A Look at Machine Learning in the Modern Age of Sustainable Future Secured Smart Cities

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Abstract Artificial Intelligence (AI) is a fascinating technology for the whole society, whether the citizen, science, business, education, government, among others. Machine Learning is a technique derived from AI that through neural networks and statistical methods, establishes logical rules to make decisions and automate processes, i.e., a method employed so that machines can learn from the data. A smart city aggregateICT (Information and Communication Technologies) to promote the performance and quality of urban services related to urban transportation, energy consumption, and distribution, and even public services (water treatment and supply; production of electricity, gas, and fuels; collective transport; capture and treatment of sewage and garbage; telecommunications; among others), in order to decrease resource consumption, wastage, and general costs. The administration of Smart Cities is possible to be efficient through the employment of data collected in real-time combined with the skills of computational intelligence, i.e., Machine Learning and its aspects. In this sense, this chapter intends to offer a scientific major contribution related to an overview of Machine learning, directing focus to Sustainable Future Secured Smart Cities, discussing its relationship from a concise bibliographic background, evidencing the potential of technology.

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1 Introduction

Machine learning is an area of computational expertise, part of the concept of artificial intelligence, which studies ways for machines to do tasks that would be performed by people. It is programming used in computers, formed by predefined rules that allow computers to make decisions based on previous data and data used by the user [1, 2].

Machine learning (ML) is a concept which in essence is a system that can autonomously modify its behavior based on its own experience through machine training, where practically human interference is minimal. Where according to programming, the computer has the ability to make decisions that can solve problems or boost internet publications, for example [2].

Machine learning is a subclass of AI, with properties to perform computational analysis of huge volumes of data using algorithms and statistical methods to find patterns in this database [1, 3].

This technique can contribute in several ways to the construction of smart cities, enabling the creation of intelligent and efficient services for the population, with monitoring of transport data, control over the use of public services, and real-time monitoring of security cameras of the municipalities [4].

The basis of the operation is the algorithms, which are defined sequences composed of information and instructions that will be followed by the computer. These sequences allow computers to make a decision according to the situation and the information that has been entered into it. It is the algorithm that carries information about how certain procedures and operations should be done or how an action should be performed. There are several types of applications and programming languages for the use of algorithms. It vary according to the need to be met or the purpose of the algorithm created [5, 6].

A smart city is a city that aggregates ICT based on constant monitoring using disruptive technologies such as the IoT, AI, and Machine Learning. Since The combination of technologies, services, connectivity with management, urban development, and administration are the basis for smart cities, with the purpose of improving the quality and performance of urban services, related to urban transportation, energy consumption and distribution, and even public services (water treatment and supply; production of electricity, gas, and fuels; collective transport; capture and treatment of sewage, garbage and overhead costs [7].

Its main feature, however, is that it doesn't have to have hand routines in place, where the system itself has the ability to learn from data analysis with increasing precision, and through it perform tasks. A valid example is the email spam filter, blocking unwanted inbox messages, and automatically improves and over time becomes more efficient [7, 8].

One of the fields where AI is having the most success in machine learning, developing algorithms with features and properties from this data, get learn patterns and decision rules. Having an exponential growth in the recent past in the amount of biological data available leading to two lines of thinking regarding the efficient storage and management of this information and, in contrast, the extraction of profitable information from this data. Since data-driven machine learning algorithms can combine them with classic statistical methods, it is efficient to extract knowledge from the data [9, 10].

There are various biological domains in which ML techniques are employed to extract knowledge from data, since computational and data mining methods must be considered and can be genuinely applied in clinical medicine to derive models that utilize predetermined information predicting a result of interest. Predictive methods of data mining can be employed for the building of decision models for digital procedures such as diagnosis, prognosis, and even treatment planning. Given that once verified, evaluated, and validated, can be incorporated into respective digital systems to medical clinical information. Where these methods and tools infer beyond a simple description of the data providing knowledge in the form of digital models [11–13].

In machine learning, the machine study material is data. The more data that feeds the systems, the more questions will be asked, and more answers will emerge to solve problems. This is why machine learning achieves its full potential with Big Data, the storage, and processing of huge volumes of data. So smart algorithms can completely scan this immensity of data to find patterns and come up with unimaginable predictions [14, 15].

This chapter has motivation focused to concede a scientific major contribution concerning the discussion on Machine Learning directing focus to Sustainable Future Secured Smart Cities, in which this manuscript has organization following in Sect. 2 will be presented the Artificial Intelligence Concepts for understanding the research. In Sect. 3, the Machine Learning Concepts will be presented. In Sect. 4 a Discussion is made around the thematic addressed in the manuscript. In Sect. 5, technology trends are argued. Just like the chapter ends in Sect. 6 with the relevant conclusions.

Therefore, this chapter intends to proffer a scientific major contribution related to an overview of Machine Learning, directing focus to Sustainable Future Secured Smart Cities, discussing and approaching the potential of both technologies, categorizing and synthesizing it from a concise bibliographic background.

It is worth mentioning that this manuscript differs from the existing surveys since a “survey” is often used in science to describe and explains the theory, documenting how each discovery added to the store of knowledge, talking about the theoretical aspects, how the academics piece fits into a theoretical model. While the overview is a scientific collection around the topic addressed, relating that this type of study is scarce in the literature, offering a new perspective on an element missing in the literature, dealing with an updated discussion of technological approaches, exemplifying with the most recent research, applications, techniques, and tools focused on the thematic, summarizing the main applications today.

2 Artificial Intelligence Concepts

AI is a field of computational science that develops devices and algorithms developed to enable machines that have similar intellect capabilities as humans, simulating the human ability to reason, perceive, make decisions and solve problems, i.e., the ability to be smart. This depicts a set of digital software, computational logic, applied and intelligent computing, and philosophical science that aims to create computers that perform functions previously exclusively human, such as perceiving the meaning in writing, whether digital or handwritten or even spoken language, digital learning, or yet recognizing facial expressions, among others. AI became possible due to the rapid development of computing, the IoT, allowing equipment and gadgets to be connected quickly to the network [16].

AI (Fig. 1) is an attractive concept for the whole society, whether the user (citizen), business, science, education, government, among others. In economic terms, there is a lot of advantage to having machines that comply with tasks that used to need human work, considering that an efficient AI solution can digitally "think" faster as also process more data than any human brain. In addition, having the power to take human skills to place and locations where people have difficulties reaching, such as outer space or even remote locations on earth, where the conditions in these places

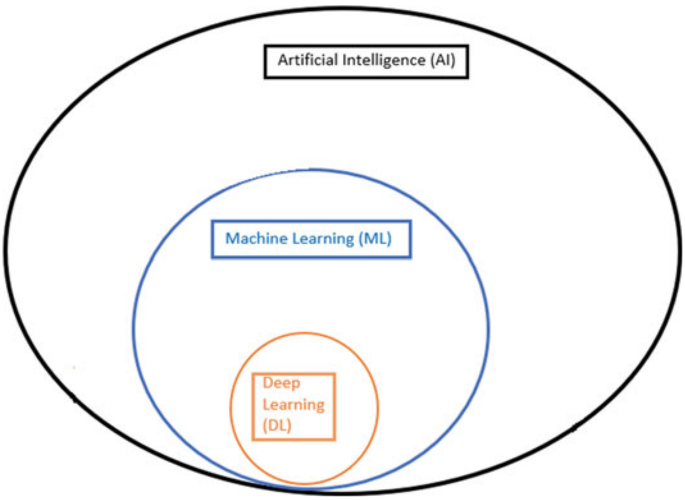

Fig. 1 AI illustration

are generally unfit for human beings, and so where human expertise can be helpful and useful [17, 18].

