IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-6, June 2019 E-ISSN: 2347-2693

Artificial Intelligence Powering Internet of Things

Suhasini Vijaykumar[1*], Avinash Yadav [2]

[1,2]Bharati Vidyapeeth's Institute of Management and Information Technology, Navi Mumbai, India

Corresponding Author:suhasini.kottur12@gmail.com Tel.: +91-7208746821

DOI: https://doi.org/10.26438/ijcse/v7i6.449456 | Available online at: www.ijcseonline.org

Accepted: 09/Jun/2019, Published: 30/Jun/2019

***Abstract*—** The IOT concept came into existence in 1999 and from there it has grown into one of the most important parts of the new fields and technologies sector. Artificial Intelligence being included to the IOT systems is the next step and it is being used in daily life. This technology is used in various fields and it is a wide range concept which can be used anywhere.

Artificial intelligence is the first and most popular option to manipulate huge data outflow and storage within the IOT community. Currently IOT is most popular with cutting edge sensors and high speed internet which are all included in a microcontroller. The streams of data flowing through Internet gather sensor and customer data which are sent and attain by terminals or workstations. With sudden popularity of cutting edge sensors and workstations, some data can have problems on storage, delays, routing problems with its network traffic etc. To avoid all these problems, many techniques have been recommended in the past 4 years and in that AI algorithms are the most accurate solution to the data mining, management and control in handling network traffic.

When the Internet of Things is power-driven by AI, then it is known as Intelligent IOT. In this paper we will review the basic components of Intelligent IOT and some vital system fields where it is used. We examine the role of AI strategies to enable such networks with intelligent communication. This paper is targeted on evaluating current solutions for the intelligent IOT connected and communicating with each other. It conveys AI techniques and algorithms which are used to create such intelligent IOT, and network solutions to use the advantages given by such capabilities.

***Keywords*—** IoT Applications, Smart Homes, Smart Buildings, Smart Manufacturing, Smart Healthcare, Intelligent IOT, Artificial Intelligence, Machine Learning.

I. INTRODUCTION

Most Information Systems exploits Internet which is a powerful tool and its network is almost available anywhere, home, workplace, also on mobiles and other devices (phones, watches). People are connecting with one other and take basic decisions and helping them in their daily course of life by linking to Internet to almost all devices which are of daily use and such concept is called the Internet of Things (IoT). The number of devices which are connected to the Internet is being recently estimated as 15 billion, but this value is very less compared to 1 percent of things that could be connected to the network [1].

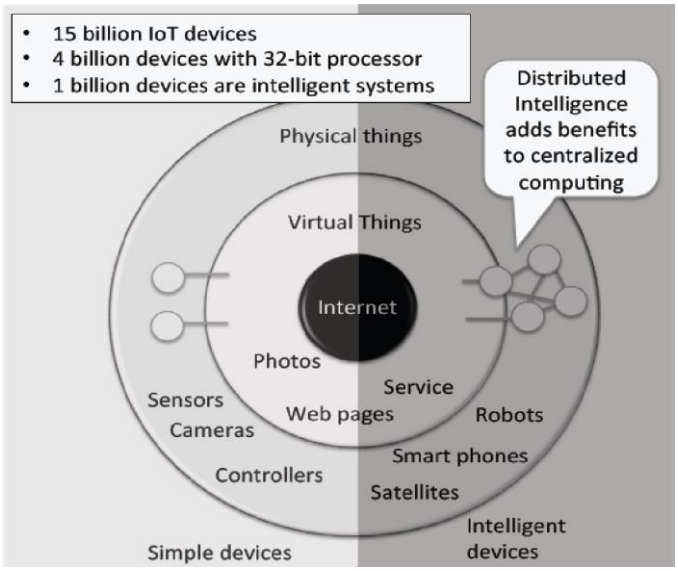

Fig. 1. Internet of Things and devices [2]

Artificial Intelligence being included to the IOT systems is the next step and it is being used in daily life. This technology is used in various fields and it is a wide range concept which can be used anywhere. Applications such as watching, searching videos, search or watch history of the videos (services – Netflix, Youtube) or recognition of people according to the recordings of the monitoring. Expert System components have an amazing ability to elucidate large datasets with its summary with the help of various different AI techniques. Humans no longer has to statistically analyze and depict all the data collected from the specific IOT structure, for example searching history of a particular employee or watching videos etc. which is a blessing for humans.

