Artificial Intelligence, Big Data Analytics and Big Data Processing for IoT-Based Sensing Data

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1 Introduction

The recent technologies such as artificial intelligence, cloud computing and Internet of things have empowered the analytics more dominant. Scholars claimed that IoT, big data analytics, AI and cloud computing are cutting-edge developments that have transformed the globe [5]. These techniques are mutually supportive and produce a number of cross-disciplinary and interdisciplinary fields of study and application. These comprise not only ICT applications, but also all types of systems in our community, covering healthcare, business industry, production, entertainment, education sector, and the environment [5]. Similarly, the big data analytics, artificial intelligence and machine learning continue to see use in various management fields [8].

The volume of data in today's business environment is astounding. Big data, though, provides a broad variety of options for enterprises, whether used separately or alongside current conventional data. Statisticians, analysts, academics and entrepreneurs, employees will use these emerging databases for sophisticated analytics that offer greater perspectives and fuel creative big data solutions. Some of the important approaches include data mining, text classification, prediction, visual analytics, artificial intelligence, statistics and language processing. The unlimited storage capability and cloud infrastructure related to cloud computing contribute to a modern domain in big data and big data handling [5]. Today, the business firms around the world are seeking at big data-enabled computational approaches including the IoT, smart assistants, artificial intelligence, machine learning, deep learning, intelligent robots, content analytics, neuroscience business models, etc. [25].

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The data analytics and big data are becoming ever more significant with the connection-ready devices and the IoT-related technologies. Recent technological developments allow for increased computational capacity for smart devices that produce real-time data rapidly [13]. The IoT gathers large volume of data that includes information about millions of things. To be able to analyse this data, it requires the aid of artificial intelligence. This form of technology helps them to see meaning and to know the contextual relations and trends that explores hidden business insights through analytics. IoT is enabling big data analytics to make instantaneous decisions. If we look deeply into it, there is a clear connection between big data and IoT.

The IoT has performed a large part in today's business scenario. For example, IoT lets e-commerce companies maintain up-to-date inventory data that minimize overstocking in warehouses by using IoT-centric sensors. In addition, IoT sensors help the monitoring of orders from original placement to final transport that guarantee that they are not scattered and delivered on time with appropriate worth. IoT encompasses technology such as RFID, cloud computing, cameras, GIS/GPS, visualization, virtual reality, and augmented reality [18]. These technologies are related to enable the business intelligence and decision-making support system. With the aid of IoT, the Business Intelligence and Decision Support System focuses on tailored consumer promotion in such a way as to find the purchasing trend through web searching on the market for their expected customers. IoT devices such as smartphones, laptops, wearable sensors or industrial sensors may be used for banking operations in the financial sector. Market intelligence can be used by many banking clients to obtain secret insights into deposits, savings, promotional events and transactions.

1.1 Big Data

The rapid development of big data focuses on new ways of capturing, storing, exchanging, saving, analysing and displaying knowledge. The word Big Data is described differently in the literature [14]. Big data is typically processed by artificial intelligence, and both of these are used ever more in healthcare research (e.g., [12, 22].). By its very nature, Big Data is an incredibly huge, complex and continuously changing domain that has the ability to transform, but can also influence our daily routine. Big data is broadly meant to be handled by artificial intelligence technique and its sub-discipline, machine learning. However, it may also be possible to handle "small" data sets by using artificial intelligence and machine learning.

1.2 Internet of Things (IoT)

With recent rapid developments in computer and networking technology, a new stage of growth in the digital era "Internet of Things" came into being. The IoT signifies the ever-growing physical objects that enable certain artifacts to communicate independently and smartly, including digital sensors, cars, buildings and other objects integrated with sensors, applications, detectors, actuators and network communication. IoT is the cornerstone of smarter network services including smart house, smart environment, energy, traffic control and healthcare. In order to strengthen economies, community and lifestyle, the IoT-based smart services offers enormous markets and opportunities. The applications of IoT devices have an effect on many different facets of citizen's life. The Internet of Things integrates sensors, applications, smart watches, wearables, smartphones, thermostats, voice-enabled devices, traffic lights, train vans, automobiles, and many more.

