospitalizations of patients in healthcare

systems. As the AI hospital management system continuously gathers real clinical data, machine learning will continue to evolve to refine its features for the continuous improvement of the healthcare organization in the long term.

Insurance companies also get great benefits from AI. Reliably identifying, analyzing, and correcting coding issues and incorrect claims save all stakeholders—health insurers, governments, and providers alike—a great deal of time, money, and effort (Davenport & Kalakota, 2019). EHFCN (European Healthcare Fraud and Corruption Network—European Health Fraud and Corruption Network), in a report published in 2019, stated that many gains have been achieved through the use of statistical analysis and machine learning in the prevention of health fraud in member states (EHFCN, 2019).

AI is also used effectively in health marketing. The first step to delivering a targeted message is the analysis of patient behavior with AI. With AI, information is obtained from laboratory results, hospital records, and the patient's internet use. By processing this information, marketing communication is adjusted according to the needs of the target audience and unnecessary negotiations are prevented.

### *11.3.12 Outbreak Prediction*

AI-based technologies are being utilized in tracking and forecasting epidemics like COVID-19 around the world. Scientists today have access to a vast number of data obtained from government agencies, satellites, social media notifications in real-time, website information, etc. Artificial neural networks help collate this data and predict everything from outbreaks of viral infections to serious chronic infectious diseases.

## 11.4 Drawbacks and Ethical Issues

AI requires a considerable amount of data to produce an efficient algorithm. AI results are just as good as the data sets for which the machines are trained. AI systems may be built with prejudices that will have to be understood and mitigated. The substantive value of justice may be considered if evidence emerges of systematic biases being built into the programming of the AI algorithms that prejudice and disadvantage certain social groups (Lysaght et al., 2019). A lack of diversity in the datasets used for medical AI training might lead to biased discrimination of algorithms against under-represented populations. Being a minority, gender, and race must be correctly and proportionally represented in training data.

There are some legal problems that arise with the use of black-box algorithms, such as medical malpractice and product liability because we cannot provide a logical explanation of how the algorithm has made its given decision. The current challenges

in AI include this legal liability and attribution of negligence when errors occur, and the ethical issues relating to patient choices (Loh, 2018).

The added risk to the privacy and confidentiality of patients is another issue. Another one of the major concerns about AI-assisted CDSS is how the machines reach decisions, and whose decision should prevail when there is a disagreement between the CDSS and the medical professional (Lysaght et al., 2019). Examining the boundaries between the role of doctors and the role of computers in patient care is still in discussion.

There are at least four types of barriers to the uptake of virtual communication between patients and physicians and between physicians and other providers: (i) The lack of regularization in the governance of compensation mechanisms and the social inequality of virtual care provided by the private sector for a fee, (ii) Regulatory barriers (electronic signature is not a common and widespread application in public) and the problem of licensing in virtual care delivery across provincial borders, (iii) The issue of the protection of email messages, particularly between doctors and patients, (iv) "Digital gap" arising from ethnic and socioeconomic gaps in access to health services.

## 11.5 Conclusions

The assumption that automation can affect only the work of a Blue Collar which demands more manual, repetitive, and less analytical behavior, gives us a false sense of security. Health has been a very late adopter of electronic systems compared with other sectors, such as hospitality and airlines. Similarly, although AI is now utilized in a range of technical equipment such as smartphones and games, this utilization remains limited in the leading edge of clinical practices. However, research is still developing in this area exponentially.

With the incorporation of AI in applications such as data processing, medical imaging, drug production, treatment plans, health assistance, and medication management, precision medicine, and consulting, the healthcare industry is undergoing a technological revolution. Diagnosis and medical care can be easily accomplished, with less time, accuracy, and less human intervention. In order to direct the medical practitioner and establish accountability between patients and physicians, AI processes will require extensive use of data interpretations to integrate human intelligence into the computer system.

There are several significant advancements that have the potential to revolutionize medicine and healthcare delivery; the use of electronic means by virtual care to minimize or eliminate face-to-face interaction; the ability to analyze vast amounts of different types of data from a variety of sources that are continuously generated by big data analytics.

In their processes and service delivery, governments are already introducing AI to increase productivity, save time and money, and provide higher quality public

services. The 2019 Government AI Readiness Index, which is conducted by Canadian International Development Research Centre (IDRC), is comprised of 11 input metrics, grouped under four high-level clusters: governance; infrastructure and data; skills and education; and government and public services. Singapore, UK, Germany, the USA, and Finland have the top five positions. As might be expected, the upper rankings of the index are dominated by countries with strong economies, good governance, and innovative private sectors, most of which are countries in the Global North (IDRC, 2019). Strategists and politicians should take steps not to further consolidate or intensify global disparities through AI.

AI transformation is happening now, and it can provide governments and healthcare organizations with a range of benefits. It is very important to improve AI applications by analyzing the real requirements and to balance the AI costs with the gains from the AI applications, without being attached to the popularity of AI. Healthcare managers and decision-makers should invest in AI by taking into account the expectations of the community and stakeholders and their level of knowledge about AI and related technologies. In order to incorporate AI solutions effectively, it should be ensured that the stakeholders communicate priorities, concerns, and aspirations and that they are dealt with legal, moral, and adequately. Strong patient and customer engagement is required for this.

There is no question that AI will have widespread effects that will revolutionize the practice of medicine, change the experience of patients, and the everyday practices of doctors. Even so, there is a lot of work to do to lay the right ethical and socioeconomic groundwork for the secure, equal, and efficient use of AI technology in health care. As the legislation and policies on AI healthcare systems change over time, it will also be important that the quality of health care be improved through the work of all stakeholders, such as payers, patients and families, politicians, diagnostic producers and providers, doctors, academics, and others.

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# Chapter 12
# An Overview of New Generation Bio-Inspired Algorithms for Portfolio Optimization

**Hilal Arslan, Onur Uğurlu, and Deniz Türsel Eliiyi**

**Abstract** Bio-inspired computing is one of the foremost subfields of artificial intelligence, which aims to tackle complex optimization problems. The main advantage of bio-inspired algorithms over traditional methods is their searching ability. Portfolio selection is a popular optimization problem in economics and finance. It aims to find an optimal allocation of capital among a set of assets by maximization of return with simultaneous minimization of risk. Since the portfolio optimization problem is NP-hard, a large number of researchers have resorted to bio-inspired algorithms to deal with the computational complexity. This study provides an overview of the new generation bio-inspired algorithms from the recently published literature for portfolio optimization. Besides, opportunities for future research within this area discussed.

**Keywords** Portfolio optimization · Evolutionary algorithms · Bio-inspired algorithms · Artificial intelligence · Metaheuristics · Financial prediction and planning · Swarm intelligence · Artificial Bee Colony · Cuckoo Search · Firefly algorithm

## 12.1 Introduction

Different capital markets always have different and variable risks and profits. Risk management and profit estimation are some of the main important factors for most investors. Portfolio optimization (PO) deals with determining an optimal strategy

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for allocating resources among a number of investment opportunities to achieve an optimal risk-profit trade-off. The main objective of PO is to establish an investment plan that maximizes the overall gain and minimizes the total risk of losing resources. This way, the investors may have a balanced and safe investment portfolio across various markets, which is usually called efficient portfolio based on the distributed investments. Generally, distributing the investments across different markets reduces the risk of capital loss, but an efficient plan should also increase the estimated profit. For example, assume that an investor wants to invest in three markets, say A, B, and C, with the following probabilities: Market A may provide 15% profit but has 15% risk of losing the invested money; Market B may provide 70% profit but has 85% risk of loss; and market C provides 3% profit and has 1% risk of losing the investment. In this case, the problem is finding the best plan to distribute the fund between these 3 markets.

Exploring an optimal stock portfolio is a difficult task that can be formalized as a risk minimization problem. The portfolio risk is usually estimated as the variance of profits, but several other factors can also affect this risk. For example, something may happen to the invested company that may cause the loss of the value of the investment. As another risk some political decisions may change the laws of the country and put the investment in pressure or reduce its value. Generally, optimization models have a wide range of applications in the financial domain. One of the feasible and efficient methods for solving these optimization problems is the use of bio-inspired algorithms. These algorithms have great power to solve complex optimization and many other problems in different areas, as well.

In this chapter, we provide a formal definition of the PO problem, present its mathematical formulation and real-life constraints. Next, we give an overview on the new generation bio-inspired algorithms for PO, and review these methods by discussing their characteristics, advantages, and adequacy. The remaining parts of this chapter are organized as follows. Section 12.2 presents the models and the constraints for the PO problem. Section 12.3 describes the traditional bio-inspired algorithms and their applications on PO. Section 12.4 provides an overview of the popular state-of-the-art bio-inspired algorithms to solve the PO, whereas Sect. 12.5 summarizes recent bio-inspired algorithms that attracted relatively less attention. Finally, in Sect. 12.6, opportunities for future research within this area are discussed.

## 12.2 Portfolio Optimization Models

The PO problem is a standard financial engineering problem. The goal is to find the best portfolio among a range of assets by minimizing risk and maximizing return on investment. The first solution framework for PO was presented by Markowitz (1952) proposed a mathematical formulation, namely the Mean-Variance (MV) Model for the problem. The MV model uses the expected returns of a portfolio as the investment return and the variance of the returns of the portfolio as the investment risk. To evaluate the portfolio risk, the model uses the variance of the stock prices.

The basic assumption of the model is that the expected returns have a symmetric multivariate normal distribution. Given $n$-assets, the classical MV model is given below (Rifki & Ono, 2012):

$$\min \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij} \tag{12.1}$$

$$\max \sum_{i=1}^{n} w_i m_i \tag{12.2}$$

subject to

$$\sum_{i=1}^{n} w_i = 1 \tag{12.3}$$

$$0 \leq w_i \leq 1, \forall i \in [1, n] \tag{12.4}$$

In the above model, $m_i$ is the expected return of the asset $i$, $\sigma_{ij}$ are the elements of the covariance matrix, and $w_i$ is the weight assigned to asset $i$. Constraint (12.3) satisfies that the sum of all assets weights equals to 1, while Constraint (12.4) defines the range of $w_i$. The MV model has two objective functions as maximizing the sum of the expected returns and minimizing the sum of the portfolio variance. All feasible solutions of this model describe a curve in the plane called the efficient frontier. An alternative model, which is known as the Efficient Frontier (EF) model or Single Objective Function (SOF) model, uses only one objective function via a scalarization of the objectives in (12.1) and (12.2). The EF model is given below (Rifki & Ono, 2012):

$$\max \lambda \sum_{i=1}^{n} w_i m_i - (1 - \lambda) \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij} \tag{12.5}$$

subject to (12.3) and (12.4).

In this model, the parameter $\lambda$ is used as the risk aversion indicator $\lambda \in [1, n]$. Essentially, $\lambda$ controls the relative significance of the expected return to risk. $\lambda = 1$ indicates that the return of the portfolio is maximized regardless of the risk. Similarly, $\lambda = 0$ indicates that the risk of the portfolio is minimized without considering the return. In other words, when the parameter $\lambda$ increases, the objective of maximizing the expected return becomes more significant.

The MV model can be solved using quadratic programming in the case of linear constraints. To avoid the computational difficulties of the quadratic structure of the MV, linear programming models with alternative risk measures were proposed by

several researchers. Konno and Yamazaki (1991) introduced the mean absolute deviation (MAD) as an alternative risk measure. Since their models do not use the covariance matrix, they have less computational cost. Young (1998) proposed a model (MM) based on game theory, which maximizes the minimum return or minimizes the maximum risk. In the MM model, the risk measure is asymmetric; therefore, it can be claimed that the MM is more appropriate than the MV and MAD for log-normal distributions. Another popular alternative risk measure is the value-at-risk (VAR) (Jorion, n.d.), which has been used in numerous works. The VAR represents the expected maximum loss on a portfolio with a certain confidence level 100(1-$\alpha$).

If the evaluation of risks, when the decision-making process are restricted to a one-time period, a single-period model is used for PO (Konno & Yamazaki, 1991; Markowitz, 1952; Young, 1998). Markowitz (1959) studied multi-period models, in which the portfolio may be readjusted several times during the planning horizon (Dantzig & Infanger, 1993).

### *12.2.1 Real-Life Portfolio Constraints*

The real-life financial market problems may include some nonlinear constraints such as the Floor-ceiling constraints (Speranza, 1996), cardinality constraints (Bienstock, 1996), minimum transaction lot constraints (Konno & Yamazaki, 1991), and the inclusion of transaction costs in the formulations (Magill & Constantinides, 1976). If these constraints are taken into account, the problem becomes NP-hard. Below we explain each of these constraints.

***Floor-ceiling constraints:*** In real-life applications of PO, some assets may have lower and/or upper bounds. This type of constraints can be constructed as follows:

$$l_i \leq w_i \leq u_i, \forall i \in [1, n] \tag{12.6}$$

where $l_i$ and $u_i$ are the lower and the upper bounds on the weight of assets $i$, respectively.