The presented paper has been planned as: - first it reviews the challenges and limitations of IOT concept with its interpretations, second it describes the skeleton of the architectures of IOT and AI and how artificial intelligence deals with the facets of communication in IOT concept and third it conveys the use of chosen techniques of AI in relation to IOT and applications of IOT system using such techniques.

1. IOT Architecture: -

Flexibility in all smart objects is required including the structure and technology for Intelligent IOT which are all included with respect to the Internet. Infrastructure is provided and the diversity of each machines and its need for pervasive transmission [1], and this should be continuous. Since the start of the IOT concept, the architecture of IOT is not clear and it cannot be defined neatly and how it should look. The outlines which are there for IOT infrastructure should be flexible enough.

The important elements of IOT concept which is the general idea for the design of IOT infrastructure is –

- Anything,
- Anyone,
- Anytime,
- Any places, services, networks.

The figure which depicts the main pillars is shown below.

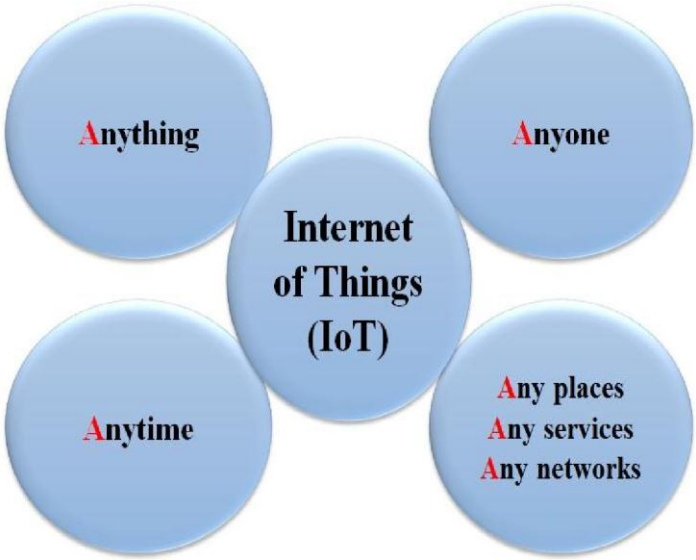

Fig. 2. Internet of Things Concept [4]

3 and 5 – layer architecture: -
One of the simplest architectures of IOT is 3-layer architecture
which is shown below and since it is introduced in early stages there are 3 layers such as-

Perception Layer: - It is the physical layer, where collection of information and sensing is done by sensors about the surroundings and it finds other IOT objects or senses some physical criteria's or specifications.

Network Layer: - This layer is held responsible for connection to IOT things, networks, devices, and servers. Transmission and processing of sensor information are its main features.

Application Layer: - This layer is bound to provide solutions related too application specific to the end users and different applications are represented accordingly such as smart cities, smart education, healthcare etc. of IOT which are utilized.

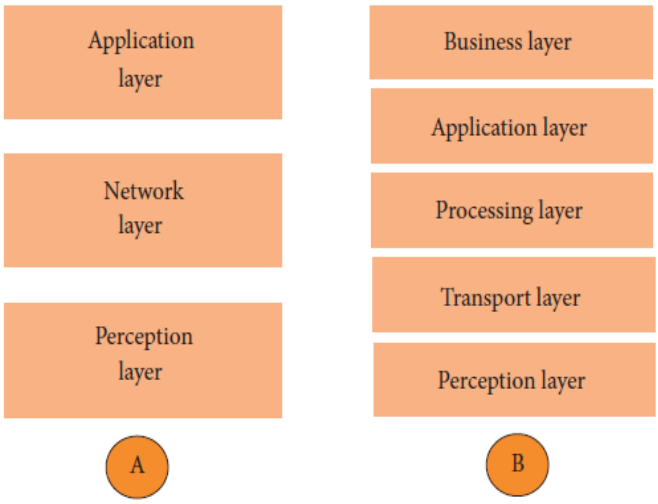

Fig. 3. IoT Architecture (A: 3 layer) (B: 5 layer) [5].

