American Journal of Artificial Intelligence and computing

ISSN : 3067-8293
Volume 1, Number 2, 2025
https://doi.org/10.70445/ajac.1.2.2025.87-104

Artificial Intelligence in Healthcare, Cybersecurity, Machine Learning, and Food Processing: A Cross-Industry Review

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Article History:
Submitted: 07-06-2025
Accepted: 18-07-2025
Published: 24-07-2025

Keywords:
Artificial Intelligence, Machine Learning, Healthcare, Cybersecurity, Food Processing, Automation, Data Ethics, Predictive Analytics.

ABSTRACT

Artificial intelligence (AI) is changing some of the major industries such as healthcare, cybersecurity, machine learning and food processing at a very high pace. In healthcare, AI promotes diagnostics, treatment planning and P4, making it even more accurate and efficient. Within the field of cybersecurity, artificial intelligence allows dynamic defense systems and predications in detecting and preventing threats, but with a possibility to be misused. Machine learning is what gives AI the power of learning, inculcating changes and making predictions across fields. AI also helps in the food industry because there is enhanced quality control, optimization of the supply chains, and safety management. Even though these areas have different use cases, they have common issues: dependence on high-quality data, ethical issues, explain ability, and employee adaptation. AI convergence and development place a strong emphasis on the need to work across disciplines, ethical development and governance. The future of AI is a quest to integrate it, not only between different technologies, industries, but also with the role of human beings, which revolutionizes the way society innovates, protects itself, and develops. This paper discusses this overlapping of forces and how we all have a duty and responsibility in guiding this potential of AI.

INTRODUCTION

Artificial Intelligence (AI) is no longer the dream of the future that only researchers could dream of but the endeavor that has within itself transformed the world today and has become the pulsating

ISSN : 3067-8293
Volume 1, Number 2, 2025
https://doi.org/10.70445/ajac.1.2.2025.87-104

engine of almost all major industries. The things that were so far restricted to scholarly fields and science fiction are now defining the practical aspects of life, which makes us live, work, and solve complex issues [1]. As AI can already be found in autonomous medical diagnostics and real-time learning and-adaptive cyber defense, the list is long on changes that it will make to the industry and social lives. Anyone who has been paying attention to the recent developments in the technical field knows that the phenomenon of AI is not just a technological trend, but an indication of a structural change in our vision of intelligence, its emulation, and large-scale use [2].

In the 21 st century, AI has started to fill the same position that electricity held throughout the Second Industrial Revolution a facilitating backbone that powers innovation within industry. Industries are no longer concerned about solely utilizing human workers to complete an assignment or process. Rather than take place, smart systems, AI, machine learning, deep learning, and neural networks are now helping and in most situations execute faster, more precise, and greater in quantity than those conducted by traditional mechanisms [3]. This mechanic to cognitive automation is a big move in its process of digital transformation.

The strength of AI does not only consist in individual breakthroughs, but it is its versatility. In the healthcare sector, AI enabled applications are increasing the level of accuracy of diagnosis, the rate at which drugs are discovered, and the personalization of treatments. With machine learning, algorithms are currently being taught to identify threats that other systems miss including the ones in real-time. In the food processing field, meanwhile, AI is making cheaper and smarter quality control, supply chain and safety monitoring capabilities possible [4]. All of this is powered by the fact that modern AI neural networks rely on machine learning the heart of modern AI which enables systems to learn directly through data, supplementing, and modifying existing patterns, and expanding capabilities without clear direction [5].

Nevertheless, the cross-industry adoption is not an easy workout. The issues of privacy in data, prejudice in algorithms, and explain ability are gaining more and more significance. Since AI systems will impact human lives, be it by diagnosing a disease or raising a security alarm, it is not an option anymore to ensure that they are transparent and accountable. Also, different fields will impose specific requirements on AI medical systems will have to focus on ethical aspects and patient safety, whereas cybersecurity will demand speed, responsiveness, and, in many cases, invisibility [6].

