The Interconnection of Internet of Things and Artificial Intelligence: A Review

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Abstract

The current world is moving forward with digitalization. In this era, new trends such as artificial intelligence (AI), machine learning (ML), the internet of things (IoT), and data analytics technologies became popular among people. People are trying to make their work easier using machines or other ways. The autonomous concept is another idea that became based on the above-mentioned trends. In the health service, agricultural sector, and business sector this IoT and AI were widely used. Therefore, AI and IoT interconnected applications become a good trend these days. Furthermore, lots of industries change their manual or electrical logistics into IoT-based platforms that can be more easily manageable, and more accurate than before. The reliability of that systems is also very high because AI is given the power to that systems. Therefore humans do not need to pay attention to lots of tasks because AI-powered IoT platforms take care of the system. This paper reviewed previous literature, and scholarly articles to identify what is the interconnection of AI and IoT. Twenty-three existing research studies were used for this study. This paper describes AI and IoT, the interconnectivity between both skills, the challenges of AI and IoT applications, and what are the fields those applications used and uses, from other researchers' perspective. This research study brings a collection of domain knowledge to the computing discipline regarding the integration of IoT and AI.

Keywords: Artificial Intelligence (AI), Data Analytics, Internet of Things (IoT), Machine Learning (ML)

1. Introduction

Artificial intelligence (AI) and the internet of things (IoT) become trending topics in the world among other technologies with the enhancement of technology in the digitalized world. Humans try to find out new things quickly and try to reduce the effort that they put into their regular work and try to convert the human brain into an artificial one that can work the same as a human brain. In the modern era, AI is being become a conspicuous trend in the industries such as construction, software development, health, marketing, logistics, transportation, education, agriculture, etc [1]. AI is a powerful tool that can use to make decisions using simulations and modules [2]. AI-powered devices and tools are more smart and able to do a particular task that saves time and resources [3]. AI can be divided into several parts which are *learning*, *reasoning*, *problem-solving*, *perception*, and *natural language understanding*, and researchers have used AI for computer vision, speech recognition, natural language processing, expert systems, game playing, intelligent robots, etc. As well, machine learning (ML), neural networks, and deep learning are the core of AI concepts.

IoT has also become a hot trend in the last ten years. The IoT concept was born in 1999, and it was introduced by a member of the RFID (Radio Frequency Identification) community [4]. The concept is based on the connection of physical devices over the internet to do a specific task or multiple tasks, and monitoring sensor values to get real-time data to do the above specific tasks. The physical devices are connected to a microcontroller board and it is the heart of the IoT system. The system can control or monitor from anywhere in the world. System monitoring and analyzing devices can be desktop computers, laptop computers, mobile phones, tablets, or specific screens. IoT can be specified as a global setup that allows the communication between human-to-human, human-to-things, and things-to-things. Communication between devices can happen through wireless or wired media. IoT is being gone to be everywhere around the human environment. IoT applications can be used in different fields such as agriculture, medicine, transportation, manufacturing, education, and people's day-to-day operations. Home automation systems, smart cities, IoT retail shops, auto-driven cars, and farming are some applications that are used IoT.

This research paper consists of a comprehensive review of the interconnection of AI and the IoT. The paper focused to identify what are the applications developed using IoT combined with AI, what are the fields that used IoT and AI, and the challenges faced in IoT and AI.

This research study brings answers to the below research questions(RQs).

RQ1: *What is the compatibility of AI and IoT?*
RQ2: *What are the economic advantages of AI and IoT integration?*
RQ3: *What are the challenges of AI and IoT integrations?*

2. Research Methodology

To conduct this literature review study, it was followed a highly structured review technique. The technique includes eight steps. Table 1 describes the steps that were selected to conduct this review. Table 1 has three columns: the first column is the step number, the second column is the step name, and the third column is described the step function.

