International Journal of Information technology and Computer Engineering
ISSN: 2455-5290
Vol: 02, No. 06, Oct-Nov 2022
http://journal.hmjournals.com/index.php/IJITC
DOI: https://doi.org/10.55529/ijitc.26.39.50

Integrating IOT and AI: Enhancing System Efficiency and User Experience

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Received: 08 August 2022 **Accepted:** 24 October 2022 **Published:** 28 November 2022

Abstract: ***The manner in which we engage with technology has been fundamentally altered as a result of the convergence of the Internet of Things (IoT) and artificial intelligence (AI). This article investigates the advantages and disadvantages of merging IoT with AI, as well as the ways in which such integration might improve both the efficiency of the system and the user experience. This article includes a literature analysis on the integration of AI with IoT, as well as examples of applications in a variety of business sectors. It also covers the difficulties that are connected with integrating IoT with AI and offers some potential solutions to these difficulties. The last part of the article discusses the possibilities for this integration to improve both the user experience and the overall efficiency of the system.***

Keywords: IOT, AI, Integration, System Efficiency, User Experience.

1. INTRODUCTION

The Internet of Things (IoT) and Artificial Intelligence (AI) are two technologies that are advancing at a fast pace and have the potential to revolutionize how we live our lives and the jobs that we do. The term "Internet of Things" (IoT) refers to the interconnection of various electronic devices, sensors, and other items that are outfitted with software, network connections, and sensors to give them the ability to gather and share data. On the other hand, artificial intelligence (AI) refers to the capacity of computers to carry out activities that would normally need the intellect of a human being. Some examples of these activities are voice recognition, decision-making, and problem-solving.

By allowing intelligent decision-making, boosting productivity, and enhancing user experience, the combination of internet of things with artificial intelligence has the potential to change a variety of sectors, from healthcare to transportation. This article investigates the advantages and disadvantages of merging IoT with AI, as well as the ways in which such

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integration might improve both the efficiency of the system and the user experience. Figure 1 shows AI-powered IoT.

Figure 1: AI-powered IoT.

Internet of Things

Even only a few decades ago, the idea of being able to have a video conversation with family members who lived on another continent was unfathomable to everyone. These days, it is an everyday occurrence. All of these things are the result of technology becoming more affordable and new gadgets appearing on the market with enhanced and augmented capabilities. Sending emails, paying bills, transferring money, or scheduling a taxi are just some of the tasks that can be accomplished with the press of a button on a smartphone.

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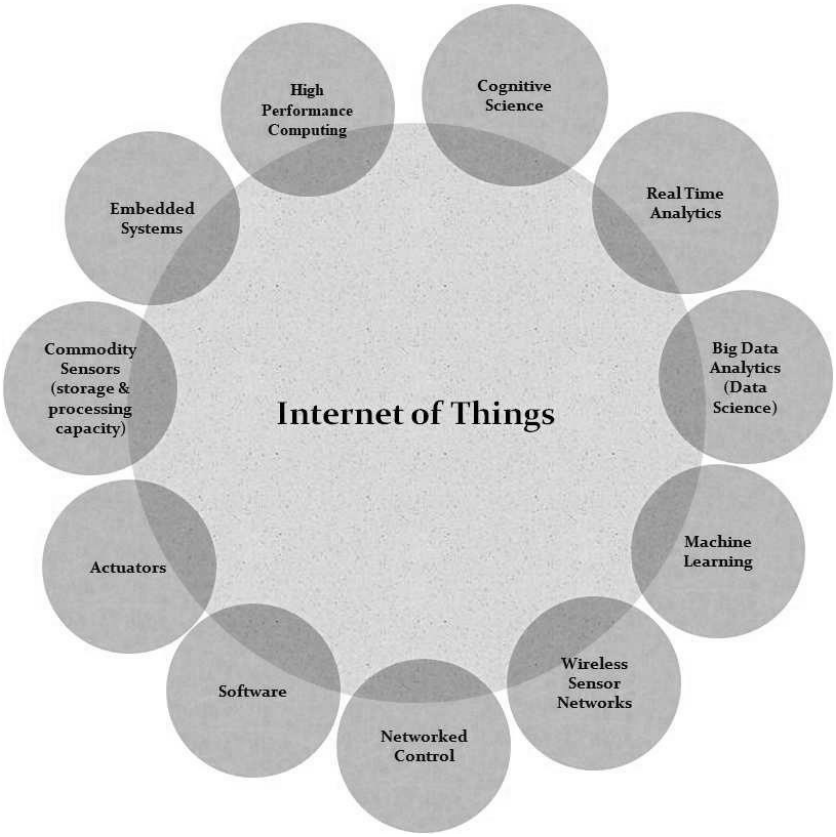