The operation of AI starts from the premise of combining data with fast processing and intelligent algorithms, resulting in the software being able to learn automatically only following pre-established standards. However, the main limitation of an AI is that the machine only learns from entering data and there is no way to incorporate knowledge into it that is not so. Still considering another limitation is that each AI system operates in isolation and only performs a specific type of function, exemplifying a system that detects payment fraud in the retail sector and is not able to detect fraud in the health sector. Therefore, it is very specific, and unlike the human being, it is not multitasking [18, 19].

Also relating the various types of artificial intelligence in relation to those systems that think like humans with the ability to automate processes such as problem-solving, or yet decision making, and digital learning (through ANN (Artificial Neural Networks)); or digital systems acting similar to humans dealing with computational devices (machines or even robots) performing tasks to people. Or even those systems capable of digitally thinking rationally trying to simulate the human logical rational, i.e., development and implementation of machines capable of reasoning, understanding, and acting (intelligent systems) and even those systems that act rationally trying imitate human behavior, i.e., intelligent agents [20, 21].

From a modern application perspective, AI is current in facial recognition and detection of smartphones, digital voice assistants integrated with devices through bots or applications. Bots are used in the most varied segments of society as a personal shopper in digital version, or to help in language learning, or even to make the arduous task of finding a new apartment a little more peaceful, or even virtual assistant that emits' medical diagnostics. The common characteristic of everyone is the goal of making people's lives easier [21, 22].

Considering the basic characteristics of AI, it is capable of reasoning given the application of logical rules to a set of data available to reach a conclusion; pattern recognition, both visual and sensory, as well as behavior; learning has given the ability to learn from mistakes and successes, acting more effectively in the future; or even a conclusion considering the ability to be able to apply reasoning in everyday human situations [23].

Advances in AI drive the employment of Big Data, which is the technology with respect to the properties to process an immense volume of data and even offer business advantages, positioning it as a fundamental technology for the sectors that it already employs as transportation, healthcare, education, culture among others [24].

2.1 The Advantages of AI

The advantages of AI are related to the reduction of errors considering that is, reducing the chances of a process failure, as also has a greater capacity to withstand hostile environments, as well having the possibility of achieving greater precision. Or even considering the data exploration with regard to the possibility of carrying out heavier work, it can be employed in procedures of mining ores and even fuel extraction from the depths of the sea, therefore, surpassing physical human limitations. Or even with regard to the daily applications vastly applied by the financial sector to organize, administrate, and manage data. AI is seen in diverse mechanisms of human daily life, as in simple examples such as GPS tool (Global Positioning System), the adjustment of typing errors, among many others. Still pondering the possibility of uninterrupted work, evaluating that machines (computational devices), unlike humans, don't have the requirement for frequent breaks. Allowing that is exercised various consecutive hours of work, without getting distracted, tired, or even weary or yet bored [25, 26].

AI-based solutions reduce costs and strengthen the relationship with customers (chatbots), considering their 24-h assistance, which makes communication increasingly immediate, providing help with high demand, being able to act as a filter, helping in the organization in order to prioritize the different requests. As a result, citizens are assisted when seeking assistance, even during non-business hours, assessing the context of Smart Cities [27].

Still reflecting on bots, this can help to resolve communication mainly in public government structures formed by clearly divided areas, acting as central points of contact between citizens of different neighborhoods, forming communication hubs. Or even provide optimization of processes representing a fundamental aid in the analysis of operations, looking for points that can be improved. Gathering and processing data, collecting the opinions of citizens, in order to present feedback related to key issues of the smart city [28–30].

The analysis of the flow of data generated in an online environment using Big Data analysis tools transforms this immense mass of raw data into useful information, considering that this goes beyond the capabilities of the human brain. Or even reflecting on the provided analytical advantage, it can use the information collected in Big Data analyses (Fig. 2) to create articulated campaigns and strategies, resulting in a larger number of more effective businesses. Still considering the forecast of results with respect to identifying trends in the consumption patterns of citizens, since by

Fig. 2 Big data illustration

AI it is possible to predict consumption with reasonable precision in a given period [31].

Or even the B2B (Business-to-Business) relationship between service providers that directly relate to the public can also be maintained by a virtual assistant, cultivating a good relationship with customers (citizens). Representing that the collection of information and the consistent analysis of data can be vital in the processes of the digital transformation of a city [32].

2.2 *Smart Cities Using Artificial Intelligence Technology*

A smart city is a city that incorporates ICT to upgrade the performance and quality of urban services, such as water treatment and supply; production of electricity, gas, and fuels, and public services, as collective transport; capture and treatment of sewage and garbage; telecommunications reducing resource consumption, and general costs. The combination of technologies, services, connectivity with management, urban development, and administration is the basis for smart cities, considering that it is essential that there is technology involved. Together with the internet that is present in more and more places, still considering the growing number of smartphones, the collection of information becomes possible through the network, in real-time, and from different points of a region [30, 32].

Most of this technology should be used in surveillance systems with visual identification, traffic management, and intelligent external lighting. The use of sensors enabling more effective prevention. Still considering the possibilities of monitoring. Since the main objective must be that of technology in the areas of AI, IoT, aiming at models focused on the development of main axes such as communication, mobility, energy, sanitation, health, safety, education, and even leisure [27, 33].

In this environment connected through people and things like cars, traffic lights, lighting systems, public transport, integrating into a network, facilitating access to data, and a wide range of services to the public. Since it is necessary to have an efficient connection infrastructure, involving solutions such as optical fiber, in addition to adequate planning and preparation of new structures, with the investment and adoption of innovative technologies, avoiding unnecessary expenses [27, 33].

It is in this sense of using technology and contributing to the well-being of people linked to the fact of living in a smart city, with the use of resources and technologies generated by this diversity of knowledge in the network. A scenario applicable for a noise sensor whose objective is to measure the noise level of the environment in decibels is to measure the noise level in a certain neighborhood and that eventually suffers from loud noises coming from commercial establishments or construction works [7].

Still evaluating that this sensor can be monitored at all times, and to control if the noise reaches a high level and maintains it for a certain period, actions (city hall) can be alerted and take some action, such as creating an awareness campaign for residents, sending technicians and inspectors to assess the problem or even activate the police force. Either taking into account those solutions that notify the time that a bus will pass, or even considering those more complex infrastructures, the possibility of determining how many people are on each bus, resulting in the user waiting and traveling in more comfort [34].

However, for all of this to be possible, it is necessary to have quality data, considering that this data may come from public transport, sensors, cameras, police reports, among many others. In addition to the processing of videos and images that can be of great use because it is a source of a lot of data. This can be performed by intelligent tools such as Machine Learning, consisting of a complex task and which may require computational resources. But it is superior to traditionally done, pondering the monitoring done by a human who is unable to monitor multiple images in real-time and recognize patterns automatically [35].