***Cardinality constraints:*** In some real-life applications, there may be an upper bound on the number of selected assets for a portfolio. This type of constraints can be shown as follows:

$$\sum_{i=1}^{n} s_i \leq K \tag{12.7}$$

where $K$ is a predefined positive integer and $s_i$ is a binary variable indicating whether the asset $i$ is selected for the portfolio or not.

***Minimum transaction lot constraints:*** In many real-life applications, the amount purchased for an asset must be a multiple of the minimum transaction lot. For example, if 50-share is the minimum lot for an asset, then the amounts that can

be purchased should be multiples of this lot, such as 50, 100, 150, or 200. Thus, $w_i$ is stated with the following constraint:

$$w_i = \frac{x_i\, p_i}{\sum_{i=1}^{n} x_i\, p_i}, \forall i \in [1, n] \tag{12.8}$$

where $p_i$ is a lot purchasing price and $x_i$ an integer number of lots that should be purchased.

***Transaction costs:*** To make the PO problem more realistic, transaction costs must also be considered. In any financial market, transaction costs such as commissions and taxes must be paid for purchases or sales. These costs may be fixed costs or proportional costs (Woodside-Oriakhi & Beasley, 2013).

## 12.3 Classical Bio-Inspired Algorithms in Portfolio Optimization

This section includes brief information about the well-known and relatively older bio-inspired population-based algorithms. We discuss only the recent studies adapted for solving the PO problems. For detailed information, the reader can refer to studies (Ertenlice & Kalayci, 2018; Gill & Buyya, 2019).

The Genetic Algorithm (GA) introduced by Holland (1975) is an evolutionary algorithm derived from natural selection and genetics. It applies the "survival of the fittest" rule to choose individuals and reproduce the next generation to solve complex design optimization problems, including continuous and discrete variables and nonlinear objective (cost) functions. The GA begins with building a random population of chromosomes corresponding to a possible solution in the solution space of the problem. The chromosomes are evaluated based on a fitness function, which represents the accuracy of a solution. Crossover, mutation, and selection operators are used to produce the next generation. The method stops when either the number of iterations reaches a predefined limit or the best fitness value does not change significantly in successive generations. The recent GA-based studies for solving the PO problem use different techniques such as clustering (Cheong et al., 2017; Mukhopadhyay & Chaudhuri, 2019; Yusuf et al., 2019), grouping (Chen et al., 2019), funds standardization (Chou et al., 2017), single index model (Madarash-Hill & Hill, 2004), symbolic aggregate approximations (Sun et al., 2014), and crowding distance (Kessaci, 2017).

The Particle Swarm Optimization (PSO) method similar to the GA is a population-based bio-inspired algorithm and was introduced by Kennedy and Eberhart (1995). It is based on observations of a social behavior, in which group members incline to follow the best member in the group. Group members called as particles are generated randomly as in GA. Each particle has a velocity dynamically adjusted with respect to its own experiences and the other particles and flows through the search space (Del Valle et al., 2008). Each particle has a fitness value and the particle with the greatest

fitness is called the global solution of the population. Generations are formed by updating the fitness values of the particles based on their velocities and positions.

Zhang (2020) proposed a PSO approach to solve the PO problem. Kaucic (2019) considered a mixed-integer programming formulation for PO and developed an improved multiobjective PSO using a repair mechanism and different constraine domination principles. Rangel-Gonzalez et al. (2020) presented a fuzzy multiobjective PSO, which is based on an auto-tuning fuzzy controller. Almahdi and Yang (2019) proposed a combination of recurrent reinforcement learning and PSO with a Calmar ratio for PO. For more comprehensive explanation of recent PSO approaches for PO, the reader can refer to (Thakkar & Chaudhari, 2020).

The Ant Colony Optimization (ACO) was introduced by Dorigo et al. (2006) as a successful bio-inspired algorithm. The algorithm is inspired by the foraging behavior of the ant colonies. Ants begin randomly searching for possible food sources due to lack of information about the neighboring environment. When they meet a food resource, they transfer some of the food back to their nest. On the road back, each ant emits a chemical substance called pheromone, determining the quantity and quality of the food resource. Thus, chemical traces are modeled in each path of the ant. However, the chemical evaporates as time passes. Only strong pheromone traces, which are roads with high-quality food sources, manage to survive. As a result, every ant in the nest tend to continue the road or roads with a large amount of pheromones on it. This type of indirect communication is called stigmergy.

The ACO algorithm was originally designed for solving the well-known travelling salesman problem in operations research. Dorigo and Blum (2005) studied on discovering the behavior of ACO as well as proving its convergence capability. Following the proven performance of the ACO algorithm, various adaptations for solving challenging problems were immediately proposed in the literature. Subekti et al. (2018) used the ACO algorithm in portfolio construction. They aimed to help the investor in choosing of assets in the portfolio using a clustering method. Their proposed ACO algorithm offered different strategies to combine securities. Abolmaali and Roodposhti (2018) proposed another ACO for solving the constrained portfolio selection problems. By combining critical components from bio-inspired algorithms, Kalayci et al. (2020) proposed a hybrid bio-inspired algorithm to solve the PO problem with a cardinality constraint. They combined ACO, GA, and artificial bee colony optimization algorithms in their study. Their numerical results confirmed the efficiency of the introduced hybrid method on publicly available benchmark problems.

## 12.4 New Generation Bio-Inspired Algorithms in Portfolio Optimization

In this section, we give an overview of more recent bio-inspired algorithms for solving the PO problems, which have attracted the attention of many researchers. We provide

the details about the origin, inspiration, and the flow of each algorithm, as well as their state-of-the-art applications on solving PO problems.

### *12.4.1 Artificial Bee Colony Optimization*

Artificial Bee Colony Optimization (ABCO) is a population-based bio-inspired algorithm that was introduced by Karaboga (2005). It was motivated by the foraging behavior of the bees. There are three different kinds of bees in the ABCO algorithm; namely, the scout, employed, and the onlooker bees. The employed bees look for food neighboring the food source, and they share their knowledge with the onlooker bees by dancing. The onlooker bees pick the good food resources defined by a fitness function. The scout bees discover the food resources. The fundamental steps of the algorithm were defined in (Karaboga, 2005). Karaboga and Basturk (2008) compared the performance of ABCO with GA and PSO, and they concluded that ABCO had better performance on the optimization of several multi-variable functions.

Ge (2014) proposed an ABCO algorithm to solve a nonlinear PO problem. They introduced a cardinality constraint in a semi-variance model. Their cardinality constraints guaranteed that the total number of assets selected in the portfolio was less or equal to a given constant value. The efficiency of the proposed ABCO was presented through several numerical examples. Bacanin et al. (2014) developed an ABCO algorithm for solving the constrained PO problem using an efficient constraint handling method. They compared their proposed algorithm with GA and the firefly algorithm and concluded that the ABCO algorithm could effectively solve PO problems. Suthiwong and Sodanil (2016) proposed an improved version of ABCO by introducing the concept of Gbest direction in the employed bee phase. On the other hand, Chen (2015) proposed another ABCO algorithm for solving the constrained PO problem. Their experimental results showed that the proposed algorithm outperformed the classical ABCO and other heuristic algorithms such as GA and PSO.

Chen et al. (2012) proposed another ABCO algorithm for the PO problem including cardinality constrains. They considered the trade-off between risk and return in their approach. The proposed algorithm used a hybrid coding, mixing integer, and real variables to implement the characteristics of the handled PO problem. They tested the proposed method on a number of stock market indices in OR-Library. Tabu search, simulated annealing, and variable neighborhood search were used to compare their results, and the numerical results verified that the proposed ABCO method had a better performance in terms of diversity, convergence, and effectiveness on the experiment dataset.

### 12.4.2 Bacterial Foraging Optimization

Bacterial foraging optimization (BFO) algorithm, introduced by Passino (2002), is a bio-inspired optimization algorithm. The main idea of the BFO method is to apply the foraging strategy of a swarm of bacteria in multi-optimal function optimization. The algorithm includes four main components. First is *chemotaxis*, which is a process where a bacterium moves by swimming while looking for nutrients. The second component is *swarming*, which is a group behavior observed in various motile species. The third component is *reproduction*, a process in which the unhealthy bacteria die while each healthy bacterium (with lower objective function values) split into two bacteria. Reproduction sustains the size of the swarm. The last component is *elimination and dispersal*. Gradual or sudden changes may occur because of various reasons in the environment where bacteria live. For instance, the local temperature rise is important and may cause a group of bacteria to die in a region. Other events can also cause all bacteria in an area to die or a group to be dispersed to a new location. In order to simulate this process in a BFO algorithm, some bacteria are randomly liquidated while their substitutions are randomly initialized in the search space. In BFO, the position of each bacterium is updated through chemotaxis, swarming, reproduction, elimination, and dispersal. The basic steps of the method were given in (Passino, 2002).

Next, we investigate the ability of the BFO algorithm to solve PO problems. Bangia et al. (1999) introduced a novel PO method that took into account both liquidity risk and market risk. Niu et al. (2017) proposed an algorithm for solving the multiobjective PO problems. They compared their results with multiobjective comprehensive learning algorithm on ten-asset PO problems and concluded that the proposed method could find better-distributed Pareto sets. Wu et al. (2020) proposed a method to solve a novel PO problem with fuzzy variables by combining BFO with levy flight. Fuzzy variables were used to express the uncertainty of future risks and returns on the assets. To find the efficient frontier associated with the PO problem, Kao and Cheng (2013) proposed a heuristic approach based on BFO. They evaluated the proposed method on benchmark data sets by comparing PSO, simulated annealing, tabu search, and GA. Their results demonstrated that the proposed method outperformed these classical metaheuristics. Tan et al. (2014) presented a new variant of BFO called Bacterial Foraging Optimization with Neighborhood Learning. The proposed algorithm was observed to improve the basic BFO remarkably in selecting optimal portfolios.

### 12.4.3 Bat Algorithm

Yang (2010a) proposed a bio-inspired algorithm called the Bat Algorithm (BA) based on the echolocation behavior of bats. Bats, which are the only mammals with wings, have excellent capability of echolocation. They use echolocation to determine prey,

refuse obstacles, and find their nests in the dark. The main idea of BA is to use the echolocation ability of bats to obtain an optimal solution. BA operates using three rules. First, the bats use echolocation to determine a distance between barriers, and food or prey. Second, the bats fly randomly in the search space with a velocity $v_i$ at a position $x_i$, with frequency *fmin*, a wavelength $\lambda$, and loudness $A_0$. Third, the frequency of the pulse rates is adjusted in the range $r \in [0,1]$ and the loudness changes in the range $[A_{min}, A_0]$. The main steps of the algorithm are described in (Yang, 2010a).

Gandomi et al. (2013) adopted BA for solving constraint optimization tasks. Strumberger et al. (2016) presented a hybridized BA to solve PO with constraints that extend beyond the classical mean-variance PO formulation. In the hybrid algorithm, they integrated BA with ABCO. The experimental studies verified that their proposed methods worked efficiently. Another hybrid BA was proposed by Chen and Xu (2019) for solving the fuzzy PO with real-life constraints. Their hybrid method was developed by combining BA and differential evolution. Yang and He (2013) published a literature review on BA and its variants.

### *12.4.4 Biogeography-based Optimization*

Biogeography-based Optimization (BBO) is a population-based bio-inspired method inspired by geosciences mathematics. The term biogeography means the research of the geographical distribution of biological organisms. Simon (2008) performed the first BBO application. The BBO algorithm assumes that each individual takes place in a habitat with the Habitat Suitability Index (HSI) parameter, which is a fitness function for evaluating the quality of the solution (i.e. the habitat). While habitats with a low HSI have a small number of species, those with a high HSI can accommodate a large number. The best solution is represented by the habitat with the highest HSI. There are two main operations in BBO, which are migration and mutation. The aim of the migration operator is to share information between habitats. The mutation operator is responsible for increasing diversity among the population. Solutions with low fitness values are habitats with low HSIs, and the mutation operator favors these solutions to mutate as it gives them a chance to improve. The habitat having the best solution in BBO is saved by the elitism operator. Fundamental steps of the algorithm were depicted in (Simon, 2008).

Ye et al. (2017) proposed a BBO algorithm for solving the PO problem. They performed numerical experiments with several kinds of constraints. Experimental results revealed that the improved BBO algorithm had a better performance in PO than GA. Giri and Dehuri (2018) proposed a BBO model for optimizing the portfolio that consists of not only static assets but also the allocation of dynamic assets. The experimental results showed that the proposed BBO improved the portfolio via dynamically selecting a small number of assets from the high-quality asset class and dropping the assets having low quality from the portfolio.

### 12.4.5 Cuckoo Search

A recent bio-inspired algorithm, called the Cuckoo Search (CS) was introduced by Yang and Deb (2009). The method is inspired by the obligate brood parasitic behavior of some cuckoo species. Cuckoo birds have an interesting breeding behavior. To increase the likelihood of their own eggs hatching, they lay their eggs in other birds' nests. This metaheuristic uses three main rules. First, each cuckoo lays its egg in a randomly selected nest. Second, the nests including better quality eggs survive in the next generations. Third, the number of available host nests is fixed, and the host bird determines the egg laid with a probability. The main steps of the algorithm were described in (Yang & Deb, 2009).