Figure 2: Converging perspectives on the Internet of Things

The term "Internet of Computers" (IoC) has been in use since 1991, and it steadily expanded in scope as an ever-increasing number of individuals began to make use of it. The Internet of Things had its start with the invention of pocket phones and other linked devices. Throughout time, it expanded to include more and more gadgets as mobile phones, desktop computers, laptops, and tablet computers became more affordable and available to the average person. According to the projections made by Gartner, Inc., there will be 6.4 billion connected items in use all over the globe in 2016, which is an increase of 30 percent from 2015. This number is expected to reach 20.8 billion by the year 2020. In 2016, an average of over 5.5 million new devices was linked to the internet every single day, revealing the enormous potential of the Internet of Things. There are many different fields that are related with the internet of things since the internet of things is formed by the continual connection of many different items. As a result, the Internet of Things (IoT) may also be seen of as a mix of many other areas. The Internet of Things (IoT) is comprised of many different domains, a sample list of which is shown in Figure 2. The majority of these domains share ideas and approaches with one another. The Internet of Things (IoT) is just a network that connects people and various inanimate and living organisms, such as appliances, agricultural fields, plants, and animals. The way that people are linked to these technologies is by the use of certain intelligent items that are attached to both of them and are able to transmit, receive, and analyze data. These intelligent objects are a representation in the network of the entity (a person or a physical item) to which they are associated.

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AI enabled IoT

The Internet of Things (IoT) is an expansive idea that includes a great number of sensors, actuators, data storage and processing capabilities that are all linked to the internet. Hence, every device that is equipped with the Internet of Things is able to detect its surroundings, communicate, store, and analyse the data that it has acquired, and then respond appropriately. The very final stage of acting appropriately is totally reliant on the preceding phase of processing. The degree of processing or action that an Internet of Things service is able to carry out is a good indicator of how intelligent it is. An Internet of Things system that isn't smart will have limited capabilities and won't be able to adapt when new data comes in. On the other hand, a more advanced Internet of Things system would include artificial intelligence and could be able to achieve the desired level of automation and adaptability. In this regard, a few instances of already existent Internet of Things services are presented below together with the operation of AI underlying them.

A. Voice assistants: These are cloud-based voice services that operate as desktop personal assistants for users. Voice assistants may be accessed via a tabletop device. They do a variety of functions by using apps developed by third parties and other smart devices that are located nearby. They are able to respond to questions, make taxi calls and restaurant bookings, play music, turn smart lights on and off, and do a variety of other duties in response to voice instructions from the user. The following are some of the most well-known voice assistants:

i. Alexa is Amazon's speech assistant, and it can be found in a variety of their devices, such the Amazon Echo, Amazon Tap, and so on. There is a particular collection of talents that together are referred to as the Alexa Skills Kit (ASK), and they are able to be customized and improved via the use of various updates and modifications.

ii. Apple Inc.'s Siri is integrated into the Apple Homepod, which operates in a manner similar to that described above.

iii. The Google Assistant that is utilized in Google Home includes extra functionality, such as the capability to identify up to six distinct individuals and get their individual data in order to have a conversation with those users.

