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The Nutrition Industry's Use of Big Data and Artificial Intelligence

Divya Sai Jaladi[1*], Sandeep Vutla[2]

[1]Senior Lead Application Developer, SCDMV, 10311 Wilson Boulevard, Blythewood, SC 29016, UNITED STATES

[2]Assistant Vice President, Senior-Data Engineer, Chubb, 202 Halls Mill Rd, Whitehouse Station, NJ 08889, UNITED STATES

*Corresponding Author: divyasaij26@gmail.com

Abstract

Impacted by globalisation, technological breakthroughs, and ever-changing customer expectations, the food business has experienced dramatic transformations over the past several decades. The use of big data and artificial intelligence (AI) has been more important in enhancing food marketing, production, and safety. The food business is ready to accept more changes and developmental chances as AI and big data analytics continue to evolve. To better serve customers, increase product quality, and drive the food sector towards a smarter, more sustainable future, more and more businesses will use artificial intelligence and big data. This paper explores the ways artificial intelligence and big data are being used in the food industry. It looks at how these technologies are influencing production, quality, safety, risk management, and customer insights. Additionally, the food business is confronted with future problems in smart production and sustainable development, as well as new technologies like smart agriculture, robotic farming, drones, 3D printing, and digital twins, which have emerged with the advent of business 4.0 and its application to the food sector. This paper provides an overview of where artificial intelligence and big data are at in the food business, outlines the problems that have been solved, and explains the present situation. Finally, it shows how the food sector is going to evolve in the future.

Keywords: AI; Food Industry; Big Data; Nutrition; Food Market

Introduction

Computers may mimic human intellect through the use of artificial intelligence (AI) systems, which enable them to learn, reason, plan, and make decisions on their own. A number of technologies, including machine learning (ML), deep learning, computer vision, NLP, and others, form the backbone of artificial intelligence (AI).

"Big data" is a vast and varied set of information, including both structured and unstructured data types like text, photos, and videos, that is often collected from the internet and other sources by a multitude of sensors or mobile devices. Specialised technologies, sometimes known as "big data technologies," are required for the storage, processing, and analysis of data sets that are typically high dimensional, dense, and processed at a fast rate. Businesses in the food sector may benefit from big data analytics in several ways, including better supply chain optimisation, improved food safety and quality, and the ability to forecast market demand [2].

The food business is heavily reliant on artificial intelligence and big data, two crucial technologies that greatly influence innovation and progress [3]. Healthcare [4], banking, transportation, manufacturing, and the gaming and processing industries [5,6] are just a few of the many current users of artificial intelligence. Using AI in these sectors has the potential to boost productivity, cut expenses, and enhance customer service.

The food industry has also made extensive use of artificial intelligence technology. Applications in food categorisation, manufacturing development, marketing, supervision, supply chain management, quality improvement, and smart sensors include big data, blockchain, ANFIS (adaptive neuro-fuzzy inference system) technology, expert systems, and fuzzy logic systems [7]. Quality and safety of food have been enhanced by technology [8]. Food quality testing, production control, and safety monitoring are all areas that can benefit from AI-assisted intelligent production and management [9].

Big data, together with artificial intelligence, is an indispensable ally in the food sector. With the help of big data analytics tools, businesses can sift through mountains of data in search of insights about things like customer tastes and market trends. Companies in the food industry may gain a deeper understanding of consumer demand, streamline their supply chains, cut down on waste, and boost production efficiency by analysing big data. It is also possible to integrate big data with other technologies, including blockchain. Blockchain technology has the potential to improve product information reliability for customers, increase transparency from farm to table, and guarantee the provenance and quality of food.

The food business stands to benefit greatly from artificial intelligence and big data as these technologies continue to advance and find more and more uses. With their rise to prominence, they will play a significant role in the food industry's modernisation and improvement efforts, making it more competitive and opening up new possibilities and threats [10,11].

Selected core journals are considered vital information sources because they reflect the most recent developments in science and technology, according to Bradford's Law [12]. When choosing which journals to include in this review, the authors combed through the relevant literature on food-related AI and big data applications found in the Web of Science database. After carefully selecting over 900 articles using the following search expression: TS = (food (detection or processing)) and (big data or (artificial intelligence and algorithms)) and year (last 5 years), we narrowed the literature down to over 150 articles pertaining to AI, big data, food or agriculture, and the latest research results. Subsequently, we used keyword cluster analysis to pertinent articles found in the Web of Science database by creating a word cloud (Figure 1 below). To aid readers in rapidly recognising crucial information, high-frequency terms are graphically indicated in Figure 1.

This is how the paper is structured. First, we provide a brief review of the food industry's present situation before diving into an introduction to the fundamental conceptual subjects of AI and big data. Section 2 explores the food industry's use of big data analytics, focussing on blockchain technology's prospective applications in supply and demand and security. In Section 3, we delve into the numerous ways AI is being used in the food business and examine the opportunities and threats that lie ahead for this technology.

The Roots of the Food Industry Crisis

Improvements in hardware, equipment, and processing techniques were priorities in the early days of the food industry's growth [3], with the goal of making food production and processing more efficient overall. To keep up with the ever-increasing demand for food while maintaining its high quality, these technical advancements were crucial efforts to enhance crop productivity and quality were spearheaded by advancements in agricultural equipment and methods throughout the early days of the food business. Stone mills and presses were among the many pieces of technology and equipment that were progressively added to agricultural production as a means to improve processing efficiency and preserve food quality and freshness. Concurrently, advancements in food processing led to the development of procedures like curing, drying, and smoking, which allowed for the preservation and transportation of foods with longer shelf lives.

The early food business was preoccupied with a number of issues, including the improvement of processing and hardware technologies, but also with the efficient linking of the whole food chain. Ineffective supply chain management caused by a lack of communication and cooperation amongst those involved in making and selling raw materials resulted in surpluses of both food and inventories. The food sector has begun to implement a more thorough supply chain management system in an effort to address this issue [4]. Information technology has enhanced data interchange and sharing across several segments, leading to better inventory and logistics management. At the same time, the food sector has taken steps like standardisation and quality certification to boost trust and collaboration among the many parts in the chain, making it easier to track where food comes from and how good it is, in conclusion, to combat the ever-increasing demand for food, the food business has, since its inception, greatly enhanced the efficiency of food processing and manufacturing by creating more effective hardware, equipment, and processing technologies. Simultaneously, a more all-encompassing system for managing the supply chain has allowed all links in the food industry's supply chain—from the production of raw materials to the consumption of finished goods—to work together effectively, setting the stage for future growth and success.

