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Role of Artificial Intelligence and Deep Learning in Healthcare, Cyber security, and Food Systems: Innovations, Challenges, and Future Perspectives

George Edison[1*]

[1]Independent Researcher, France

[1]Geogeedison2nice@gmail.com

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Corresponding Author

George Edison

Geogeedison2nice@gmail.com

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ABSTRACT

Through deep learning and artificial intelligence the healthcare and cyber security sectors can work faster and smarter while maintaining secure food systems across our planet. Al technology helps medical specialists diagnose better and find security threats early while guiding farmers with precise crop actions. Several important barriers including ethical problems and legal restrictions make progress more difficult. The future will develop AI systems that work fairly with clear processes while uniting with new technology types. AI development require responsible methods and ethics to create value with minimal safety hazards. Well-planned use of AI systems helps companies solve global issues in their business sectors.

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INTRODUCTION

AI and DL, or, in simple terms, Machine Learning, are two of the hottest trends of the century that finds application in almost all fields. In healthcare, cyber security, and the food industry the use of these forms of computational techniques is making it easier to solve problems, increasing efficiency, and accuracy and automating the whole process. This review seeks to discuss the various applications of AI and Deep Learning, potential issues and the future possibilities of the application of AI and Deep Learning in these significant areas [1]. Artificial intelligence is defined as human-like thinking ability of machines where they are designed to work, learn, reason and conclude things on their own. It comprises various fields such as, Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), and Computer Vision. Of these, Deep Learning has received considerably much attention because of big data handling capability and the ability of learning the hidden patterns which has led to revolutionary leaps in automation and decision making [2].

There is also another category of ML called deep learning that has artificial neural networks that mimic the human brain. These networks are composed of multi-layered neurons so that the former can learn many representations from the latter. The algorithms in DL are of the three categories; supervised learning, unsupervised learning and reinforcement learning in that they grow progressively better in their performance over time. Deep Learning success has been made methodical by aspects such as increased computation power, availability of data sets and enhanced algorithms [3].

IMPORTANCE OF AI IN VARIOUS SECTORS

It has also been evident that AI is a disruptor in numerous sectors such as healthcare, cybersecurity, and food systems.

Healthcare: AI has transpired to impact on diagnosis, treatment planning, drug discovery, and even the observation of patients. There is no doubt that machine learning algorithms can be designed in a way that could effectively diagnose an illness such as cancer through images even at a highly advanced stage. Since the use of value-based care offers key insights on the possibility of an

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individual's health condition changing in the near future, artificial intelligence and predictions play a big role in helping the healthcare givers to recognize possible risks in health and in providing Continue providing care plans that is a personalized approach to the people [4]. Besides, utilization of artificial intelligence such as robotic surgeries in surgeries and health assistant bots offer a boost to patients and hospitals.

Responsibilities of AI in cybersecurity: With the increase of cyber threats to any organization, AI has become vital in improving the security measures in an organization. Cybersecurity solutions that integrate artificial intelligence technologies are effective in identifying risks and threats that are becoming more and more frequent; these algorithms analyze the characteristics of the traffic in the various segments of the Net and determine the probability of their being related to malevolent activity [5]. Pressurization in Deep Learning augments the methods for securing authentication, enhances the cryptographic processing, and shortens the time for threats' management. The applied integration of AI in cybersecurity is helpful to organizations in the fight against cybercriminals through process optimization [6].

Food Systems: It is interesting to note that AI has invaded almost all aspects of the food chain, including production, processing, and distribution. In general, the use of AI in farming makes the management of resources efficient, tracking of crops' status, and enhancing the productivity. These Deep Learning models inspect the quality of food, identify impurities and enhance the safety aspect of food. Notably, with the help of artificial intelligence, the efficiency of supplying food to consumers and the reduction of food waste are also addressed. Considering the increasing application of AI and Deep Learning in these domains, this review will reveal [7].

