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An Overview: Methodology and Applications of "Things That Think"

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ABSTRACT – In the last couple of years, the Internet of Things (IoT) has changed a lot the way we live and now it takes center stage in evolution and vision called Industry 4.0 or the Industry of Internet. We'll see how IoT is going to transform our lives, and the speed at which innovation and development are happening in this field, "Transform" can be an understatement. Around 10 billion IoT devices are available in 2019 and according to statistics, the count is going to reach 25 billion by the end of 2025. The amount of data a single device senses-actuates-processes-stores is enormous and managing this much data can be a redundant and tedious task. Here, Artificial intelligence comes into action, with available smart solutions and endless development in the field, it provides way more efficient and smart way to process, store, and manage huge data. Also, with the help of artificial intelligence, the IoT devices can make smart real-time decisions that take the automation to the next level.

Keywords: Internet of things, Artificial Intelligence, Cloud, data, Machine learning.

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I. INTRODUCTION

The Internet of Things (IoT) is a term that is gaining a lot of popularity these days, it has been introduced in recent years to which is a technology used to define objects that can connect and transfer data via the internet. "Thing" refers to any device collecting data through various sensors and transferring them to different devices on the same network. IoT based smart devices generate a huge volume of data often called big data that is very difficult to be processed by traditional data processing algorithms and applications and due to that processing, storing and visualizing that much data is very difficult. The IoT and Artificial Intelligence together will play a vital role in various ways in the future. We will see how using Artificial Intelligence we can intelligently manage and control "Things".

Section I is the general overview and introduction, Section II discusses background and introduction to important terms, Section III consists of the basic components, Section IV discusses on how Artificial intelligence is integrated into the IoT systems and the methods used, Section V covers real-time applications and the development in the particular domain.

II. BACKGROUND AND TERMS USED

Background: This paper discusses the general overview of Artificial Intelligence, the Internet of Things, Cloud and their various components. Also, how IoT uses Artificial intelligence to enhance and improve efficiency. Therefore, we will discuss the applications and how integration of AI makes already existing technologies even better.

Motivation: Artificial Intelligence is the field which is explored a lot and development in this field is massive, while IoT is a very fresh technology which is gaining popularity and interests of a lot of people. Integrating these two technologies increases the possibilities and applications and together these will define the future.

Terms:

1. **Artificial intelligence:**

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions) and self-correction. Particular

applications of Artificial Intelligence include expert systems, speech recognition and machine vision

2. **Internet of things:**

Internet of Things (IoT) is a complete ecosystem of various connected devices and physical objects that can connect, transfer data and are accessible through the internet. The 'Things' in IoT can be anything, it can be a sensor, it can be a device or even a vehicle with built in sensors, even a person is included in this. Any object that has an IP address and has a capability to connect to the internet in order to collect and transfer data over the defined network with any manual assistance or intervention as such comes under this. The use of embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.

3. **Cloud (cloud computing or storage)**

Cloud Computing is a term given to any kind of service over the internet, it involves delivering, hosting, processing services over the internet. These are broadly classified into three categories:

- Infrastructure-as-a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Software-as-a-Service (SaaS)

The name cloud computing was inspired by the cloud symbol that's often used to represent the Internet in flowcharts and diagrams.

III. COMPONENTS OF IOT AND ARTIFICIAL INTELLIGENCE

1) Components of IoT

- Smart devices
- Network
- Gateway
- Cloud
- Analytics
- User Interface

2) Components of AI

- Hardware Components of AI
  - Numerical Processing
  - General Problem Solving
  - Heuristic Search
  - Natural Language Processing
  - Experts Systems
  - Artificial Neutral Networks
- Software Components
  - Machine Language
  - Assembly Language
  - High level Language
  - LISP Language
  - Fourth generation Language
  - Object Oriented Language
  - Distributed Language
  - Problem-solving Language
- Architectural Components
  - Uniprocessor
  - Multiprocessor
  - Special Purpose Processor
  - Array Processor
  - Vector Processor
  - Parallel Processor
  - Distributed Processor

IV. METHODOLOGY

The IoT architecture works as shown in Fig. 1. Various kinds of sensors continuously sense the real-world changes happening around them, from here the data collected is transmitted through local networks like Bluetooth to the controlling devices or it is directly transmitted to the cloud via a secured network over the internet. Here the data is first stored in a real-time database. Now here the AI comes in and interprets the data and processes it and stored the important information and discards the redundant data, it also takes real-time decisions based on the input from the IoT devices/ Sensors and generates specific outputs respectively.

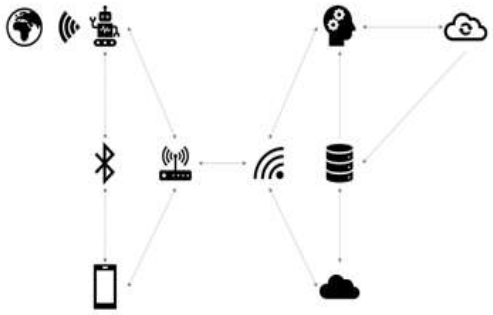

Fig. 1

The approach can vary based on the requirements. A cloud-based AI model can be very effective in the case of huge data processing. With enormous data sets which are difficult to store on a small hardware and with cloud-based ML models the efficiency and accuracy increases. While, if the case doesn't deal with huge data coming in or the response time or latency is the priority then, an on-deviceAI can efficiently manage the rapid changes and requirement of fast and real-time processing and output.