A smart city needs several sensors installed throughout the environment, considering the ability of these sensors to extract data, be processed by smart technology, and make a decision. However, in general, a sensor has limited storage capacity and measures data in real-time. Therefore, this does not maintain a long-term history, implying the need to include technologies for trend analysis or the application of AI and Machine Learning techniques, in addition to a centralized environment that offers access and communication on all these devices simultaneously [36].

Thus, for the correct implementation of smart cities, the use of technologies such as chatbots (service robots) and Machine Learning is essential. Assessing that from them it will be possible to understand the needs of citizens and even engage them throughout the process, through analysis of the data collected, enabling the creation of algorithms that improve the interaction of residents with smart cities [37].

In the sensor monitoring scenario, it is possible to use sensors to control noise pollution, prevent flooding, public safety, environmental health, agriculture, and urban pollution and fires. Considering specific problems that can be solved or mitigated through constant monitoring using disruptive technologies such as IoT, AI, and Machine Learning to innovate and transform life in cities. And even considering those solutions so that the environment and the urban environment are more accessible and cleaner for society, making the population occupy more frequently the squares and streets where live, providing better leisure [38, 39].

Still considering a city with thousands of sensors (of different types, brands, and models) it is essential to have a location that can capture data from all of them, store them in a repository where various resources will be available. Or even considering that under certain specific conditions, actions can be triggered remotely (and eventually, automatically) [38, 39].

At the same time that the application of AI and Machine Learning techniques facilitate the real-time monitoring of large cities (metropolises) through the processing of videos and images, processing this data in real-time. Considering the recognition of people, license plates, accident sites, and a multitude of possibilities that can be extracted from videos and images. In this scenario, cities can be safer and smarter. Data from the city's various sensors are collected and sent to a cloud architecture, for example, where all devices are configured and can be tracked and managed remotely [40].

3 Machine Learning Concepts

Artificial Intelligence (AI) can be understood as an area of study, with a broader concept, which uses technology to simulate a structure of human thought and, thus, solves problems, i.e., it is the science of technology that simulates human tasks. ML is a technique derived from AI that, through statistical methods and neural networks, establishes logical rules to automate processes and make decisions, representing, human intervention is minimal, i.e., a method used so that machines can learn from the data [22, 23, 40].

Machine Learning technology makes it possible to generate conclusions that are not necessarily programmed, acting on the development of a set of rules and systems that are able to analyze information and automatically acquire learning at high processing speed. Machine Learning is responsible for developing sets of rules and systems capable of analyzing data and automatically learning from them. In other words, it is a way for computers to act and make decisions based on data with digital autonomy. In a current and modern scenario, it is from these conclusions, and with the feedback of these results, that the knowledge produced can be incorporated into a digital system, improving the accuracy of the tool [1, 14, 40].

Cognitive computing has made Machine Learning technology possible, as companies and institutions from different sectors use it to get closer to the customer and make life easier, especially in virtual commerce. Still considering the guarantee of data security, acting on several fraud attempts with stolen or cloned credit cards, based on predictive analyzes, allowing systems to be able to quickly recognize and stop most of these attempts, and even reduce costs [6, 41].

More precisely, technology can be described with a set of computational and statistical techniques that can be used in different areas of modern society, from medicine, agriculture, to business, and even the stock market. The technology is based on algorithms that allow machines to learn about a particular field of analysis, bringing quick and accurate answers to that specific field that has been “trained”. ML is a type of AI that favors the way a computer understands and learns when it is presented with new data, which are constantly changing [14, 15, 41].

In the modern context, technology can be applied to trends in vision and expectations about a particular product, customer shopping behavior, analysis of customer sentiment by extracting meaningful information from customers, related to their attitudes, emotions, and opinions, or even through inventory analysis and planning, internal process improvements, among many other aspects that can be accomplished by pre-processing algorithms using raw information that can be explored in search of patterns. Or even evaluating the performance of machine learning employed daily in thousands of operations in the Financial Market, guiding most decision-making related to the proper investments to be made, and what are the best times for selling and buying shares and assets [4, 7, 41].

Unsupervised Learning (Fig. 3) is the attempt to find a more informative representation of the available data, since in some cases, getting annotated data is extremely costly or even impossible. Generally, this more informative representation is also

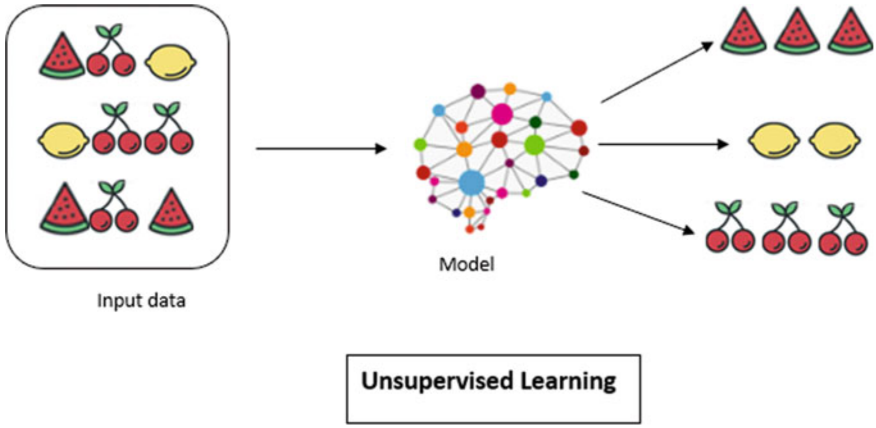

Fig. 3 Unsupervised learning illustration

simpler, condensing the information into more relevant points. Through this technique, it is possible to automatically find patterns and relationships in a data set even without having any prior knowledge about the data. An example of a common application today is the classification done in an automated way by emails [12, 41–43].

Supervised Learning (Fig. 4) is the area of Machine Learning that concentrates most applications where most problems are already well defined. It is the attempt to predict a dependent variable from a list of independent variables, this technique has a basic characteristic related to the data used to digital training containing the desired response, i.e., it includes the dependent variable resulting from the considered and observed independent variables. In this perspective, the data are recorded with the responses or classes to be predicted [12, 42, 43].

Among the best-known technics related to supervised learning problem solving are artificial neural networks, linear regression model, vector support machine (kernel machines), logistic regression, decision trees, nearest k-neighbors, and Naive Bayes. As for decision trees, this visually represents an algorithm through a tree graph and its possible consequences, this is a way to obtain a quick and wide view of the choice possibilities available in a trade [12, 42, 43].

Classification is a Machine Learning process consisting of a subcategory of supervised learning, generally used to assign a category to some type of entry. Its use is more common when the predictions are of a different nature, i.e., it can be answered in a binary way with "yes or no". An applicable context is the determination of a person's sex through an image. Like Regression it is another subcategory of supervised learning, but it is used when the value that is being predicted requires a more complex answer than a simple "yes or no" and follows a continuous spectrum. In an applicable context are customer service chatbots to answer questions [2, 44].