1.3 Artificial Intelligence

Artificial intelligence is the capacity of machines to conduct activities that typically require human intelligence [2]. In recent times, businesses have recognized the importance of integrating new computational methods, relying on large data and seeking to incorporate deep learning and artificial intelligence techniques into better data processing. Artificial intelligence-driven big data analytics capture more useful knowledge from which companies can develop their decision-making skills [8]. The growing amount and complexities of business data have led to the commercial deployment of artificial intelligence. The scholars concluded that the use of artificial intelligence and data analytics will include a variety of potentials to promote service offerings, efficiency and results [9].

Artificial intelligence researchers focus on deep learning and natural language processing to help computers understand correlations and assumptions. Artificial intelligence finds its presence all over the world in today's new knowledge age. Artificial intelligence systems have emphasized to boost the expertise of market analytics and intelligence. Artificial intelligence in business is increasing that are able to refine computer algorithms to recognize patterns and observations into large volumes of data and to make fast strategic decisions that are expected to remain successful in real time. Artificial intelligence and business intelligence provide superior and efficient outcomes of strategic decision [1]. Similarly, the significance of big data analytics, artificial intelligence, and machine learning has been at the front of research in diversified field such as in operations and supply chain management [8]. IT applications that incorporate artificial intelligence and modern cloud infrastructure technology would allow logistics professionals to develop their existing order management more efficiently [17]. In healthcare sector, for instance,

artificial intelligence can display clinical pictures easily and accurately to take timely decisions.

2 Applications of Artificial Intelligence

Most businesses probably use some form of artificial intelligence, whether or not they know it. Accordingly, the machine learning, deep learning, automation, robotic process, and other types of artificial intelligence are integrated, allowing users to refine and simplify their business processes. Artificial intelligence technique has been applied in various field including healthcare [7], logistics industry (e.g., [17].). Artificial intelligence and high-tech cloud computing technology can make order handling more cost-effective in the logistic and supply chain [17]. Further, the convergence of technologies such as cloud computing, distributed artificial intelligence, middleware, network servers and database technology supports these kinds of architecture criteria [19].

Applications such as smart transportation networks, strategic partnership, logistics and decision support in industry have arisen from big data, IoT, artificial intelligence with IoT [18]. Techniques like artificial intelligence and big data have been applied in the field of healthcare, especially, for cancer treatment [7]. Moreover, the artificial intelligence and machine learning in the past decade has had an immense influence in the fields like manufacturing, telecommunication, development and healthcare [7].

3 Applications of IoT

Today, the diligences of IoT in the intelligence warehouse are to handle orders, grouping of items, distribution schedules, and record keeping using RFID, sensor, and wirelessly enabled objects successfully. The IoT sensor is used to track the order from the beginning to the end, ensuring that the requested goods is not broken and arrives on time. This would reduce the cost and time associated with delivering orders to clients. Intelligent logistics in the e-commerce and manufacturing industries, powered by IoT and Industry 4.0, allows for flexible manufacturing, lean production, and e-commerce expansion [18].

Material handling, automation, production scheduling, quality control, defect detection, maintenance, and machinery supervision have all seen significant advances as a result of Industry 4.0. In many aspects, IoT devices play a critical part in Industry 4.0's smart manufacturing process. IoT targets clients for personalised marketing in a method that recognises the buying trend through Internet browsing in order to sell to the desired customers.

In this line of thought, IoT serves as a strategic partner, introducing e-commerce to the next generation. In the financial industry, IoT devices such as smartphones,

laptops, wearable sensors and industrial sensors might be used for banking operations.

Banking executives, for example, may monitor consumers using smartphones, tablets, and other digital devices, as well as bank retail sites [26].