Identify how AI and Deep Learning have been applied to and used in the case of healthcare, cybersecurity, and food systems. Discuss the ethical, technical, and regulatory concerns likely to be faced within the implementation of AI in the above mentioned fields. Give ideas on trends those are yet to be established, changes that can be done, and growth areas of these industries regarding AI solutions [8]. In view of these findings, this paper aims at presenting the state of the art and future prospects of the AI, particularly the Deep Learning in these sectors in an effort to contribute to the knowledge of researchers, policymakers as well as professionals in these fields.

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ARTIFICIAL INTELLIGENCE AND DEEP LEARNING: AN OVERVIEW

AI and DL are two classical technologies today's world could scarcely imagine without and remain at the avant-garde of progress in numerous fields. AI is a comprehensive concept of structuring methods that allow machines to reproduce human behavior while Deep Learning is a part of the ML that concentrates on applying the neural networks for the analysis of data patterns. This subtopic reviews the background to the topic of AI and Deep Learning, as well as their history and major elements [9]. Artificial intelligence can be defined as the computer imitating human intelligence and experience. Such cognitive functions as learning, reasoning, problem solving, perception, and language comprehension are currently in the capabilities list. There are basically three classifications when it comes to AI based on its hardness [10].

Created for certain purposes like: recognition of objects, identification of voice, or controlling of sickness. It has a very limited operation capability and cannot perform functions not programmed into it. They include; it also includes some common known artificial intelligence home assistants such as Siri, Alexa, and Google Assistant. An intelligent agent that is able to accomplish any information processing task that a human can do. It will incorporate reasoning skills, problem solving and has the capacity to take independent decisions [11]. Currently, no such AI exists. Abusive artificial intelligence is a concept where artificial intelligence is superior to human intelligence in every shape and form. There are still discussions on whether this is true or not and up to date it is still an object of controversy.

Artificial Intelligence (AI) deals with the utilization of technology to empower computers to learn and optimize themselves with relations to a task without coding. The major categories of the Machine Learning algorithms are as follows: It means the learning is based on training data that contain data and labels. They include image detection and spams e-mail detection. The unsupervised learning method tries to make patterns or structures from the set of data for studies it does not use original labels. Some examples are clustering of clients and detection of outliers [12]. The model is capable

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of learning through the use of penalties and incentives for the decision made by the model. Examples are in the games like chess using trivial artificial intelligence and self-driving cars. Considering the capabilities of ML, Deep Learning is one of the most sophisticated subtypes of it that is based on artificial neural networks (ANNs). Deep learning is, therefore, a type of learning inspired by the structure of the human brain to independently extract features and recognize patterns in a dataset [13].