Reinforcement learning is applied when the machine tries to digitally learn what is the better action to take, depending on the circumstances in which that action will

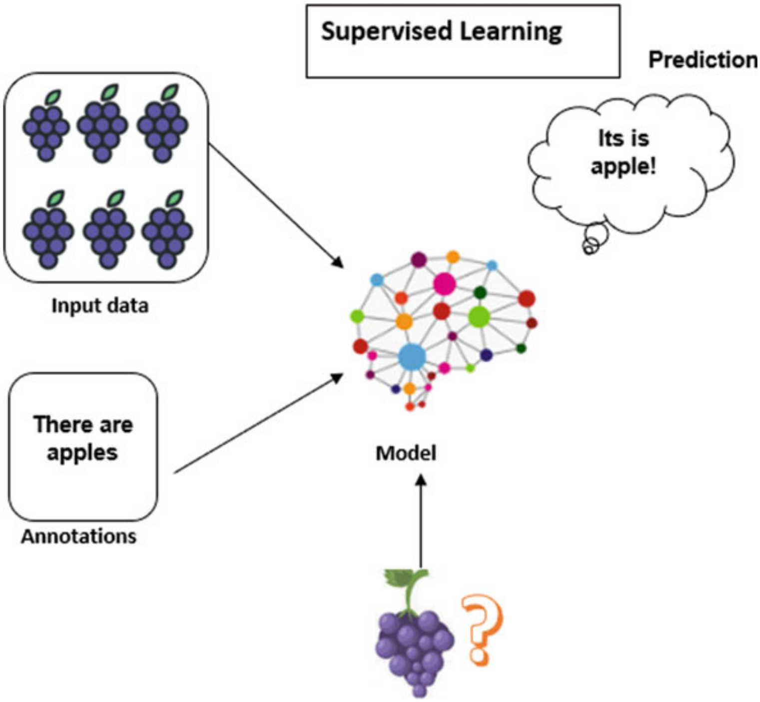

Fig. 4 Supervised learning illustration

be executed. It is closely linked to the future context considering that this is a random variable, i.e., as it is not known a priori what will happen, a digital approach that takes into account this uncertainty is desirable, and is able to aggregate any changes in the digital environment of the decision-making process of the best decision [44].

3.1 Deep Learning

Deep Learning is inspired by the learning capacity of the human brain by using so-called deep neural networks, which speed up learning machines. This is a subcategory of Machine Learning using neural networks with many layers of processing to enhance machine learning. Deep neural networks are the first family of algorithms that do not require manual resource engineering, given their ability to learn on their own, processing high-level resources from raw data [42, 45].

This technique is able to use special types of neural networks to learn complex patterns and read large amounts of raw data, making decisions in a much more agile and accurate way based on data, which drastically reduces the chances of losses. It has been used, for example, in the automatic translation of languages without the need for a human intermediary [43, 45].

The benefits of deep learning are in the development of diverse applications working in computer vision, speech recognition, and language processing. Helping to develop different areas through artificial intelligence such as object perception, online automatic translation, and voice search recognition, among many others [45].

3.2 Natural Language Processing (PLN)

Natural Language Processing (PLN) is a subarea of AI that studies human communication by computational methods, it is the ability that computers have to understand and generate human language. This focuses on understanding natural languages and, thus, making it easier with technologies for everyday life. The term “processing” means analysis and understanding, that is, related to the ability of machines to deal with the way people speak and write, overcoming spelling errors, abbreviations, ambiguities, slang, and even colloquial expressions, among others [46].

Considering that this technology is necessary since human language does not only involve the understanding of words, what needs is that the machine is able to interpret speech when the word has a double meaning, or even when the organization of words in a sentence is not according to grammar, tone of voice among other aspects [47].

In general, all applications that use word processing can be transformed into PLN, given the technology’s ability to make a machine understand the meaning of phrases spoken and written by humans, either by text or by voice. Still pondering that in view of the popularization of chatbots and intelligent FAQs (Frequently Asked Questions), PLN provides the ability to deal with customers naturally, even if automated [48].

4 Discussion

Still pondering other benefits such as optimization of online ad campaigns in real-time; analyze feelings in texts on social networks; improved user experience in online search results; prediction of failures in various equipment; offering best offers for each customer based on their navigation analysis; fraud detection and network intrusion prevention; spam filtering in e-mails and even pattern recognition in images, among others.

It is recognized that digital cognition has brought a universe of new possibilities that can be applied today, evaluating the context of application in banks through new forms of relationship with customers, data protection, and prevention of financial fraud. Still reflecting on the aspect of data analysis that allows the ideal products for each customer to be offered in the online market in a personalized way and at the exact moment of their needs. Or even touching on information security with respect to the development of new tools with the use of algorithms that identify suspicious accesses and enhancement of unauthorized digital intrusion.

Thus, cognitive systems are the result of the convergence of significant advances in various branches of computer science, from hardware aligned with more powerful and cheaper processors and storage, natural language processing through Machine Learning technologies such as neural networks and pattern recognition. Finally, Machine Learning empowers machines by making the machine-human relationship more conversational, personalized, contextual, and intelligent.

AI and Machine Learning are more and more common concepts for the application of technologies in different situations of daily life, being in great evidence in different instances of society, from search engines, social networks, media streaming, virtual assistants even present in video games, and even in the public government world related to citizen service, through chatbots as a tool that transforms the communication and interaction of these bodies with their citizens.

Machine Learning is the area within AI that allows segmentation and standardization of behaviors, allowing that through a sensor structure and even just a digital environment, the machine uses algorithms to collect a huge volume of data, learning from them, and then, making a determination or prediction about some behavior of that data.

Machine learning contributes to smart cities as a solution to the main challenges in the interaction between humans and machines, related to the computer's ability to understand what the user is asking or wants to request. With Machine Learning, the city's infrastructure has the ability to learn through interaction with the user (inhabitant), enabling the crossing of information to identify exactly what the citizen is demanding, or what needs to be met. Or even through digital bots based on Machine Learning, it can contribute in different ways to the construction of smart cities, enabling the creation of intelligent and efficient services for the population, with the monitoring of data on transport, control over the use of services and real-time monitoring of municipal security cameras.

Natural language processing is another advantage of machine learning, even considering cultural variations, conjugation variations, typos, slang, and typical Internet abbreviations. Allowing these bots to be programmed to offer information about the climate, making it possible to respond to various variations of this same intention and even to identify which city location the user wants the information from, considering metropolises and megalopolises with a vast urban territory. Technologies that integrate with image, voice, and video is also a possibility with Machine Learning, given that these audio messages can be transcribed with good precision and can even generate responses in audio. Related that machine learning can make user recognition by photo, to release some chatbot functionality.

With the proper technological management, cities start to become more secure, efficient, and modern, with an organized flow of interconnected information, thus reaching the level of smart cities. That is, through the use of technological solutions for the management of energy, water, design, public lighting, and logistics, but also ways to improve education, culture, politics, and the economy.

Within this prism, the IoT is mainly concerned with connectivity and interaction between the numerous devices, and even connected elements and scattered sensors, the greater the ability to generate intelligence. Providing digital management of related aspects such as water with respect to tracking water consumption, leak detection, and control, and through the utilization of sound sensors capturing the flow frequencies in pipes, and through AI processing techniques to differentiate sounds of pipes with normal flow and pipes with leaks, and even perform water quality monitoring. At the same time as with energy, it is possible to carry out automation and tracking of domestic energy consumption, intelligent public lighting, and dynamic electricity prices; and even mobility with respect to real-time public transport, predictive maintenance of transport infrastructure, traffic lights, and smart parking; among others.