The current paper proposes a cross-sectoral, in-depth review of the role of AI in reshaping four priorities areas: healthcare, cybersecurity, as machine learning as a subject, and food processing. Instead of tackling these industries separately, it is the interactions, common struggles and solutions that artificial intelligence will allow their implementation in a smart way that the article examines. It

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is by analyzing such divergent and at the same time connected domains that we strive to bring light to the potential and challenges of AI in becoming the pulse of industry and the digital era [7].

SMART HEALING: THE AI REVOLUTION IN MODERN MEDICINE

Modern medicine is changing at a rate that would have been inconceivable only a few years ago as Artificial Intelligence continues to transform the field. Whether it is predictive diagnostics, robot surgeries, and virtual health assistants, AI is showing signs of redefining the delivery, accessibility, and management of healthcare [8]. This digital revolution is not merely one of upgrading what we have, it is a re-thinking through and a re-designing of the healthcare ecosystem, in which machines learn off the data to augment clinical decisions, to eliminate human error, and improve the care of more patients [9].

Among the biggest AI effects that the sphere of healthcare can have, there is the possibility to analyze enormous amounts of data rapidly and with an impressive accuracy. A notable example is that of medical imaging where the deep learning has out-right transformed the performance of imaging scans (x-rays, MRIs, CT scans, etc.) by identifying anomalies sometimes as good and better as experienced radiologists [10]. Millions of images are used to train these systems to learn to recognize patterns associated with diseases like cancer, tuberculosis and neurological disorders. The outcome is early diagnosis, quick turn arounds and decreased pressure on medical practitioners [11].

The recent topics conducted in engineering, and physical systems have high chances of integration with artificial intelligence. Modeling of robot manipulators including the two-link planar robot arm can be improved with techniques of AI like the reinforcement learning and the application of the neural networks in the inverse kinematics which enhances control accuracy and flexibility in dynamic situations [12]. In fluid mechanics, AI may be applied in mesh optimization and surrogate modeling, and automated parameter tuning that would greatly minimize the computational expenses at the cost of accuracy [13]. Model free transfer learning can be used to enhance control systems such as in the ball and beam mechanism by both model-free reinforcement learning and neuro-fuzzy controllers. Elementary vibration studies may be involved with AI to recognize patterns, detect anomalies and predict maintenance based on sensor data. Also, AI may help with various techniques of environmental engineering, including sewage treatment process and outfall storage systems, and optimize them to prioritize efficiency and sustainability through real-time monitoring, predictable analytics, and automation [14].

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https://doi.org/10.70445/ajac.1.2.2025.87-104