4 Technologies and Methods Supporting Big Data and IoT and Artificial Intelligence

4.1 Deep Learning (DL)

Deep learning is a modern aspect of artificial intelligence, and has recently shown the possibility of increasing the performance of IoT big data analytics [2]. The latest increase in Internet of Things data has contributed to the emergence of creation of real-time data collection, along with the computer learning, deep learning, and computing technologies. The DL algorithms enable scholars to process huge quantities of fresh data instantaneously with superior precision and greater performance. In several fields, deep learning has functional and critical implications, including robotics, language processing, detection of images and expression, drug development, enhanced clinical diagnostics and precision medicine [7].

4.2 Cloud Computing

In cloud computing, monitoring, management and review of data takes place. Using Cloud infrastructure allows for more scalable, low-cost, consistent, durable, and reliable functionalities [23].The cloud computing provides high reliability, scalability and autonomy required for next-generation Internet of Things applications [11]. Cloud computing has benefited from IoT paradigm to dynamically deliver many new services, and IoT-based cloud computing will be expanded to create new services and applications in the digital world [15]. The cloud-based centralized storage is used to handle large volume of big data more effectively for real-time data processing, data analytics, diagnosis, prediction and visualization [27]. However, cloud computing has the limitations such as high latency, mobility, overhead communication and awareness of the location while handling the unprecedented amount of big data in real time [30]. The technique called fog computing is implemented at the edge of the network to overcome the aforementioned limitations in order to offer better services to the end users.

4.3 Machine Learning

Machine learning is the best way to take advantage of the hidden observations and trends from the vast volume of data set with the least human guidance support [6]. Machine learning involves a number of methods, such as predictive analytics, data mining, identification of patterns and different modelling. Through executing predictive and prescriptive analytics to support intelligent clinical facilities, the healthcare industry is keen to use the implementations of machine learning approaches in actionable knowledge bases.

Machine learning is a type of artificial intelligence that allows machines to learn without being explicitly taught and to utilise past outcomes to enhance future results, according to researchers [21]. Machine learning approaches are used in healthcare for the prediction of disease incidence and reasoning, decision support for medical surgery or treatment, the extraction of healthcare information, the study of different health data and the discovery of medicines [24]. For example, various machine learning techniques are used for mining from large-volume data sets; decision trees, support vector machines, neural networks, reduction of dimensionality, etc. [6].

4.4 Computational Techniques

Traditional health data processing techniques have been ineffective due to their inability to manage large amounts of complex data [10]. Huge data is utilized solely for analytics, which involves mining big data for information and key insights. Media, cloud, online, IoT sensors and databases are just a few of the data sources that may be utilised to collect massive amounts of big data [16]. The use of intelligent agents in the healthcare sector includes the recovery of health information from big data, disease diagnostic decision support systems, organising and arranging activities for physicians, nurses, and patients, exchange of medical information, medical image processing, automation, simulations, bioinformatics, medical data management, and health decision support systems [24]. Different data mining processes can be used in healthcare to extract efficient information, including classification, association rule mining, regression, clustering, detection, analysis, decision trees, and visualisation [16, 20]. Data mining is the practice of extracting patters and connections that can produce information or observations from databases or large data sets [16].

5 Big Data Analytics

Big data analytics is a type of modern analytics that includes advanced capabilities including predictive models, mathematical algorithms and what-if analysis driven by analytics systems. The introduction of cloud computing and big data analytics has made it easier to process huge volumes of data and business transactions [29]. Now the big data analytics and cognitive computing have been focused for improved decision-making [25]. Big data analytics techniques enable data scientists, data analysts, statistical modelers, mathematicians and other analysts to explore increasing quantities of organized transaction data, and other types of data that are sometimes left unexploited by traditional BI and analytical systems. This involves a mixture of semi-structured and unstructured data. For instance, Internet clickstream data, web server logs, social networking site information, consumer email text and survey answers, cell phone records, and computer data are collected by IoT.