The main advantage of the CS algorithm over other bio-inspired algorithms is that it requires less parameter tuning. Thus, it can be applicable to optimization problems efficiently. Marso and Merouani (2020) used the CS algorithm to predict financial distress. El-Kholany and Abdelsalam (2017) proposed a variant of CS to solve the constrained project PO problem. They integrated CS with Monte Carlo simulation to determine the best portfolio. Kong (2016) proposed a modified version of CS by taking advantages of the local searching strategy, intelligent learning strategy, and self-adaptive mechanism. They claimed that their proposed CS greatly improved the performance of CS, and efficiently performed to solve the PO problem with investment constraint. Sefiane and Bourouba (2017) presented a CS-based method for solving the financial PO problem. They showed that the proposed method is better than GA and ACO with respect to accuracy and efficiency.

### 12.4.6 Firefly Algorithm

The Firefly algorithm (FA) proposed by Yang (2010b) is inspired by the behavior of fireflies and their flashing patterns. There are three main rules in the execution of FA. First, a firefly is able to attract another firefly disregarding its gender. Second, the attractiveness and the brightness are correlated, both decrease as distance increases. Attractiveness represents the brightness of the firefly. The less bright firefly will approach a brighter firefly. If there is no brighter firefly around, it will fly randomly. The third rule is: a firefly's brightness is defined by the search space of the objective function. The main steps of the method were described in (Yang, 2010b).

The FA was first designed for unconstrained optimization. Later, it was improved to solve various numerical optimization problems (Yang, 2013). Yang et al. (2014) modified the original FA to solve the cardinality-constrained mean-variance PO problem with entropy constraint. They improved the exploration power of the original FA at early iterations of the algorithm. The proposed algorithm outperformed PSO, simulated annealing, GA, and tabu search. Tuba and Bacanin (2014) proposed an upgraded FA for solving the unconstrained PO problem. They compared their proposed method on data sets in the OR-Library. Their results demonstrated that the

proposed method outperformed GA, tabu search, and simulated annealing. Salehi (2019) also proposed FA to solve the extended fuzzy PO problem. Fuzzy mean-variance-skewness model was extended to a fuzzy mean-variance-skewness kurtosis model in their proposed approach. The model was solved by using FA, and the proposed method was compared against the exact method using LINGO software based on accuracy and time. Their results showed that the proposed FA achieved high-quality results for the fuzzy PO problem.

### *12.4.7 Harmony Search*

Harmony search (HS) is a music-based optimization method proposed by Geem et al. (2001). It originates from the observation that the purpose of music is to seek perfect harmony. Finding harmony in music corresponds to finding optimality in the search process. When a musician is improvising, he or she has three possible options. First is playing any well-known tune from his or her memory accurately. The second is playing music similar to the aforementioned tune. The third is to compose some random notes. Geem et al. used these three separate ways corresponding to the usage of harmony, pitch adjustment, and randomization during the optimization procedure in HS. The main steps of HS were given in (Geem et al., 2001).

The HS algorithm has various application areas in science and engineering optimization. Esfahani et al. (2016) used HS algorithm for solving the PO problem. Lai et al. (2019) proposed the HS method to solve the sharpe-ratio-based PO problem. They used the dataset incorporating ten Malaysian companies covering a one-year period. They achieved satisfactory results. Seyedhosseini et al. (2016) proposed a hybrid algorithm to solve the PO problem by combining HS and ABCO. They claimed that the hybrid approach offered good approximations to the efficient frontier of investment and outperformed HS and GA in terms of all levels of risk. Tuo and He (2018) proposed another hybrid algorithm combining HS and Teaching Learning Based Optimization (TLBO) to solve a cardinality-constrained mean-variance PO problem. To improve the global optimization performance, they used a modified HS and TLBO incorporating a dynamic selection strategy to balance the local utilization power with the global exploratory power.

## 12.5 Other Recent Bio-Inspired Algorithms in Portfolio Optimization

In this section, we summarize some other recent bio-inspired algorithms, which attracted relatively less attention from the researchers for solving PO problems.

Invasive Weed Optimization (IWO) is a recent bio-inspired algorithm introduced by Mehrabian and Lucas (2006). The algorithm is inspired from colonizing weeds.

The authors claimed that IWO was efficiently designed for solving optimization problems. The efficiency and the effectiveness of IWO was compared with a set of benchmark multidimensional functions. Experimental results reported that IWO outperformed shuffled frog leaping, memetic algorithms, GA, and PSO. For solving the multiobjective PO problem, Rezaei Pouya et al. (2016) proposed an IWO algorithm. They applied their proposed model to periodical data of some corporations of the Tehran Stock Exchange Market in 2013. Results were compared to the PSO method, and they revealed the superiority of the proposed IWO. Hajnoori et al. (2013) used IWO to forecast the stock price. The performance of their algorithm was competitive with PSO and GA. Another recent study for solving the PO problem can be found in (Goli et al., 2019).

A novel biologically inspired algorithm was the Krill Herd (KH) algorithm developed by Gandomi and Alavi (2012) for solving optimization problems. The approach was inspired by the herding behavior of krill individuals. Tehrani et al. (2018) used the KH algorithm to solve the PO problem and found the efficient frontier. Their results showed that KH had a good performance in finding the efficient frontier and optimized portfolios. Tuba et al. (2014) developed a KH algorithm for solving the constrained PO problem. The proposed algorithm was verified on benchmark sets and produced remarkable results.

Mirjalili et al. (2014) introduced the Gray Wolf Optimizer (GWO) algorithm inspired by gray wolves. GWO mimics the hunting mechanism of gray wolves and their leadership hierarchy. Evolutionary programming, GA and PSO were used for comparison. Numerical results showed that GWO was competitive with these well-known nature-inspired algorithms. Ren et al. (2018) proposed GWO to solve the multi-constraint second-order stochastic dominance PO problem. The results of the algorithm were promising and the authors claimed that the algorithm promised great potential to be successfully applied to other PO problems.

Another recent powerful bio-inspired algorithm, called the Symbiotic Organisms Search (SOS) was developed by Cheng and Prayogo (2014). In order to survive and spread in the ecosystem, organisms adopt symbiotic interaction strategies. SOS mimics these strategies and is able to solve many complex problems efficiently. Pillay and Ezugwu (2019) used SOS to predict stock price. Mohammadi et al. (2016) solved the PO problem using SOS. The proposed method was tested on real data and the results verified that it was able to efficiently solve PO and interact with the actual limitations properly. Feshari and Nazari (2018) proposed a hybrid algorithm integrating GA with SOS to solve PO. To demonstrate effectiveness and stability of the hybrid approach, it was tested on Tehran stock exchange market between the years 2009 and 2017.

For solving optimization problems, Mirjalili (2015) proposed a new bio-inspired inspired algorithm called the Ant Lion Optimizer (ALO) as an alternative approach. The algorithm was inspired by the hunting behavior of ant lions. Kaushal and Singh (2018) used the algorithm to allocate stocks in a portfolio. Their proposed ALO produced remarkable performance compared to GA on the stocks of some Indian organizations in the Bombay Stock Exchange.

Mirjalili and Lewis (2016) proposed another recent bio-inspired method, namely, Whale Optimization Algorithm (WOA). Humpback whales have a specific hunting strategy called bubble-net. WOA originates from this strategy. Since WOA is based on a simple theory, easy to use, and requires few parameter settings, it is widely used for global optimization problems. For solving the multi-constraint PO problem, Zhai et al. (2020) used WOA. The results verified that the proposed algorithm performed very well in the presence of hard constraints on FTSE100 index stock data.

## 12.6 Conclusion

The PO problem, a well-known problem in finance, belongs to the group of hard optimization problems. Therefore, classical algorithms cannot cope with it successfully. Recently, bio-inspired algorithms have great attention from researchers for solving such problems efficiently. Since the first bio-inspired algorithm was proposed, major advantages have been identified and various new bio-inspired algorithms are being introduced to the literature in a daily manner. In this study, we reviewed many new generation bio-inspired algorithms adopted to solve the PO efficiently. The ABCO, BFO, BA, BBO, CS, FA, and HS have been among popular metaheuristics for solving the PO problem. Among these algorithms, the ABCO algorithm has been recently gaining increasing attention as it has a direct fit on the PO structure. It achieved remarkable performance compared with many other competitive algorithms in the PO domain. Hence, we believe that the ABCO algorithm will become even more popular for solving the PO problem in the near future. The BFO is another promising algorithm considering its strong parallel search ability and avoiding local minimum, which are both important for PO. Although the convergence speed of BA is slow and its optimization precision is low, it requires few parameter adjustments. For this reason, many recent studies use BA in a hybrid algorithm. In addition, recent studies show that FA provides a good balance of exploitation and exploration and can be effectively used for solving the PO problem.

Other state-of-the-art metaheuristics such as IWO, KH, GWO, SOS, ALO, and WOA have attracted relatively less attention from the researchers for solving the PO problem up to now. In the very near future, we believe that enhanced variants of these algorithms will make significant contributions to the literature in realistic portfolio management due to their superiority in solving hard and complex optimization problems. Furthermore, employing hybridization in the solution approaches by combining positive characterizing of several bio-inspired algorithms will contribute significantly in achieving a remarkable performance out of bio-inspired algorithms.

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# Chapter 13
# The Effects of Artificial Intelligence on the Insurance Sector: Emergence, Applications, Challenges, and Opportunities

**Işıl Erem Ceylan**

**Abstract** Like many sectors around the world (health care, manufacturing, transportation, customer service, banking, etc.), insurance sector has also started to adopt the artificial intelligence (AI) technologies to a large extent. With this adoption process, insurance companies can instantly respond to customer needs in the light of digital data and focus more on value-added areas. AI technologies also contribute to effective communication with customers, reduce costs, develop new products and services, and improve the competitive environment to prevent insurance companies from being indifferent to these technological developments. On the other side, these technologies identify potential risks in advance, inform the insured, and support them to take the required precautions. While this situation is supportive for the insured part, it may create a number of threats for insurance companies as it causes a decrease in insurance premiums. These threats are pushing insurance companies to go through a number of transformations in their business models to turn the disadvantaged situation in their favor. This being the case, addressing these innovations is of great importance not to fall behind these developments. From this point of view, this chapter explores the AI innovations and their effects on the insurance sector and reveals the use cases of global and Turkish insurance in the implementation of AI.

**Keywords** Artificial Intelligence (AI) · AI use cases · Insurance sector · Turkey

## 13.1 Introduction

The insurance sector plays a critical role in helping businesses and individuals to manage their risks, because of both the size of the premium they collect and the investments made with this premium. This role is of great significance in terms of the durability of the economy. The transformations caused by technological developments in the business process and the changes caused by consumer preferences may have both

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positive and negative repercussions on the insurance sector. As advances in artificial intelligence, blockchain, cloud technology, and Internet of Things (IoT) require high investment in the short term, it seems to have yet to give firms a cost advantage. However, in the medium term, these technologies are expected to reduce the costs and increase the efficiency of the sector (KPMG, 2019). In addition to cost and efficiency advantages, these innovations also contribute to the emergence of creation of new insurance products, services and business models. Traditional insurers have opportunities to modernize and reinvent themselves by these technological developments (Institute of International Finance, 2016).

Financial services, particularly banking, is one of the leading sectors in the use of artificial intelligence in Turkey. In this sector's prominence, stiff competition, artificial intelligence programs' accelerated implementation, data management in general, and having strong foundations in adopting technology have played an important role (EY Consulting LLC [BAE] and Microsoft, 2019). Although the insurance sector has lagged behind technology and digitalization due to the fact that it is an area with a lot of regulation compared to the banking sector, it has gained momentum recently. Looking at the world wide, Turkey is 39th in the field of insurance and the per capita insurance expenditure corresponds to almost a tenth of the rate in Europe. As this indicates potential in future periods, a significant amount of resources has been transferred to the insurance sector by international investors. This transfer of resources is a very important contribution in the field of innovation and employment, as the basic structure of the insurance sector is aligned with the digitalization processes. The transformation brought about by digitalization is expected to lead to important developments in the insurance sector if it can be implemented in the right way and time (*Dunya Newspaper*, 2019, Kocakafa, 2019).

Recent developments occurred in insurance sector show that technological change is very rapid and companies that fail to adapt to this speed will lose their chance to compete successfully. Their business model will be formed by the opportunities that technology offers them. But to date, studies on the effects of AI on insurance sector seems underdeveloped in terms of both research and practice. At this point, the motivation for this paper is to determine the state of affairs of AI's applications in both Turkish and the global insurance sector and investigate the effects of these innovations on this sector. The paper is structured as follows: Sect. 13.2 reviews the related studies. Section 13.3 begins with a brief history and overview of AI innovations. This is followed by the Sect. 13.4 that presents the development process of these technological innovations in both all over the world and Turkish insurance sector and their use cases. Section 13.5 intends to reveal the opportunities and challenges faced in this process. Then, some predictions are made regarding the use of AI technologies in the related sector and their future status is discussed in the last section.