Machine Learning applied in Smart Cities generates public transport optimization since the technology can be applied at bus stops and through bots offer information to users at transportation points and bus stations to digital systems that optimize bus transport mesh with timesheets in real-time based on pieces of information such as passenger volume, a daily report of the number of passengers transported, or indicators of the vehicle fleet authorized to circulate providing public transport service in the city, or even the number of daily trips per line. And so, companies will be able to optimize services according to users' demand, reflecting that it will be more accurate about the arrival time of buses. Still aiming the AI applied in the analysis of the users' experiences by means of data collection, storage, and combined with other Machine Learning techniques such as Deep Learning, promoting possible adaptations to user paths, use of multimodal transport, and even expansion of the adhesion to the network public transport by users.

Machine Learning can also be applied in Smart Cities derived from the management of AI-based traffic systems giving cities the technological potential to upgrade the analysis and monitoring of this data through intelligent traffic management, traffic light control, camera monitoring, among other aspects. Also correlating video systems allowing the identification and recognition of distinct modes of transport, or even identification of accidents and the differentiation between vehicles and pedestrians, knowing where it occurred and avoiding congestion, by means of sensors that collect information about traffic for the management of traffic lights, but also generation of statistical insights on the movement of cars and people in urban centers. Through the use of such data to analyze strategies and activate flow control devices (predictive approach) for the future, still related aspects based on planning for better control of natural resources and creation of more beneficial mobility conditions, Machine Learning has sensors to detect traffic conditions and automatically reprogram traffic lights.

With regard to security, Machine Learning can be used in Smart Cities allowing the transformation of any analog or IP security camera into surveillance equipment that generates important data for public security. Evaluating that through this, computer vision technology can be used, identifying patterns of cars, license plates, faces, and movements to improve the monitoring capacity. Since the technology allows the quick identification of people who transit in the regions monitored by cameras, who through artificial neural networks are able to interpret data and perform facial recognition, even if the environment has many people. Another great advantage with respect to applicability is the fact that the poles have presence sensors for energy saving when people are not passing by, making it possible to reduce costs and increase the efficiency of public equipment. Still considering the video monitoring systems allowing the counting of the volume of people in specific events, based on the recognition and identification of individuals, or even through Machine Learning, it is possible to indicate whether a certain route is evaluated safe for women, collecting information through the scattered sensors related to the presence of movement of people in the streets, presence of policing, open stores, real-time mapping of crimes, detection of shots, public lighting or harassment, among other criteria.

Machine Learning can also be applied in Smart Cities with regard to monitoring air quality through air quality sensors, which can create a network of sensors with properties for capturing air samples, and performing analysis. And then inform its quality by means of pollution indicators, by measuring particles of fossil fuel or fires, managing to indicate in real-time the existence of fires foci near a forest that represents a danger of devastation.

In Health, Machine Learning can be used in Smart Cities in some hospitals which use technology to monitor processes. Still evaluating that technology can improve treatments through machines capable of suggesting possible diseases that may affect individuals over the years. Or even by means of a digital diagnosis carried out based on the patient's history and on the indicators identified in his exams, allowing for the prevention or even starting certain treatments earlier.

Machine Learning can be used to optimize the collection and recycling of waste by acting in order to optimize the selective collection, by means of cameras utilized both in dumps as also in the recycling process, it manages to identify the types materials and separate them for process recycling, reducing the risk of physical injury to workers and increasing the recycling potential of these cities. Still considering that waste management with sensors and smart tools results in logistics and monitoring solutions, enabling the cleaning of public roads, as well as the efficiency of transport cars. Generating a chain of benefits favoring the city dweller with regard to reducing the rates of disease proliferation and contributing to the improvement of the urban environment.

In Education, Machine Learning through bots also reaches teaching strategies, adopting modern and innovative initiatives, providing more dynamic classes considering that students interact with virtual platforms to dialogue with teachers and perform exercises. Assessing that with the use of an intelligent platform, the student can more easily monitor their performance and identify the subjects that need improvement. The intelligent system, also using algorithms, identifies each student's ability to understand the subjects and indicate which classes he needs to attend again to reinforce the learning, and the teachers have the ability to monitor the individual performance of the students. Relating that through AI technology it is an opportunity to create smart schools and cities to encourage the active participation of students.

With regard to the exploratory question of the data, the analyzes range from the behavior of citizens to the classification of emotional analysis on web platforms, dictating the opinion of these citizens about public administration and bringing essential data to the internal environment for changes in behavior and strategies, with these adjustments aimed mainly at improving the care and services offered.

Machine Learning used as a planning tool is an essential tool for public administration planning as it switches from manual to automated activities. Considering that in manual analyzes, the search for answers seems like a slow analysis, often short-sighted and biased. The analysis through Machine Learning, in addition to being fast, with hundreds or even thousands of crosses of collected data variables, is impossible to be done by a human. Still pondering the analysis of data through Machine Learning, it brings information that could have gone unnoticed in manual analysis, given that the crossing of data by technology may be much deeper and adequate to the needs of the public administration.

The challenges for implementing Machine Learning in Smart Cities are related to the need for a mass of quality data, which can be obtained through a sensor structure, however, investment is required. Still evaluating one of the main challenges of smart city technologies is the issue of privacy, considering that human rights become sensitive to the possibility of constant monitoring. As a result, privacy rights need to be known so that AI applications do not create conflicts between the public administration and citizens.

It is necessary that everything to be connected from cars, traffic lights, lighting systems, public transport, even citizens, it must be networked, i.e., this requires an efficient connection infrastructure that involves solutions such as fiber optics or other sufficient connections. In addition to considering the proper planning and preparation of these structures, with the investment in works for the adoption of disruptive technologies, avoiding unnecessary expenses and loss of time in the future.

Another objection to the advancement of AI technologies is the concern with sustainability, considering that these tools and solutions must be aligned with the need for environmental conservation of the planet. Another key point is that there are debates about the network infrastructure capacity necessary for communication between devices and sensors scattered. To make interconnections feasible, problems with the lack of internet signals in certain locations need to be properly addressed, but this requires more investment.

Communication with residents are actions to create smart cities that communicate efficiently, it is necessary, that it understands their behavior and listen to their wishes. Actions focused only on technologies, result in a waste of money and time. Even in one aspect, technology is a strong ally, allowing it to be monitor, analyze, and understand the behavior of the population. It is necessary to meet the needs of citizens and for the development of new smart cities, in this perspective technologies such as chatbots through Machine Learning are essential to understand the needs of citizens and even engage them in this process. Still looking for the use of technologies for data analysis such as Big Data, improving the interaction of residents with smart cities.

However, what makes management possible, based on the collection, reading, and real-time processing of data, in order to generate insights, are the cognitive computing tools. Representing that through them, AI solutions become autonomous and capable of making relevant decisions in the face of the information collected.

4.1 Role of ML for Secured Smart City

Digital security in smart city paradigms that range from robotic aspects to automatic traffic management, or from home appliances to civic infrastructure, considering that cities are connecting, ensuring that their smart device networks are increasingly vast and Internet-enabled. In this approach, the secure digital control of infrastructures becomes even more acute, given the spread of increasingly specific technologies such as considering machine learning, neural networks, cognitive analysis, and even the decision tree to detect targeted attacks and provide proactive protection against threats future. Specifically, machine learning systems for cybersecurity require encyclopedic knowledge and highly refined specific skills in a variety of fields including big data, computational processing, and applied systems programming.