The incorporation of a wide variety of AI specializations into these voice assistants is primarily responsible for their impressive versatility. Automatic far-field voice recognition, wake word detection, speech to text conversion, natural language processing and understanding, contextual reasoning, dialogue management, question answering, conversational artificial intelligence, and other similar tasks are carried out continuously to allow voice assistants to perform functions in real time.

B. Robots: Current developments in the area of robotics have led to the construction of robots that have a greater human resemblance and are capable of interacting with people while comprehending, reciprocating, and expressing certain human emotions. The fact that robots are equipped with various sensors, actuators, and AI that enables them to continually learn and modify themselves over time makes them examples of Internet of Things devices in and of themselves.

i. Pepper, a humanoid companion created by SoftBank Robotics and modeled after a human being, is a human-shaped robot that can engage in conversation with real people. It is able to

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comprehend a person's state of mind by analyzing factors such as the expression on their face, the way they move their bodies, the tone of their voice, the words they choose, and so on. It is able to recognize four human feelings, namely happiness, sorrow, anger, and surprise, and it responds accordingly via movement, touch, speech, and the display on its screen. It has the ability to travel freely and communicate with both people and other machines that are in the area. Pepper is utilized in a business setting to communicate with clients in a variety of retail establishments.

ii. Sophia is a social humanoid robot developed by Hanson Robotics. She has an incredible human-like appearance and can communicate her feelings via more than 50 different facial expressions. It is able to keep eye contact with the human while they are talking, which is a very socially acceptable behavior. Sophia is the first robot in the history of the world to be granted full citizenship in a nation. She has even participated in a concert and has granted a number of interviews.

iii. Moley Robotics' Robotic Kitchen is a highly developed and completely working robot that has been incorporated into a kitchen. It is able to produce cuisine of expert quality from its recipe database and comes equipped with robotic arms, an oven, a cooktop, and a touchscreen device for human interface.

These robots have made extensive use of a variety of technologies, including natural language processing, computer vision, shape recognition, object recognition, detection and tracking, block chain technology to analyse inputs and responses, facial recognition, voice recognition, speech-to-text technology, obstacle recognition, haptics, and many others, in order to improve their performance and make them more useful.

C. Intelligent Gadgets: In an Internet of Things, in addition to voice assistants and robots, there are also smart things and devices that are present. These objects and gadgets make it easier for people to do their work. The applications of object recognition, face recognition, voice recognition, speech and expression identification, deep neural networks, transfer learning, computer vision, and other AI-enabled technologies are used by smart things that are empowered with artificial intelligence.

i. June's Smart Oven is designed to ensure that food is cooked to perfection every time. It is equipped with a high-definition camera and a food thermometer, both of which contribute to the automated monitoring of the food that is being cooked within the oven, and it is able to adjust cooking modes as required. This oven can be controlled by Alexa and will provide recommendations and allow the user to select the automated cook programme based on an analysis of the user's preferences.

ii. SkyBell is an HD WiFi doorbell that is manufactured by Honeywell. It gives the user the ability to answer the door using either a smartphone or a voice assistant. In order to inform the owner of the house that someone is at the door, the video camera mounted on the doorbell transmits a notification and a live feed to the owner's phone. Even if the owner is at a different place, they can still communicate with the other person via SkyBell. Trespassers and burglars have been deterred as a result of this measure.

iii. Smart Lights from Deako may be operated remotely through smartphones and voice assistants such as Alexa or Google Assistant. They are linked to the internet, so they are able to get software updates whenever they become available.

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iv. Automotive AI by Affective is an in-cabin sensing artificial intelligence that can be utilised in highly autonomous automobiles and robo-taxis. By the use of in-cabin cameras and microphones, it analyses the faces and voices of passengers to determine the mental and emotional condition of those travelling in the car.