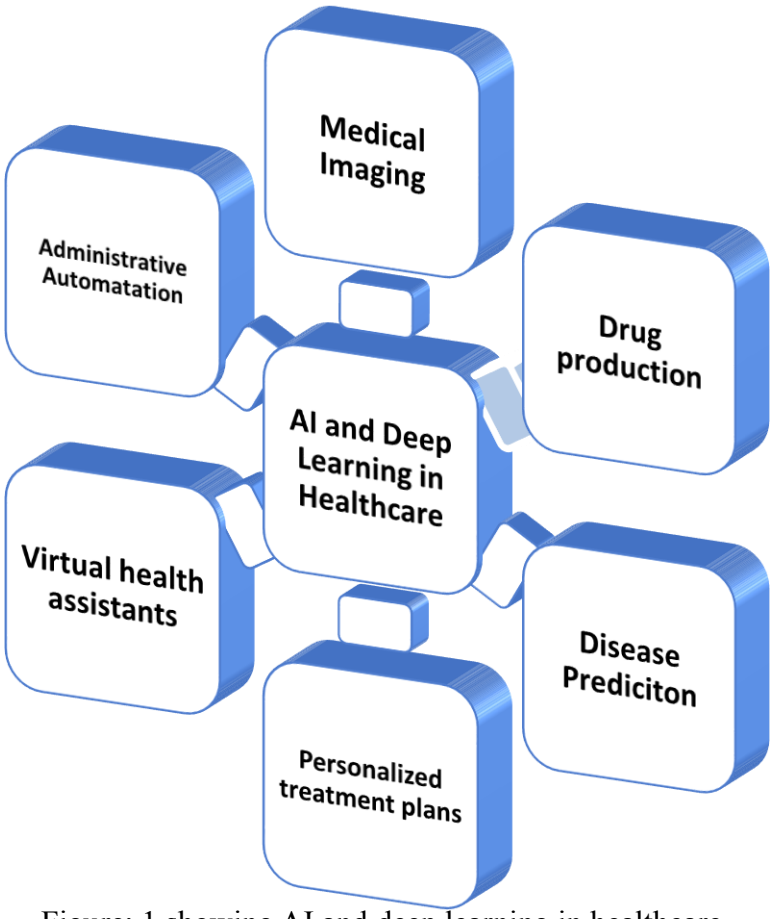

Figure: 1 showing AI and deep learning in healthcare

It is significant to notice that development of AI technology has and I define in phases based on the technological advancement's achieved and periods of recession: The definitions of AI were given by Alan Turing and John McCarthy. The initial AI development involved rule-based systems and symbolic techniques and approaches [14]. Lack of capacities of computation and lack of data gave rise to the first 'AI winter' which is characterized by reduced funding's and loss of interests. Neural

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networks were introduced and brought into problem as there were constraints in computational power. Back propagation led to better training of the neural networks since it could predict the error values. Expert systems and knowledge-based reasoning denotes the applications of artificial intelligence [15].

End computing power, and GPUs, bigger datasets, as well as enhanced algorithms contributed to the reinvention of AI. Models, including CNN and RNN, were considered by experts as being revolutionary and were applied to problems of images and natural language processing, and to artificial intelligence. Today, artificial intelligence is closely associated with such industries as healthcare, cybersecurity, finance, manufacturing and many others [16].

KEY COMPONENTS OF DEEP LEARNING

The Deep Learning models can be made of multiple layers, which in turn analyze the data in layers. The fundamental components include:

Artificial Neural Networks (ANNs): These comprises of intermediate node known as the neurons which are layered into the input layer, hidden layer as well as the output layer. The cell with the information then integrates and passes the information to the subsequent layer [17].

Convolutional Neural Networks (CNNs): More suitable for image and video vibrations, CNNs are filters like edges, shapes, and textures.

Recurrent Neural Networks (RNN): It is one of the most popular network architectures that are specifically suitable for analyzing sequential data such as speech and time series data [18].

Transformers: Contemporary architectures such as the GPT (Generative Pre-trained Transformer) are changing natural language understanding and AI-copying or writing. Both, AI and Deep Learning, have been steadily evolving as subparagraphs, over the years and have advanced due to varying aspects such as the computational power available, availability of more data and better algorithms [19]. This technological advancement has become vital in sectors like health, protection, and food chain through enhanced decision making and robotics. It is useful to first establish an import of the fundamentals as well as the history of advancement in the field of artificial intelligence. In the remaining part of this paper, the various innovations that have emerged due to AI and Deep Learning

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will be discussed with consideration of the challenges related thereto [20].

APPLICATIONS OF AI AND DEEP LEARNING

Artificial Intelligence (AI) and Deep Learning (DL) have inspired different industries through automation of process, better decision making and optimization. These technologies are also especially revolutionary within healthcare, cyber security, as well as in the food industry where they respond to multiple issues, enhance processes and create development opportunities [21]. This section addresses the usefulness of AI and Deep Learning in these sectors under consideration. AI has adopted tremendous changes in healthcare by making a faster analysis of medical diagnostics, accurate treatment plans, and better patient care. Some key applications include:

Specifically, Convolutional Neural Networks (CNNs) have gained popularity from its high performance in the diagnosis of medical images X-ray and CT scans and MRI scans. These diagnostic systems help radiologists in diagnosing an ailment such as cancer, tuberculosis, and pneumonia with high accuracy. For instance, IBM Watson as well as Google's Deep Mind have been learnt to detect abnormalities in scans thus decreasing mistakes among health care practitioners besides increasing early diagnostic capability [22].