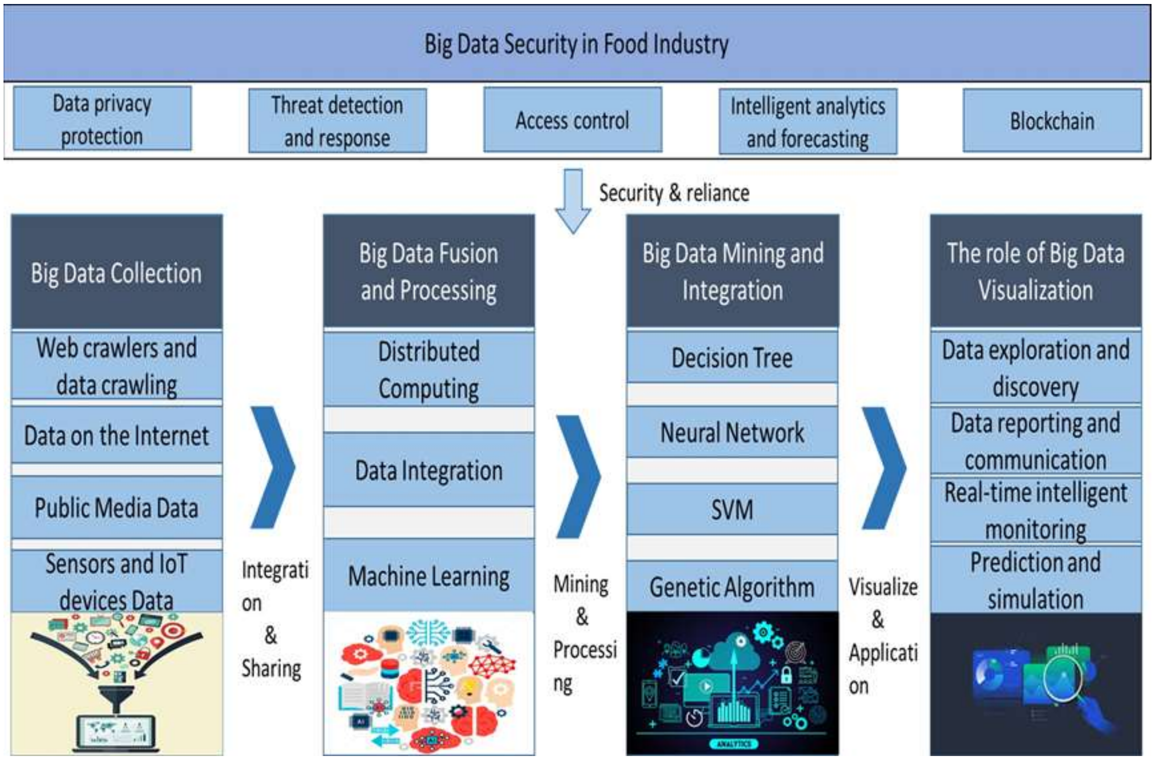

Figure 1. Five aspects of big data security in the food industry and the processing model of big data.

What the Food Industry Is Doing Right Now

Agricultural, fishing, and cattle operations are all part of the food business, which now encompasses many different fields, such as food processing, retail, and food service [3]. From farming to fork to plate, it encompasses the whole food value chain and is a massive international business. Customers have more and more options when it comes to food, and they want it to be safe and secure. The food business makes extensive use of several emerging technologies, such as blockchain, 3D printing, artificial intelligence, and big data. Productivity, waste, food quality and safety, mass demand, and customer retention may all be enhanced with the implementation of these new technologies [5].

Food Safety: Why It Matters

There has always been a lot of interest in food safety concerns. To guarantee food safety and make money for components of the food supply chain, it is essential to set up a safety trace-ability system [6–9]. In order to assist government agencies in anticipating food safety-sensitive information and in identifying periodic and trending food safety critical issues quickly through big data analysis, the food safety cloud [2] brings together food safety work with information technology, the internet, and big data in order to accomplish data and information technology for food quality traceability and identification. At the same time, it can aid customers in making healthy food choices by providing information about the food's origin, composition, personalised nutrition programs, standards, and other individualised services, as well as dietary structure advice. Machine learning has made great strides in the area of food safety [1] by improving the ability to identify possible sources of food contamination. Using a supervised learning approach, we can teach the model to include a wide range of manufacturing process factors, including chemical composition, humidity, and temperature. This program is able to spot irregularities in manufacturing in real-time and recognise patterns linked to previous food safety events. To assist ensure only high-quality food makes it to store shelves, image analysis utilising convolutional neural networks (CNN) can detect even the tiniest of surface flaws or foreign items with pinpoint accuracy. To improve the accuracy of product quality monitoring, the use of deep learning technology has emerged as the cutting edge in the area of food quality [3-5]. In order to obtain fine-grained categorisation of product appearance and quality attributes, sequential models like recurrent neural networks (RNN) [6] and short-term memory networks (LSTM) [7] can be used to track various parameters in real-time on the assembly line. One way to enhance product quality is to train convolutional neural networks on high-resolution photos. This allows for the detection of minute colour changes or form abnormalities.

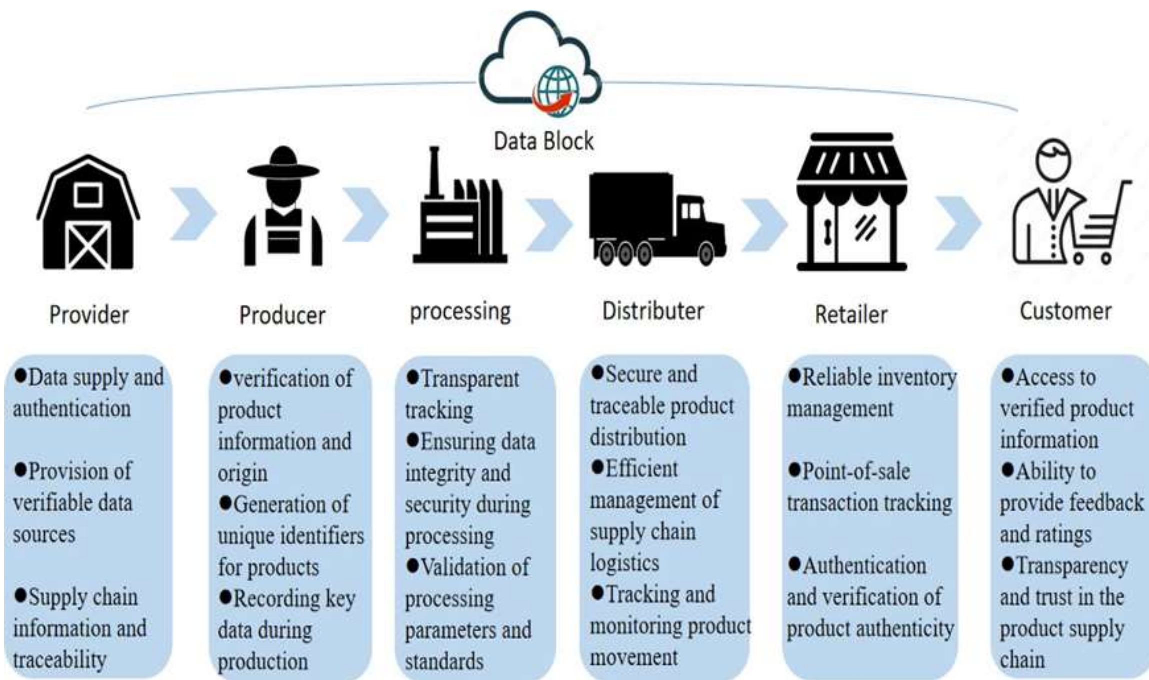

Figure 2. The process of the food supply chain in a blockchain system and the specific behaviors of different participants.