Table 1
Research Methodology Steps

Step Number	Step Name	Step Description
01	Reason for review	Identify the reason for the review and it is described in the research identification.
02	Research Questions	To conduct the review in a structured way, the research questions were identified.
03	Select the search string	The search string is used to select literature.
04	Initial literature selection.	By using the search string, literature was selected using Google Scholar from different databases such as IEEE-Xplore, Springer, Science Direct, and many journals.
05	Inclusion/ Exclusion	To filter the papers from the domain, the paper inclusion and exclusion criteria were applied
06	Quality Assessment	To select correct and suitable papers, the paper title, abstract, and conclusions were read each paper. From this selection, 23 papers were finalized for this review.
07	Synthesizing	On top of the selected papers, synthesizing was applied.
08	Reporting	By reading and exploring the selected literature, final observations and results were identified and reported.

The search string:
{[(AI*) ∧ (IoT*)] ∨ Interconnection*}; *for *, lexicographically suitable words were used.*

The selected search string was queried in Google Scholar. Google Scholar was used as the key search engine to find literature. Mainly, research studies were selected from IEEE Digital Explore, Springer, Science Direct, Hindawi, Willey Online Library, Uppsala University Repository, and other databases.

After the selection of initial papers: the selected papers were screened by viewing the title of the paper, keywords of the paper, and abstract of the paper. The studies which are outside of the domain of AI and IoT were excluded from the initial collection.

To conduct this review study, the following research studies were selected. Below table 2 describes the titles of the selected literature and column one describes the citation number and column two describe the topic of the selected research paper.

Table 2
Titles of Referred Articles

[1]	IoT-Enabled AI-Based Model to Assess Land Suitability for Crop Production
[2]	A Survey of Artificial Intelligence and Internet of Things (IoT) based approaches against Covid-19
[3]	AI-Enabled Sensing and Decision-Making for IoT Systems
[4]	Synergy of IoT and AI in Modern Society: The Robotics and Automation Case
[5]	A Review of Artificial Intelligence in the Internet of Things
[6]	Artificial Intelligence in Internet of Things
[7]	Challenges in the Integration of Artificial Intelligence and Internet of Things

[8]	Internet of Things (IoT): A Literature Review
[9]	Role of Artificial Intelligence in the Internet of Things – Review
[10]	Review on Artificial Intelligence with Internet of Things- Problems, Challenges and opportunities
[11]	Research on Artificial Intelligence Enhancing Internet of Things Security: A Survey
[12]	The Relation Of Artificial Intelligence With Internet Of Things: A survey
[13]	Application of AI and IoT in Clinical Medicine: Summary and Challenges
[14]	Survey on IoT security: Challenges and solution using machine learning, artificial intelligence and blockchain technology
[15]	A comprehensive review on automation in agriculture using artificial intelligence
[16]	Technology assisted farming: Implications of IoT and AI
[17]	Survey on Machine Learning and Deep Learning Algorithms used in Internet of Things (IoT) Healthcare
[18]	A Survey on the Internet of Things (IoT) Forensics: Challenges, Approaches and Open Issues
[19]	Business models based on IoT, AI and blockchain
[20]	Transforming Business Decision Making with Internet of Things (IoT) and Machine Learning (ML)
[21]	Internet of Things (IoT)-Enabled Unmanned Aerial Vehicles for the Inspection of Construction Sites: A Vision and Future Directions
[22]	Machine Learning in IoT Security: Current Solutions and Future Challenges
[23]	A survey of machine learning for big data processing

Below table 3 presents a statistical summary of the selected literature for publication format. The selected research studies were published as book chapters, journal articles, conference papers, thesis, and survey articles. Table 3 is with two columns: the first column denotes the publication format and the second column denotes the number of papers for each category.

Table 3
Research Publication Format

Publication Format	Number of Papers
Book Chapters	01
Conference Papers	4
Journal Articles	15
Thesis	1
Survey	2

To visualize the selected paper distribution among the set of papers, the below pie chart was illustrated by using Minitab statistical software. According to that, most of the papers were published as journal articles.

Table 5 presents a statistical summary of the selected literature for publication year. The most of selected research studies were published in the year 2020. For the research study, the research articles were selected within the last seven years.