AI can help tailor treatment plans of treatment depending on a person's genetics, their lifestyle, and medical history. This is because Deep Learning creates algorithms for identifying how patients will likely to behave when treated with certain drugs, so as to minimize side effects and increase efficiency of the treatment. Moreover, the Information technology applied to the drug discovery process through, molecular modeling, lead identification and predicting the efficacy of the drugs, cuts the time and the costs of drug development in the pharmaceutical industry [23]. Surgery executed with the use of Robotic technique with Artificial Intelligence is on the rise, as it has less complicity and risk when it comes to performing a procedure.

Robots that are used in surgeries like the da Vinci system offer information in operations making them less invasive and improved hand movement. Postoperatively, AI is helpful in tracking the illness progression and potential complications of the patients. Chatbots and voice assistants designed for patients and for scheduling the appointments as well as for checking the symptoms are the uses of AI.

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Due to this, using NLP, to make these systems recognize and answer to the queries of the patients will make them friendlier and decrease the work of doctors and other technicians [24].

As the number of threats increases, it is possible to prevent them only with the help of artificial intelligence. Real time data analyses are used by Deep Learning models to diagnose situations that require contingency measures and to maximize the success of security measures. Most of the traditional systems of cybersecurity are based on the process of defining rules for threat detection which make them useless in situations that involve new threats. AI-based solutions, therefore, learn from the activity in the network and are able to identify the patterns that are malicious [25]. Three advantages of Deep Learning are that it can identify malware or an anomalous connection as phishing, or an inner threat with more precision than traditional approaches. The AI security can be increased by implementing facial recognition, fingerprint scan, and behavioral biometrics. All these advance the ways in which users are verified and or decrease identity fraud. In spending patterns, AI helps the financial institutions in the detection of the fraudulent transactions in the undertaking [26].

On the one hand, the importance of AI to up the defense of cyber security is seen real, but on the other hand, there are some impacts to data privacy that are elicited by the use of AI. They meant that there is a necessity to introduce artificial intelligence-based security for data encryption and access. It also includes adversarial attacks, which are cases when attackers tamper with the AI models themselves, which is more an ongoing problem and an issue that is still receiving attention. AI is revolutionizing the food industry because it helps to optimize performance, control quality and manage supplies [27]. These technologies within their application affect global problems like food shortage, environmental and waste management issues. Precision farming is being driven by artificial intelligence to track the condition of the soil, its moisture content, weather, and even water them. Deep Learning models identify diseases, nutritional deficiencies and pest invasions in plants and enable farmers take the necessary precautions with a view of fashioning increased crop yields. There is a growth of new AI-based farming solutions with companies like John Deere and IBM Watson in this sector [28].

Machines with the help of Artificial Intelligence check defects, adulterations, and deterioration in food products. Learning techniques identify food products that may lack proper color and appearance due to the different safety regulation measurements. For instance, in the food industry AI is applied for determination of pathogenic bacteria in the foods and discerning between healthy and diseased

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people [29]. AI helps in logistics through demand forecast, minimum wastage of food, and implementing a better network for distribution. These models are meant to decipher the patterns of consumption such that supplies are well relayed to the consumers. Of major benefit, artificial intelligence reduces overstocking and deteriorating food products in the store's warehouses and stores. Artificial Intelligence and Deep Learning today have permeated into healthcare, cybersecurity and food sector and have helped in enhancing the value delivery [30]. In health care, AI boosts diagnosing, prescribing of medicine, and surgery by robotic systems. AI comes to play a significant role in cybersecurity today due to the following reasons; Thus, AI is evident in food systems including in agriculture, food safety, and supply chain. However, there are various issues that have to be looked into, like ethical issues, protection of data, and cost of implementation. The next section of this paper will discuss the above challenges individually [31].