How the Food Industry is Being Digitally Transformed

The food business is experiencing digital transformation because to the ever-increasing capabilities of technology [8]. Production efficiency has been greatly enhanced by automated and smart manufacturing technology, while customer wants have been better understood with the help of big data analytics. To top it all off, blockchain technology makes the supply chain more transparent and traceable, which is great for food safety. On the other hand, new technology is opening up exciting prospects for food innovation in the future, such 3D-printed food and virtual reality. Big data, blockchain, and artificial intelligence will be further explored in this article, along with their important functions and benefits in the food business. These digital developments lay a strong groundwork for the use of AI and big data.

The Use of Big Data in the Food Sector

The term "big data" describes information sets that are massive in size, diverse in nature, and challenging to handle [2–3]. The lightning-fast development of several technologies, including the internet, mobile internet, cloud computing, the internet of things, and computers, is the root cause of this. Science and technology have advanced thanks to data creation, and the massive amounts of data opens up fresh possibilities and presents fresh obstacles for data analysis. The five V's are often included in big data. Big data's volume is a measure of its size. One defining feature of big data is the massive volume of data involved, which is insurmountable by means of conventional data processing techniques. The rate of data generation and transmission is called velocity. Data comes in a wide variety of forms and kinds. Getting valuable insights and information out of huge data is what makes it valuable. The data must be accurate and credible for it to be considered veracity. This data necessitates distributed computing and storage solutions since it is extremely challenging to handle and analyse using conventional databases or data processing tools. Data technology encompasses all aspects of data, including its gathering, storing, administration, analysis, and visualisation. The ability to gather, store, manage, analyse, and visualise data more effectively is essential for big data technology, which varies from small data technology since it must handle bigger data quantities. Big data technology allows us to gain a deeper understanding of consumer preferences, industry tendencies, product efficacy, and other data points, which in turn helps businesses with decision-making and market research. Conversely, big data has the potential to supply food-related analytical findings and vast amounts of information to aid food corporations in making decisions.

Data analysis, food traceability, nutrition, and health are some of the food-related big data applications [3]. In today's world, big data plays a crucial role [4]. Many fields can benefit from it, including commerce, healthcare, transportation, banking, the arts, entertainment, and science. Urban traffic management, intelligent transportation systems, travel mode analysis, and traffic congestion prediction are only a few examples of the transportation and mobility-related uses of big data that Torre-Bastida et al. [5] covered. Organisations may enhance their decision-making, productivity, product quality, and customer experience through the study of big data [6], which can provide unexpected facts and insights. One sector where big data is already making an impact is the food business [7]. To provide one example, Zuheros et al. [8] utilised big data to suggest an AI-based sentiment analysis decision model for user-generated restaurant recommendations. This model would sift through and assess user-submitted reviews. Big data analytics, according to Delanoy and Kasztelnik [9], can help food manufacturers make their products safer and more secure. Both AI and big data technologies have advanced substantially alongside the expansion of the IT sector. There can be synergies when big data and artificial intelligence are integrated. With the use of AI, big data can be processed using methods like computer vision, natural language processing, deep learning, and machine learning. This allows humans to better understand and comprehend the data and information contained inside. Many people's lives have been greatly improved and made easier by these sophisticated technology. These two technologies have accomplished exceptional outcomes in flavour matching, food safety, and food testing, particularly in the food business [4].

What Big Data Can Do for the Food Industry

Humans' dietary demands have grown in tandem with their technological and economic capabilities. These days, people care more about the nutritional value and flavour of the food they eat [4]. When it comes to meeting people's unique dietary requirements, conventional food science and technology fall short. Revolutionary advances in supply chain optimisation and food safety have been brought about by the rising technologies of artificial intelligence and big data analytics in the food sector. Big data is a key component in food safety, and the future of food safety is the internet in conjunction with artificial intelligence [5]. By utilising big data technology, Kazama and Sugimoto [6] have created a neural network that can translate recipes from one country to another according to their ingredients and composition. This helps to bridge the gap between regional food styles and introduces people to exotic cuisines from all over the world. To help individuals pay more attention to the food they eat and determine its nutritional value, Kalra et al. [7] developed a nutritional evaluation system that uses big data. This system analyses recipes to determine a dish's nutritional value.

Furthermore, surveillance cameras were utilised by Whitehouse et al. [4] to keep an eye on the kitchen, which increased food safety and gave diners more peace of mind. In addition to improving the quality of food, artificial intelligence (AI) and big data may guide customers towards better restaurants and provide managers with the information they need to make the most informed decisions. With the use of big data, Lee et al. [9] created a predictive model of restaurant reviews that may assist both customers and restaurant management in making well-informed judgements. In 2018, Ajit Maru described how small-scale food producers or localised food systems can benefit from AI and big data integration. They can use these technologies to create data-driven agriculture [5] tools and applications that are more suited to their needs. Producers of locally sourced foods may respond more quickly and effectively to changes in demand by receiving and acting on input in real time. Also, local food systems may be supported in the long run by implementing a blockchain-based traceability system that allows small-scale farmers to be more open and honest with their product information. This would boost customer confidence in local products. Figure 2 shows the various uses of big data in the food industry, such as improving product quality and traceability, analysing consumer trends and the market, enhancing product safety, and fostering innovation and sustainability. Along with the big data processing paradigm, Figure 3 shows five facets of food sector big data security.

The Food Industry's Big Data Applications' Bottleneck

The food industry is currently heavily utilising big data technologies throughout various areas of the supply chain, from manufacturing to sales to consumption [6]. Big data technology has several potential benefits, including better marketing techniques [3], more efficient production, and higher quality products, but it also has some potential drawbacks. Data privacy, quality control, and prejudice are all examples of such challenges. A large amount of data, including details on customers' habits, likes, and dislikes, has to be gathered and examined in order to do big data analysis. There is a risk of customers' privacy being compromised due to the illicit access and exploitation of this data. Despite the fact that big data analytics may assist manufacturers in comprehending customer wants and requirements, it has the potential to cause manufacturers to prioritise market demand over product safety and quality, endangering customers' health. The utilisation of historical data in big data analytics for the purpose of making predictions and conducting analysis raises the possibility of bias. Producers run the danger of making a poor or reckless choice if they rely solely on data analysis to inform their selections.