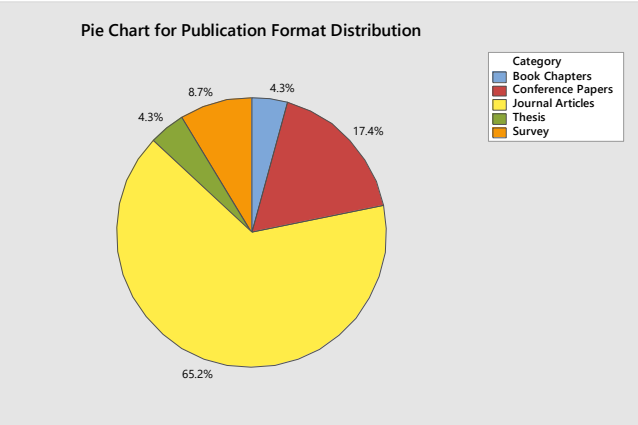

Fig. 1. Pie Chart for Distribution of Publication Format

Table 4
Research Publication Distribution according to the Year

Publication Year	Number of Papers
The year 2021	5
The year 2020	8
The year 2019	4
The year 2018	4
The year 2016	1
The year 2015	1

3. Artificial Intelligence

In the review on "Artificial Intelligence in the Internet of things", the authors have highlighted what is AI and a few main branches of AI with their concepts, process, and related work on IoT [6]. According to their paper, AI was created to allow programmers to create programs that allow computers to learn, and AI is the science and engineering that attempts to make machines intelligent by teaching them to understand human language and solve problems and achieve goals in the same way that humans do. Automatic learning, computer vision, fuzzy logic, natural language processing, heuristics, and intelligent agents are some of the fields of AI that may be split. They defined six rules in AI;

1. It must design not to exceed humanity
2. It must be transparent about the technology and rules.
3. It should be maximizing the effectiveness
4. It should have algorithmic responsibility
5. It designed for intelligent privacy

6. It must not be biased [5]

The researchers have answered the issue with AI and IoT, which rises when handling huge data generated with the least power computers. According to the paper [2], AI is the study of imbuing intelligence into computers so that they may do activities that previously required the use of the human intellect. In terms of applicability, adaption, processing speed, and capabilities, AI-based systems are quickly evolving. Machines are growing capable of performing jobs that aren't as regular. While human intelligence is defined as "taking" a flawless decision at the right moment, AI is defined as "choosing" a correct decision at the right time. To put it bluntly, AI cannot make decisions with the same ingenuity as humans. It may be claimed that human inventiveness will always modify the function of productive labor, but AI-based systems have ingeniously decreased human effort repeatedly and can provide outcomes in a very short amount of time. The majority of current AI research may be classified as 'Narrow AI.' This implies that technology can only help with jobs. As a result, numerous areas have converged to propel AI forward [6].

According to the research paper [7], AI is a technology that enables us to make any computer intelligent, a computer-driven robot, or software that thinks intelligently in the same manner that a person does. AI is becoming a more advanced technology day by day. AI is a human intelligence process that will be felt by machines. ML and deep learning are AI programs that can automatically learn from experience and enhance performance. Deep learning is a subset of ML that is made up of algorithms that teach it how to do tasks such as speech recognition and face identification with enormous volumes of data [7].

According to the [8] research paper, AI refers to electronic settings that are aware of and respond to human presence. In an ambient intelligence environment, technologies work together to assist individuals in carrying out their daily tasks in a simple, natural manner by utilizing information and intelligence concealed in networked devices [8].

The discipline of AI is concerned with intelligent machines, or rather, with embedding intelligence into computers, since "***artificial intelligence is the science and engineering of producing intelligent machines***." AI has evolved into a critical component of the computer industry, assisting in the resolution of some of society's most complex issues. Expert systems, or computer programs that imitate the logic and performance of human experts, are one type of AI. On the other hand, may be defined as a computer program that solves complicated issues that would normally need a great deal of human knowledge. To do this, it uses rules or objects to reflect human knowledge to imitate the human reasoning issue [4].