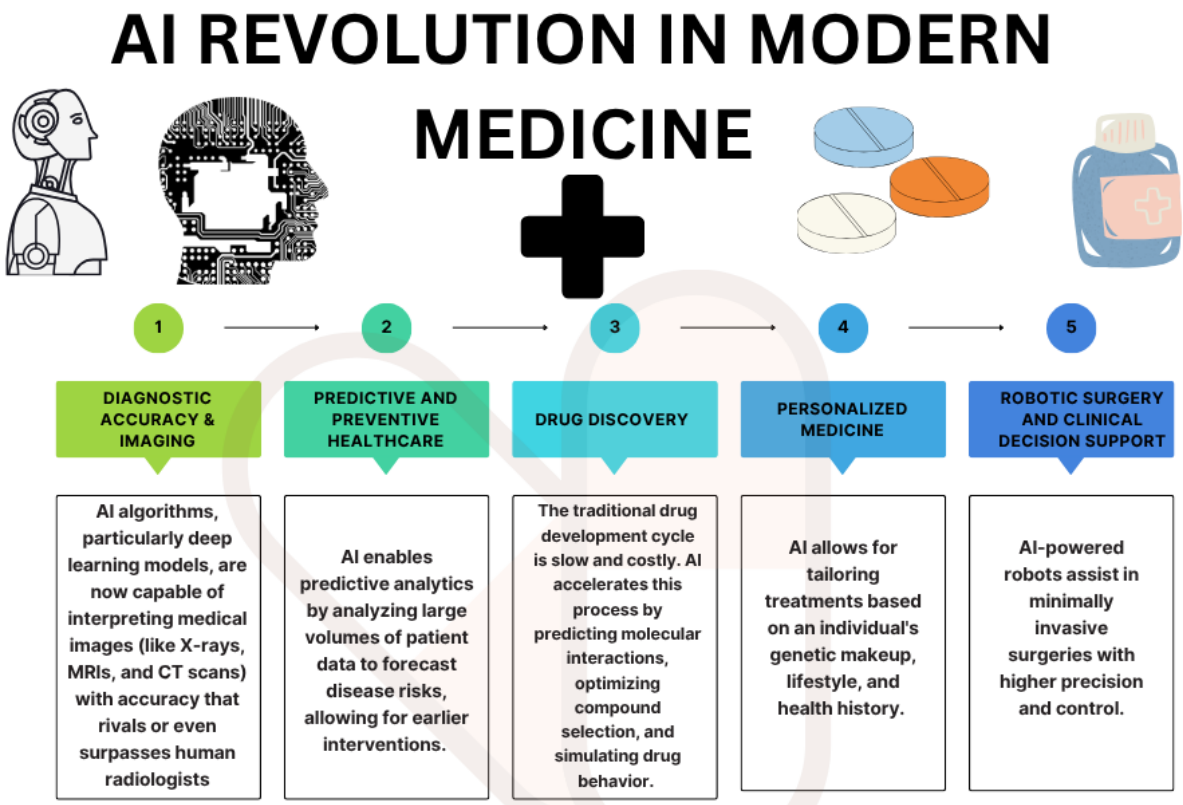

Figure: 1 showing AI revolution in medicine

Although all of that is positive in terms of combining AI with healthcare, there are also serious ethical and practical issues that adopting AI in healthcare is raising. Privacy of data is a serious issue and is mostly an issue when handling delicate medical records. There is also an algorithmic bias where the results will be biased or even unsafe when systems are trained on non-representative datasets [15]. Further, the decision to use a decision-making process that is comprised of a black box brings about the issue of accountability. However, the trend of change in the healthcare sector through AI is not disputed. AI is emerging as a crucial sidekick in healthcare by aiding clinicians and simplifying the process, and improving patient outcomes [16]. With the technology getting more mature, it should convert to building explainable, fair, and clear AI systems that represent the utmost levels of care. The combination of machine intelligence and human experience is the future of healthcare the world could use, since now, it has entered a new period of so-called smart healing [17].

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DIGITAL ARMOR CYBER-SECURITY, DETECT, SUSPECT, AND ACT: THE USE OF AI IN PROACTIVE CYBER DEFENSE

With increasing digital world, the threats are increasing as well. As organizations have become more dependent on networks and cloud services, so have the number of threats in the form of cybersecurity systems increased as well as in sophistication. Conventional rule-based security systems tend to fall behind in the trend of cyber-attacks [18]. It is against this volatile environment that Artificial Intelligence has come in as a key line of defense- with the speed, scalability and flexibility that even the best of human based systems lack.

Cybersecurity systems AI is an AI-driven security defense system that uses machine learning algorithms to identify, mitigate and counter threats in more real-time. In comparison to the fixed security models, AI systems utilize data in the past and can continually learn new information about attack vectors. Such transformation of reactive to proactive security will help organizations to detect and shut threats prior to their causing serious havoc [19]. As an example, AI is able to pick up very small patterns that could point toward a phishing attack or an insider threat much sooner than a human analyst would pick those up.