D. Internet of Things in Industrial Settings: In addition to its usage in connected homes, the Internet of Things has a significant application area in a variety of industrial settings. These systems do statistical and financial analysis of a whole firm, and then, using various AI and machine learning algorithms, they make forecasts.

i. Primer is a product offered by Alluvium, a company that offers solutions for the industrial sector. A real-time Stability Score analysis is generated by Primer using the data that was gathered, the sensors that were present in the system, and the assets. Its purpose is to detect possible problems a considerable amount of time in advance, and it assists operators in determining the nature of any abnormalities that may occur and in implementing any required adjustments to anything from a single sensor to an entire facility.

ii. Plutoshift is another solution that is built on industrial IoT. It offers help for educated decision making, enabling industrial organizations to continually monitor the performance of their assets, and assesses the financial effect.

So, when AI and IoT are integrated, the prospects and potential of both of these technologies may potentially improve. As the Internet of Things (IoT) creates data, machine learning (ML) and big data analytics (BDA) have the potential to identify insights in the data that are of enormous value. The data that is generated by the Internet of Things is rendered worthless in the absence of artificial intelligence. AI is essential to the Internet of Things because it is physically impossible for a person to sift through all of the data that is generated by IoT. In addition to this, the machine will be able to learn on its own if a new pattern in the data is discovered, which is something that a non-AI Internet of Things system would be unable to achieve.

The benefits of integrating AI with IoT are as follows:

The combination of AI with IoT provides a number of advantages, including the following:

a. Internet of Things devices may make choices in real time based on the data they gather by using AI algorithms. This enables IoT devices to react more quickly and effectively to changing environmental circumstances.
b. AI algorithms may assist in optimizing the operation of Internet of Things devices by evaluating data and suggesting areas for improvement, which can lead to improved efficiency. This may result in a more productive use of resources and a higher level of efficiency overall.
c. Using AI algorithms, Internet of Things (IoT) devices are able to determine when maintenance is necessary. This eliminates unscheduled downtime and lowers operating expenses.
d. The combination of AI and IoT may deliver a more customized and intuitive user experience by learning from user behavior and preferences. This can lead to an overall improvement in the quality of the user experience.

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Advantage of combining AI with IoT

The Internet of Things (IoT) devices capture all of the data and transport it to the cloud or any other location where data may be collected over the internet. This is one of the advantages of merging AI with IoT. AI serves as the "brain" of AIoT and contributes to the process of decision making as well as modeling how robots could behave or react.

In the following paper, we will explain five concrete benefits of AI and IoT that will revolutionize the way that organizations function and identify customers (in figure 3).

Figure 3: Advantage of combining AI with IoT

Improved Relationships with Our Clients

When AI and IoT are combined in the right way, the benefits that come from this combination are not only available to workers but also contribute to an improvement in the quality of the experience provided to consumers. The time has passed when it was necessary to speculate about the desires and demands of the client. These up-and-coming technologies are being used by businesses to collect massive amounts of data in real time on their customers. Businesses today have access to the data and technology necessary to build goods and services that are tailored to meet the specific requirements of their target audiences. Both AI and IoT play important roles in the process that we are describing. Businesses are increasingly automating the whole of the data organization process in order to guarantee that customers will always get a response that is timely and relevant to their inquiries. Consumers are already becoming used to the practise of obtaining prompt and precise responses and reactions. Since these gadgets can learn user preferences and alter themselves appropriately, the whole customer experience may be significantly enhanced.

According to projections made by Gartner, Inc., the market for the Internet of Things (IoT) in corporate and automotive settings would expand by 21% between 2019 and 2020, reaching 5.8 billion endpoints. It is anticipated that by the end of 2019, there will be 4.8 billion endpoints in use, which is a 21.5% increase over 2018.

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Affordable in all aspects

Because of the present scenario with COVID19, the majority of businesses are coming under great pressure to reduce expenses without sacrificing production. AI and Internet of Things have the potential to be a solution that will save the company money. Artificial intelligence and the internet of things can instantly gather and analyze data in order to evaluate whether or not a component or operation has become unreasonably costly to maintain. A company that has early access to the data is able to find opportunities for cost reductions without compromising efficiency. An organization is able to reduce its expenditures via the implementation of change after it has identified the factors that influence costs. These developing technologies provide executives the ability to cut down on wasteful expenditure and improve the efficiency of corporate activities.