4. IoT

IoT is a collection of physical objects “things” that are integrated with sensors, programming, and numerous interfaces to communicate with and replace the information with other devices and structures through the internet. From simple nuclear family articles to complicated modern devices, these tactics are used. IoT allows devices/items to monitor, identify, and understand a situation or environmental conditions without the need for human intervention. From everyday items like kitchen equipment, autos, indoor regulators, and children's screens to the internet through implanted devices. IoT is widely employed in many officialdoms, just as AI expertise [9].

The phrase “IoT” is already widely used, yet there is no universally accepted definition or understanding of what it means. Kevin Ashton, executive of AutoIDCenter (MIT), coined the phrase "IoT" in 1999 while chipping away at the roots of structured "radio recurrence distinguishing proof" (RFID). He coined the phrase to reflect his vision of a society in which every electronic device is organized, and everything (physical or electronic) is tagged with information specific to that item. IoT also known as the Internet of Objects (IoO), is a development of the internet in which the things/objects distinguish themselves by transmitting data about them. They can acquire data about themselves from various products and things, or they can be part of higher-level administrations. [10]

IoT is evolving and remains the most anticipated information technology concept. According to the research paper [8], the phrase “IoT” has gained popularity over the last decade by portraying the idea of a worldwide infrastructure of networked physical things that enables anytime, everywhere connection for anything and not just everyone. IoT is a worldwide network that permits communication between human-to-human, human-to-things, and things-to-things, which is everything in the world, by giving each object a unique identity. IoT portrays is a world in which almost everything may be connected and interacts in a more sophisticated manner than ever before. Most of us associate "connection" with technological equipment such as servers, laptops, tablets, phones, and smartphones. Sensors and actuators embedded in real objects from highways to pacemakers are linked over wired and wireless networks in what's known as the IoT, which typically uses the same internet protocol (IP) that links the internet [8].

Applications of IoT were listed below according to the research paper [7].

1. Smart houses
2. Wearable’s
3. Connected cars
4. Industrial internet
5. Smart cities
6. IoT in Agriculture
7. Smart retails
8. IoT in health care
9. Energy management

The concept "Internet of Computers (IoC)" has existed since 1991 and has progressively grown in size as more people began to use it. The Internet of Gadgets (IoG) began with the introduction of pocket phones and linked devices, and as mobile phones, computers, laptops, and tablets became more affordable and accessible to the general public, the internet of devices increased in size. In 2016, there were around 6.4 billion linked items on the planet, up 30% over 2015, and 20.8 billion by 2020. In 2016, almost 5.5 million new items were linked every day, demonstrating the IoT's enormous potential. Because numerous devices are constantly linking to build an IoT, it is related to a variety of specialties. As a result, the IoT may be conceived of as a collection of different domains. The IoT is a network of physical objects and humans. Humans are linked to these gadgets via smart items that can send, receive, and analyze data and are tied to both. These smart objects reflect the entity in the network to which they are connected. [9]

5. The connection between AI and IoT

In a lot of research articles, AI-enabled IoT was discussed in many main topics. IoT is a huge idea that encompasses so many detectors, actuators, data storage, and data processing capabilities, all of which are interconnected through the internet. As a result, every IoT-enabled gadget may detect its surroundings, transmit, store, and interpret the data it collects, and take appropriate action. The last phase of acting in accordance is completely reliant on the processing stage. The degree of processing or action that an IoT service can do determines its genuine smartness. A non-smart IoT system will have restricted capabilities and will not be able to adapt in tandem with the data. A better IoT system, on the other hand, will contain AI and may be able to achieve the real aim of automation and adaptation [6]. The below-mentioned examples were elaborated in their paper which combined context with IoT and AI.

1. Voice assistants such as Alexa, Siri, and Google Assistant
2. Robots like Pepper, Sophia
3. Smart devices; Smart Oven, SkyBell
4. Industrial IoT like primer, Plutoshift

The research paper [11] has mentioned the security of IoT and how it can be enhanced with AI. Because of the unique nature of IoT security and the limits of existing solutions, new security technologies are urgently required. AI offers a broad variety of applications as a new technology path. In the realm of AI, ML is a study topic. Its theory and methods have been used to a wide range of engineering challenges to address complicated problems. Transaction and decision algorithms are two types of ML algorithms that are used in IoT security [11].