## 13.2 Related Studies

This section deals with some existing studies made as to AI technologies in the financial services sector. The literature on the subject is investigated under two main financial sectors: banking and insurance. While the first one focuses on the state of affairs of AI technologies in the financial sector especially banking sector [7; 8; 9; 10; 11], the second mainly deals with the studies related to the insurance sector [12; 13; 14].

*Kurode* (2018) addressed the applicability of artificial intelligence technologies in the financial services sectors such as banks, insurance companies, and credit rating agencies. Additionally, the study also focused on the advantages and disadvantages created by the use of these technologies. Similarly, *Medetoglu and Tutar*'s (2020) studies measured the extent to which AI practices in the financial sector have an impact on the individuals' habits such as payment, savings, and accumulation. Results from the survey study, which applied to 500 people, showed that the way users used artificial intelligence differed in terms of age, gender, occupation, and income distribution. The survey also concluded that there was a right correlation between the age, income, and education levels of the participants and their confidence in artificial intelligence, and that the effective use of artificial intelligence in the financial sector provided great convenience for the users. *Lakshminarayana and Deepthi* (2019) also aimed to determine the opportunities and challenges of AI technologies usage in the banking sector and examine the so-called technological applications in the leading Indian commercial banks. According to their study, it was concluded that digitalization had both positive and negative effects on customary financial models. *Sabharwal* (2014) conducted a structured interview of branch heads of the selected 16 scheduled banks of Meerut by using GAP analysis in order to determine whether or not the selected banks are using AI technologies. The study also examined the differences in the use objectives of banks using AI technologies. The empirical findings showed that none of the banks included in the analysis have benefited from AI technologies other than new private sector banks. *Xie*'s (2019) study addressed the development and application of AI and machine learning technologies in financial field and analyzed their impacts on both macroeconomics and microeconomics. In the study, risks arising from the use of artificial intelligence were also discussed and it was also emphasized what can be done to make the most accurate use of these technologies in the financial system.

*Yildirim* (2019) examined the potential effects of insurance technologies on the insurance sector. The study focused mainly on the development of InsurTech firms, the innovations they brought to the insurance industry and their usage areas. Separately, the current situation Insurtech technology in Turkey and the possible issues that may be faced by the insurance companies were also evaluated in the study. Zarifis et al. (2019) investigated the 20 case studies of AI in insurance, seven are UK insurers, three are from other European countries, six are from North-America, and four are from Asia, by using an exploratory approach. According to the findings, four business models emerged and they generally showed that insurers use AI for improving

effectiveness and completely benefit AI for new sources of data and customers. *Singh and Chivukula* (2020) examined the impacts of AI technologies such as deep learning and machine learning on the insurance industry. For this purpose, they focused on how AI technologies can overcome the challenges that might occur in the so-called industry. As for conclusion, some recommendations were made to resolve the current and potential challenges.

## 13.3 A Brief History and the Concept of Artificial Intelligence

Artificial intelligence is the ability of a computer or a computer-controlled robot to perform various activities in a similar way to intelligent creatures. Artificial intelligence studies are often aimed at developing artificial guidelines similar to these by analyzing human thinking methods. More technically, artificial intelligence is a branch of computer programming. It is an effort to add intellect, learning ability, and accordingly reasoning ability to the program developed. With the thought put forward by Alan Turing toward the end of World War II, it was imagined that a program could be learned. Thanks to this learning ability, the computer was imagined that it could have artificial intelligence over time (Russell & Norvig, 2010, Turing, 1950). In 1955, John McCarthy used the concept of "artificial intelligence" for the first time. According to him, artificial intelligence is "the science and engineering of making smart machines." Artificial intelligence studies accelerated in some of the leading universities in the 1960s. The US Department of Defense supported these efforts. There was concrete progress in the 1970s, but artificial intelligence close to the expected human intelligence did not occur. Thereupon, the Ministry of Defense reduced its funds. In this sense, the 1980s are called "Artificial Intelligence Winter." Since the beginning of 2000s, artificial intelligence studies gained momentum again. The spread of the Internet, the exponential increase of data amounts, the fact that the computing power has been moved to the cloud, and quick accessibility and scalability have increased the computing power. Nowadays, artificial intelligence has attracted the attention of internet giants and leading technology manufacturers. Firms such as Google, Facebook, Apple, Amazon, Microsoft, Baidu, IBM, and similar companies have teamed up, invested, bought other companies and experts, and started to market value-added products with certain steps. On the one hand, personal assistants started to appear with the voice recognition feature on our smartphones (Aksu, 2017).

## 13.4 Emergence of Artificial Intelligence in the Insurance Sector

The packages and services offered by insurance companies were more complex in the past than in the present. With the technological developments in the insurance sector, all the products and services offered by insurance companies have been brought together and customers have access to all the necessary information about the products and services with one click (Yayvak & Ozbey, 2019). Artificial intelligence technologies have become an important expenditure item in the financial services sector and are growing rapidly. While hedge funds and HFT companies were the main users in the early stages of the emergence of these technologies in the financial sector; it now finds application area by many financial institutions, from banks to regulatory agencies, to FinTech, and insurance companies (Buchanan, 2019).

Many technological innovations, such as AI, blockchain, and machine learning, have emerged in the insurance sector especially in automating claim handling processes, making customer relations more effective, detecting fraud and preventing risk over the past few years. It is possible to say that the adaptation process of the insurance sector to these technologies has been slower compared to many sectors such as health care, education, financial services, ecommerce, and human resources. However, the multifaceted nature of the sector greatly increases the application areas of these improved technologies (Rivelli, 2020).

### *13.4.1 Artificial Intelligence in Global Insurance Sector*

The need for data processing in the insurance sector has increased dramatically all over the world, and it has gained great importance to construct artificial intelligence models that can analyze this data accurately and predict it accurately for months and years to come. There is a certain increase in the number of policies produced due to the trend of insuring everything around the world. At this point, there is the awareness that these processes should be digitized and automated in some way. In the market research conducted to decrease the high policy costs reflected to the consumers, it is seen that the solution is through artificial intelligence. Because it has been observed that the biggest reason for insurance companies to increase their policy prices is risky policies and frauds. Worldwide, 10 to 20% of all policy and insurance transactions were found to be fraudulent. Artificial intelligence eliminates the risk factor by providing analysis of data and documents. Similarly, when the damage occurs, it calculates the cost of the damage by analyzing the photos taken and sent to the system and does not leave it to the initiative of a service, expert, or master. It says which part is damaged and needs to be replaced. Thus, it eliminates the factors of people making wrong decisions target (*Teknopark Ar-Ge ve Teknoloji Journal*, 2020).

The insurance sector effectively utilizes artificial intelligence in claims, policies, human resources, information technologies, and many other processes. The technology in question can conclude in a very short time on a complaint, taking into account both policies and post-policy developments. With artificial intelligence, the post-accident investigation processes are reduced from 58 min to 5s on average. This situation provides significant advantages both in terms of Labor and time costs. The accuracy of the results of the system has been increasing over the years, allowing for new services. Fast tracking and analysis of new customers is becoming possible (Insurance Association of Turkey, 2019). There are several practical applications of AI in financial services sector such as algorithmic trading, portfolio composition and optimization, model validation, back testing, chatbots and robo-advising, virtual customer assistants, market impact analysis, regulatory compliance, stress testing, and fraud detection (Buchanan, 2019).

Technological developments that enable new and innovative products to emerge in the financial services sector have spawned the concept of FinTech. This concept generally covers several fields such as banking, payments, investments, lending, wealth management, insurance, advisory, etc. and reveals the link between technology and software to deliver innovative financial products and services. Considering the insurance sector, InsurTech addresses the current insurance challenges and opportunities and is known as a FinTech sub segment (Arslanian & Fischer, 2019, Sun, 2017). In addition to providing solutions to the problems in insurance sector, structures that will reduce the cost and risk of the insurance company, make the life of the insured easier, make it more flexible, and transform it into a better experience have entered into our lives with InsurTech concept. In the literature, the concept of InsurTech is defined as innovative insurance technologies. In this period of rapid change and transformation, these innovative technologies are expected to provide great benefits to be able to apply analytical and innovative solutions into real life in the right way and in time (Kocakafa, 2019).

Traditional insurance is based on a reactive basis; it focuses not on preventing unwanted events from occurring, but on compensation payments in the event of those events. On the other hand, by following a proactive approach, InsurTech startups tries to provide insurance products and services by creating new conditions or changing the course of the existing conditions, and constantly following the risky behavior of the insured and helping to reduce these risks (Arslanian & Fischer, 2019: 42). They support projects that offer more accurate personal insurance policies by analyzing the behavior/use of vehicles and people with Internet of Things applications, identifying risks and minimizing risk occurrences, thus contributing to the development of the sector. In the field of insurance, it is possible to come across many InsurTech startups that want to bring solutions to the problems of the sector both at the user level and by internal processes and that undertake striking works. The USA, UK, Germany, and the Netherlands are the countries that have made the biggest breakthroughs in the InsurTech field in the world. These startups, backed by the government and leading insurance companies, do very large volumes of work. Some of them are shown in Table 13.1 (Acer, 2017, Fintechistanbul, 2017, Utkueri & Tamer, 2018, Zaidi, 2017):

**Table 13.1** Leading InsurTech companies around the world

| Name of InsurTech company | Origin | Founding year | AI tools | The functions/use cases |
|---|---|---|---|---|
| Captricity | California | 2011 | Machine learning technology (digitizing a handwritten document directly and interpreting it into artificial intelligence) | Digitizes hundreds of thousands of new job applications, resulting in a reduction of up to 50% in insurance companies' staff costs |
| Tractable | London | 2012 | Deep learning algorithm | Estimates how much damage there is when the vehicle is crashed. Makes the cost calculation automatically in car insurance cases. The crashed vehicle uploads the vehicle photos together with an estimate to the insurance claim management system and artificial intelligence algorithms compare the photos with the cost estimate to guarantee accuracy |
| Zendrive | San Fransisco | 2013 | Machine learning technology (sharing the data it collects with the driver as actionable data) | Measures and improves the driving habits by using sensors on smartphones. Learning that traffic accident rates on a particular street are increasing, Zendrive's artificial intelligence is able to say, "you better not go on this street" when approached on that street |
| Cape analytics | USA | 2014 | Machine learning and computer imaging technology | Provides information on the roof of each building such as material type, usage status, and total area covered by the building. The elements that are binding in insurance policies such as solar panels, lighting lights, and chimneys can be easily identified by this system for each building |
| Lemonade | USA | 2015 | Artificial neural network algorithm | Provides 24/7 policy production and damage approval to be completed within 90 s. When any case occurs, it takes about 3 min to get paid |

Additionally, there are several chatbots widely used in the insurance sector all over the world and these are given names to make them more human-like. For instance; *Magda* is a chatbot of Link4, the first motor insurance policy sold online in Poland. *Allie* is Allianz's online assistant available 24/7. Co-op Banking Group uses *Mia* in answering customers' insurance queries. In Canada, RBC Insurance uses *Arbie*. *Nienke* is also a chatbot of NN group in Dutch. In France, *Marc* works for health insurance offering of Credit Agricole and *Hanna* is also a chatbot of the Swedish Social Insurance Agency (Huckstep, 2020). It is possible to say that there are several benefits of using chatbots. Firstly; the huge use of online research tools changes market dynamics and increase market transparency. This will result in positive results on the part of the customer. In addition, insurance companies have some advantages in reducing their costs, increasing their sales and providing a better service to their customers (Capgemini, 2017).

### *13.4.2 Artificial Intelligence in Turkish Insurance Sector*

With an asset size of TL 178 billion, the Turkish insurance sector accounts for approximately 4% of the Turkish financial sector. A total of 62 companies, including 38 non-life, 18 life and retirement, 4 Life and 2 reinsurance, are operating in Turkish insurance sector as of the end of September 2019. However, the sector, which has a high growth potential, is performing lower than expected due to low consumer awareness and the overall structure of consumer perception. Nevertheless, 2020 is considered as a year in which some movements will occur for the insurance sector. The insurance sector, just like many other sectors, has started to focus on big data, artificial intelligence, and digitalization. Investments in these areas now occupy important places in the company's budgets (KPMG, 2019).

The impact of rising momentum of artificial intelligence technologies on every sector is enormous. The financial sector has taken its place in Turkey as the most important of the leading sectors, especially by expanding the use of technology in the banking sector much earlier and making investments. However, this change and development has not developed in parallel with the insurance sector, which is another player of the financial sector. Problems in sectoral profitability, high investment costs, and human resource factors have had a big impact on this situation. However, technological changes began to appear in the process that began with the introduction of foreign investors into the insurance sector in the 2000s (Bilgin, 2018).