The 3 - layer architecture gives clear idea about IOT, but it is still not enough for IOT research since research always focuses on minute details of IOT because of that 5 - layer architecture was introduced which additionally includes transport, processing and business layers.

Transport Layer: - The sensor data is communicated between the perception layer to the processing layer and in reverse through grid networks such as WSN, RFID, NFC, Bluetooth etc.

Processing Layer: - Middleware layer is used to gather data, interpret and find conclusions and process large amounts of data which is coming from transport layer. This layer supports and manages a variety set of functions to the layers which are below processing and it is being used with various technologies such as AI, fog/cloud computing, database and big data etc.

Business Layer: - The entire supervision of IOT structures and its system which consists of various applications, business and cost models with the end users security and privacy is done by this layer.

2. Artificial Intelligence Concepts :-

Artificial Intelligence is technology or a field of computer science which manages with the methods or techniques to simulate the human behaviour or its mind within the computers or machines which makes it easy for human to communicate with other devices.

Machine Learning also called as Expert Systems is one of the most important techniques of AI and it really makes machines or devices intelligent as per the human mind and they learn from their surroundings without being externally hardcoded [3]. Such capabilities are supported by machine learning techniques.

These IOT structures or systems create large quantities of data and such data is impossible to analyze by human brain and have a quick action on it. Thus AI provides capabilities such as IOT can learn and quickly adapt to the surroundings and act accordingly. These expert systems abilities which enhances the decision making skills of IOT systems and even helps to answer unforeseen problems. Currently expert systems are powered by adapting various wireless technologies like RFID tags with sensors and actuator nodes [3]. Because of IOT which is an upcoming ground-breaking technology the Internet has transformed into an integrated Future Internet. Machine learning algorithms are organized into following types:

Supervised learning: - In this type of approach, learning is done with the help of instances and in this a function is executed from a dataset and then this function is used to find new output of objects or an input. Supervised learning helps the learner to map the inputs to outputs into one of several classes which is its main goal [3]. Examples of such approach are:

- **Classification**: A model has to be developed by learner in which all inputs are categorized into classes and a class is subjected to unclassified inputs.
- **Regression**: In this approach outputs are discrete and not continuous.

Table 1: Supervised Machine Learning Algorithms [3]

ML Algorithms for Classification	Tasks
Support Vector Machine	To supervise human behaviour and mind in smart homes.
KNN, Naïve Bayesian, C 4.5	Analysis of various human movements and postures such as standing, sitting and lying posture.

Unsupervised learning: - In this approach learning is done through observation or monitoring over things. There are no labeled examples available for this learning approach. Finding hidden patterns and trends in data is the main goal of this algorithm. Below are the algorithms which follow unsupervised machine learning approach:

- **Clustering**: This technique is used to combine similar data or objects together and such inputs and not known beforehand. The main aim is to make decisions that increase or maximize our profits or rewards and rather not to produce a classification [6]. This process can produce correct results as it does not compute on existent examples for categorization but it is a slow process.

Table 2: Unsupervised Machine Learning Algorithms [3]

ML Algorithms for Clustering	Functions
2 Phase k-Mean Algorithm	In e commerce applications, to categorize products based on ratings.
Density Based spatial clustering of applications with noise (DBSCAN)	To find the combinations and structures in data to find and predict patterns.

3. IOT using Artificial Intelligence Architecture: -

The critical component related with the processes of structures of IOT and with AI is the location or the placement in the architecture. Performance and accurate amount of information (knowledge of the system) is an important element so that the AI techniques cannot be placed at each level. Fig 4 shows the general idea of including the AI techniques in relation to important IOT architectures.