The primary functions of transaction algorithms are information discovery and data preparation. To collect the general features of the dataset and give the foundation for decision algorithms, transaction algorithms employ limited samples and basic models. Decision algorithms are primarily responsible for business choices and employ various decision-making processes to lower the ratio of misjudgment and maximize total profit. Single decision-making, sequential decision-making, and integrated decision-making are three types of decision algorithms that may be classified by methods and situations [11].

According to the research paper [9], comprehending the role of AI in the IoT revolution was discussed. Simulated intelligence is expected to do many intelligent tasks, such as speech recognition, language interpretation, dynamics, and so on, without the need for human intervention. The IoT, on the other hand, connects a network of networked devices that exchange data across a network. IoT gadgets have found their way into our daily lives and are hoped to provide a higher degree of comfort. These contraptions rely on web structure and generate unimaginable amounts of data that may be applied to client behaviors, tendencies, unique information, and so on, and so cannot be ignored. Nonetheless, many endeavors are unaware of how to store and cycle such massive amounts of data. The growth and capacity of IoT are being hampered because of this. For this situation, the man-made intellectual capability may be a huge assistance in sifting through the deluge of data generated by IoT devices. It allows you to examine facts and make good decisions based on what you find [9].

The relationship of AI with IoT was discussed with some applications as below.

1. Home Automation
2. Oil Field Production
3. Smart Hotel

AI algorithms and approaches can evaluate and learn from the massive amounts of data generated by linked IoT devices, allowing public services and value to be created. AI's rising popularity, which gives superior data analytics choices, has a significant impact on IoT usage. The discipline of AI is concerned with intelligent machines, or rather, with embedding intelligence into computers, i.e., "***artificial intelligence is the science and engineering of producing intelligent machines***". AI is the study of machine intelligence as well as the discipline of computer science that seeks to develop it [12].

6. The connection between AI and IoT and challenges in IoT and AI

IoT and AI each have their own set of issues; when these two technologies are combined, the challenges become much more complicated. Some of the issues include the following [7].

1. Security
2. Compatibility and complexity
3. Artificial Stupidity

4. Lack of Confidence
5. Cloud Attacks
6. Technology

In the research paper [13], the authors have discussed the applications of IoT and AI in clinical medicine with a summary and challenges. Intelligent medical IoT exhibits a variety of new capabilities as a result of the combination of AI, IoT, and the medical business. IoT connection terminals provide a wide range of data modalities, which come in a variety of formats and have cross-domain fusion capabilities. As a result, multidisciplinary knowledge fusion is required in this sector, such as medical, AI, big data, information engineering, and so on. New features, on the other hand, provide new obstacles, and smart medical IoT faces several dangers and challenges [13].

1. Information Security is Threatened
2. IoT Data Standards are Missing
3. Risks Brought by the Refinement of Specialties
4. Impact of AI on Ethics
5. Medical Compound Talents are Lacking

In the research article [18], the authors began by providing an overview of IoT technology and its application areas. Security issues were discussed using ML, AI, and blockchain technology. In the conclusion, they have mentioned an analysis of issues. In recent years, the IoT has got a lot of interest from both the scientific community and the business community. The IoT gadgets are being produced in massive quantities, and they have already reached the global population. These smart gadgets are linked to a variety of apps that collect data from their surroundings. Because IoT devices have limited resources, they are susceptible to assault. IoT applications, security, and privacy are crucial [18].

7. IoT Applications Powered by AI

7.1 Agricultural sector

The research article [14] discusses several automation techniques such as IoT, wireless communications, ML, AI, and deep learning. Crop diseases, lack of storage management, pesticide control, weed management, lack of irrigation, and water management are some of the issues that plague the agriculture industry, and all of these issues may be remedied utilizing the approaches stated above. Today, it is critical to decipher concerns such as the use of dangerous pesticides, regulated irrigation, pollution management, and environmental repercussions in agricultural activity. Automation of farming processes has been shown to boost soil gain while also strengthening soil fertility. This paper compiles the findings of several researchers to provide a quick overview of how automation is being implemented in agriculture today. This paper also discusses a proposed system for flower and leaf identification and watering that can be implemented in a botanical farm using IoT [11].