Anomaly detection is one of the major AI cybersecurity applications. The AI models can help identify deviations in a network or system by creating a baseline of what is normal in the device, and flag anomalies that may indicate a breach, infection, or unauthorized access. Such systems have successfully worked in settings where the size of data and the number of users would result in impracticality of manual monitoring. One of the biggest benefits of AI in cybersecurity is the importance of AI in threat intelligence [20]. Through the scanning of world threat feeds, dark web message boards, and other databases on the incidents, the AI systems can process millions of data points to predict the upcoming threats. This allows the security teams to mitigate vulnerability and renew defense work prior to the exploit going mainstream. Artificial intelligence tools also have the potential to be used in sorting out occurrences, giving a higher priority to the most critical alerts and minimizing the noise of false positives-which optimizes the response [21].

Besides, authentication and access control is being revolutionized by AI. Alternatives such as facial recognition or voice identity verification or behavioral biometrics already provided by biometric systems based on AI are more secure and convenient to use than passwords. Real-time adaptive authentication solutions are capable of analyzing contextual components (such as the location of the log in or the utilized device) that can be used to determine the level of risks and implement the adequate security level [22]. There are however risks associated with integrating AI in cybersecurity. Attackers are also using AI in the same way as the defenders. There are bad guys coming up with AI-

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based phishing mails, deepfake voice, and even evolvers where the malware can make itself invisible. This endless arms race demonstrates the necessity of constant innovation, a degree of regulation and co-operation between industries [23].