By integrating the big data analytics with an artificial intelligence algorithm, it facilitates to analyse and observe the likelihood thresholds for a wide range of patients and DVH [22]. The combination of big data analytics with machine learning can help managers with decision-making and to predict unanticipated losses brought about by defective manufacturing processes [28] (Fig. 1).

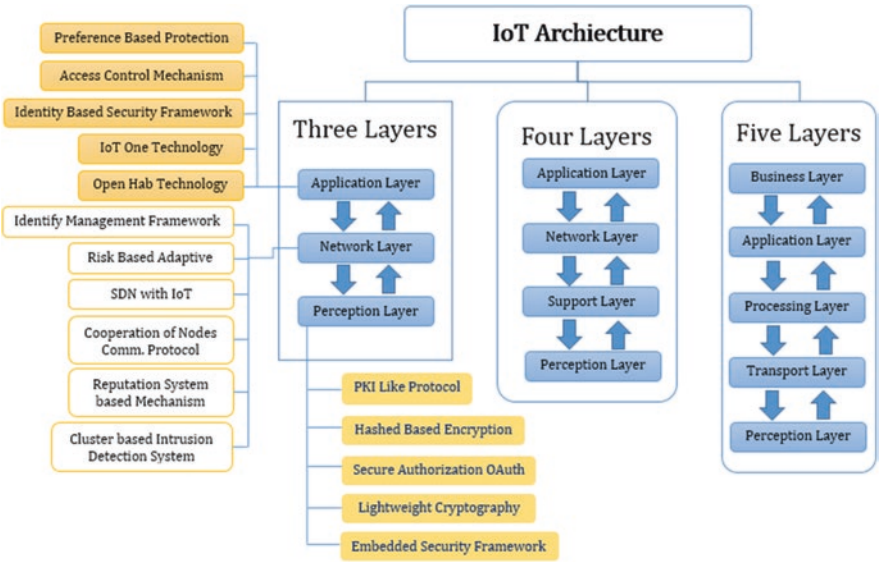

Fig. 1 Architecture and security mechanisms for IoT applications

6 IoT-Based Sensing Data

The IoT creativity has made it easy to link everything to the Internet. Now, nearly all artifacts, for instance, homes, business firms, warehouses, and even towns, are linked to the systems of network to gather data and exploit it for numerous purposes. In order to change daily life, the IoT connects everyone with new forms of resources. With this the modern technologies like cloud computing and big data are also joined. IoT sensor data are used to manage data in the smart building environment [23]. Accordingly, the sensors are typically tools that sense and react to environmental inputs that arise from different sources, for instance, bright, humidity, movement and pressure. These sensors produce useful data and these data can be exchanged with other linked devices and systems. The sensors are really important as they perform crucial operations for business enterprises. For instance, sensors can notify the possible issues before they create big losses or problems. Hence, the businesses can get ready the pre-arrangement for maintenance and prevent costly interruptions. The sensor data is able to support business decision makers to understand important patterns and produce well-versed decisions based on the situation.

Though the IoT has been around for decades, it is now sophisticated enough to go popular through sectors that are revolutionizing itself with modernization in digital era. Now the IoT-based sensors let enterprises to build innovative technological solutions and change their business models. There is a great importance in IoT automation from companies who want to do their jobs with a minimum personnel disruption and a decreased loss of efficiency.

7 Big Data Processing

For any kind of data that reaches an enterprise (in several instances, there are several sources of data), this is most certainly not really cleaner and is not in a manner which can be captured or analysed explicitly by internal employees or outside the enterprise. Hence, the data processing typically involves data purification, optimization, aggregation and processing. In order to enhance decision-making IoT, big data and cloud computing strategies should be implemented [3]. Big data analytics is a nuanced method of analysing big data to expose information – for instance invisible anomalies, trends, market characteristics and consumption patterns that can help businesses to make better business strategy and actions. The use of big data analytics and cloud computing techniques has allowed massive data sets to be managed [29].