The authors of the research paper [17] discuss the technology-assisted farming implemented by IoT and AI. The purpose of this article is to explain how the IoT has changed the agriculture industry. According to the survey, 70% of India's population relies on agriculture for a living, but agriculture's position is no longer hidden from society. Temperature, rainfall, humidity, fertilizer requirements, water requirements, and other factors may all be predicted with the use of technology. Modern agricultural approaches based on IoT, and AI are altering old agriculture practices while also making farming lucrative [18].

7.2 Health sector

Covid-19 is a trending factor in current years from 2020. The authors of the research paper [2] have conducted a survey of AI and IoT based on approaches against Covid-19 which is related to the health sector. This study examines a variety of AI applications and strategies that can help us defeat Covid-19 and win the war. Computer vision, speech recognition, natural language processing, and data analytics are just a few examples of AI application subdomains. The report identifies areas where AI and the IoT combine to give effective methods for preventing, diagnosing, and reducing Covid19. The report also includes a review of research on technological applications against Covid-19 and data sources connected to it, as well as a survey of research efforts and methods on these topics. The authors also suggest a unique method for detecting Covid-19 in its early stages, which combines AI-enabled IoT sensors with conversational capabilities.

Another Survey on ML and deep learning used in IoT healthcare. This research attempts to comprehend in depth the algorithms that have the potential to enhance healthcare systems based on IoT, the majority of which have already been deployed. Because of the reliance on AI and deep learning, there is a significant likelihood of a human mistake. The performance of training algorithms is improved when standardized data sets are used instead of unstandardized data sets, which reduces complexity and computation time [16].

The healthcare industry is perhaps the most vulnerable to serious security breaches of all IoT-based domains. This might be explained by the fact that IoT applications in this industry are cross-organizational, as well as their heterogeneity, fragmentation, and enlarged attack surface. As a result, although remote health monitoring technologies are revolutionizing the healthcare business and enhancing people's lives, they also raise new questions concerning the privacy and security of users' medical data. Malicious actors, for example, might attack fitness trackers to profit from the information acquired. Wearables, such as fitness wristbands, have also become popular in forensics as a source of digital evidence [2].

7.3 Business

According to the master thesis [19], the major goal is to show how to think about integrating these new technologies into business models and evaluating the most important parts during the business planning stage. It has the potential to assist future companies in seizing opportunities and overcoming problems in the new business climate. To enable physical asset transactions on the blockchain, a solution to connect online and offline resources must be developed, which is the essential notion of a blockchain-based supply chain system. Even though several theories have been proposed, the definitive solution has yet to be found. Because blockchain will become the backbone for practically all sorts of transactions in the future, understanding such patterns might help entrepreneurs better develop their business models. In addition, the sample pool is quite tiny due to time and resource constraints. In the future, a larger sample pool will be preferable to produce a more precise and thorough study [19].

The author of the paper [20] is devoted to enumerating and presenting the most recent problems in implementing disruptive technology in business operations. The authors have shown an architectural model for an IoT and ML-based application that can be linked with a variety of different corporate apps to provide real-time data analytics, visibility, and decision-making. A few IoT and ML-based commercial applications in areas such as manufacturing, pharmaceuticals, and hospitality have been briefly covered. Finally, the authors have outlined the primary issues and potential remedies [20].

7.4 Unmanned aerial vehicle

IoT is described as the intelligent linking of things to the internet using some active sensors. Better building site inspection method using an IoT-enabled drone. By doing so, one can also handle the limitations of the IoT, such as network scalability, processing limitations, and various provisions for various applications. Unmanned aerial vehicles with IoT capabilities could be proposed as a way to not only overcome these limitations but also improve these three crucial IoT expectations. IoT has exploded in recent years and is now heavily utilized across several industries. The IoT idea, put simply, refers to connecting systems with various internet capabilities. Therefore, it chooses machine-to-machine communication the majority of the time. Therefore, the research suggests connecting the drone to a base station system where a construction site supervisor is monitoring the status of work [21].