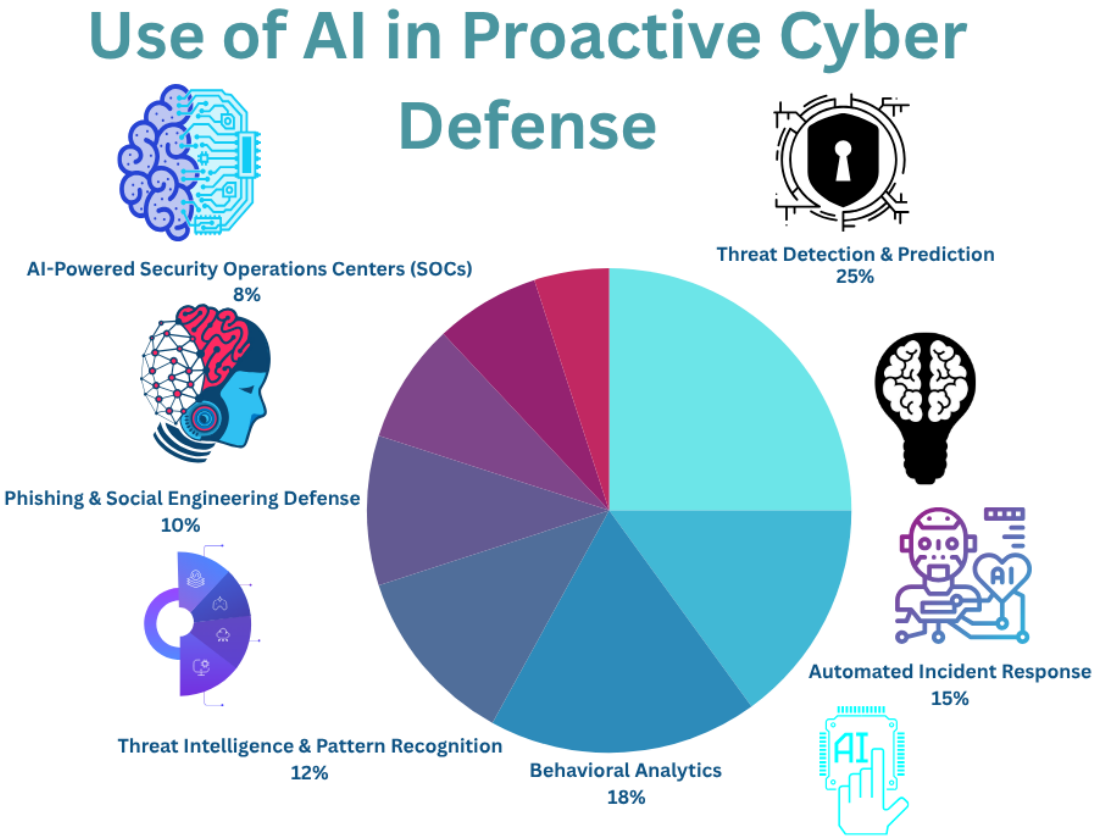

Figure: 2 showing Use of AI in proactive cyber defense

What is more, excess reliance on opaque AI systems might cause some ethical and accountability problems, particularly when automated systems unjustly penalize valid user behavior as an unsafe threat or fail to recognize a real threat due to prejudice or a lack of training examples. AI is taking the shape of a digital shield of the cybersecurity of today: It allows the design of smarter, quicker, and more flexible defenses [24]. However, in order to achieve its full potential, organizations should strike a balance between automation and transparency, human control, and informed future prediction in a dynamically changing threat environment [25].

LEARNING MACHINES: THE BRAIN BEHIND THE AUTOMATION BOOM

Artificial Intelligence revolution is based on a platform called Machine Learning (ML). The ML, so-called brain of the AI, allows systems to identify patterns, remodel on the basis of experience, and develop over time without being programmed directly to cope with each situation. It is getting under the hood that is facilitating the power behind intelligent automation across a variety of industries, in

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seemingly unrelated areas such as healthcare diagnosing and cybersecurity, financial predictive analysis and customized marketing [27]. In the absence of ML, AI would simply consist mainly of predetermined rules. Using it, machines are able to change, anticipate, and make intelligent decisions in an extremely dynamic and complex environment.

In its most basic form, ML is based upon data, which are large amounts of both structured and unstructured data with the help of which features are extracted and inferences are made. Machine learning can be divided into three broad categories supervised learning (model-based techniques that learn on labeled data in order to make predictions e.g., diagnosis of an illness based on a scan); unsupervised learning (where a system discovers the hidden structure of unlabeled data e.g. identify an undocumented threat in the cyber domain); and reinforcement learning (where an agent learns by interacting with some environment to maximize some reward signal e.g. exploration of a warehouse by a robot) [28].

At a more practical level, some of the examples of the types of functionality that ML can provide include recommendation systems (like that of Netflix and Amazon), fraud detection (like in the banking or e-commerce sector), and speech and image recognition (like in talking robots and autonomous cars) [29]. Within the scientific context, the ML is speeding up scientific discoveries like working off genomic data sets, modeling chemical reactions as well as climate model forecasting. The ability of ML to constantly improve based on new data and adjust its performance is what makes it so disruptive and perfect in applications where performance is critically important and data are highly complex [30].

Nevertheless, with the increased need in ML applications comes the increased difficulties. Data quality and bias is one of the greatest problems. When a model is trained on biased or even unfinished datasets, it may result in unfair or inaccurate outcomes especially in a delicate branch of knowledge such as criminal justice or health. The issue of bias has to be solved by leavening dataset curation, making algorithms transparent, and adopting inclusive design principles. Explain ability is another essential issue [31]. The internal elaborate decision-making mechanism of many ML models, more so, deep learning models is sometimes considered a black box since the mechanism cannot be easily understood. When important decisions may be made in the context of medicine or law, when achieving the accuracy of the conclusion, the stakeholders want to have an opportunity to comprehend how and why an algorithm has made a specific decision [32]. As a result, there has been growth in terms of the development of Explainable AI (XAI) which is an up-and-coming field that is devoted to ensuring ML systems are easier to explain as well as hold accountable [33].