The areas where the AI is being used by the insurance firms are the *inspections* to validate the underwriting decisions, *Internet of Things* for a superior service to the customers, *end to end automation* for helping insurers to automate the complex processes, *claims acceleration* for paying claims in hours or days rather than weeks via chatbots, visual based AI categorization or machine learning, *pricing sophistication* by applying machine learning and nonlinear models for balancing the capacity and demand, and the *risk identification and classification* by using machine learning

and deep learning techniques for identifying the customers likely to cause substantial damage (Jones et al., 2019).

As in the whole world, the Turkish insurance sector closely follows artificial intelligence technologies and several insurance companies such as Ak Sigorta, Allianz, Anadolu, Sigortam.net, Sompo Japan Insurance, and Mafphre contribute to the integration of the industry in these technologies through mobile applications. For example, *ADA (Aksigorta Digital Assistant),* the first artificial intelligence application of the Turkish insurance sector, separates and classifies documents in the damage investigation process. The license, accident report, invoice, declaration, and accident photo, which constitute 70% of the damage documents transmitted to Aksigorta via email with the "Image Recognition and Classification" capability brought to ADA, are automatically recognized, classified, and added to the related damage file by robot technology. In the first 4 days of using the "Image Recognition and Classification Engine," which has a daily 5,000 mail processing capacity, 3,258 documents received with 938 mail (electronic mail) were processed by ADA and these documents were classified with a success rate of 98.4% (Aksigorta, 2021). Answering Turkey in general about 2,680 from 500 agencies requested by the ADA, the answer time has fallen from 2 h to 2 min. Additionally, it provides significant support to human resources, call center, finance and accounting, damage, UW, agencies, brokers and corporate sales channels, as well as legal departments (Icozu, 2020).

*B2Metric AI Hunter* is also on its way to becoming the best **InsurTech** company in Turkey. It plays a leading role in the product development of artificial intelligence-based software and solutions in Turkey in the focus of the insurance and finance sector. It enables companies, especially in the finance, insurance, and retail sectors, to use artificial intelligence technologies to make sense, optimize, and forecast sales, customer, and image data. It minimizes errors by ensuring that risk management of these firms is done correctly with an artificial intelligence infrastructure tailored for insurance companies. It also detects and blocks fraud activities during insurance transactions with deep learning technology and allows them to optimize policy cutting operations (Fintechistanbul, 2019). It uses the selling techniques such as cross-selling and up-selling in order to increase the introduction of the products to customers. This initiative also enables to make claims management with no mistake. By using the analysis system, even the smallest damage in the car can be realized (b2metric.com, 2020). Thanks to its advanced machine learning algorithms, B2Metric software delivers 15% better results than the analytical systems on the market. This means loss costs, 10% savings in policy process costs (Target, 2020: 63).

## 13.5 The Effects of Artificial Intelligence on the Insurance Sector

It is highly likely that developments in artificial intelligence will change the dynamics of the insurance sector in terms of both insurer and insured (Kessler, 2017).

### *13.5.1 Challenges and Barriers*

Strong regulations, fraud attempts, and complexity are the most encountered challenges in the insurance industry (Corea, 2019). In addition, information asymmetry, automation in transactions, and cyber risks also come across as the challenges posed by the use of AI in the insurance industry.

#### 13.5.1.1 Information Asymmetry

The parties to an insurance contract have different levels of knowledge, resulting in information asymmetry. The insurer tries to predict the behavior of the insured party by conducting surveys, observations, and statistics. The insured also strives to show low risk and to increase the value of the policy. This information asymmetry leads to moral hazard and adverse selection problems. Advances in artificial intelligence and data collection have been extremely effective in eliminating the negative effects of this information asymmetry and in conducting insurance transactions in a more comprehensive manner. Thus, the cost of accessing information is reduced to a minimum and information becomes a commodity that can be processed easily (Kessler, 2017: 7–8). The insurance sector has taken into account all the data available in the market when making risk modeling, before AI technologies began to become widespread. However, this data was at the level specified by the potential customers or from the other sources. However, with the development of AI technologies, the data in question has become much more comprehensive, and only a few have remained under the control of potential customers. In this case, insurers do not need to directly ask for the information they need while performing their transactions. While this situation is described as a good development in risk management and correct pricing for insurers, it may create a loss of confidence for customers. Customers may have a negative attitude toward insurance companies with the idea that insurers use the relevant information insidiously (Josefowicz, 2019).

#### 13.5.1.2 Automation in Transactions

Advances in artificial intelligence technology have increased the level of automation adopted in the transactions carried out in the insurance sector. Formerly, automation

was only used in the simple processes requiring low decision-making skills such as data entry, compliance checks, standard customer communications, and managing rule-based decisions. But now, these technologies are used in almost each transaction such as property assessment, estimation of the customer insights by analyzing large scale of data, personalized customer interactions (chatbots, etc.), fraud detection, and claims verification (Capgemini, 2017: 4). Duration of these transactions decreases significantly, a process that normally takes months can be completed in a few minutes with artificial intelligence technologies. This provides significant cost savings for the insurer and contributes to the efficiency of underwriting and claims processing (Kessler, 2017: 8).

#### 13.5.1.3 Cyber Risk (Intentional or Unintentional)

Artificial intelligence technologies bring many benefits, but can also lead to some intrinsic risks. These risks, also known as cyber risks, manifest themselves as a program error or malicious cyber-attacks that may occur in artificial intelligence software and cause a negative deviation in the decisions to be taken (Kessler, 2017: 9). Thanks to cyber security, artificial intelligence technologies make important contributions to users in detecting potential threats and taking timely measures against them. However, because of the malicious use of these technologies, cyber security violations may occur and cause some systemic economic problems (Maull et al., 2019).

Artificial intelligence is used in damage, policy, human resources, information technology, and many other processes. This technology may come to a conclusion in a very short time about a complaint, considering both policies and the developments after the policy. The algorithm learns on its own and begins to make decisions. However, this raises some issues such as responsibility for decisions, security, control mechanisms, and economic or social risks. It is necessary to make appropriate arrangements and to deal with risks transparently (Insurance Association of Turkey, 2019). Machine learning algorithms and other types of AI technologies make use of training data to develop a solution for how to follow a path when faced with different situations. With the advent of additional data in this process, the AI technologies in question adjust their approach iteratively. However, this causes two challenges in the field of cybersecurity. Firstly, the fact that the decisions are made automatically and without any human participation by AI technologies leads to the inability to detect them if any mistake occurs. Second, the reason for the decisions taken may not always be clear to the auditors, because the decision-making techniques and data used by AI technologies are not sufficiently transparent (Goosen et al., 2020).

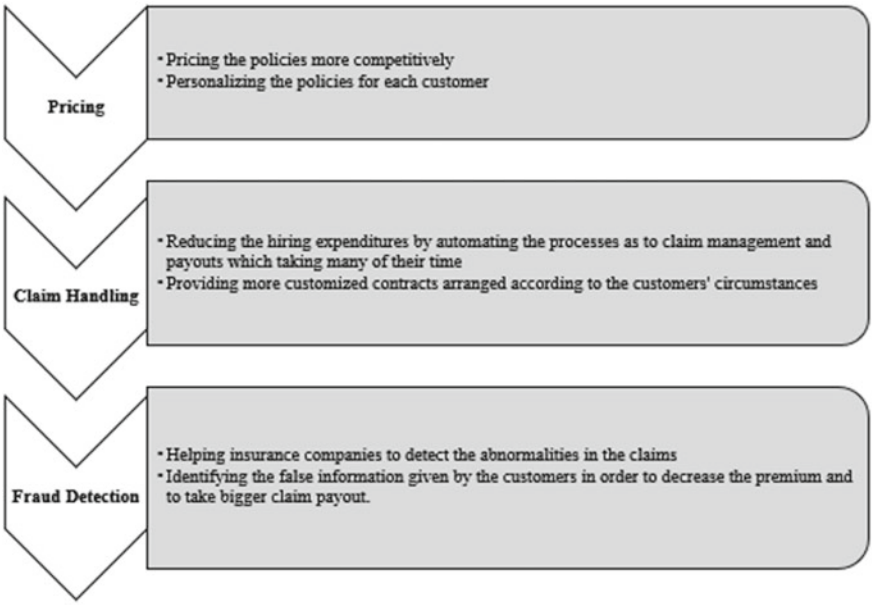


**Fig. 13.1** Top opportunities of AI technologies in the insurance sector. *Source* Rivelli (2020)

### *13.5.2 Opportunities*

The most important opportunities for using AI technologies in the insurance sector often arise in pricing, demand processing, and fraud detection (Fig. 13.1):

AI technologies allow customers to provide information to a chatbot and quickly receive personalized product recommendations and offers. With AI technologies that enable automatic analysis of customer profile, instant commitment and pricing are achieved and many insurance products can be purchased online within minutes (Cognizant, 2019). Besides the opportunities listed above, it is possible to mention about many benefits of AI technologies to the insurance industry. One of these benefits emerges at the point of customer relations and workforce. For example, instead of dealing with a single customer, AI technologies make it possible to interact with multiple customers simultaneously with AI technologies. Thereby, employees may focus on the businesses that provide added value (Accenture Insurance Financial Services, 2017).

### *13.5.3 Future Trends*

The insurance sector should have a very dynamic and flexible structure in order to maintain its existence in the face of the innovations brought by AI technologies.

Considering the differences that related innovations have created between today and tomorrow of the sector, it is expected that there will be changes in four key points:

As can be seen from Fig. 13.2, there are likely to be drastic changes. For instance, a more proactive approach is expected to be adopted in the future when the attitudes of insurance companies are taken into consideration. While actions are first initiated by customers previously, with these developments, insurance companies are greatly likely to prevent the so-called customer actions by establishing a better follow-up and forecasting mechanism. There will also be changes in products, promotions, and pricing and more emphasis will be placed on individualism. While offerings were determined in a standard manner formerly, in the future offerings will be determined by taking into account individual customer needs and preferences (Deloitte, 2019: 9).

The effects of AI technologies in the insurance industry are expected to become more noticeable over the next decade. These technologies, which can mimic the perception, reasoning, learning, and problem-solving abilities implemented by the human mind, will turn the direction of the insurance sector from "perception and repair" to "learning and prevention" (Balasubramanian et al., 2018).

Looking at the future trends regarding the use of AI in the insurance sector, it is possible to mention about five main issues: sharing economy (sharing cars, work

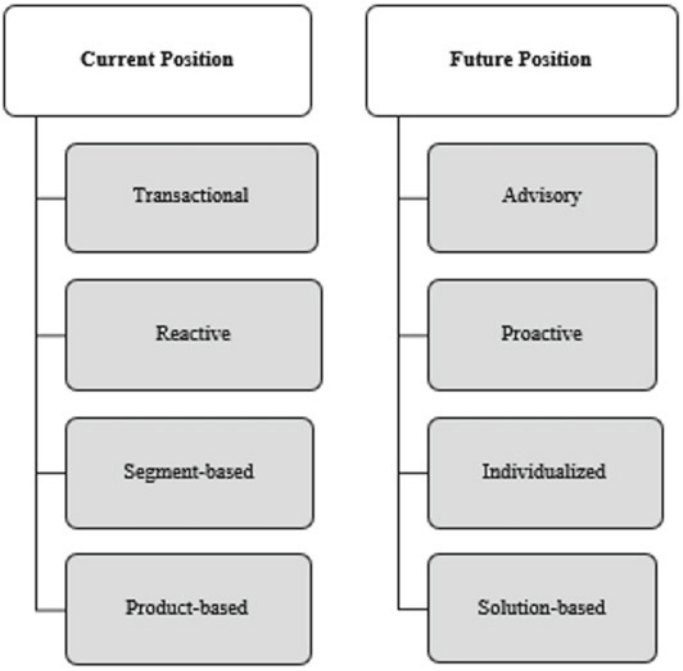


**Fig. 13.2** Basic differences between today and tomorrow of the insurance sector. *Source* Deloitte (2019)

areas, logistics, accommodation, and parking spaces), on-demand economy (insurance coverage only when used), commercial cybersecurity (lack of understanding), autonomous vehicles, and risk prevention (The AI Forum of New Zealand, 2019). It is possible to monitor everything occurred worldwide by the Sharing Economy. According to this expansion, AI applications may price both a single client and a specific risk at individual level. It has also a great impact on the probability of a bad situation and the predetermination of the costs caused by this situation (Scardovi, 2017).

## 13.6 Conclusion

The digital transformation process, which has accelerated with the emergence of digital technologies, such as blockchain, internet of things, artificial intelligence, and big data, has significantly increased the number of digital investments in the insurance sector, as in all sectors, in order to meet customer expectations and stay behind these developments. By applying promising artificial intelligence technologies, insurance companies can make their business processes more efficient and carry out the services they offer in a personalized manner. Fraud detection can also be done by using chatbots and some fraud analytics. In addition, while these technologies provide a significant decrease in the operational costs of the sector, they create high increases in profitability.