In smart cities, there are connected devices, from speakers or smart lights, which can be vulnerable to digital criminals that allow access to a home network, connected infrastructures such as buildings, highways, and traffic lights, which could be digitally invaded, paralyzing companies or the city itself. In this context, cybersecurity extends far beyond personal or corporate networks encompassing technological solutions to protect city networks and, revolving around digital systems, whether at home or in the workplace, given the increasing amount of data that is created by people, houses and buildings, which is valuable for cybercriminals.

Considering that the concept of smart cities involves the adoption of massive technology to improve public services such as health, environment, safety, food and transport, considering that these connected devices must operate together in homes, offices, and public spaces, considering the districts that already use sensor networks to prevent natural disasters, citizens who use smart keys to pay for subway tickets. However, there is still no standard for how these devices should operate or be protected, without a digital security standard for connected infrastructure, it is crucial that safety is always first during all systems control, from sensors to processing of data in the cloud.

In this sense, it is worth noting that the smarter a city in terms of incorporating technologies into its infrastructure, the more vulnerable it is to cyberattacks, considering that each "smart component" (connected) in the city becomes a potential target to cyber attacks that can cause damage, sometimes immeasurable, both in value and in extent. Thus, the main challenge of cybersecurity is the rapid evolution of the risks to be managed, creating strategies to protect the digital system from known and unknown risks, investing in more proactive and adaptive approaches.

A promising technology to increase the cybersecurity of smart cities in the face of the complexity of scenarios related to events at different levels of infrastructure is machine learning acting as a form of monitoring that helps to mitigate the continuous risks of data loss and theft, performing machine analysis of the data environment to detect the most complex cyberattacks reliably and accurately. Whereas ML works through continuous monitoring and real-time assessments, responding to security attacks and incidents, and automating tasks making the digital attack prevention system more effective.

As previously mentioned, machine learning algorithms are able to predict future actions based on data analysis, allowing the detection of malicious activities that could go unnoticed by a conventional antivirus. In addition to identifying threats, it also allows automating actions, which, in short, means that it is possible to stop digital attacks before it starts.

ML also helps ensure data protection without constant monitoring, related to cloud computing that allows smart city digital users to use their private mobile devices to access corporate information, since the tools themselves are able to perform actions to interrupt cyber attacks, without invading digital privacy. Also mentioning that ML includes network analysis and vulnerability assessment, presenting an adaptive security platform that manages to filter data and transmit only potential threats to human analysts, which reduces false-positive alerts.

Or even the use of ML technology is capable of using behavioral analysis since social engineering actions adopt digital attacks that exploit vulnerabilities in users' behaviors and actions. In this sense, ML allows thousands of computers, devices, and users to be audited in time. real, in a single point of control, still analyzing information from the network and offering protection from internal and external threats through intelligent learning alerting about these potential risks.

Thus, ML has become an essential part of most modern cybersecurity strategies as tools used to prevent cyber attacks, allowing decision making in an autonomous or almost autonomous way with regard to the defense of information systems. In this regard, it is recommended to adopt ML as a digital security approach combining other technologies such as Deep Learning, capable of quickly detecting and controlling even the most sophisticated digital attacks.

4.2 Challenges of Using AI in Smart City

The biggest obstacles to the inclusion of AI in Smart Cities are data, i.e., the lack of useful and relevant data, free of built-in bias, and that do not violate privacy rights. As well as the challenges of the business process, integrating AI in the functions of a smart city, since this is one of the main factors that prevents the adoption of AI, regarding the structural challenges, considering that when AI is built on platforms that already exist, such as management systems, adoption is easier; and even cultural, since people are still trying to deal with the implications of AI, what it can and cannot do.

Or even related to the issue of the cost of tools and development of AI systems, analyzing that the costs of labor and technology can be high. Since building new AI systems is very expensive in terms of money and staff, considering those smaller cities, it would mean having to hire a third party to do this specialized work.

Legal and regulatory risks are a significant issue especially in regulated sectors, considering the lack of transparency in AI algorithms, which should consist of a model like a black box, for digital security criteria, but the model's explainability and transparency are still questionable. This makes it difficult for a smart city or a department-specific to it, to explain its decision-making process to regulators, users, government board members, and other interested parties.

Just as cybersecurity is a risk of using AI with respect to data collected independently, and possible vulnerabilities in the AI solution itself. Even though AI technology is increasingly being used to defend against cyber threats, it still brings with it new digital security challenges, as a technology for cybercrime and cyber invasion also becomes more widespread, containing the potential for malicious insiders, capable of digitally poisoning training data aimed at creating AI algorithms for fraud detection of all transactions and operations in a smart city.

5 Trends

Autonomous objects, such as drones, autonomous vehicles, and robots, will employ even more AI to automate processes performed by peoples. In this regard, automation will further explore AI delivering advanced behaviors that are able to interact and respond more naturally to people and the environment [49].

Augmented Analytics is directed on a particular area of Augmented Artificial Intelligence, which employs ML to transform the way analytical content is made, shared, and consumed. The resources of this technique will be important for data preparation and even data management, process mining, business management, and even Data Science platforms. Still evaluating the trend in advancing rapidly along the Hype Cycle (a graphical representation of the stages of a technology's life cycle) which is one of the most important sources of a trend in technology. Reflecting on the employment of real-time event data directed for incident detection, identification, and response and the sophisticated adoption of ML acting against threat intelligence that with potential to increase the digital visibility of unknown cyber-risks and strengthen the position of operations centers digital security. Pondering that aiming for the maturity of this science and data technology in the context of cybersecurity means empowering the digital resources with the AI techniques to act while minimizing cyber-risks respective to false positives [50].

Realizing the significance of data science with respect to information security and advancing the development of AI-oriented and enhanced solutions by providing a digital ecosystem of AI models and algorithms, as also as creation and implementation of tools adapted to integrate AI resources and models into an intelligent solution. The premise comes from, before providing or predicting the digital security of business data and information, it is first necessary that this be interpreted, deciphered, and understood. From that, recognized which data represent the digital risk at that moment, or in a universe of daily, weekly, monthly, or according to seasonality analyzes, and thus make a decision. That is, in view of the digital existence of cyber risk in relation to the integrity and confidentiality of data and information, decision-making will also be compromised, compromising digital fatality at the end of the system structure. Representing a pragmatic view on the data life cycle, pondering the fact that most cybersecurity experts use machine-based tools for digital security operations [33, 51].

Or even reflecting on the trend in the volume of billions of sensors and terminals connected in the environment, reflecting on the respective technology aspect of a digital twin, i.e., a digital representation of an entity or system in the real world. Considering that these "digital twins" will potentially serve billions of things, reflecting in the improvement of the ability to visualize and collect the correct data, apply the analyzes and rules and effectively respond to the determined objectives [38, 39, 51].