Limitation also exists in nature scalability and computation cost. The complicated models are

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Volume 1, Number 2, 2025
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expensive to train; they consume many resources, i.e. a lot of computing power and energy. Therefore, developers are experimenting with more efficient learning defense such as transfer learning, federated learning, and self-supervised learning to cut down the reliance on large-scale datasets and centralized infrastructure [34]. It is more than a technology. In some sense, machine learning is a change in the concept of solving a problem, data processing, creating intelligent systems. ML will keep promoting innovation as it evolves, and its ethical development will play a pivotal role in enforcing its advantages in society equitably and efficiently [35].

FARM TO FORK: AI IN FOOD PROCESSING: FLAVORING

These changes happening to the global food industry are being done rather secretly and quietly but the transformation which the industry is going through with Artificial Intelligence being more involved in the way food is being produced, processed and delivered. The food processing industry was once a low-tech industry but today it is catching with smart automation, smart analytics and machine learning to meet growing expectations of quality, safety and sustainability, and efficiency [36]. AI is assisting manufacturers across farming areas to the factory floor by helping them to streamline production and minimise waste, energy use and human error.

Quality control should be considered one of the most effective applications of AI in food processing. In the past, quality checks were done manually by visual inspection because this is time-consuming, inaccurate and easily overlooked. Currently, computer vision systems with AI are installed on manufacturing lines to identify defects, color variation, and contamination as they happen [37]. They examine high-resolution photos, so that each item can pass safety and aesthetic conditions--be it the sorting of fruits according to their maturity state or the detection of foreign objects in packaged food. These technologies allow recalling products much faster and much more accurately, minimizing recalls and raising the consumer confidence.

Process optimization is also AI that is revolutionizing. Artificial intelligence techniques and algorithms are used to analyze sensor, machine and production line data to anticipate equipment failure, suggest schedule of maintenance, and optimize the activity. Such predictive maintenance helps to prevent downtime, spare parts move, and throughput. As an example, AI can predict when a conveyor motor is about to break or more effective set points in food preservation systems. Machine learning In supply chain and inventory management, AI is making it smarter to predict demand and resource allocation [38]. The availability of ingredients or demand by consumers can be predicted by making use of AI models through analyses of data of their patterns, changes in the market, and previous sales. This will enable the companies to handle stock better and to avoid wastage and to make appropriate production schedules, particularly in case of perishable products [39].

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Figure: 3 showing AI role in the food processing

Another important direction where AI is the crown jewel is food safety. This is done by constantly checking processing conditions with the help of sensors connected to the IoT, and the AI is able to identify anomalous temperature, humidity, or hygiene rates, as it might indicate the risk of contamination. It also can help in tracing ingredients across supply chain and pinpointing the source of contamination in case of outbreak as well as it can also help in ensuring health regulations are observed [40]. Moreover, AI is also leading to innovation in the product area; based on knowledge of consumer preferences and reviews, it suggests new flavors, formulations or packaging design. This is how not only does AI enable the efficiency of operations but also promotes novelty and responsiveness to the market [41].

Although such developments are in place, issues like huge cost of entry and integrating it with legacy frameworks and adapting the workforce still persist. With the increased accessibility of AI, however, this is going to be a common ingredient in the food processing of the future: which is not only safer, more sustainable, and more satisfying, but also is better produced and transported, all the way to the fork [42].

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CONVERGING CURRENTS: WHAT HEALTHCARE, CYBERSECURITY, ML AND FOOD TECH HAVE IN COMMON?

On the face of it, such sectors as healthcare, cybersecurity, machine learning recognition, and food processing might resemble two ends of a spectrum: they are controlled by different missions, technologies, and regulations. But on closer inspection, using the prism of Artificial Intelligence (AI), unexpectedly high convergence develops. Both the sectors may have different functions; however, they have a shared set of issues, breakthroughs and paths of transformation with intelligent systems [43]. The trend is that AI has become the integrating force that links such disciplines due to similarities and dependence on data, pattern recognition, real time decisioning, and need to be automated and customized.