In the insurance sector, where the risk is high, the majority of jobs are done by people, which is a factor that increases the error rate. It is thought that as a result of increasing use of artificial intelligence by insurance companies, human-based errors will decrease and revenue will increase accordingly. It is also expected that artificial intelligence will help insurance companies in creating new markets and that artificial intelligence technologies will benefit insurance companies in the coming years in terms of renewal and growth in the insurance sector as in every sector. Finally, it is emphasized that the differentiation of artificial intelligence in terms of new products and services may also be the reason for the preference of the insurance company for the customers.

Considering the overall Turkish financial services industry; it is possible to state that banks are at the top of the sectors that adapted to the transformation process the fastest, but the insurance sector is still in the beginning stage at the point of keeping up with the so-called process. Merely, the insurance sector is expected to achieve an average income growth of 17% by 2022, according to the forecasts for the future of the related sector. At this point, insurance companies should revise their current approaches and adapt to digital transformation as quickly as possible in order to seize the opportunities brought by this transformation process and eliminate the difficulties. Thanks to artificial intelligence technologies, insurance companies may acquire different skills in solving complex problems, developing new products and entering new markets.

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# Chapter 14
# Understanding the Utilization of Artificial Intelligence and Robotics in the Service Sector

**Büşra Alma Çalli and Levent Çalli**

**Abstract** Artificial Intelligence (AI) is increasingly posing a threat to human service jobs in several sectors. According to projections, AI will put a remarkable percent of service sector employment at risk, including a wide range of jobs. Since AI offers chances to improve service provision efficacy and enhance consumer engagement, it is expected that artificial intelligence and service robots will become widespread in many countries. It is anticipated that service provision tasks will be affected by automation and artificial intelligence in different ways. Regarding the replacement of jobs, it is envisaged that job designs will transform on a task-based rather than top-down basis, with simple cognitive and analytical tasks being performed first by service robots, and then complex emotional and social tasks are likely to be supported by robot-human collaboration. As a result, it is critical to assess artificial intelligence as it penetrates every aspect of our life, particularly in terms of consumer acceptance & use and the service industry, where it is perceived as a significant threat to service jobs. Depending on the predictions regarding the widespread applications of AI shortly and the change of job designs in the service sector, the evaluation of the current research in the area is critical for reducing the gap between practitioners and academic studies. Until far, most AI for service research has classified the service tasks and attempted to explain how the transformation of jobs can take place on a task basis. On the other hand, some research has conceptually discussed the potential benefits and drawbacks of AIs in the service industry. A stream of research has empirically measured user acceptance of different AI applications, their antecedents, and consequences. Hence, this chapter aims to synthesize and discuss the previous literature findings to have a broad understanding of the current research output. Some literature gaps, particularly in terms of human-robot interaction, have been identified, and avenues for future research have been emphasized. Finally, a roadmap for future research is presented.

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**Keywords** Artificial Intelligence · Robotics · Human-robot interaction · Service robots

## 14.1 Introduction

In 2004, autonomous vehicles were identified as hard to imagine due to the difficulties of simulating human perception in traffic; six years later, in 2010, Google announced the autonomous vehicle project, and today, several manufacturers are selling self-driving cars (Frey & Osborne, 2017). Today, artificial intelligence (AI) applications are successfully used in various industries; while they offer significant convenience and advantages, they also computerize a considerable amount of work. The predictions show that especially service sectors such as office and administrative workers, labor in production, and transportation and logistics employees will be at high risk due to AI applications and robotization in the near future (Frey & Osborne, 2017).

When AI and robotics are merged as different disciplines, intelligent robots can evolve using AI as a brain. Robots can therefore walk, talk, and communicate with others (Marr, 2020). The word "*Robot*" etymologically comes from the Czech word "*Robotnik*," which means slave and is defined as "*a machine controlled by a computer that is used to perform jobs automatically*" (Cambridge Dictionary, 2021; Online Etymology Dictionary, 2021). Robotics is classified into three broad categories: Industrial robots; we can see the best examples in the automotive industry. Professional service robots include cleaning up nuclear waste areas or minefields that are dangerous for humans. Personal service robots communicate and assist people by providing information or assisting us in homes, works, or elsewhere (Bartneck & Forlizzi, 2004; Rodriguez-Lizundia et al., 2015).

Regarding the professional service robots, services are transforming with AI applications. With the increasing and widespread use of big data, AI has become the focus of companies that want to remain competitive (Li et al., 2021). AI, represented by machines that demonstrate elements of human intelligence (HI), is being more widely used in services and is now a significant catalyst of innovations. Robotic systems for homes, restaurants, hotels, and hospitals have automated many aspects of life (Huang & Rust, 2018). Artificial intelligence applications offer technology-based service encounters by reducing face-to-face communication. Thus, the concept of interaction in the service sector is redefined (Ivanov & Webster, 2019). According to Matzner et al. (2018), AI would have two effects on the service sector. First, it creates the ability to make service provision and customer engagement more effective and efficient. Second, AI threatens human service workers across various fields, from bus drivers to call center agents. However, James Wilson & Daugherty (2018) indicates that companies achieve the most significant performance improvements in flexibility, scale, decision-making, speed, and personalization when humans and machines work together. Assembly robots for manufacturing, fraud detection for banks, chatbots for customer service, and robot advisors for financial workers or fashion stylists are

just a few examples of this collaboration. Consequently, service robots offer ways to improve the efficiency and effectiveness of services and use of AI applications for clinical diagnosis or intelligent chatbots enhance customer engagement. Accordingly, service provision deployed by people and/machines affects both employees and customers. Different service types require different types of intelligence, categorized as mechanical, analytical, intuitive, and empathetic (Huang & Rust, 2018). Based on Huang and Rust (2018), AI classification and some of its core properties are as follows:

- ***Mechanical AI***: Exhibits a minimum level of learning and depends on observations to behave and respond consistently. However, it is accurate, reliable, and efficient.
- ***Analytical AI****:* Based on the evidence, analytical AI learns systematically. It provides a reasonable, analytical, and rule-based learning mechanism. IBM's chess player Deep Blue is an example of this type of AI.
- ***Intuitive AI****:* It has an understanding capability and learns intuitively. Artificial neural networks or deep learning mechanisms can support intuitive AI.
- ***Empathetic AI****:* Provides empathic learning depending on experience and has the capability of emotion detection and robust computing power. Hanson's robot Sophia integrating emotions for decision-making is an example of this type of AI.

It is more difficult for AI to imitate intuitive and empathetic behaviors, and therefore it takes longer to create practical AI applications with intuitive and empathetic intelligence (Huang & Rust, 2018). According to Huang and Rust (2021b), AI can be applied to the service industry in different tasks in three ways. Figure 14.1 illustrates this triple approach expressed as mechanical, thinking, and feeling.

When the service business aims to maximize efficiency while keeping the difference offered to the consumer at a minimum, the level of artificial intelligence to

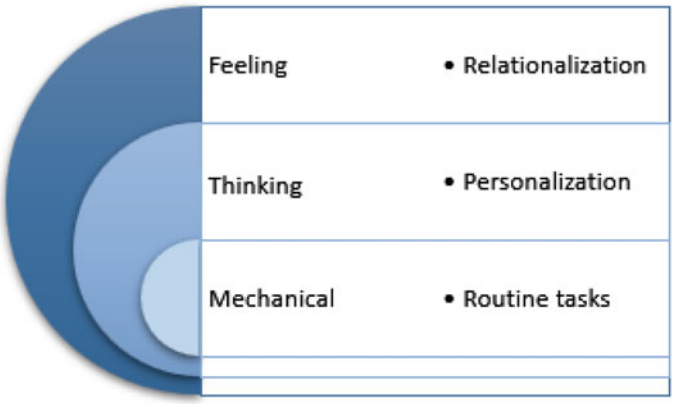


**Fig. 14.1** The use of artificial intelligence in the service industry. *Source* Adapted from Huang and Rust (2021b)

be utilized is at the lowest level and is called mechanical AI. If the communication with the customer is not of great importance in a service task, fast food ordering with self-service automat, cleaning, or delivery robots in a hotel can be examples of mechanical AI.

Huang and Rust (2021b) conceptualized artificial intelligence, which learns from data and produces meaningful results, as Thinking AI. Especially when there is sufficient data and the problems to be solved are defined correctly, thinking AI offers a practical solution for the business in personalizing the services. Customer segmentation and product recommendation systems are now used extensively as examples of this form of artificial intelligence in a wide range of service industries. Feeling AI, which is not yet common and at a development level, is expressed in a way that includes both thinking, mechanical level capabilities, and experiences. Today, we see more low-level applications such as chatbots. It is stated that high-level practices that have empathy and understanding will read human emotions and create a natural dialogue environment for customers in the service industry (Huang & Rust, 2021b).

Robotics is an important field that is becoming more relevant for service management, although it has been chiefly used to assist or substitute mechanical and routine tasks that do not involve skilled and qualified employees. While most workers find such service work unappealing, and those who do it often suffer from physical or mental health problems, this choice offers significant opportunities for restructuring work and efficiency. Furthermore, autonomous robots are developing improved senses, agility, and functionalities, allowing them to execute a broader range of manual activities and, as a result, altering the essence of employment in a variety of occupational groups. Besides, socially assistive robots may perform a wider range of supportive roles, such as safeguarding, physical interaction, and cognitive assistance (Matzner et al., 2018). Recently, social distance and quarantine measures have gained importance to cope with the COVID-19 threat. Since the adverse effects of these measures on businesses and the economy are apparent, it is necessary to focus on practices that will keep businesses operating. In this context, artificial intelligence technologies that offer low social interaction and physical contact levels are considered (Li et al., 2021).

Li et al. (2021) mentioned service robots, production/delivery robots, social media online services and smart suggestions, intelligent augmented reality, and smart home applications as examples of artificial intelligence-based service encounters. These technologies offer flexible interaction and interactive participation. Some of them provide the active involvement of participants and trigger innovations (Li et al., 2021). Li et al. (2021) categorized service robot utilization as artificial intelligence-facilitated service encounters. Service robots used in this context are autonomous and intelligent to a great extent. Further, they are good at data storage and retrieval (Prentice et al., 2020).

## 14.2 Service Robots

As an important subject of study in engineering and computer science disciplines, service robots will soon be more popular due to the decreasing costs and advanced computing techniques (Mende, 2017). Jörling et al. (2019, p. 405) defines service robot as:

> *information technology in a physical embodiment, providing customized services by performing physical as well as nonphysical tasks with a high degree of autonomy.*

The service robot definition of Jörling et al. (2019) includes autonomous vehicles, autonomous vacuum cleaners, and companion robots as service robots; however, Amazon Echo or Google Home is not considered service robots because they are not autonomous. Despite advancements in service robots, consumers face difficulties creating positive attitudes toward their use because robots are a new technology and fear and anxiety around robots (Song, 2017). In this sense, humanoid service robots follow a path that removes some obstacles in human–robot interaction. For example, Pepper which was launched as the world's first social humanoid robot has features that can be used in companies and schools, identifying basic human emotions, recognizing faces, and chatting with people. Like an assistant, Pepper can welcome, inform and guide people (SoftBank Robotics, 2021).

Pepper is pictured in Fig. 14.2. performing as a customer assistant in a retail store.

According to the review of Lu et al. (2020), literature on service robots cover four major topics:

(1) How robotics can support workers by automated service procedures and other advantages
(2) Difficulties that employees can face as companies incorporate service robots


**Fig. 14.2** Service robot: pepper. *Source* https://www.instagram.com/sbreurope/

(3) Human–robot teamwork in service provision
(4) The impact of robots on service employment and associated employee skills and development.

The research focusing on hotel context has similarly concentrated on human resources management, cost–benefit analysis, service provision, and quality (Lin & Mattila, 2021; Wirtz et al., 2018). According to Jörling et al. (2019), although the bulk of research on service robots has focused on technological issues, more research is needed on consumers' views of the results achieved by service robots.

## 14.3 Impact of Robots on Service Provision

### *14.3.1 Impacts on Customers*

User interactions with humanoid service robots referring to robots with human-like anatomy will quickly become a common occurrence in the marketplace. It is unknown, though, whether these humanoid robots would positively or negatively impact customers and businesses as opposed to human workers (Mende et al., 2019). van Doorn et al. (2017) stated that robotic systems enable employee–customer experiences since humanoid robots can substitute or work with frontline service personnel to provide customer service. However, customer service results in terms of well-being, satisfaction, and loyalty are determined by robot features such as perceived warmth, attractiveness, competence, and customer-related factors like technological readiness, relationship orientation, and anthropomorphization (van Doorn et al., 2017).

Čaić et al. (2019) concentrated on the value of social robots on customers in elderly care services. They explored that consumers receive practical, emotional, and social assistance from robots. Their personal values motivate their interactions with robots, and perceived warmth and perceived competence characteristics of robots have a moderator effect on the customers' assessments of robots' co-creation/destruction skills. From the customer perspective in different service contexts, Jörling et al. (2019) investigated the drivers of responsibility for the consequences of service provision by robots. Findings revealed that customers might feel accountable for the outcomes of robot-delivered services, particularly for the negative ones if they own the robot. On the other hand, customers feel less control and responsibility for positive service results when the autonomy level of the robot is high. The capability of consumers to impede the robots' autonomy empowers them to experience more control and responsibility for good results (Jörling et al., 2019).