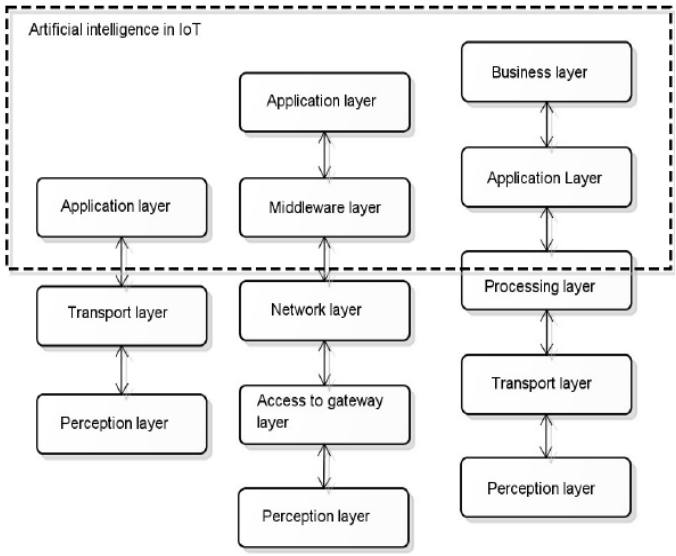

Fig. 4. Including the artificial intelligence in the IoT architectures [1]

The best location or places for AI techniques is its computing power for example like servers and its placement has a decisive effect on different elements too. So, it is all about the generalizable conclusions of reuse. The location of different AI techniques can be correlated or compared to human brain. The truth is that all the information and its related conclusions or decisions with its learning are located in server rooms thus it can be used in a larger context.

Figure 7 shows the basic idea of data flow in the IOT structures, using AI. There are 3 important components [1] in the flow of data -

- **Primary communication**: – Actual data which is related to real world is sent to various IOT structures.
- **Context communication**: – Data having correct context is already processed by IOT systems so that devices can react suitably to take proper decisions.
- **Native communication**: – It is a secondary communication channel between IOT structures.

4. Artificial Intelligence Converging With IOT :-

The sudden boom and advancement in AI has created impact which has caused IOT to converge with AI to such limit that its quickly becoming crucial to IOT solutions. The main elements of IOT are connectivity, sensor information and robots which will finally lead to a prerequisite for all IOT devices to become smart. Thus IOT needs intelligent devices and machines because of that AI is needed.

Since AI is converging with IOT, the growth of IOT is being driven by 6 main aspects (Fig 6) of which the most crucial aspect is the big data and fog/cloud computing. IDC has estimated that the growth of IOT will have an exponential rise in quantities of data being created or generated and the number of devices linked to the Internet will rise from 5 billion in 2016 to 80 billion in 2025 which can generate up to 180 zettabytes of data per year where it was 4.4 zettabytes in 2013 and 44 zettabytes in 2020.

Since, data can be used only if it can analyze or process that data to give knowledge or information which is useful for organizations and that information should have creativity and context. Intelligent IOT is also known as connected intelligence where both AI and IOT are in same equation. IOT solutions are impacted in 2 key aspects such as enabling real-time responses from IOT systems for example like analyzing faces; and post-event processing where we need to find out different arrangements in data over time and performing predictive analytics.

AI enables enhanced IoT systems applications through capabilities such as –

- **Predictive analytics**: - 'What is going to happen?'
- **Prescriptive analytics:** – 'What are we going to do?'
- **Adaptive/continuous analytics:** – 'What should be the accurate actions/decisions, and how can we adapt to the recent changes?'

IOT's capability to support real-time feedback or processing is crucial to adapt to such learning systems, since other technologies do not support such advanced AI/analytics. Thus, AI and IOT are both going to need each other.