Among the most vivid similarities, the criticality of data can be pointed out. In each of those industries, patient data in healthcare, threat data in cybersecurity, sensor data in food manufacturing, and training data in machine learning development, reaching the kind of scale and quality that AI systems require is crucial to driving the market in these sectors [44]. Success in every field implies the opportunity to gather, clean, analyze and implement information. Still, they all have comparable problems with data privacy, protection, and standardization (particularly when it comes to sensitive or regulated data) [45].

The other common theme is the necessity to have real-time intelligence. In hospitals, AI should promptly read vital signs over to warn clinicians about the decline. Milliseconds are important in terms of security when it comes to detecting an active breach. The AI should quickly detect a defect or an anomaly on production lines. This demand of speed and precision has quickened the use of edge computing, fondled learning, and cloud-AI hybrids in every industry [46]. All these technologies guarantee that decisions may be made near the data source without compromising computation capabilities and data integrity. The third area of overlap is in the risk and ethical-ness. Every industry needs to comprehend the impact of the decision of the machines. A misdiagnosis on the part of an AI would damage a patient in health care [47]. A false negative in cybersecurity would lead to the theft of data. A concealed safety violation in the food technology might result in mass recalls. In addition, the issues of algorithmic prejudice, lack of transparency, and accountability also reverberate in every sphere. Therefore, claim for the development of explainable, ethical, and responsible AI design is becoming common across the board [48].

Another emerging trend is the interdisciplinary collaboration. Developments made in one area are becoming increasingly applicable to another one. To take an example, in cybersecurity, anomaly detection techniques were applied to detecting abnormalities or equipment failure in factories. On the

ISSN : 3067-8293
Volume 1, Number 2, 2025
https://doi.org/10.70445/ajac.1.2.2025.87-104

same line of thought, the medical documentation models of natural language processing are also reconsidered to cover legal tech, customer support and compliance reporting [49]. The above cross-pollinations are indicators of the scalability and miscellaneous of AI when used with care. Every industry experiences a transformation in the labour force as AI rearranges duties, responsibilities and skills needed [50].

Instead of supplementing humans completely, AI is supplementing professionals- gaining doctors, analysts, engineers, and quality controllers and speeding up decision-making by making better-informed ones. Digital literacy is becoming a universal priority and Blackburn is upskilling. It is not only AI that is improving individual sectors but it is also creating a new network amongst the sectors. Independent of industry, ever more integrated, innovative, and efficient solutions may be realized as the fruitful interaction of these converging currents is recognized [51].

THE ROAD AHEAD OF TOMORROW'S INTELLIGENCE

With the continuous development of Artificial Intelligence, its further development may be marked by either an enormous potential or an imminent question. Although the existing applications already revolutionize such industries as healthcare, cybersecurity, machine learning, and food processing, we are just tapping into the capabilities of AI. The future of the road is directional to an even more autonomous way; increased integration with human decision8making and wider ethical, social, economic consequences [52]. To get through this future will involve a sensible combination of new technologies, governance and accountability.

Among the most awaited changes is the emergence of the more generalized and multi-modal AI systems. In contrast to the narrow AI, which can be applied to particular tasks, future models will be more flexible, they will be able to process texts, pictures, sound, and even actual physical sensor data concurrently. That is, smarter assistants, more correct diagnostics, the free communication of machines and humans, and more platforms that could work in various fields [53]. This may mean a system that does not simply take data and analyse it, but will do the same, but talk in normal words or become more nuanced due to user feedback in a case like healthcare or food tech.

Artificial Intelligence-human collaboration is another large trend. The future development of AI is not about replacing people but co-intelligence, where machineries create, evaluate, and empathies in human intelligence. As an example, clinicians can utilize not only AI to perform analysis but also use AI as a second opinion generator, and food scientists can consult generative AI to create prototypes of new products. Transparency, usability, and trust will be the key determinants to the success of these collaborations [54].