Careful application of big data technologies is required to prevent unwanted impacts, such as data privacy concerns [4] and quality control difficulties, which can impede the development and advancement of the food business. Consumers' entitlement to due process should be bolstered by stricter government oversight and laws. Some have proposed blockchain technology as a way to deal with the problems and consequences of big data [5]. People think that "Blockchain combined with Big Data" is a great way to share data. Food integrity, safety, and security, as well as smallholder support, monitoring, and management, are just a few of the ways that blockchain technology has altered the food supply chain. Additionally, it uses technology to digitally sign and validate papers, as well as to confirm and keep tabs on who owns what in terms of intellectual property and private information monitors medical records for patients, facilitates smart contracts [6], and other related technologies. Smart contracts and decentralised apps may also be connected to blockchain-based decentralised ledger systems [7]. According to what De Filippi said in 2016 [68], distributed ledger technology (blockchain) makes data storage more secure by removing a potential weak spot in the system. The data is reliably guaranteed to be transparent and intact since each block incorporates information from the one before it, creating an immutable chain structure. Second, data access permissions may be defined and enforced using the smart contract features of the blockchain [9]. Smart contracts allow you to choose which parties can see, edit, or exchange particular kinds of data. This approach enhances the degree of data privacy management and makes sure that data access can be traced and managed.

The Principles of Blockchain

The agri-food supply chain may reap several benefits from blockchain technology, which is one of the hot new technologies right now [7]. The term "blockchain" refers to a distributed ledger system that originated with Bitcoin and records all digital transactions and occurrences in a public ledger that can be verified at any moment using cryptographic blocks. Data immutability and decentralisation are the two main characteristics of blockchain, which effectively eliminates the issue of mutual distrust and makes recorded information more legitimate and dependable. By tagging each food item with a distinct digital identification, blockchain technology enables traceable supply chain management in the food industry [2]. These details include the food's cultivation circumstances, batch number, and sell-by date. In addition to assisting with food waste reduction, this will also provide customers with tools to measure the environmental impact of their food choices and coordinate the sharing of surplus supplies. Traditional authentication methods frequently have issues like fraud, but using blockchain technology can effectively avoid these problems [11]. Another area of focus has been food authentication in the food supply chain [3]. This includes food ingredients, production date, production source, processing, and technology used.

Using smart contracts developed on the Ethereum platform and blockchain technology, Lin et al. [5] suggested a framework for constructing a food tracking system. The framework is specifically used in the food sector to guarantee the safety and transparency of food production and supply networks through the use of blockchain technology. In order to solve the problem of food (chicken) tracking, Mohan et al. [6] suggested a strategy that integrates current food quality systems and technologies across the whole supply chain and makes use of blockchain technology. In their study, Kim and Laskowski [3] utilised a blockchain modelling technique that incorporates IoT devices to gather and exchange data from various sources across the supply chain. Concerning the use of decentralised blockchain networks across the supply chain, the research also discusses the matter of whether or not common data standards exist at various points. In contrast, Kumar and Iyengar [1] developed a blockchain-based solution for the rice supply chain with the intention of enhancing management security. Using blockchain technology to address security concerns in the rice supply chain, this example has direct relevance to the food business. It should be noted, though, that not all blockchain applications are equally concerned with food safety; others may be more concerned with logistics or economics.

By bringing together producers, consumers, suppliers, and regulators, blockchain technology offers a monitored and managed full-chain solution in the agri-food supply chain, from the production of raw materials to the store shelves. It also significantly improves food traceability [8]. Furthermore, producers may further cut costs and boost overall manufacturing sector efficiency with smart contract technology. Not to mention that a reputation-based trading system may be developed with the assistance of blockchain technology and its potential transparency. It is common practice to depict communication and operations as one-way in blockchain systems used to food supply chains. Figure 4 shows the steps involved in a blockchain-based food supply chain and the actions of many parties involved, and Table 1 shows how blockchain technology may provide visibility and auditability across the food supply chain, boost product quality and safety, and increase customer confidence in goods.

Nevertheless, there will be future problems and obstacles that blockchain technology must overcome [84]. The logic and execution of blockchain systems may get increasingly intricate as more components are integrated, such as RFID, smart sensors, smart robotics, biometric data, the Internet of Things (IoT), and big data. The rising operational and maintenance expenses of blockchain technology may also discourage new entrants to the food supply chain, despite its extensive use in global supply networks. Furthermore, oligopolies and giants might form if major corporations use blockchain technology that is privately licensed. Furthermore, the question of how to enhance the regulatory framework pertaining to blockchain technology persists, and has to be discussed in more depth. When it comes to the correct use of blockchain technology and bitcoin transactions, prominent politicians and specialists are still at odds.

AI in the Food Industry

Discussing AI in the food industry is like diving into a sea of untapped possibilities and state-of-the-art technology. A.I. has had far-reaching effects on the food business at every level, thanks to the fast advancement of science and technology. Revolutionary shifts are occurring in food production, quality control, and safety as a result of technological advancements such as expert systems, fuzzy logic systems, ANFIS, NIRS, CVS, and the use of sensors and artificial intelligence in the food business [8]. These technologies serve distinct purposes in problem-solving and process-optimization, and they differ from big data in terms of their features and application situations.

Food Industry Knowledge-Based Expert Systems

Expert systems, a type of knowledge-based AI [7], may automate decision-making and problem-solving in the food business by mimicking experts' thought processes and knowledge structures [9]. By combining domain experts' expertise with machine learning and natural language processing, the system may automate the solution of complicated issues using reasoning capabilities. Assessing food quality, recognising food safety issues, and optimising manufacturing processes are just a few examples of the many applications that might benefit from expert systems.

Furthermore, there are expert systems that are capable of ongoing improvement through learning [9]. The system may become better at addressing problems and updating itself as more data and expertise is added. Computer applications that incorporate several domain-specific issue solutions are known as knowledge-based systems or expert systems. The algorithm may make decisions that seem to be made by humans. The most crucial parts of this system are the reasoning machine and the knowledge base, but it usually has six parts: the human-computer interface, the knowledge base, the inference engine, the interpreter, the comprehensive database, and the knowledge acquisition module. The knowledge base contains a vast amount of information organised in "IF-THEN" statements, including facts, objects, cases, and rule conditions. Together with human specialists, the reasoning machine can process this information in a targeted way, allowing it to solve a wide range of issues.

Expert systems have been utilised in food manufacturing, quality testing, and risk assessment because to the high importance of food safety in the food production business [1]. The food industry also makes use of expert systems; for example, web-based systems for banana plant pest and disease diagnosis [9], intelligent expert system databases for automatic control of product quality indices [93], and expert systems for coffee based on fuzzy logic models [14-24].

Expert Systems: Looking Ahead and Overcoming Obstacles

Our prediction for the future is that sophisticated control procedures in food processing, control modelling, multivariate and nonlinear processes, and others will use a combination of knowledge-based expert systems with techniques like fuzzy logic and neural networks. Hybrid fuzzy expert systems, in particular, may benefit greatly from fuzzy logic's capacity to deal with ambiguity. Companies in the food industry may benefit from knowledge-based expert systems in several ways, including lower production costs, more productivity, better product quality, and increased market competitiveness. Due to inadequate software and hardware, expert systems were unable to realise their full potential in the 1990s. Expert systems are very useful and have been used recently because to the fast advancements in software and hardware as well as in artificial intelligence and machine learning, it is an essential component of AI [36-65] and has applications in many areas, including engineering, medical [95], business, and food.