Empowered Edge is another trend with regard to solutions that facilitate data processing close to the source, more related to the computational topology in which data and information are processed and collected, and even the delivery of content is placed closer to the end of the network. What reduces traffic and latency, evaluating the context of Smart Cities using Machine Learning nourished by data through the Internet of Things (IoT), are roots of data generation normally associated with sensors or embedded devices. Still pondering the use of Edge Computing technology serving as a decentralized extension of the networks of the desired territory, i.e., the respective coverage of a single location, cellular networks, or even data center networks. Assessing that Edge Computing technology and Cloud Computing tend to follow evolution acting as complementary models, i.e., with distributed servers and the network edge devices themselves, and not just cloud services managed only on centralized servers [52, 53].

Conversation platforms tend to change the way users interact with the digital world, given the technologies Augmented Reality (AR), Virtual Reality (VR), and even Mixed Reality (MR), contributing as services of immersive experience. This applied in the context of Smart Cities represents a change, combined in the models of perception and interaction, increasing the ability to communicate with users in many human senses providing a richer environment to provide differentiated information [54].

Blockchain technology is an alternative to the centralized models of digital trust that make up the majority of value record holders. Pondering those centralized trust models by adding delays and costs to transactions. Blockchain affords an alternative trusted digital model, as the technology eliminates the requirement for central authorities in arbitrating digital transactions. In other words, involving IoT, AI, as also refined Blockchain technics, or encompassing chatbots and ML. Given this universe of BigData, as also the digital quantity and quality of cyber-threats to all cyberspace manipulated, altered, created, organized, or even with the disposal of information, increasingly relates the digital complexity in the sphere of cybersecurity. This digital complexity, however, is proportional to all this technological evolution. What requires complex elements that support more sophisticated scenarios, which can be achieved from current Blockchain technologies and concepts [29, 54].

From the Smart Cities perspective, intelligent spaces are related to physical or digital environments populated by humans and enabled by technology. From that context, ecosystems are increasingly connected, intelligent and autonomous, allowing multiple elements that include people, machines, processes, services, and things in an intelligent space creating a more immersive, interactive, and automated experience, whether through VR, AR, or even MR [7, 27, 28, 54].

Still relating a study by Webroot, he highlighted that 88% of cybersecurity software have in general AI-based solutions, most usually aimed at malware identification and detection, IP spoofing, and even pharming identification and detection. This represents the strength that data science, increasingly, in this context of cybersecurity with AI [55].

Training ML models with adequate data to identify and recognize threat events that dynamically evolve in real-time, including the use of third-party threat exchange data and even internal network data for full visibility. Considering that environments according to the Smart Cities premise must be safe, with analysis mechanisms and the ability to identify, integrate, and adapt to the scenario of the changing event in real-time. Applying decision-making processes, processing, and the use of tools to extract information from data, unifying statistics, data analysis, and related methods supporting digital knowledge management. Meaning to understand and analyze real phenomena from data., i.e., capture, study, sharing, transmission, and visualization of vast volumes of data [4, 9, 55].

The next step related to chatbots is to boost Machine Learning when it comes to developing robots that are capable of learning on their own. Through cognition systems allowing technology when analyzing user responses that are not in the bot database, to be able to interpret the user's emotion. Based on the words used or even in the tone of voice the tool is able to recognize the mood of the user so that it can adapt the way of communicating with it, with other approaches and suggestions [4, 9, 55].

6 Conclusions

The administration of smart cities can be increasingly efficient through the use of data collected in real-time combined with the skills of computational intelligence, i.e., Machine Learning and its aspects. What through technology is possible to learn more and more about the city and, consequently, apply this knowledge to improve infrastructure, security, and resource allocation. Assessing that much of the public infrastructure of large centers and metropolises are used in excess, inefficiently, or even not used. And since the use of real-time information is shared between people and even the digital infrastructure, it can be useful in several situations.

In this context, AI, Machine Learning improves urban systems and city management, still pondering that from the context of Smart cities, not only technology, but communication is also necessary. The basic premise is to use technology [56–59] to improve the lives of citizens and expand the technological concept throughout the installed smart city model. Assessing that within the new modern paradigm, urban environments have ceased to be only digital to become centers of communication, operation, and interaction between different devices, with the aim of improving the lives of residents, as well as government management. The idea of a smart city is grounded on the use of innovative technologies, services, and management, which make management more efficient, enhance the quality of life of its residents, while also taking into account areas such as mobility and access to services, and providing a more economically and environmentally sustainable city. This adjective "intelligent" adds the premise of a society that generates an infinity of data in real-time, from different sources. Which, through Big Data and Machine Learning, favors the idea of a city that intensively uses modern interconnected technologies to manage and improve people's quality of life.

The differential of these concepts applied to cities is that it focuses on alternatives to use technology to promote sustainability and connectivity. A smart city tends to create a digital infrastructure capable of working together with autonomous cars, public Wi-Fi, and an entire infrastructure with the latest technology. It values urban mobility and the construction of green spaces, or even allowing traffic control with the use of underground sensors. This makes it possible, for example, to reprogram traffic lights when there is a lot of traffic, or even add a pneumatic system around the city to manage waste, avoiding the need for garbage collection trucks, and more distribution of carbon dioxide throughout the environment. The use of AI is grounded on the premise of optimizing, and expanding the digital reach among diverse operations, considering intelligent algorithms to identify and recognize patterns and, thus, become able to carry out forecasts and actions with velocity and accuracy. The digital efficiency of these algorithms depends on the volume and quality of the data, which can be obtained by sensors, applications, cameras, among others. The adoption of Machine Learning and AI tools strengthen and play a significant role in identifying possible risks, hunting for threats, and even for security incident response programs. That is why it is not enough to have a Security Operations Center in a Smart City, but around it, there must be a digital structure that shares the equivalent concerns as the cybersecurity team seeks to strengthen defenses against digital threats.

The use of AI and Machine Learning is associated with the concept of smart cities with respect, which in these types of cities have characteristics related to the use of management strategies, projects, and technologies aimed at increasing the quality of life of denizen and greater efficiency in resources and services provided. If digital refers to use itself, being smart means using technology in the best possible way, with several applications working at the same time to impact the city in its entirety. Considering that an intelligent urban space makes it possible to manage its resources, municipal services, public security, and infrastructure through AI tools and their aspects, data science, and even IoT.