Improvements in the Effectiveness of the Operations

The integration of AI into applications for the internet of things may result in greater operational efficiency. The capabilities of machine learning allow for data to be processed and predictions to be made in ways that are impossible for humans to achieve. With the assistance of this technique, lengthy computations may be performed on extensive data sets in a relatively short amount of time. On the basis of the calculations, suggestions may be made to improve the operational effectiveness of the workplace. Businesses are already making investments in these technologies in order to improve their overall productivity. AI and IoT have the ability to identify inefficiencies in a process and suggest improvements based on best practices.

According to research conducted by McKinsey, 82 percent of businesses that have used machine learning and artificial intelligence have seen a financial return on their investments.

Extremely Secure and Risk-Free

The integration of AI with the internet of things has the potential to provide an additional layer of protection. The combination results in fewer accidents in the workplace. Enterprises are able to anticipate future security issues and automate an instant reaction when they combine machine learning with machine-to-machine communication. Using connected sensors to identify possible environmental safety dangers that employees are unaware of might be a useful use of this technology. These technologies make it possible to create a risk-free and protected business environment. Many applications that combine IoT with AI may assist businesses in accurately predicting and managing a wide range of risks and dangers, including those related to the safety of workers, to cyber-attacks, to financial losses, and so on.

Put Your Attention on Up-and-Coming Goods and Services

The combination of Internet of Things with artificial intelligence has the potential to pave the way for the development of innovative and powerful new goods and services. Gathering and analyzing massive amounts of data enables firms to make more informed choices in response to changing circumstances. Natural language processing (NLP) is becoming more capable of enabling humans to communicate directly with machines, eliminating the need for a human operator in most situations. AI is a logical complement to Internet of Things installations

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because it enables improved services and operations, which in turn gives businesses a competitive advantage in performance.

Data Storage and Data Processing

According to what we know, the primary objective of both the Internet of Things and the Cyber Physical System is to develop an independent system that is capable of responding appropriately to a wide variety of circumstances located all over the world. This would ultimately help human's live better lives. Smart objects, which resemble the nodes in a graph, and the connections that exist between them, make up the fundamental building blocks of the IoT-CPS architecture. Assuming that all of the nodes and connections have been established, data is constantly being created and sent from one node to another. But, the SOs are at a loss as to what they should do with it. Since they are unable to store it and do not know how to handle it, the whole system is rendered worthless because of this. Without enough data storage and processing units, it is impossible to realise the goal of having full autonomy, which includes the ability to make choices and carry out actions. This is a fundamental characteristic that is required not just locally in intelligent objects but also globally in the whole system. Little data sets will continually be introduced into the system, and the SOs will be responsible for their management. These data sets may be temporarily held in the SOs until a job is completed, at which point they can be relocated to the global data store. It is possible that the data storage of the whole system may not get streaming data. But, it will most likely receive big chunks of data gathered at random intervals. The role of big data analytics is vital if one want to efficiently manage both of these different kinds of data in real time.

It is still uncertain what precisely has to be done during the processing step, however all of these data are going to be saved first. We anticipate that a smart system, such as IoT-CPS, would function on its own, observing its environment (using a variety of factors), gaining wisdom from previous encounters, comprehending the requirements of the situation at hand, and taking appropriate measures as a result. Learning through experience is essential for any item or system that is to successfully mimic human behaviour. Since it is possible that human interaction will not be accessible or preferred most of the time, it is necessary for the system to learn on its own. With the assistance of artificial intelligence, all of these things are able to be accomplished successfully.

Examples of Combining AI with the Internet of Things

The combination of artificial intelligence with the internet of things offers a wide range of potential applications in a variety of fields. Such instances include:

a. **Home automation:** The Internet of Things devices that are integrated with AI may learn from user behaviour and alter settings to create a more individualized and energy-efficient way to live.
b. **Healthcare:** Internet of Things (IoT) devices may gather patient data, and artificial intelligence (AI) algorithms can evaluate this data to deliver real-time medical advice and increase the accuracy of diagnosis.