3.2. Systems for Fuzzy Logic

One major drawback of conventional general expert systems based on body of knowledge is their inability to deal with issues that go outside the boundaries of their knowledge database. Results will not be predictable from a rule-based system when it encounters challenges not covered by the knowledge base. Originally proposed by Zadeh in 1965, fuzzy logic is a solution to the issues that conventional expert systems have when dealing with ambiguous and imprecise input. To solve issues involving fuzzy notions, artificial intelligence researchers have developed fuzzy logic systems, which are based on fuzzy logic principles. Fuzzy logic systems are superior to classical logic systems for dealing with issues with fuzzy boundaries because the truth value of a statement can take on any value between zero and one. Fuzzy set theory also makes it easy to cope with ambiguity and convert expert knowledge into quantitative functions that computers can handle. Fuzzy logic applications do not need complicated mathematical relationships, in contrast to traditional statistical and analytical approaches, which frequently fail when dealing with expert knowledge. To mimic the structure of rule-based expert systems, fuzzy models can be described using language rules that are easy to understand. Fuzzy logic systems, which have recently emerged, can enhance the generalisability of expert systems while also introducing the inaccurate and stereotyped aspects of human judgement.

The values of variables are represented by fuzzy logic in a linguistic form, with each interpretation corresponding to a fuzzy set. The fuzzy system then uses these representations to make judgements. A fuzzy input set is created by the process of fuzzyification [10], which entails converting explicit values into associations. Typically, a membership function fuzzy system's correspondence falls somewhere between zero and one. Another name for fuzzy rules is "IF-THEN" rules, where IF is a precondition and THEN is the consequence. The stages that make up the fuzzy logic system are as follows: Before applying rules to map fuzzy inputs to fuzzy outputs, the real values are first converted into fuzzy values. Statistical techniques are then used to combine the outcomes of the fuzzy rules, resulting in a fuzzy output. Defuzzification is the last step in converting fuzzy output to concrete real values. The fundamental process flow of a fuzzy logic system is formed by these interrelated processes. These procedures are shown in Figure 5 for a fuzzy logic controller [65-80].

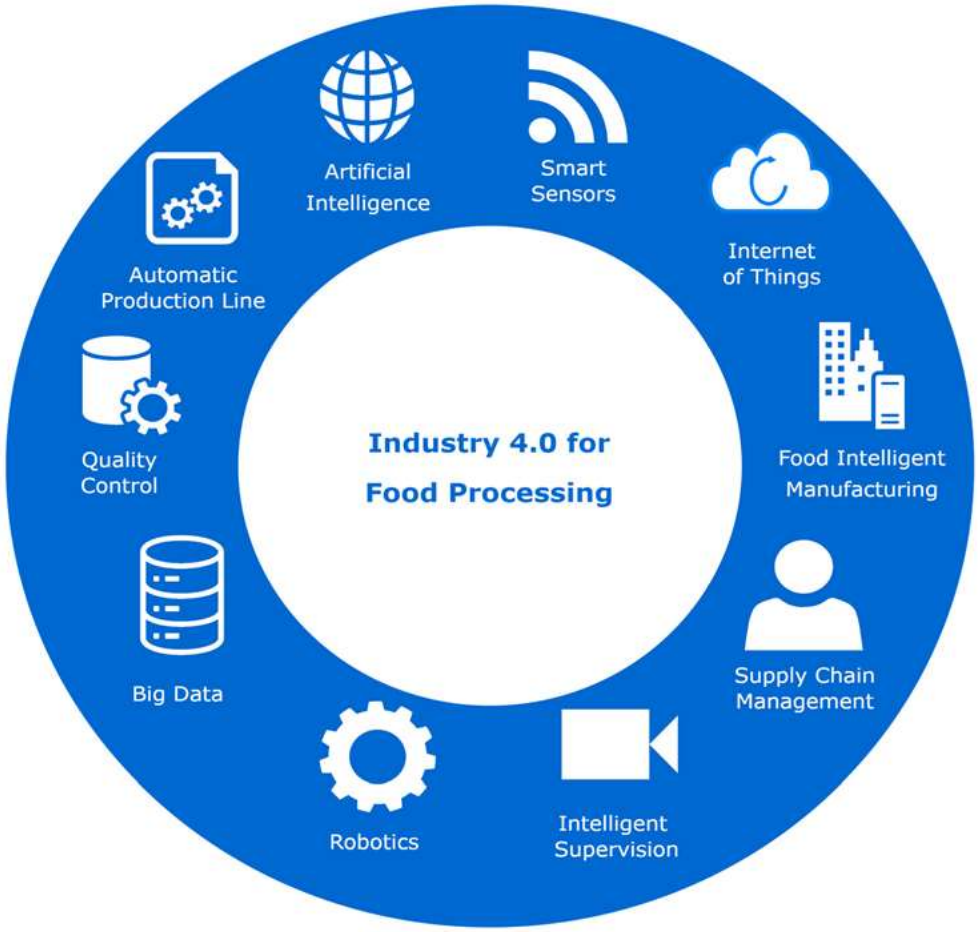

Figure 3. Key technology elements related to Industry 4.0 for food processing.

AI in the Food Industry: Looking Ahead and the Obstacles to Overcoming

Because of the food business revolution, the food industry has changed drastically and quickly in the past several years. Intelligent farming, automated farming, unmanned aerial vehicles, three-dimensional printing, and digital twins are some of the AI-based technologies that will underpin the food sector of the future. Meanwhile, the food manufacturing sector is transitioning from a phase of manual to an automated production phase, all because of robotics and automation in the sustainable food business. As part of this shift, automation is also making its way into marketing, customer service, warehousing, and packaging. Nevertheless, the food industry's workforce is facing increased demands due to the rise of these new models. On a global scale, food safety concerns have grown in recent years. With the advancement of IoT technology, which can identify items and trace them back to every step of food manufacturing and processing, this problem can be helped. By using the technologies of the Fourth Industrial Revolution, often known as Industry 4.0, the idea of Industry 4.0 for food processing aims to enhance the safety and quality of processed meals in the modern digital age. Much of the focus in recent years has been on Industry 4.0 as it pertains to food processing technologies, which is changing the game in many areas of the food business, such as food inspection and processing. Artificial intelligence (AI) is finding more and more applications in the food business as a result of business 4.0 for food processing. AI provides novel solutions to the many problems that crop up in the food industry. Improvements in food processing quality and safety, standardisation of production processes, reduction of production costs and time, conservation of energy and resources, and reduction of food loss and waste are all outcomes of Industry 4.0, which involves integrating technology or intelligent systems into traditional industries. The components of Industry 4.0's food processing connected to artificial intelligence and big data are illustrated in Figure 8.