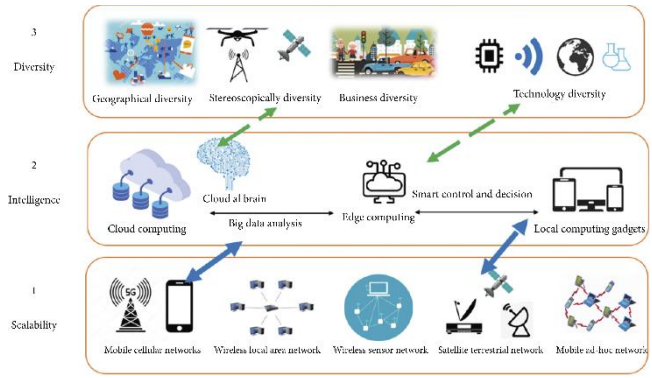

Fig. 2. Three Constraints of IoT [21]

With automated intelligence, the three conditions listed below must be met to provide accurate results: The scalable network architecture sometimes referred to as network scalability, should be established. Intelligence is defined as ensuring the best computing algorithm that quickly extracts the data and determines the outcome. support for a variety of sensors to collect data is known as diversity. The above figure 2 presents the diagram for the main IoT constraints for reliable vehicle-based systems [21].

8 Machine learning techniques for IoT security in IoT networks

ML algorithms can be divided into four main categories. These are supervised, unsupervised, semi-supervised, and reinforcement learning algorithms. Under each category many example algorithms are available. The IoT network's core security and privacy challenges are the focus of ML techniques. More specifically: malware analysis, distributed denial of service (DDoS) assaults, anomaly and intrusion detection, and attack detection and mitigation were taken into the account [22] [23].

In IoT networks, supervised learning techniques are used to solve challenges related to spectrum sensing, channel estimation, adaptive filtering, security, and location by using labeled data. Regression and classification are two different sorts of approaches that fall under this category. For prediction and modeling of the available data sets, classification under supervised ML is performed. To predict continuous numeric variables, regression is employed. Some of the popular classification algorithms are Support vector machines (SVM), Naive Bayes, Random Forest, and Decision Trees. To determine the difference between two points belonging to two different classes, SVM employs a method known as kernels. The non-linear decision boundaries can be modeled by SVMs. It becomes challenging to model huge datasets with SVM since it is inherently memory-intensive, difficult to choose an appropriate kernel, and memory-intensive. Random forests are typically favored over SVM as a result. While Naive Bayes (NB) is employed to simulate actual issues like spam detection and text classification. Random forest algorithms are perfect for simulating real-world issues since they are naive and assume that all input features are independent of one another [22].

Random forest methods can adjust to the size of the given data set and are simpler to implement. Compared to other supervised algorithms like SVM and NB, these methods require more time to train. However, it is more accurate and requires less time to anticipate. Additionally, it is built on building a graph with leaves and branches that represent decision and class, respectively. A top-down strategy is used to categorize an event by iterating through the tree until a class is selected. The two most well-known regression techniques are logistic regression and nearest neighbors. These algorithms, also referred to as "instance-based," use the most comparable training data to generate predictions for each new observation. But these algorithms struggle with high-dimensional data and require a lot of memory [22].

The group of unsupervised learning algorithms works with unlabeled data and makes heuristic use of input data. These are employed in load balancing, cell clustering, anomaly, fault, and intrusion detection. Data groupings based on some inherent similarities and differences are done using clustering, which falls under the topic of unsupervised learning. There are no right or wrong answers because the clustering is unsupervised. Data visualization is employed to assess the correctness of the results. The clusters in datasets can be pre-labeled if there is a possibility for a correct or incorrect answer, and in this case, classification methods are preferable. Popular clustering algorithms include hierarchical clustering and K-means. The most often used algorithm is K-Means, which creates clusters based on the geometric separations between data points. Around centroids, clusters assemble to form globular structures of the same size. Before clustering, the number of clusters must be determined, however, this is not always feasible or efficient. Additionally, cluster formation is weak if clusters are not spherical. The majority of IoT applications use unsupervised learning techniques with very little baseline environmental knowledge, which is comparable to how to live creatures naturally learn. For instance, zero-day attacks on IoT networks typically start with little to no information [22].