Yet with increasing autonomy and power of AI systems, regulation and ethics will gain, in turn,

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special importance. Some problems, such as data privacy and accountability of algorithms and macro effects of mass training of AI, should be resolved. There is an already emerging form of regulatory measures in play in different parts of the globe, nonetheless what will prove an uphill task is balancing innovation and protecting the interest of the folk [55]. The idea of the Responsible AI will probably define the policy, business strategies, and public opinion within the next decade.

Workforce development and education also have imperative roles to play. To adapt to the ever changing nature of work as guided by AI, constant learning and up skilling will be necessary. It is particularly true of industries undergoing a rapid transformation into the digital space including agriculture, logistics and public health. The sum of technical literacy of future professionals and the presence of ethical literacy in AI will contribute to inclusive and equitable development [56]. The future projection contains the long run of AI, which might refer to additional profound integration with other technologies such as quantum computing, brain-computer interface, and synthetic biology, providing opportunities that have additional risks than are unanticipated in a larger way than ever before [57]. What direction must technology take in human society is not only a technological question but also a philosophical one: What should be the role of AI in the civilization of man? And how come we make it aligned with common values?

CONCLUSION

Rapid development of Artificial Intelligence is no longer an unrealizable promise, but a workable reality that has changed some of the most significant aspects of the society. Whether it is healthcare and cybersecurity or machine learning innovation or food processing, AI cannot be seen as a simple technological improvement as it is a structural force that redefines patterns in decision-making, service delivery, and solving problems. The tendency of such fields to merge due to the impact of AI shows the versatility of technology as well as the prospect of integrating various issues that can be solved intelligently and data-wise.

In health care, AI has moved on beyond the basic automation to intelligent assistive technology. It is currently used in diagnostics, individualized therapies, and robotizations of surgical operations, and it increases the rate of medical services and its precision. The convergence of virtual health assistants, predictive analysis, and genomic modeling can make the proactive and patient-centered care approach a reality and set an era of smart healing.

Artificial intelligence is serving the role of a digital sentinel by identifying danger in the field of cybersecurity even before it can occur. Machine learning can monitor individual computers and servers, detect anomalies, analyze behaviors and respond to a given threat in real-time and at scale that would otherwise be unmanageable by any human system. The same technology, however, is now

ISSN : 3067-8293
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being weapon zed by malicious actors and causes defenders to stay in an equal footing, agile, and vigilant. Due to the existing AI-cybersecurity arm race, innovation, openness, and moral use should be reinforced.

The root of all these advancements can be found in machine learning, as this is what makes AI flexible and accurate. It enables systems to adapt to new conditions and learn about their data, including unknown, hidden patterns that would not be noticeable to a human analyst. Although ML allows performing smart diagnostics, predictive maintenance, and fraud identification, the technology gives rise to severe concerns regarding bias, explain ability, and energy efficiency, which are to be addressed to support its ethical and sustainable application.

Food processing industry, as well, is welcoming AI through all stages of the supply chain. Safe, efficient and less wasteful food production can be achieved through inspecting the products by using computer vision, predictive analytics to forecast demand, or real-time sensor-based contamination detection. Although it is a traditionally manual industry, food tech is currently at the forefront of industrial revolution. By going beyond the surface of these industries, one will notice that they share the need to work according to AI-based data processing, run in real-time, and deal with the complicated environment. All of these topics are characterized by the ethical issue of workforce transformation and interdisciplinary collaboration, and this once again points to the fact that the effects of AI are interrelated.

In the future, the future of AI is intersectional (not just between technologies, such as quantum computing or the IoT, but also between fields and cultures). In the long term, there will be a sweet spot in developing responsible AI to help achieve benefit and limit the damage. The policies should change along with the technology, and the stakeholders should cooperate to make sure that AI systems will be based on human values, fairness and inclusivity. AI is not a separate tool anymore but is getting to be a connective tissue between industries. Its smart existence is weaving together into the cloth of the new industry not only to improve performance but to make real the new frontier of relationships between humans and machines. After the beginning of the journey, it is a common obligation to mound the destination.

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