There has been a recent uptick in the number of studies delving deeply into the food industry, and this trend will likely continue as more AI methodologies become available and new AI applications are added. Personalised nutrition, synthetic food, supply chain management, sales forecasting, aided cooking, and energy efficiency in food production are just a few areas that are benefiting from the most recent and innovative artificial intelligence (AI) technology. New synthetic meals, such as plant-based meat and egg-free cakes, may be made utilising methods comparable to 3D printing and machine learning and biotechnology, as opposed to conventional organically produced components. Deep learning and computational vision technologies, enabled by the Internet of Things, may significantly reduce energy and material waste, leading to more efficient and eco-friendly industrial processes. Simultaneously, AI has the potential to improve food production quality by autonomously regulating process factors like temperature, humidity, and ventilation according to environmental indicators that are monitored. By keeping an eye on potential dangers like weather and natural disasters, AI can intelligently monitor vast supply networks to guarantee food traceability and enhance business reaction to emergencies.

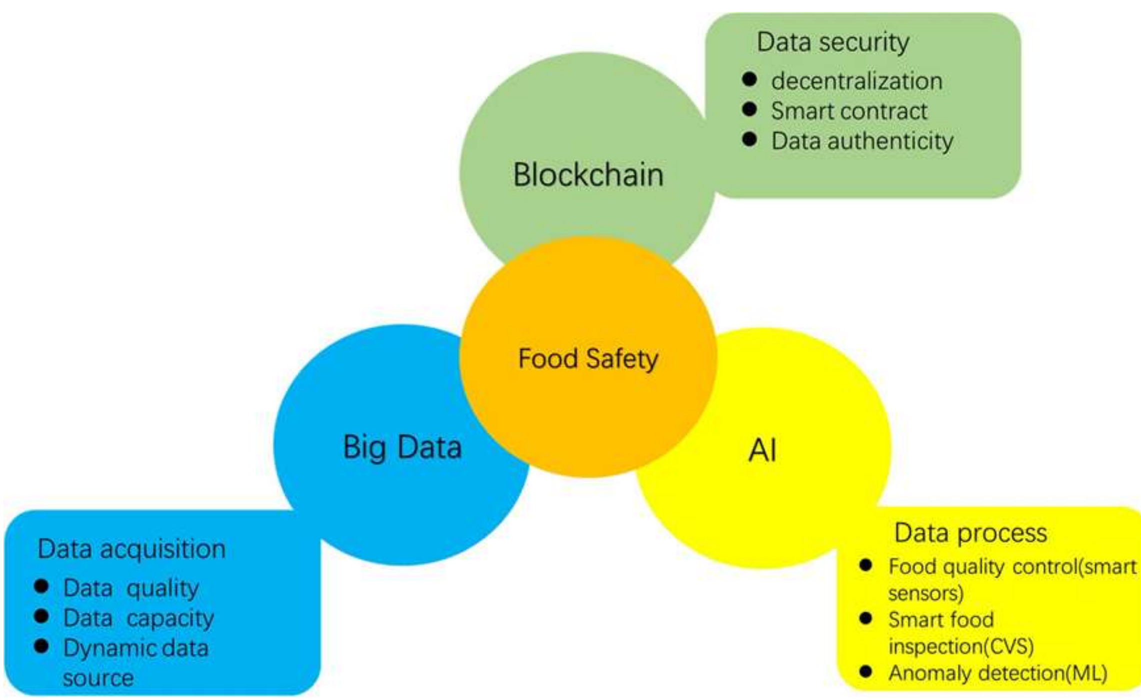

Figure 4. The relationship between food safety, big data, blockchain, and AI.

Issues that might influence the distribution and manufacturing of food, a process known as supply chain management. To properly anticipate customer buying behaviour, sales forecasting involves putting massive quantities of data into AI models, such the recently popular ChatGPT 4.0 model. In order to generate personalised sales estimates, it is necessary to take into account aspects such as weather, customer buying behaviours, and characteristics like food recipes and tastes. Assisted cooking is the practice of using computer vision technology to help cooks with tasks such as recipe creation, item identification, and dish quality control. Smart bracelets, smart scales, and sports watches are all the rage these days; not only can these wearables access users' physical data, but they can also be integrated with AI technology to analyse users' conditions and offer more tailored solutions for health management.

Conclusion

Analysing the opportunities and threats presented by big data and AI in the food business, this study delves into their potential uses and discusses their potential benefits. This review's study demonstrates that the food business may greatly benefit from artificial intelligence and big data. The food industry has reaped several benefits from the implementation of these technologies, including higher production, lower costs, enhanced control of the supply chain, along with better and safer products. Data privacy and security, technological complexity, and integration with conventional procedures are a few of the obstacles that AI encounters in the food sector. Improved detection accuracy in the food industry is within reach, thanks to ever-improving deep learning algorithms; data security is assured by combining blockchain with big data and AI; and the advent of Industry 4.0 has sped up the development of numerous technologies in the food industry, which is anticipated to realise numerous industrial applications. Furthermore, the food business will be propelled towards intelligent operations, sustainability, and innovation by the tight integration of big data and AI.

References

[1] Pasham, S.D. (2017) AI-Driven Cloud Cost Optimization for Small and Medium Enterprises (SMEs). The Computertech. 1-24.

[2] Alam, K., Mostakim, M. A., & Khan, M. S. I. (2017). Design and Optimization of MicroSolar Grid for Off-Grid Rural Communities. Distributed Learning and Broad Applications in Scientific Research, 3.

[3] Agarwal, A. V., & Kumar, S. (2017, November). Unsupervised data responsive based monitoring of fields. In 2017 International Conference on Inventive Computing and Informatics (ICICI) (pp. 184-188). IEEE.

[4] Gudepu, B.K., O. Gellago, and R. Eichler. (2018) Data Quality Metrics How to Measure and Improve Accuracy. International Journal of Modern Computing. 1(1): 51-60.

[5] Gudepu, B.K. and D.S. Jaladi. (2018) The Role of Data Quality Scorecards in Measuring Business Success. The Computertech. 29-36.

[6] Gudepu, B.K. and D.S. Jaladi. (2018) The Role of Data Profiling in Improving Data Quality. The Computertech. 21-26.

[7] Tulli, S.K.C. (2023) An Analysis and Framework for Healthcare AI and Analytics Applications. International Journal of Acta Informatica. 1: 43-52.

[8] Gonugunta, K.C. (2016) Oracle performance: Automatic Database Diagnostic Monitoring. The Computertech. 1-4.