CHALLENGES AND LIMITATIONS OF AI AND DEEP LEARNING

However, it has to be noted that like any modern technological innovation, AI and DL too provide immense prospects in not only the respective fields of healthcare, cybersecurity, and food systems, but almost every sector known to man while having its drawbacks and limitations as well. Therefore, these are the challenges that involve ethical and legal frictions as well as the technical and operational issues that influence the dependability, security, and equity of the AI-based solutions [32]. That is why it is crucial to meet these challenges in order to make artificial intelligence to be used responsibly and effectively. Among the most important issues that one can identify while considering AI development and deployment, one of the toughest is the ethical and legal issues of its application [33].

The use of alternative resources in agriculture and food production is gaining attention, such as poultry manure being explored as a substitute for soybean in fish feed. The development of alternative meats is revolutionizing sustainable food systems, offering innovative solutions for future food security. Additionally, advancements in technology are transforming healthcare, with the integration of the Internet of Things (IoT), block chain, and artificial intelligence (AI) enhancing efficiency, security, and patient care in modern medical systems [34-36].

Deep Learning models receive this name because their decision-making methods remain hard to

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understand. People have doubts about how AI makes crucial choices when it hides its internal workings in fields like medical treatment and data security. Scientists build XAI standards to decode AI decisions but it remains tough to teach AI logic to regular people [37]. AI systems need large amounts of data to work yet their dependency creates important problems with user privacy and system security. Artificial Intelligence systems attract many attempts from hackers to break in. Attackers can gain access to weak spots in AI systems plus tamper their learning materials or adopt malicious practices to misguide AI protection mechanisms. Healthcare at a sets containing AI-assisted patient information become vulnerable to criminal attacks by unauthorized users to steal personal data. AI security systems that protect from threats must evolve fast to match enemy developments yet attackers develop better cyber-assaults with AI help [38].

AI systems need reliable training data but its collection faces difficulties when working with medical and food production sectors. Medical and agricultural databases usually lack sufficient complete and matching information necessary to build dependable AI systems. Data privacy rules block sharing of sensitive records which limits the quantity of datasets AI experts require for their work. AI technologies require extensive personal data to work which creates important moral issues about how these data records are managed [39]. The health industry must keep patient information confidential at all times. Cybersecurity systems that use artificial intelligence for surveillance need to protect both national security and personal privacy at the same time. Digital collect and use consumer data in food systems to help businesses must follow both user consent and ethical data handling rules [40].

Advanced AI technology meets organized obstacles that limit its use across different sectors. Deep Learning models need high-performance GPUs and TPUs plus important computing power to function properly. Teaching AI models to work becomes costly when organizations need cloud computing power since smaller organizations have limited access to these services. AI infrastructure expenses make it hard for startups and developing nations to get started with AI technology [41]. Business sectors find it hard to add artificial intelligence into their existing systems because they lack proper compatibility and trained staff plus expensive setup expenses. To support medical care AI needs to operate directly within Electronic Health Records and hospital operational platforms. AI security tools need to support existing security methods to protect computer systems. AI monitoring systems for food systems need to interface with existing supply chain systems. Companies require AI

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systems made to expand across their multiple platforms effortlessly [42].

AI systems achieve their best results within testing conditions but can face problems when tested across actual operating conditions. A model that receives training from one dataset will normally fail to produce beneficial results in various geographic areas and different circumstances. Medical AI systems trained on medical images from one nation will not work well in other countries because of healthcare system and population differences [43]. The way AI controls agricultural systems does not easily fit with farming practices that differ from where it was first programmed. Scientific teams widely study how AI can predict results across numerous conditions. AI technology automation worries workers across various sectors including production, customer services and information processing. The development of AI driven jobs in specific areas increases labor need but it makes human workers less essential in routine manual tasks. Businesses and government leaders should provide training to teach employees new AI-based work skills [44].