Mende et al. (2019) examined the influence of humanoid robots on customers having food services. As compared to humans, humanoid service robots cause consumers feelings such as eeriness and human identity threats. Besides, when users

communicate with a humanoid service robot instead of a human, they exhibit compensatory responses such as they value prestige purchases, seek social affiliation, and demand and consume more food.

According to van Pinxteren et al. (2019), although service robots may help customers in terms of ease, flexibility, responsiveness, and efficiency and provide cost reduction for service providers, market penetration is hampered by a lack of confidence. Firms, therefore, apply human-like characteristics to robots to increase trust; however, anthropomorphism theory remains unclear regarding its proper implementation.

According to human–robot interaction, designs for humanoid robots should have "natural" characteristics, look and behave like real people, and have an "empathic" ability to communicate with the world (Fong et al., 2003). Since people ascribe feelings and thoughts to robots as they interact with them, incorporating human-like characteristics is assumed to affect how people see robots (Epley et al., 2007). In this context, *anthropomorphism* is used to explain the object's behavior by giving it human characteristics. An anthropomorphic entity is identifiable by having a face and a physical body, with the addition of actions and feelings (Murphy et al., 2017). van Pinxteren et al. (2019) explored that anthropomorphism influences trust, intention to use service robots for public service, and enjoyment. According to Mori et al. (2012) "*the uncanny valley theory*," when the robot looks like a human to a certain point, the user perceives a positive feeling close to human–human interaction. However, the humanoid robots may cause a feeling of revulsion at a certain point. Spatola et al. (2019) revealed that the four robots shown in Fig. 14.3 differing in anthropomorphism were not evaluated as similarly warm and competent by the participants in their research. Participants perceived iconic and human-like robots as more competent


**Fig. 14.3** Less to most human-like robots. *Source* Spatola et al. (2019)

and warm. In particular, their results show that the iconic robot is perceived as more competent than the human-like robot and support "*the uncanny valley theory.*"

Accordingly, companies have gradually added human-like functionality to their self-service technology machinery in order to improve their customer experience. Fan et al. (2016) aimed to investigate the customers' relationship with an anthropomorphic computer in the sense of a service failure. In particular, the authors examined the combined effects of machine voice, a sense of power for a person, and other clients to influence the switching intentions of customers upon the breakdown of a self-service technology breakdown.

Rely on the anthropomorphic nature of a self-service technology, the perception of power and the existence of other customers and users' attitude to the self-service technology breakdown differ. It was discovered that anthropomorphism adversely affects the customer's intentions to change the system; for example, a voice similar to a human invites consumers to proceed to utilize the machines (Fan et al., 2016).

### *14.3.2 Impacts on Employees*

Employees are frequently concerned about the effect of service automation on their jobs. As a result, organizations must be as open as possible regarding the consequences for employees. Open and transparent internal communications and making the process visible for everyone are essential in employee engagement (Lacity & Willcocks, 2016).

Fleming (2019) examined the effect of service robots on employees in different contexts. When service robots take over parts of occupations, they can simplify service procedures and cause semi-automatic tasks. Nevertheless, there would be no massive unemployment because of environmental restrictions, and employees would need to be skilled as service robots are introduced (Fleming, 2019). Huang and Rust (2018) proposed a theory related to artificial intelligence job replacement. Four types of intelligence are defined in principle to carry out service tasks—mechanical, analytical, introduction, and empathetic—and determine how companies can decide between people and machines. The theory says that job replacement primarily occurs on the task level rather than on the job level and for more manageable intelligence tasks.

AI initially performs certain activities in the service sector, a phase of transformation seen as an enhancement, and then proceeds to eliminate human labor if it can take up entire tasks. As the AI mission is progressed from lower to greater intelligence, the relative value of intelligence for service workers changes over time. One of the significant implications of the theory is that analytical capabilities will be less critical as AI handles more analytical tasks. On the other hand, softer intuitive and empathic skills will be more significant for service staff. In the end, AI will be able to carry out even intuitive and empathetic tasks that allow novel ways of integrating human–machines to conduct services and lead to a significant threat to employees (Huang & Rust, 2018).

**Table 14.1** Service delivery task and potential replacement outcomes

| Task type | Examples | Future scenario |
|---|---|---|
| Simple cognitive/analytical and simple emotional/social tasks | Purchasing tickets for the train, car rental, pick-up service, and supermarket check-outs | Robots dominance in service provision |
| Complex cognitive/analytical and simple emotional/social tasks | Insurance, government services, stockbroking, and other services demanding good analytical capability for the back office | The increasing role of robots in service provision |
| Simple cognitive/analytical and complex emotional/social tasks | Tourism, sporting, and entertainment services | These services will continue to be provided by people in general |
| Complex cognitive/analytical and complex emotional/social tasks | Complex tasks in health care, nursing, and higher education environment | • Mixed (human and robots)<br>• It is questionable that robots will have the ability to handle the complex emotional problems sufficiently in social intelligence and communication<br>• These services are so sophisticated that human actors are unlikely to feel secure in providing such services without AI assistance |

Adapted from Wirtz et al. (2018)

Wirtz et al. (2018) also discussed the role of service robots in future employment and highlighted that different service delivery tasks would be affected differently. The summary of their arguments is demonstrated in Table 14.1.

According to (Huang & Rust, 2018), skills and labor that different types of AI can replace are reprensented in Table 14.2.

Regarding the healthare context, with the further infusion of the technologies into healthcare services, physical and spatial distances between service suppliers and their clients eventually elevate. Service separation is growing in the theoretical and scientific curiosity of service academics, but the literature about service separation has to this day been concentrated on the context of the customers (Green et al., 2016). Green et al. (2016) explored the experience of health services providers in telehealth utilization as a separated service delivery. Interviews at various hospitals and healthcare facilities demonstrated a necessity to handle changes associated with the role and the position of service providers. Further, service suppliers were found to undergo "depersonalization," "clinical voyeurism," and "intangibility negotiation" (Green et al., 2016).

**Table 14.2** Type of intelligence, associated skills, and labor

| AI | Skill | Labor |
|---|---|---|
| Mechanical | Skills that need little to no educational background | Salespeople, cap drivers, and restaurant staff |
| Analytical | Professional skills that need particular expertise and knowledge | Data scientists, business analysts, engineers, and accountants |
| Intuitive | Skills that need creativity and problem-solving capability | Doctors, sales and marketing managers, and lawyers |
| Empathetic | Social skills that need communication and relationship establishment capability | Politicians and psychiatrists |

Adapted from Huang and Rust (2018)

Barrett et al. (2012) examined the influence of robots on the professionals in hospital pharmacies. According to the study, robots offer employees the advantages of team collaboration, more time to focus on advanced and customer-oriented work, enhance institutional authority, and strengthen their position in the organization. Besides, employees may improve their technological skills as approved robot caretakers. On the contrary, employees can experience a loss of control and dissatisfaction due to a lack of communication with customers and a challenge to their daily routine as a result of robots bringing changes to their work (Barrett et al., 2012; Lu et al., 2020).

The study of Lacity and Willcocks (2016) is another paper investigating the effects of service automation on employees within different service contexts. According to researchers, organizations can acquire substantial benefits from innovating their service practices. Getting benefits depends on a good service automation vision encouraged by the top management, putting effort into effective processes which create value for both customers and the organization and supporting the development of organizational skills and capabilities.

Depending on the case studies they performed, Lacity and Willcocks (2016) indicated that many workers are concerned about the effects of automation. They observed businesses using service automation software to automate the routine and tedious tasks, and they were not informed about any layoffs related explicitly to service automation in the organizations they analyzed. Rather than being fully automated, tasks were restructured and developed. Service automation enabled businesses to avoid increasing the number of employees by redeploying existing employees to other company operations. It is crucial that they discovered that employees did not see automation as a challenge but instead saw it as an opportunity to have more customer-related work with more minor routine tasks (Lacity & Willcocks, 2016).

In terms of hospitality services, quick-service restaurants have been the pioneers that automate their operations for eliminating costs and improving quality, and robotic technologies facilitate achieving these aims (Noone & Coulter, 2012). Noone and Coulter (2012), examining the impacts of robot collaboration with employees rather than job replacement, discovered that the cognitive capacity of employees improved.

## 14.4 Theories and Frameworks on the Acceptance and Use of Service Robots

Davis (1989) presented the Technology Acceptance Model (TAM), which outlined the factors that influence consumers' adoption of technology. The theory describes that technological acceptance, or the actual use of new technology, is based on external factors predicting perceived ease of use and perceived usefulness of the technology, affecting attitude and behavioral intention (Davis, 1989). Venkatesh and Davis (2000) have revised TAM over time and proposed Technology Acceptance Model 2 (TAM2) by including new variables that determine perceived usefulness. TAM2 was extended by subjective norms, result demonstrability, image, output quality, and job relevance. These factors were introduced as determinants of perceived usefulness and behavioral intention (Psylla, 2020).

In an attempt to construct a theory that would be broadly applicable in many areas of related academic science, Venkatesh et al. (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT posits that behavioral intention is determined by social influence, performance, and effort expectancy. Behavioral intention, together with facilitating conditions, affects use behavior. Further, a set of moderator variables were introduced, including gender, age, experience, and voluntariness of use (Psylla, 2020).

Venkatesh and Bala (2008) developed TAM3 by extending TAM2 and proposing determinants of perceived ease of use. Furthermore, they suggested that the determinants of perceived usefulness have no effect on perceived ease of use and that perceived usefulness has no impact on perceived usefulness. As a result, TAM3 claims that there are no cross-over impacts. Individuals shape their perceptions of ease of use regarding a particular system by stabilizing their perceptions to various general computer views and later changing their perceptions of ease of use relying on practical experience with the given scenario. Furthermore, multiple traits and feelings, such as computer self-efficacy, computer playfulness, and computer fear, are predictors of perceived ease of use (Venkatesh & Bala, 2008).

Regarding the service robot context, the Service Robot Acceptance Model (sRAM) by Wirtz et al. (2018) and the Automated Social Presence (ASP) by van Doorn et al. (2017) are two robust conceptual models used for investigating the acceptance and the use of service robots. The sRAM framework, Wirtz et al. (2018) used the TAM for analyzing why service robots are accepted and used. Wirtz et al. (2018) also utilized the role theory (Solomon et al., 1985) to concentrate on needs and role congruency. By doing so, they claim that consumer acceptance is contingent on how well robots can meet practical needs such as dominance as well as social-emotional and psychological needs (Lu et al., 2020; Wirtz et al., 2018). Wirtz et al. (2018) proposed that functional, socio-emotional, and relational factors affect customer acceptance of service robots and the actual use. These factors are presented in Fig. 14.4.

Regarding the ASP, the model proposes that the relationship between technology infusion into the service frontline and service and customer outcomes is mediated

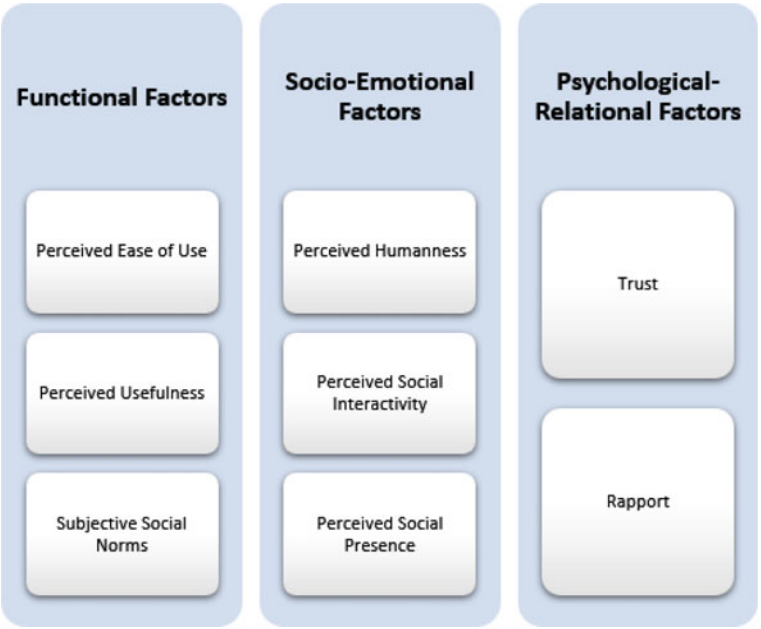


**Fig. 14.4.** sRAM model and proposed factors. *Source* Adapted from Wirtz et al. (2018)

by social cognition and psychological ownership. Social cognition factors include warmth and competence, while psychological ownership factors include receptiveness, attractiveness, and manipulability. Further, the relationships are influenced by customer attributes, likewise relationship orientation, anthropomorphization, and technology readiness (Lu et al., 2020; van Doorn et al., 2017).