[9] Gonugunta, K.C. and K. Leo. (2017) Role-Based Access Privileges in a Complex Hierarchical Setup. The Computertech. 25-30.
[10] Gonugunta, K.C. (2018) ZDL-Zero Data Loss Appliance–How It Helped DOC in Future-Proofing Data. International Journal of Modern Computing. 1(1): 32-37.
[11] Mandaloju, N. kumar Karne, V., Srinivas, N., & Nadimpalli, SV (2021). Overcoming Challenges in Salesforce Lightning Testing with AI Solutions. ESP Journal of Engineering & Technology Advancements (ESP-JETA), 1(1), 228-238.
[12] Kothamali, P. R., Banik, S., & Nadimpalli, S. V. (2021). Feature Engineering for Effective Threat Detection. International Journal of Machine Learning Research in Cybersecurity and Artificial Intelligence, 12(1), 341-358.
[13] Kothamali, P. R., & Banik, S. (2021). Data Sources for Machine Learning Models in Cybersecurity. Revista de Inteligencia Artificial en Medicina, 12(1), 358-383.
[14] Mandaloju, N., Karne, N. V. K., Mandaloju, N. N., & Kothamali, N. P. R. (2021). AI-Powered Automation in Salesforce Testing: Efficiency and accuracy. Universal Research Reports, 8(1), 121-134.
[15] Gudepu, B.K. (2019) AI-Enhanced Identity and Access Management: A Machine Learning Approach to Zero Trust Security. The Computertech. 40-53.
[16] Gudepu, B.K. and R. Eichler. (2019) The Power of Business Metadata, Driving Better Decision Making in Business Intelligence. The Computertech. 58-74.
[17] Gudepu, B.K. and O. Gellago. (2019) Unraveling the Divide: How Data Governance and Data Management Shape Enterprise Success. International Journal of Modern Computing. 2(1): 50-59.
[18] Gudepu, B.K. and E. Eichler. (2020) Metadata is Key to Digital Transformation in Enterprises. International Journal of Modern Computing. 3(1): 26-33.
[19] Gudepu, B.K. and R. Eichler. (2021) CCPA vs. CPRA: A Deep Dive into Their Impact on Data Privacy and Compliance. The Computertech. 34-46.
[20] Gudepu, B.K. and D.S. Jaladi. (2021) GDPR Compliance Challenges and How to Overcome Them. International Journal of Modern Computing. 4(1): 61-71.
[21] Gudepu, B.K. and D.S. Jaladi. (2022) Why Real-Time Data Discovery is a Game Changer for Enterprises. International Journal of Acta Informatica. 1(1): 164-175.
[22] Gudepu, B.K. and D.S. Jaladi. (2022) Data Discovery and Security: Protecting Sensitive Information. International Journal of Acta Informatica. 1(1): 176-187.
[23] Gudepu, B.K., D.S. Jaladi, and O. Gellago. (2023) How Data Catalogs are Transforming Enterprise Data Governance: A Systematic Literature Review. The Metascience. 1(1): 249-264.
[24] Tulli, S.K.C. (2022) Technologies that Support Pavement Management Decisions Through the Use of Artificial Intelligence. International Journal of Modern Computing. 5(1): 44-60.
[25] Tulli, S.K.C. (2023) Warehouse Layout Optimization: Techniques for Improved Order Fulfillment Efficiency. International Journal of Acta Informatica. 2(1): 138-168.
[26] Gudepu, B.K. (2016) The Foundation of Data-Driven Decisions: Why Data Quality Matters. The Computertech. 1-5.
[27] Gudepu, B.K. (2016) AI-Powered Anomaly Detection Systems for Insider Threat Prevention. The Computertech. 1-9.
[28] Gudepu, B.K. (2017) Data Cleansing Strategies, Enabling Reliable Insights from Big Data. The Computertech. 19-24.
[29] Gudepu, B.K. and O. Gellago. (2018) Data Profiling, The First Step Toward Achieving High Data Quality. International Journal of Modern Computing. 1(1): 38-50.
[30] Tulli, S.K.C. (2023) Enhancing Marketing, Sales, Innovation, and Financial Management Through Machine Learning. International Journal of Modern Computing. 6(1): 41-52.

[31] Tulli, S.K.C. (2023) Application of Artificial Intelligence in Pharmaceutical and Biotechnologies: A Systematic Literature Review. International Journal of Acta Informatica. 1: 105-115.
[32] Dalal, A., Abdul, S., Kothamali, P. R., & Mahjabeen, F. (2015). Cybersecurity Challenges for the Internet of Things: Securing IoT in the US, Canada, and EU. International Journal of Machine Learning Research in Cybersecurity and Artificial Intelligence,6(1), 53-64.
[33] Dalal, A., Abdul, S., Kothamali, P. R., & Mahjabeen, F. (2017). Integrating Blockchain with ERP Systems: Revolutionizing Data Security and Process Transparency in SAP. Revista de Inteligencia Artificial en Medicina,8(1), 66-77.
[34] Dalal, A., Abdul, S., Mahjabeen, F., & Kothamali, P. R. (2018). Advanced Governance, Risk, and Compliance Strategies for SAP and ERP Systems in the US and Europe: Leveraging Automation and Analytics. International Journal of Advanced Engineering Technologies and Innovations, 1(2), 30-43.
[35] Kothamali, P. R., & Banik, S. (2019). Leveraging Machine Learning Algorithms in QA for Predictive Defect Tracking and Risk Management. International Journal of Advanced Engineering Technologies and Innovations, 1(4), 103-120.
[36] Banik, S., & Kothamali, P. R. (2019). Developing an End-to-End QA Strategy for Secure Software: Insights from SQA Management. International Journal of Machine Learning Research in Cybersecurity and Artificial Intelligence, 10(1), 125-155.
[37] Pemmasani, P.K. and M. Osaka. (2019) Red Teaming as a Service (RTaaS): Proactive Defense Strategies for IT Cloud Ecosystems. The Computertech. 24-30.
[38] Pemmasani, P.K. and M. Osaka. (2019) Cloud-Based Health Information Systems: Balancing Accessibility with Cybersecurity Risks. The Computertech. 22-33.
[39] Pemmasani, P.K. and K. Anderson. (2020) Resilient by Design: Integrating Risk Management into Enterprise Healthcare Systems for the Digital Age. International Journal of Modern Computing. 3(1): 1-10.
[40] Pemmasani, P.K., K. Anderson, and S. Falope. (2020) Disaster Recovery in Healthcare: The Role of Hybrid Cloud Solutions for Data Continuity. The Computertech. 50-57.
[41] Pemmasani, P.K. and D. Henry. (2021) Zero Trust Security for Healthcare Networks: A New Standard for Patient Data Protection. The Computertech. 21-27.
[42] Kothamali, P. R., & Banik, S. (2019). Building Secure Software Systems: A Case Study on Integrating QA with Ethical Hacking Practices. Revista de Inteligencia Artificial en Medicina, 10(1), 163-191.
[43] Kothamali, P. R., & Banik, S. (2019). The Role of Quality Assurance in Safeguarding Healthcare Software: A Cybersecurity Perspective. Revista de Inteligencia Artificial en Medicina, 10(1), 192-228.
[44] Kothamali, P. R., Dandyala, S. S. M., & Kumar Karne, V. (2019). Leveraging edge AI for enhanced real-time processing in autonomous vehicles. International Journal of Advanced Engineering Technologies and Innovations, 1(3), 19-40.
[45] Dalal, A., Abdul, S., Mahjabeen, F., & Kothamali, P. R. (2019). Leveraging Artificial Intelligence and Machine Learning for Enhanced Application Security. International Journal of Machine Learning Research in Cybersecurity and Artificial Intelligence, 10(1), 82-99.
[46] Kothamali, P. R., Banik, S., & Nadimpalli, S. V. (2021). Feature Engineering for Effective Threat Detection. International Journal of Machine Learning Research in Cybersecurity and Artificial Intelligence, 12(1), 341-358.
[47] Kothamali, P. R., & Banik, S. (2021). Data Sources for Machine Learning Models in Cybersecurity. Revista de Inteligencia Artificial en Medicina, 12(1), 358-383.
[48] Mandaloju, N., Karne, N. V. K., Mandaloju, N. N., & Kothamali, N. P. R. (2021). AI-Powered Automation in Salesforce Testing: Efficiency and accuracy. Universal Research Reports, 8(1), 121-134.
[49] Kothamali, P. R., & Banik, S. (2020). The Future of Threat Detection with ML. International Journal of Advanced Engineering Technologies and Innovations, 1(2), 133-152.