The public's acceptance of AI depends on their trust which weakens when people fear losing their jobs and question ethical uses of AI plus doubt the truth of AI-related information. People must trust AI systems when these systems show what decisions they make and use guidelines that follow human ethics through public education programs. Leaders from government and business need to build standard rules about AI usage to protect public safety while enabling proper AI use [45]. Deep Learning technology and Artificial Intelligence offer great industry benefits across healthcare and cybersecurity but these benefits come with important hindrances. The usage of AI systems must follow proper ethical rules to make them use this technology in a safe way. Organizations need strong protection systems to keep private information safe from harm. Research organizations need to solve technical problems with AI to make this technology available everywhere. The societal effects of artificial intelligence on job safety and public trust need proper management. Experts across different fields and sectors need to cooperate to develop solutions that make AI work positively for society. The following section will examine upcoming directions of AI technology while presenting new ways to handle existing problems [46].

EMERGING AI TRENDS IN HEALTHCARE, CYBERSECURITY, AND FOOD SYSTEMS

New artificial intelligence systems will combine health data points like genes and habits to design

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appropriate medical plans for every patient. Mini-AIs will help create more precise medicines while making drug development faster and cheaper. Medical scanning machines will learn to recognize diseases sooner because AI medical models improve their diagnosis skills every day. AI techniques will speed up medical image evaluation while making results more reliable [47]. People can track real health details and doctors can see disease risks with medical technology that AI connects to. AI systems can extend medical support without patient or doctor interruptions all day long. The technology will create security measures that upgrade themselves by learning about modern cyber-attacks. Future security systems will bring AI and block chain together to secure data securely from attacks [48].

Zero-trust systems will get their power from artificial intelligence to establish tough user identity and endpoint protections over digital platforms. AI systems will observe and block insider security risks as they happen. New AI systems using quantum computing will create better decryption methods that shield against quantum cyber-attacks. Using AI technologies in farming will let farmers apply water and pesticides better while using less fertilizers. Genuine robots and drones powered by AI will run farm tasks to produce more harvest with less damage to the environment. AI systems will instantly check food quality to find harmful substances and follow health control standards [49]. Smart technology platforms controlled by artificial intelligence make food deliveries better by decreasing waste and enhancing how much food reaches everyone in the world. With AI assistance companies can manufacture plant-based and lab-made meat products that save natural resources. AI tools will test food contents for better dietary advices to customers. Scientists develop Explainable AI (XAI) systems to help users understand how AI makes decisions [50].