## 14.5 Empirical and Experimental Studies Related to Use of Service Robots

In the face of an aging population and a growing labor shortage in the developed world, robots are being seen as possible solutions. However, if robotics needs to be used by aged consumers in the future, they must be embraced. Although a significant segment of the elderly population might be open to supporting innovations, technology adoption remains a complicated issue. Even though a variety of technological instruments are designed to meet the needs of the elderly, these innovations are often not used because of reasons such as (non) adaptability (Heerink et al., 2009). It is vital to research the acceptance of the use of service robots not only in the context of the elderly care services but also for the use of different user groups in other areas.

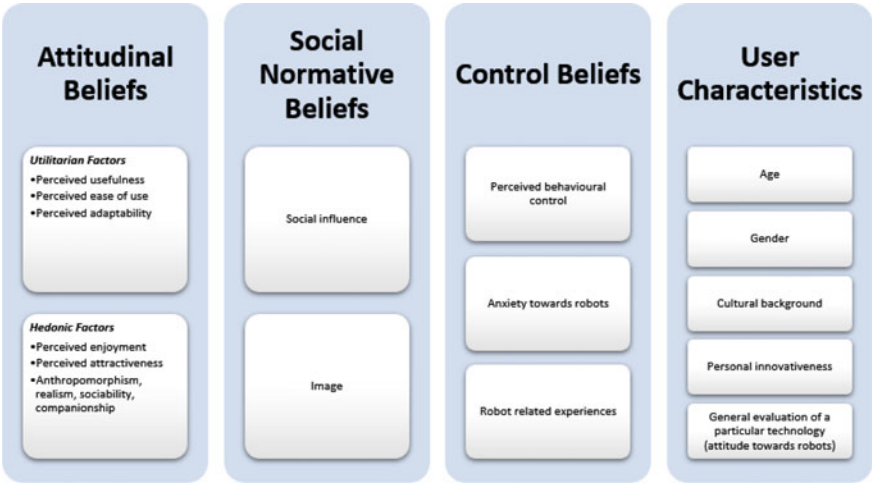


**Fig. 14.5** Determinants of acceptance of social robots. *Source* Adapted from De Graaf and Ben Allouch (2013)

In this context, studies in the literature have focused on different variables regarding robot acceptance. De Graaf and Ben Allouch (2013) grouped these variables as utilitarian, hedonic, social normative beliefs, and user-related factors. The variables belonging to these categories and observed to be effective in previous studies on robot acceptance are presented in Fig. 14.5.

Utilitarian variables are concerned with a product's practicality and usability. Hedonic variables, differently, contribute to a user's experience when utilizing a product and therefore have no apparent connection to task-related objectives. Usefulness and ease of use are well-known utilitarian factors derived from the TAM, and they are important determinants of intention to use in the field of human–computer interaction (De Graaf & Ben Allouch, 2013).

The perceived capacity of the device to respond to the evolving needs of the user is known as the robot's adaptability (Heerink et al., 2010). The utilitarian factors, attitude, and intention to use are all influenced by perceived adaptability. In addition to general TAM variables, De Graaf and Ben Allouch (2013) also mentioned companionship, anthropomorphism, sociability, and realism as specific factors influencing users' robot acceptance. Among user characteristics, general evaluation of a particular technology is related to the general perceptions of individuals toward technology, and people's general attitudes about technology affect how they assess its effect on culture and how they comprehend it (De Graaf & Ben Allouch, 2013).

Psylla (2020) stated that service robot literature has mainly focused on the use of service robots in health care, hospitality, and information technology contexts. Considering the potential and contributions of the use of service robots in marketing, Psylla (2020) examined the impact of social robots on customer loyalty and inspiration and explored that robot characteristics, including personalization, ease of

use, and aesthetics, significantly determined customer loyalty and inspiration in a supermarket context.

Heerink et al. (2009) measured the acceptance of a social robot which has a role in elderly care. Interestingly, perceived ease of use was found the only factor determining intention to use. Perceived usefulness did not affect intention to use, and variables including anxiety and perceived enjoyment did not influence perceived usefulness and ease of use. Trust significantly predicted perceived sociability, which then had an effect on social presence. Besides, social presence had a positive direct effect on the perceived enjoyment factor. Using the UTAUT model, Heerink et al. (2010) investigated assistive social agent technology acceptance. Among proposed factors including social influence, attitude, perceived usefulness, perceived ease of use, perceived enjoyment, and trust, only trust did not significantly affect intention to use. Perceived adaptability significantly determined perceived usefulness. While the effect of anxiety on ease of use was determined, it was observed that it did not affect perceived ease of use. Social presence had an influence on perceived enjoyment. Further, the effect of trust on perceived sociability and perceived sociability on social presence was proven.

Another study examined the correlates of use intention, actual use, and use attitude for social robots. Perceived enjoyment was found a significant correlate of actual use. Regarding the intention to use, attitude, adaptability, companionship, and perceived behavioral control were the variables that demonstrated a significant link. On the other hand, usefulness, enjoyment, and sociability were significantly related to use attitude (De Graaf & Ben Allouch, 2013).

Fridin and Belokopytov (2014) investigated the acceptance of socially assistive robots, which assist users in education. Attitude and perceived usefulness significantly predicted intention to use, while no impact was observed for the perceived enjoyment. Perceived sociability had an influence on the perceived enjoyment, and it was explored that perceived usefulness was determined by anxiety and perceived adaptability.

When it comes to service robot use in retail sectors, retail service robots can be used for enhancing operations with customers and provide customer satisfaction (Song, 2017). Retail service robots are customer service robots that use artificial intelligence to assist customers in exploring stores, searching items, and performing transactions. Retail service robots are designed to have a convenient shopping environment, provide relevant product details and reviews, amuse consumers, and communicate with human staff, although they have not yet been broadly commercialized (Barnett et al., 2014). Retail service robots can also deal with customer queries. For instance, they can bring luggage, provide guidance, and support people with disabilities. These robots can communicate feelings and engage in social interactions such as offering advice and engaging in debate (Kiesler & Hinds, 2004; Song, 2017). Kiesler and Hinds (2004) and Song (2017) conducted an experimental study to test the proposed human–robot interaction model. Based on the hypothesized relationships, the effects of usefulness, social capability, and appearance on the attitude toward human–robot interaction were tested. All variables revealed a significant impact on the outcome variable. Further, attitude toward human–robot interaction influenced intention to

use retail service robots, and anticipated service quality significantly impacted attitude toward human–robot interaction and intention to use service robots (Kiesler & Hinds, 2004; Song, 2017).

Lin and Mattila (2021) focused on the use of service robots in the hotel context. Variables including perceived privacy, functional benefits, novelty value, and the robot appearance were examined for their effects on the attitude toward service robots and the overall hotel experience. Customers' attitudes were significantly affected by perceived privacy, functional benefits, and appearance factors, whereas appearance and perceived privacy had no impact on the anticipated overall hotel performance. However, it was explored that functional benefits also impacted the anticipated hotel experience (Lin & Mattila, 2021). A recent study focused on the COVID-19 effect on the service robot preference of customers.

Experiments conducted revealed that customers' attitudes toward service robots became positive when the COVID-19 pandemic was noticeable. Hence, the COVID-19 threat was significantly affected customers' preferences (Kim et al., 2021). Regarding the service robot use in the hotels, Jia et al. (2021) analyzed the impact of the robot interaction on customers' behavior. Particularly, the influence of anthropomorphism was examined, and the findings revealed that customers were more inclined to accept robots having a medium level of human-likeness compared to robots having a high level of human-likeness. Another experimental study was conducted by Zhong et al. (2020), who investigated the customers' intention to buy related to the hotels where robot services are offered. It was explored that the purchase intention of consumers who viewed a film about robot hotel services was much greater than those who viewed a film about traditional hotel services. Most contemporary evidence concentrates on the technical features of service robots or consumer adoption behavior rather than the consumers' behavioral or psychological response to the robot (Thomsen, 2020). Depending on this argument, Thomsen (2020) examined the influences of appearance, service customization, and service efficiency on the experiences of hotel customers.

Further, robot anxiety, self-image congruity, and technology readiness of customers were considered to evaluate the impact of robot features on the brand equity of the hotel. Contrary to what was expected, whether the robot was humanoid did not affect the users' experience. On the other hand, service efficiency was found to be a significant variable influencing users' experience. Choi et al. (2020) examined users' experiences in terms of perceived service quality. Human employees and service robots were compared with regard to the service they provided. Employee services were found to offer a better service quality and physical service atmosphere. However, in terms of outcome quality no significant difference was reported (Choi et al., 2020).

## 14.6 Conceptual Studies Related to Use of Service Robots

When the conceptual studies in the service robot literature are examined, it is observed that these studies can be easily gathered under several headings. Some of these have proposed conceptual models investigating service robot acceptance and use in general (van Doorn et al., 2017; Wirtz et al., 2018). Čaić et al. (2019) study more specifically suggested a model for understanding and explaining human–robot interaction in the context of elderly care services. Huang and Rust (2021a) have developed a conceptual framework investigating how artificial intelligence can be used for marketing research strategy and actions. Li et al. (2021) proposed a model to understand the factors affecting the execution of artificial intelligence-based services and the effects of services, again with sector-specific research.

A limited number of studies are in the form of literature reviews and highlighted the shortcomings in the relevant literature (Belanche et al., 2020; Lu et al., 2020). Belanche et al., (2020), emphasizing the design principles of service robots, proposed a conceptual framework regarding the elements that should be integrated into the design of these robots. Lu et al. (2020) discussed the results and effects of service robot applications for employees and customers by synthesizing the studies in the literature. Many studies debating the impacts of AI have explained the effects on employees, the impact of artificial intelligence on business designs and professional groups, and the possible scenarios for the future, the types of AI-based tasks, and predictions about their transformation (Barrett et al., 2012; Fleming, 2019; Huang et al., 2019; James Wilson & Daugherty, 2018; Noone & Coulter, 2012). James Wilson & Daugherty (2018) and Noone and Coulter (2012) also discussed the implications for operational business.

## 14.7 Conclusion

The literature on the use of service robots has generally focused on the effects, advantages, and disadvantages of robots providing services and customer adoption and use of these technologies. The effects on customers are generally considered in the context of the success of these technologies, satisfaction, and customer loyalty, and the factors affecting these outcomes have been investigated. Further, the future effects of robots and artificial intelligence on the workforce have been a very interesting area for academics. Therefore, the impact on employees has been discussed in many conceptual studies. It is thought that service provision tasks will be affected by automation and artificial intelligence in different ways. Regarding the replacement of jobs, it is envisaged that job designs will transform on a task-based rather than top-down basis, with simple cognitive and analytical tasks being performed first by service robots, and then complex emotional and social tasks are likely to be supported by service robot–human collaboration.

Studies investigating how service robots will have an impact on employment in the future have not discussed how different sectors will be affected. In existing studies, service tasks were generally classified and how the transformation could take place on task basis was explained. In this sense, it is necessary to have studies in the literature that take into account specific sector dynamics, address and discuss this issue in particular sectors, and analyze the possible effects on labor for different sectors. In addition, it is important that there are studies that investigate the effects on employees in detail, as well as effects on businesses and organizations such as efficiency, service quality, and customer satisfaction. Studies that propose a roadmap for dealing with transformation and the consequences of these technologies by addressing the resistance to change and offering methods that can cope with this resistance in the context of change management and organizational psychology will make an important contribution to the literature. Moreover, ethical issues regarding the use of robots should be examined in future studies.

Similar to the argument of Lu et al. (2020), we found that the existing studies are largely fragmented. They have approached the phenomenon from different aspects and highlighted different issues regarding service robot use. Most of the studies are conceptual, and the empirical studies that examined the acceptance or use of service robots have mainly used technology acceptance and use theories and frameworks such as TAM, TAM2, and UTAUT. To the best of our knowledge, the Service Robot Acceptance Model (sRAM) by Wirtz et al. (2018) and the Automated Social Presence (ASP) by van Doorn et al. (2017) are the only models that have been developed for the service robot context. For that reason, more research is required for building theory. Depending on the fact that most research has examined the intention to use, more empirical studies analyzing actual use and different outcome variables such as continuous intention to use are necessary.

Theories about service robots can be tested for different contexts by extending them with other variables. It has been observed that a limited number of factors related to user characteristics have been tested in studies. Accordingly, future studies may examine more personality traits of users and the effect of psychological and behavioral factors on the robot acceptance and use. Regarding utilitarian factors, factors such as system complexity and interface complexity that affect these factors can also be explored by future studies. As Psylla (2020) emphasized, it has been found that the service robot literature generally focuses on the fields of health care, hospitality, and information technology. There is a need for studies investigating the use of service robots in many fields, especially in education, law, marketing, banking, and finance. Again, how the COVID-19 effect affects the use of robots in different sectors is an important research topic. It is also important to emphasize the essential aspects of service robot design and the criteria required to develop human-centered designs in terms of usability.

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