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c. Manufacturing: Internet of Things devices have the ability to gather data on production processes, and artificial intelligence algorithms have the ability to optimize these processes to enhance efficiency and minimize costs.

Difficulties Associated with Combining AI with IoT:

Integrating IoT with AI, despite the many advantages it offers, also presents a number of problems, including the following:

a. Security: It is becoming simpler for cybercriminals to acquire access to sensitive information as the number of devices that are linked to the internet continues to increase. The use of AI may also be utilized to develop more complex forms of assault.

b. Concerns have been raised over individuals' privacy as a result of the gathering and use of personal data by AI algorithms and internet-connected gadgets. It is of the utmost importance to secure user data and to make sure that it is only used for appropriate reasons.

c. Interoperability is a problem that hasn't been solved yet, and it affects both the Internet of Things (IoT) and artificial intelligence (AI) systems. Since many different devices and systems use proprietary protocols, it may be challenging to integrate them with one another or with other devices and systems.

d. Because of their potential for complexity, AI and IoT systems often call for the use of specific knowledge and abilities throughout their development and ongoing maintenance. Because of their inherent complexity, enterprises may find it challenging to implement these technologies.

e. Ethical implications: There are worries concerning the ethical implications of AI and IoT, including problems relating to prejudice, justice, and accountability. These concerns stem from the fact that there is a lack of clear boundaries between the two.

f. Regulation: As artificial intelligence (AI) and the internet of things (IoT) continue to advance, rules need to advance with them to guarantee that these technologies are utilized in an ethical and responsible manner. Nonetheless, coming up with laws that are adaptable enough to keep up with the quick pace of technology advancement may be a difficult task.

In order to address these challenges, it will be necessary for various stakeholders, including governments, the private sector, and academic institutions, to work together to develop standards, policies, and best practices for the responsible application of technologies involving artificial intelligence and the internet of things.

2. CONCLUSION

However, in general, the combination of IoT and AI technologies has the potential to increase system efficiency and improve the user experience by enabling more proactive and intelligent decision-making based on real-time data. This, in turn, can improve system efficiency and enhance the user experience. The Internet of Things (IoT) and artificial intelligence (AI) working together may help improve and automate operations, save operational costs, and give customers with more customized experiences. In addition, Internet of Things devices are able to create vast volumes of data, which can then be used to train AI models, hence enhancing

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their accuracy as well as their performance over time. In general, the combination of AI and IoT has the potential to revolutionize a variety of business sectors while also enhancing the ways in which humans engage with technology.

Future scope

The combination of Internet of Things (IoT) with artificial intelligence (AI) technologies has a broad future reach since it has the potential to change a variety of businesses and areas. The following are some possible areas of expansion and development in the future:

Intelligent and energy-efficient houses and buildings may be created via the combination of internet of things (IoT) technology with artificial intelligence (AI). The use of sensors and AI algorithms enables houses and buildings to reduce their overall energy consumption, enhance their level of safety, and provide their inhabitants more customized experiences.

The Internet of Things and artificial intelligence may work together to enhance patient care and results in the healthcare industry by allowing remote consultations and telemedicine, monitoring and analyzing vital signs in real time, and forecasting health hazards based on data analysis.

Manufacturing: The combination of IoT and AI has the potential to increase product quality while also optimizing production processes, hence reducing waste. Manufacturers are able to monitor machinery, anticipate when maintenance will be required, and manage production schedules thanks to the IoT and AI algorithms.

Agriculture: Farmers are now able to monitor crops, forecast weather patterns, and optimize irrigation and fertilization schedules thanks to the IoT and AI algorithms.

In general, the combination of AI and IoT has a large future scope since it has the ability to revolutionize a variety of businesses and domains by enabling intelligent decision-making that is based on real-time data. This transformation might occur in a number of different ways.

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