Reinforce learning methods develop the reward and action link between the agent and the environment by taking advantage of different stages. This action-reward relationship is highly helpful in addressing a variety of IoT issues. It does not require a large training data set, but the agent must be familiar with the state transition function. Despite being computationally straightforward, reaching a steady state takes a long time. Utilizing reinforce learning techniques in the dynamic settings of IoT networks presents several difficulties, including the sluggish convergence and understanding of the state transition function or optimal policy [22].

Security and privacy are just two of the key areas in the IoT domain where deep learning might offer more effective solutions. Deep learning is dependent on strong function approximation, estimate, and learning capabilities. Due to their resource limitations, IoT devices might not be able to host or perform sophisticated computational algorithms for tasks like communication, analysis, and prediction [22].

As a result, deep learning-based algorithms outperform traditional theories and methods while having lower latency and complexity. Deep neural networks are also proficient at identifying and defining low-dimensional representations from any kind of high-dimensional data patterns (text, image, or audio). In heterogeneous IoT networks, DDoS detection and authentication are accomplished via deep reinforcement learning and its derivatives. Deep deterministic policy gradient, continuous deep Q-Network, prioritized experience replay, asynchronous N-step Q-learning, deep SARSA, Dueling network deep Q-Network, and asynchronous advantage actor-critic are the main deep reinforcement learning algorithms used for security and privacy [22].

Table 5 presents an overview of security challenges in IoT networks and applied ML and deep learning techniques to detect the particular situation according to the [22].

Table 5

IoT network security issues and applied machine learning techniques

Objective	Techniques for Machine Learning
Authentication	▪ Deep Learning ▪ Recurrent neural networks ▪ Q-learning and Dyna-Q ▪ Deep Neural Network
Attack Detection and Mitigation	▪ SVM ▪ Deep Learning ▪ Unsupervised learning, stacked autoencoders ▪ Extreme Learning Machine (ELM)-based semisupervised Fuzzy C-Means (ESFCM) ▪ K-Nearest Neighbour and SVM
Distributed DOS Attack	▪ K-Nearest Neighbour ▪ Support Vector Machine ▪ Random Forest and Decision Tree ▪ Neural Network ▪ Multivariate Correlation Analysis (MCA) ▪ Q learning
Anomaly/Intrusion Detection	▪ K-means clustering and Decision Tree ▪ Artificial Neural Network ▪ Novelty and Outlier Detection ▪ Decision Tree ▪ Naive Bayes
Malware Analysis	▪ Recurrent Neural Network (RNN) ▪ ensemble learning algorithm Random Forest supervised classifier

	▪ Deep Eigensapce Learning and Deep Convolutional Networks ▪ SVM ▪ PCA (Principal Component Analysis), one-class SVM, and naive anomaly detector based on unseen n-grams ▪ CNN (Convolutional Neural Network) ▪ Artificial Neural Network ▪ Linear SVM ▪ SVM and PCA

9 Conclusion

IoT and AI are both trending topics in recent years. IoT and AI are both extremely strong technologies on their own. IoT – AI is created when AI and IoT are combined. AI is the brain of a system, while IoT devices are the digital nervous system. In this review paper, AI and IoT were defined from a few authors' papers. The main part of this paper was the interconnection between IoT and AI.

The research study has brought the answers for *RQ1*, *RQ2*, and *RQ3* respectively within the discussion. The research study has identified that the integration of AI and IoT is more powerful for day-to-day operations of real life and organizational functionalities. By considering the business approaches, agriculture, education, health, vehicle autonomy, fuel production, and smart cities are the most economical points for enhancing the capacities with IoT and AI integration.

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