[50] Gonugunta, K.C. (2018) Apply Machine Learning Oracle Analytics–Combined. The Computertech. 37-44.
[51] Gonugunta, K.C. and K. Leo. (2018) Oracle Analytics to Predicting Prison Violence. International Journal of Modern Computing. 1(1): 23-31.
[52] Kothamali, P. R., Banik, S., & Nadimpalli, S. V. (2020). Introduction to Threat Detection in Cybersecurity. International Journal of Advanced Engineering Technologies and Innovations, 1(2), 113-132.
[53] Dandyala, S. S. M., kumar Karne, V., & Kothamali, P. R. (2020). Predictive Maintenance in Industrial IoT: Harnessing the Power of AI. International Journal of Advanced Engineering Technologies and Innovations, 1(4), 1-21.
[54] Kothamali, P. R., Banik, S., & Nadimpalli, S. V. (2020). Challenges in Applying ML to Cybersecurity. Revista de Inteligencia Artificial en Medicina, 11(1), 214-256.
[55] Kothamali, P. R., & Banik, S. (2022). Limitations of Signature-Based Threat Detection. Revista de Inteligencia Artificial en Medicina, 13(1), 381-391.
[56] Kothamali, P. R., Mandaloju, N., & Dandyala, S. S. M. (2022). Optimizing Resource Management in Smart Cities with AI. Unique Endeavor in Business & Social Sciences, 1(1), 174-191.
[57] Gonugunta, K.C. (2018) Role of Analytics in Offender Management Systems. The Computertech. 27-36.
[58] Pemmasani, P.K. (2023) National Cybersecurity Frameworks for Critical Infrastructure: Lessons from Governmental Cyber Resilience Initiatives. International Journal of Acta Informatica. 2(1): 209-218.
[59] Pemmasani, P.K. (2023) AI in National Security: Leveraging Machine Learning for Threat Intelligence and Response. The Computertech. 1-10.
[60] Pemmasani, P.K. and D. Rock. (2023) The Impact of Ransomware on Government Agencies: Lessons Learned and Future Strategies. International Journal of Modern Computing. 6(1): 64-74.
[61] Pemmasani, P.K. and D. Rock. (2023) Cloud Storage Security in Government Agencies: Protecting National Data from Cyber Threats. The Metascience. 1(1): 239-248.
[62] Gonugunta, K.C. (2019) Weblogic and Oracle-Revolutionizing Offender Management System. International Journal of Modern Computing. 2(1): 26-39.
[63] Gonugunta, K.C. (2019) Utilization of Data in Reducing Recidivism in Nevada Prisons. International Journal of Modern Computing. 2(1): 40-49.
[64] Gonugunta, K.C. and K. Leo. (2019) Practical Oracle Cloud for Governments. The Computertech. 34-44.
[65] Gonugunta, K.C. and K. Leo. (2019) The Unexplored Territory in Data Ware Housing. The Computertech. 31-39.
[66] Tulli, S.K.C. (2022) An Evaluation of AI in the Classroom. International Journal of Acta Informatica. 1(1): 41-66.
[67] Tulli, S.K.C. (2023) The Role of Oracle NetSuite WMS in Streamlining Order Fulfillment Processes. International Journal of Acta Informatica. 2(1): 169-195.
[68] Tulli, S.K.C. (2023) Utilisation of Artificial Intelligence in Healthcare Opportunities and Obstacles. The Metascience. 1(1): 81-92.
[69] Tulli, S.K.C. (2023) Analysis of the Effects of Artificial Intelligence (AI) Technology on the Healthcare Sector: A Critical Examination of Both Perspectives. International Journal of Social Trends. 1(1): 112-127.
[70] Gonugunta, K.C. and T. Sotirios. (2020) Data Warehousing-More Than Just a Data Lake. The Computertech. 52-61.
[71] Gonugunta, K.C. and T. Sotirios. (2020) Advanced Oracle Methodologies for Operational Excellence. International Journal of Modern Computing. 3(1): 11-25.

[72] Gonugunta, K.C. and A. Collins. (2021) Data Virtualization and Advancing Data Migration in Mission Critical Environments. The Computertech. 24-33.
[73] Gonugunta, K.C. and M. Chen. (2022) How Oracle analytics could help Higher Education deliver value to Educators/Students? International Journal of Acta Informatica. 1(1): 138-150.
[74] Gonugunta, K.C. and M. Chen. (2023) Real Time Data Analytics on Active Data Guard. International Journal of Modern Computing. 6(1): 75-90.
[75] Gonugunta, K.C., M. Chen, and Y. She. (2023) Combining BI and Analytics in Higher Ed. The Metascience. 1(1): 265-283.
[76] Pemmasani, P.K. and M. Osaka. (2021) The Future of Smart Cities: Cybersecurity Challenges in Public Infrastructure Management. International Journal of Modern Computing. 4(1): 72-85.
[77] Pemmasani, P.K., M. Osaka, and D. Henry. (2021) From Vulnerability to Victory: Enterprise-Scale Security Innovations in Public Health. International Journal of Modern Computing. 4(1): 50-60.
[78] Pemmasani, P.K., M. Osaka, and D. Henry. (2021) AI-Powered Fraud Detection in Healthcare Systems: A Data-Driven Approach. The Computertech. 18-23.
[79] Pemmasani, P.K. and M.A. Abd Nasaruddin. (2022) Resilient IT Strategies for Governmental Disaster Response and Crisis Management. International Journal of Acta Informatica. 1(1): 151-163.
[80] Pemmasani, P.K. and M.A. Abd Nasaruddin. (2022) Strengthening Public Sector Data Governance: Risk Management Strategies for Government Organizations. International Journal of Modern Computing. 5(1): 108-118.