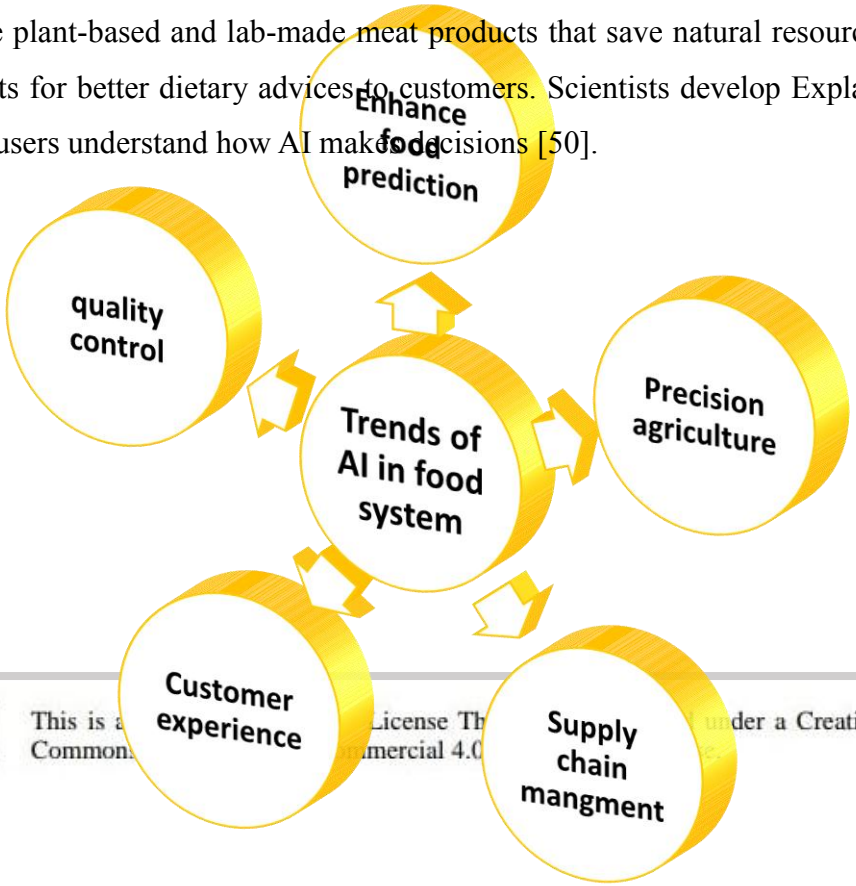

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Figure: 2 showing trends of AI in food system

Following advanced algorithms with fairness monitoring will assist AI systems in avoiding harmful biases during decision processes. AI technology does not intend to replace skilled human workers but helps them perform better by improving decision-making tools. Healthcare and cybersecurity systems with AI will use cobots to help humans do their work in these industries plus farming. AI platforms will connect to block chain networks, IoT systems, and 5G systems to build more robust security measures and speed up operations. When AI and quantum technology combine they can create better systems for handling data and protecting private information [51].

Nations across the world create AI rules to control how AI should be used ethically plus how personal data should be protected safely. Safety and fairness requirements need standardization tools to protect the people who use artificial intelligence systems. Companies should establish rules to create ethical AI solutions while developing these systems [52]. Ongoing talks about AI ethics determine rules regarding how systems handle unfairness plus promote open standards and responsibility monitoring. To make the best use of AI technology employees need special training programs that help them switch to AI-based tasks. Businesses and government organizations must unite their efforts to design policies that train people on AI technology and help workers develop new job skills [53].

Existing technologies will create breakthrough industry changes that seem impossible today. The healthcare system will become better through AI-driven tests and treatments that match specific patient needs plus wearable digital health devices. AI will help better discover security threats while improving login protection and encryption against quantum attacks. Food systems will use AI to improve soil utilization, protect food quality and enhance logistics processes [54]. The breakthroughs need to be balanced against ethical dangers to personal information and program guidelines. AI

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systems must develop in a responsible way through transparency to make sure their advantages exceed their dangers. Interdisciplinary partnerships between experts and fields will develop AI safely and make new discoveries possible for future generations [55].

CONCLUSION

Artificial Intelligence (AI) and Deep Learning (DL) development has powerfully changed how healthcare works plus secured computers from risks and enhanced food system strength. These technologies have revolutionized multiple sectors through their ability to work faster and make better choices. AI helps healthcare professionals find diseases sooner while producing new drugs and robots used in operations plus tailoring patient care for improved health results. AI systems in cyber security detect more threats accurately and block fraudulent activities that make digital protection better. AI technologies in food systems make agricultural production more effective and protect consumer safety while running the entire supply pipeline better.

Despite its benefits AI creates ethical issues with personal data exposure and creates problems with programmed bias plus control systems. Big datasets generate security and transparency issues when handled in medical and financial fields. Developing AI systems requires powerful computers and enough resources which keep some communities from accessing this technology. More organizations require explainable AI systems because people depend on complete understanding and simple decoding of automated decision processes.

Future developments in AI technology will prioritize fairness enhancements while making it work better with scalable systems and bringing it together with emerging technologies for quantum computing and IoT. Officials from government agencies and business must unite to make AI rules that protect AI system rights and moral standards. Our societies need AI training and skill development combined with cross-discipline research to navigate the path ahead with AI technology.

The full benefits of AI are clear to see when you examine the situation. Through ethical usage AI can solve various major global problems especially by defending us from healthcare threats and cyber-attacks and helping us solve the food supply and environmental issues. Society can achieve better innovation and sustainability while boosting economic growth when it uses AI technology

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purposefully and helps everyone benefit from it.

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