Related towards this accumulation of data and the advancement of computational power, the need for more advanced big data analytics techniques is of the greatest priority. There are numerous platforms or frameworks to process big data including Spark, Flink, Storm, Samza, and Hadoop. Hence, by using big data handling, the large volume of data obtained by many heterogeneous bases can be

managed and viewed by effective means, thereby allowing managers to make superior decisions [28].

8 Architectural Design of Big Data Analytics and IoT-Based Sensing Data and Processing

8.1 Data Collection Sources

The big data comprises of large volume, and heterogeneous sources of data including structured, unstructured and semi-structured data. The terms structure, unstructured, and semi-structured are frequently stated in the context of data and analytics. Simply, we can define the structured data as the data within a database or some kind of data management application. This structured data is systematized into an organized warehouse that is usually a database. The unstructured data can be defined as the data that is not pre-arranged or does not have predefined data model; hence, it is not a good match for a conventional relational database. The semi-structured data refers to the data that does not exist in a relational database, but it has some organizational features to analyse. This data can be stored in the relationship database using some method, for instance, XML data.

8.2 Big Data Analytics and Processing

The big data analytics handle large volumes of data to discover unseen trends, market tendencies, buyer preferences, associations and other intuitions. Hence, the enterprises can conduct quantitative and qualitative analysis with less time, money and personnel resources by using big data processing techniques.

8.3 Big Data Analytics Platforms and Tools

Big data analytics tool offers intuitions from huge data sets obtained from big data collections. These platforms and tools support enterprises tendencies, patterns, and association in data and synthesize the information into visual images, reports, and consoles of understandable form. In the industry, various big data analytics tools are available such as Hadoop, Talend, MongoDB, Spark, Kafka, Storm, Cassandra.

8.3.1 Big Data Analytics Techniques

This includes various big data analytics techniques such as artificial intelligence, deep learning, machine learning, data mining, text mining, neural networks, and intelligence agent. The big data that resides in the big data analytics platforms and tools can be analysed by using these techniques. These sophisticated techniques and efficient algorithms can interpret the collected big data. As a results, these techniques convert the data into more meaningful files (Fig. 2).

8.3.2 Big Data Processing Framework

The big data framework was created as many enterprises failed to incorporate a good big data practices into their organization, while the advantages and business cases of big data are obvious. The big data processing framework bring the advantages including big data structure and capabilities, big data-driven firm; it is vendor-free, hence, it can be used irrespective of technology, tools, or common platform as it can be applied through functional areas or country boundaries, and it can detect core and measurable capabilities for enterprises. In this proposed architecture the big data can be processed and handled to generate meaningful output files such as reports, OLAP, queries and mined data.

8.4 IoT Sensing Data

Today, the amalgamation of sensor-based communication technologies with the big data analytics made possible to apply IoT-based applications to enhance the quality of life. The motive behind the increasing usage of IoT devices is that they can make human life more comfortable [4]. Hence, the IoT sensors and devices can collect the data from various sources such as home, smart city, industry, etc.

9 Limitations and Challenges in IoT-Based Sensing Data

In view of advances in the field of medical image diagnosing, there are complexities like data and object complexity and validation issues [7]. Prior studies highlighted the challenges associated with IoT, and these can be addressed in the future research direction, for instance, poor management, identity management, trust management and policy, security, storage, authentication, authorization, securing network, privacy, data communication [4].