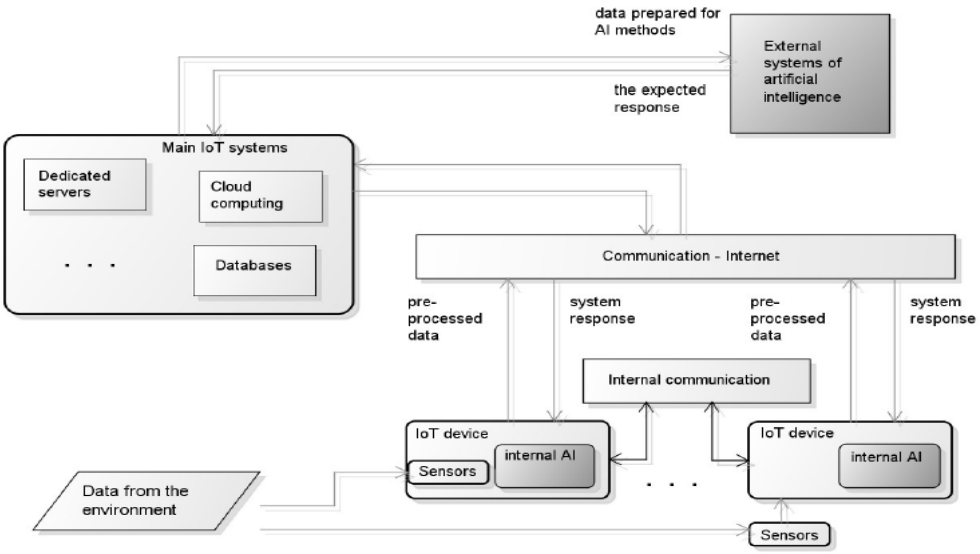

Fig. 5. Usage of artificial intelligence techniques in IOT systems data flow diagram (Basic idea) [1]

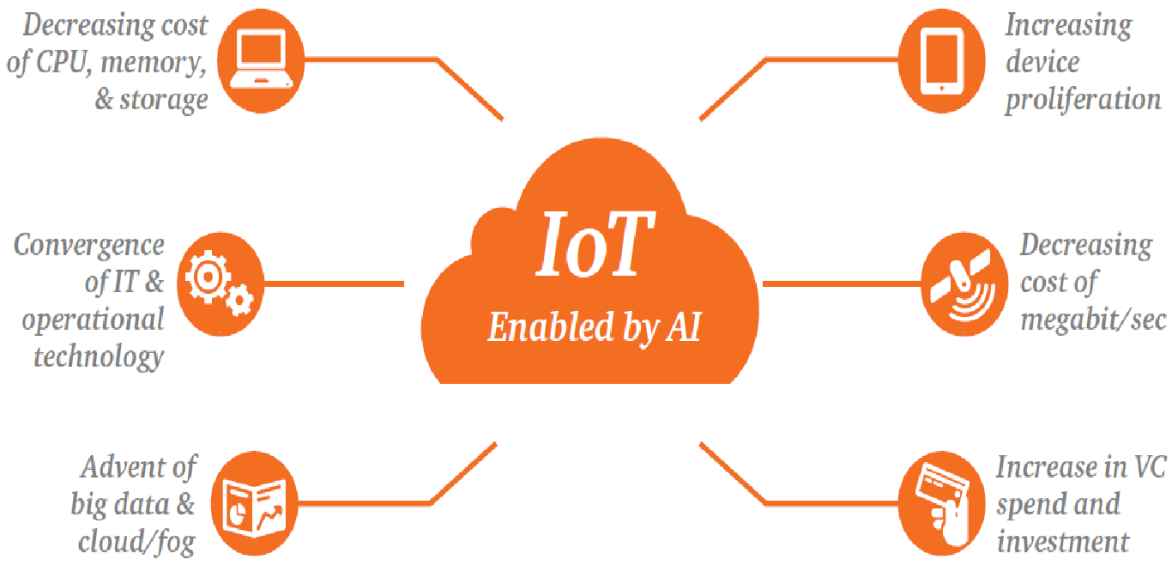

Fig. 6. Drivers of IOT Growth [6]

5. AI Powered IOT Applications :-

The scale and range of amazing benefits both AI and IOT has to offer, it's hardly surprising that many industries or organizations have started to take further steps to capture the opportunities [6] given by combining AI and IOT. Some of the examples are –

Smart Healthcare: - Various body activities, functions and metrics are supervised by intelligent IOT sensors which enhance safety and maintain health. For example, a construction company is using body sensors to avoid injuries to workers and improve labor productivity by applying body sensors which can supervise the load-carrying capability and the body posture of workers and manual laborer's. Some smart wearables like Fitbit, Smartwatch which tracks people's activity levels and help them to change their behavior's so that they can improve their well-being and can support overall health.