References

1. Alpaydin E (2020) Introduction to machine learning. MIT Press
2. Mohri M, Rostamizadeh A, Talwalkar A (2018) Foundations of machine learning. MIT Press
3. Chen Z, Liu B (2018) Lifelong machine learning. Synthes Lect Artifi Intell Mach Learn 12(3):1–207
4. Hutter F, Kotthoff L, Vanschoren J (2019) Automated machine learning: methods, systems, challenges. Springer Nature
5. Raschka S, Mirajalili V (2019) Python machine learning, no 1. Packt Publishing
6. Cielen D, Meysman A, Ali M (2016) Introducing data science: big data, machine learning, and more, using Python tools. Manning Publications Co
7. Ullah Z et al (2020) Applications of artificial intelligence and machine learning in smart cities. Comput Commun
8. Rebala G, Ravi A, Churiwala S (2019) An introduction to machine learning. Springer
9. L'heureux A et al (2017) Machine learning with big data: challenges and approaches. IEEE Access 5:7776–7797
10. Zhou L et al (2017) Machine learning on big data: opportunities and challenges. Neurocomput 237:350–361
11. Rajkomar A, Dean J, Kohane I (2019) Machine learning in medicine. N Engl J Med 380(14):1347–1358
12. Monteiro ACB et al (2020) Development of a laboratory medical algorithm for simultaneous detection and counting of erythrocytes and leukocytes in digital images of a blood smear. In: Deep learning techniques for biomedical and health informatics. Academic Press, pp 165–186
13. Monteiro ACB (2019) Proposta de uma metodologia de segmentação de imagens para detecção e contagem de hemácias e leucócitos através do algoritmo WT-MO
14. Neapolitan RE, Xia J (2018) Artificial intelligence: With an introduction to machine learning. CRC Press
15. Kubat M (2017) An introduction to machine learning. Springer International Publishing AG
16. Al-Turjman F (ed) (2019) Artificial intelligence in IoT. Springer
17. Yao M, Zhou A, Jia M (2018) Applied artificial intelligence: a handbook for business leaders. Topbots Inc
18. Joshi P (2017) Artificial intelligence with python. Packt Publishing Ltd
19. Lehman-Wilzig S (2020) Book review: an introduction to communication and artificial intelligence 1461444820929995
20. França RP et al (2020) Potential proposal to improve data transmission in healthcare systems. In: Deep learning techniques for biomedical and health informatics. Academic Press, pp 267–283
21. Murphy RR (2019) Introduction to AI robotics. MIT Press
22. Flasiński M (2016) Introduction to artificial intelligence. Springer
23. Jackson PC (2019) Introduction to artificial intelligence. Courier Dover Publications
24. Iafrate F (2018) Artificial intelligence and big data: the birth of a new intelligence. Wiley
25. Strong AI (2016) Applications of artificial intelligence & associated technologies. Science [ETEBMS-2016] 5(6)
26. Sterne J (2017) Artificial intelligence for marketing: practical applications. Wiley
27. Allam Z, Dhunny ZA (2019) On big data, artificial intelligence and smart cities. Cities 89:80–91
28. Franca RP et al, Better transmission of information focused on green computing through data transmission channels in cloud environments with Rayleigh Fading. In: Green computing in smart cities: simulation and techniques. Springer, Cham, pp 71–93
29. França RP et al (2020) Intelligent applications of WSN in the world: a technological and literary background. In: Handbook of wireless sensor networks: issues and challenges in current scenario's. Springer, Cham, pp 13–34
30. França RP et al (2020) Improvement of the transmission of information for ICT techniques through CBEDE methodology. In: Utilizing educational data mining techniques for improved learning: emerging research and opportunities. IGI Global, pp 13–34

31. França RP et al (2020) A proposal based on discrete events for improvement of the transmission channels in cloud environments and big data. Big Data IoT Mach Learn Tools Appl 185
32. Rich MK (2003) Business-to-business marketing: strategies and implementation. J Bus Indus Market
33. Srivastava S, Bisht A, Narayan N (2017) Safety and security in smart cities using artificial intelligence—a review. In: 2017 7th international conference on cloud computing, data science & engineering-confluence. IEEE
34. Mohammadi M, Al-Fuqaha A (2018) Enabling cognitive smart cities using big data and machine learning: approaches and challenges. IEEE Commun Mag 56(2):94–101
35. Yigitcanlar T et al (2020) Contributions and risks of artificial intelligence (AI) in building smarter cities: insights from a systematic review of the literature. Energies 13(6):1473
36. Skouby KE, Lynggaard P (2014) Smart home and smart city solutions enabled by 5G, IoT, AAI and CoT services. In: 2014 international conference on contemporary computing and informatics (IC3I). IEEE
37. Voda AI, Radu LD (2018) Artificial intelligence and the future of smart cities. BRAIN. Broad Res Artifi Intell Neurosc 9(2):110–127
38. Giyenko A, Cho YI (2016) Intelligent UAV in smart cities using IoT. In: 2016 16th international conference on control, automation, and systems (ICCAS). IEEE
39. Badshah A et al (2019) Vehicle navigation in GPS denied environment for smart cities using vision sensors. Comput Environ Urban Syst 77:101281
40. Singh S et al (2020) Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city. Sustain Cities Soc 63:102364
41. Qiu J et al (2016) A survey of machine learning for big data processing. EURASIP J Adv Signal Process 1:67
42. Goodfellow I et al (2016) Deep learning, vol 1. MIT Press, Cambridge
43. Charniak E (2019) Introduction to deep learning. The MIT Press
44. Sutton RS, Barto AG (2018) Reinforcement learning: an introduction. MIT Press
45. Kim KG (2016) Book review: deep learning. Healthcare Informat Res 22(4):351–354
46. Hassanpour S, Bay G, Langlotz CP (2017) Characterization of change and significance for clinical findings in radiology reports through natural language processing. J Digital Imag 30(3):314–322
47. Marquez JLJ, Carrasco IG, Cuadrado JLL (2018) Challenges and opportunities in analytic-predictive environments of big data and natural language processing for social network rating systems. IEEE Latin Am Trans 16(2):592–597
48. Yim W et al (2016) Natural language processing in oncology: a review. JAMA Oncol 2(6):797–804
49. Kunze L et al (2018) Artificial intelligence for long-term robot autonomy: a survey. IEEE Robot Automat Lett 3(4):4023–4030
50. Lui A, Lamb GW (2018) Artificial intelligence and augmented intelligence collaboration: regaining trust and confidence in the financial sector. Inf Commun Technol Law 27(3):267–283
51. Radulov N (2019) Artificial intelligence and security. Security 4.0. Secur Future 3(1):3–5
52. Garg S et al (2018) UAV-empowered edge computing environment for cyber-threat detection in smart vehicles. IEEE Netw 32(3):42–51
53. Dai Y et al (2019) Artificial intelligence empowered edge computing and caching for internet of vehicles. IEEE Wire Commun 26(3):12–18
54. Farshid M et al (2018) Go boldly!: explore augmented reality (AR), virtual reality (VR), and mixed reality (MR) for business. Bus Horizons 61(5):657–663
55. GAME CHANGERS: AI and machine learning in cybersecurity. Webroot: Smarter Cybersecurity. https://www-cdn.webroot.com/8115/1302/6957/Webroot_QTT_Survey_Executive_Summary_December_2017.pdf. Accessed 20 Sept 2020
56. Chinmay C, Joel JPCR A comprehensive review on device-to-device communication paradigm: trends, challenges and applications. Springer: Int J Wire Pers Commun 114:185–207. https://doi.org/10.1007/s11277-020-07358-3

57. Lalit G, Emeka C, Nasser N, Chinmay C, Garg G (2020) Anonymity preserving IoT-based COVID-19 and other infectious disease contact tracing model. IEEE Access 8:159402–159414. https://doi.org/10.1109/ACCESS.2020.3020513, ISSN: 2169-3536
58. Chakraborty C, Gupta B, Ghosh SK, Das D, Chakraborty C (2016) Telemedicine supported chronic wound tissue prediction using different classification approach. J Med Syst 40(3):1–12. https://doi.org/10.1007/s10916-015-0424-y
59. Chakraborty C, Gupta B, Ghosh SK (2016) Chronic wound characterization using Bayesian classifier under telemedicine framework. Int J E-Health Medi Commun 7(1):78–96. https://doi.org/10.4018/IJEHMC.2016010105