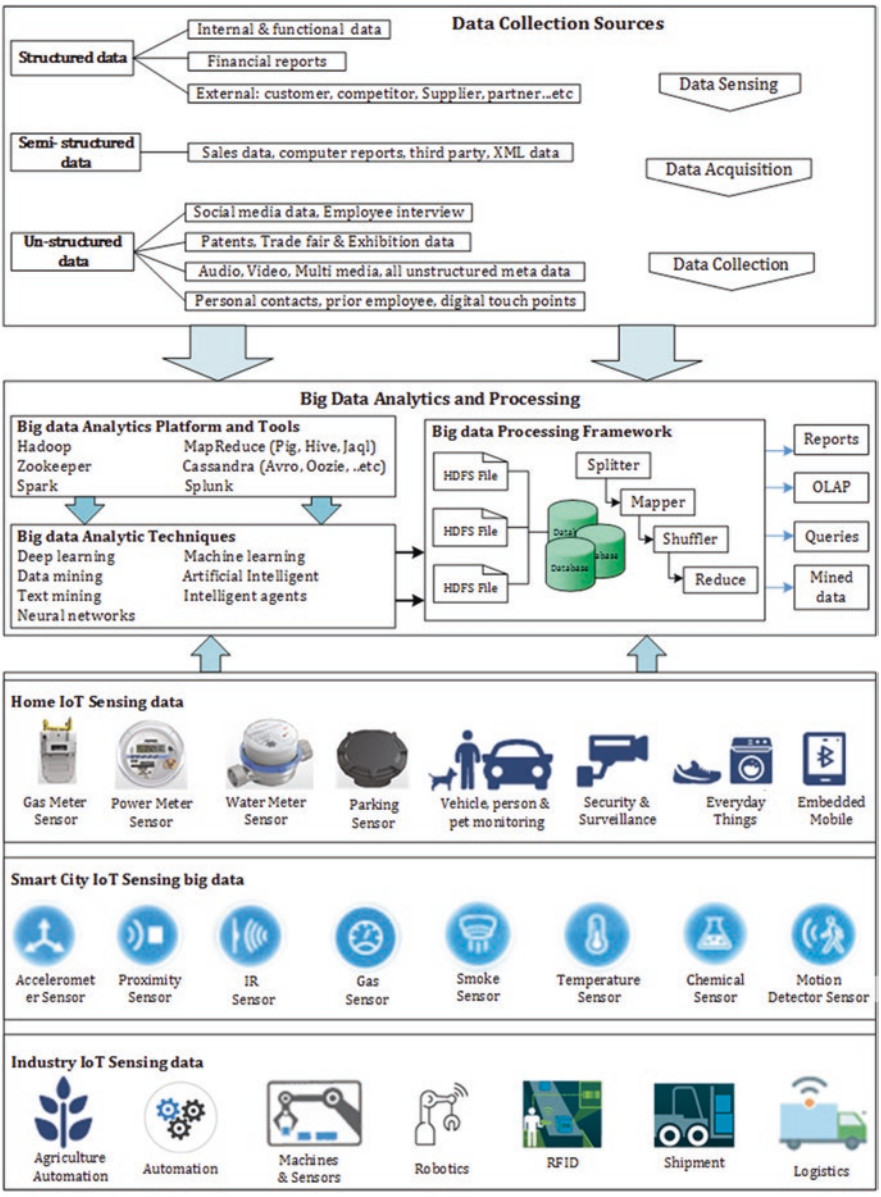

Fig. 2 Big data analytics and IoT-based sensing data and processing

10 Conclusion

The recent years have seen a rapid growth in the size, range, speed, and worth of large volume of data. Hence, the augmented applications of IoT devices by

integrating big data, artificial intelligence and analytics have been increased in recent times. Moreover, the recent emergence in computer platforms, advancement in networking technologies made it possible to adopt IoT-enabled sensors in various sectors. This chapter discusses the mixture of artificial intelligence, big data analytics, and big data processing in the development of IoT. This chapter comprises of different layers in IoT architecture and proposes an architectural design by integrating big data, IoT, analytics and IoT data sensing sources. Accordingly, this proposed design offers complete ideas about the usage and application of big data, IoT, and IoT data sensing sources.

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