Smart Manufacturing: - Big manufacturing and industrial organizations such as aircraft, automobiles, mines and domestic appliances are supporting their machinery to execute predictive maintenance and produce autonomous factories with the help of sensors. For example, to decrease machinery breakdowns without increasing its maintenance costs most manufacturing companies uses IOT sensors to avoid all these problems.

Smart homes: - IOT sensors can be used in smart homes to help people in their homes for its daily activities for example, giving notifications to consumers about the maximum usage of dryers or washing machines and decreasing home costs. It improves energy efficiency by switching on and off air-conditioning and heating at the right time to take advantage of off-peak rates and it enhances household experience, for example by keeping climate control appropriately to make it work for different individuals. Examples like energy usage, opening of garage door, replacing refrigerator etc. such insights, alerts and recommendations are gathered and generated by energy monitors which are plugged into users' electrical panel.

Smart buildings: - Risks such as fire and flooding are reduced by attaching IOT sensors to the buildings and it can also bring down operational costs, increases safety and improves energy efficiency [6] by monitoring the movement of people and adjusting temperatures accordingly through such capabilities. Large organizations and construction companies working with insurance companies make smart buildings reducing the insurance premiums for the organizations which perform such capabilities.

Oil rigs: - Many oil manufacturing companies spends huge amounts on obtaining and executing special-purpose oil drilling machinery. When such machines fail to operate, the companies must face huge losses and having the cost of equipment means having spare machines is not economically feasible [6]. IOT sensors connected to oil rigs and related equipment which can

monitor continuously and provide notifications on preventative maintenance and supporting important reductions in operating costs.

II. CONCLUSION

Many technological advances and transformations have been brought by IOT and AI in different branches of computer science and it can be regarded as the future technology for communication with other devices and its computing. Artificial intelligence integrated into IOT systems allows all devices to take its own decisions which should be the following step taking into account that all devices are going to be connected to Internet 24/7 online. Interaction between people and machines is possible due to the capabilities of IOT devices which consists of AI. Thus IOT is capable of handling various complex problems using artificial intelligence but it is going to be seriously challenging and it is strongly recommended to use artificial intelligence in place of embedded processors. Thus, IOT is also called as intelligent IOT or Internet of intelligent things.

Generally speaking, the importance of artificial intelligence is that it implements the most important law of data conversion and creating intelligence which is the main purpose.This is the profound law or rule which governs all information activities in the big data age. Thus this paper investigates how artificial intelligence is introduced within IOT and investigates its usefulness in IOT. It also discusses various IOT AND AI architectures with some of its important application areas.

REFERENCES

[1] Aneta Maranda, Daniel Kaczmarek, "Selected methods of artificial intelligence for Internet of Things conception", 2015.

[2] Artur Arsenio, Fernando Nabais, "Internet of Intelligent Things: Bringing Artificial Intelligence into Things and Communication Networks", August 2014.

[3] Bharti Nathani, Rekha Vijayvergia, "The Internet of Intelligent Things: An Overview", Dec 2017.

[4] Zeinab Kamal Aldein Mohammed, Elmustafa Sayed Ali Ahmed, "Internet of Things Applications, Challenges and Related Future Technologies", Jan 2017.

[5] Pallavi Sethi, Smruti R. Sarangi, "Internet of Things: Architectures, Protocols, and Applications", Jan 2017.

[6] https://www.pwc.com/gx/en/industries/communications/assets/pwc-ai- and-iot.pdf