V. HOW INTERNET OF THINGS USES ARTIFICIAL INTELLIGENCE

IoT is about connecting devices and making use of the data generated from those devices. AI is about simulating intelligent behavior in devices of all kinds. There is a clear intersection

between the Internet of Things (IoT) and Artificial Intelligence (AI). As IoT systems will generate vast amounts of data, then AI will be functionally necessary to deal with this huge volume of data if we want to use the data in a sensible manner. Data is only useful if it creates an action. To make data actionable, it needs to be supplemented with context and creativity. IoT and AI together is this context, i.e. 'connected intelligence' and not just connected devices.

Traditional methods of analyzing structured data and creating action are not designed to be efficient and to process the vast amounts of real-time data that stream from IoT devices. This is where Artificial Intelligence come in the picture, the real-time analysis and response becomes critical for extracting optimal value from that data.

AI has advantages in both real-time and post event processing:

Real-time processing – responding quickly to conditions and building up knowledge of decisions about those events, e.g. remote video camera reading license plates for parking payments

Post event processing – identifying patterns in data sets and running predictive analytics, e.g. the correlation between traffic congestion, air pollution and chronic respiratory illnesses within a city center

To be more accurate when we use AI, it really means the use Machine Learning (ML). Machine Learning provides the ability to detect patterns in data presented. And it uses this ability to learn from these patterns and then adapt and adjust the ways in which is analyses the data or triggers actions.

With ML embedded into an IoT environment you get more 'connected intelligence':

- Predictive analytics - 'What will happen?'
- Prescriptive analytics - 'What should we do?'
- Adaptive/continuous analytics – 'What are the appropriate actions or decisions? And How should the system adapt to the latest changes?'

Edge is also a part of the IoT ecosystem, and we are now seeing AI being implemented in the edge. With greater processing power and longer battery life, manufacturers are implementing AI processes in 'edge' devices. For example, a remote video camera – there is no need to transmit the whole video, only data based on certain triggers, e.g. number and location of parking spaces or ANPR, etc. This can be determined on the edge device.

VI. AI POWERED IOT APPLICATION

Internet of Things and Artificial Intelligence is radically reshaping the technological landscape. And it is Expected to play a major role in the looming times, here are some examples as how Artificial Intelligence is used in Internet of Things:

1) Manufacturing

With automation in the industry IOT will reduce the men power in manufacturing plant. We can access each machine and device using IOT infrastructure (such as wireless sensor networks). With the help of IOT systems we can connect manufacturing unit to a different application. By use of these applications we can enhance the productivity of manufacturing. All types of manufacturing industries such as aircrafts, automobiles, household appliances, food and beverage, mining, etc. are integrating smart sensors into their machinery in order to perform prognostic analysis and augment their efficiencies. These industries are looking to set up an autonomous unit which is soon going to be the future rage. Such a setup with smart sensors will help the industries in detecting the vital threat areas and thus diminishing machinery collapses and be lowering down costs. and with the integration of AI in this ecosystem will provide numerous advantages in the flow of the industry, with applications like smart monitoring, intelligent tracking, pattern recognition, defects and quality control and with constant learning of these devices from the surrounding environment will increase the efficiency and accuracy of these devices even more. With the help of such system we can

2) Smart Home

The most explored domain of IoT is got to be the use of IoT in home automation, the term smart home means connecting all home appliances to a common network where each device communicates and shares data with each other. With the introduction of AI in this increase the ease of use and also makes the whole system even more smart. With the integration of AI all the devices will be able to make intelligent and real-time decisions with any human interference of any kind.

Smart home technologies aim to make our lives easier and comfortable by presenting a chance to control the devices remotely, regardless of the location. For example,

Based on your daily routine the system can make decisions in day to day activities like turning on the TV show which you watch daily, start brewing your coffee when by learning the time around which you get ready for work, automatically turn on lights and AC when you reach near your house, etc. Additionally, in case of a casualty, for example fire, it can sense the abnormal environment and open all the windows and contact emergency services. to unlock all doors and make a call to the fire department. It can also be used to efficiently manage electricity

consumption by sensing that no in home or no one is using those appliances and switching them off. It can also be used for security purposes, to monitor unauthorized access to anyone.

3) Smart Cities

Smart cities include smart homes and offices, advanced traffic control systems, smart water supply, safer and automated transportation, security and surveillance and smart lighting.

- Advanced traffic control systems: In IOT car can be treated as smart object and we can use IOT services to make driving smart. With the help of IoT systems like traffic monitoring or traffic signal detection, we can avoid many casualties that happen at a huge rate every day. We can also take traffic routing guidelines to avoid overcrowding and to manage the moving traffic in a more efficient way to make it more convenient for daily commutes. By using IOT it would be possible to track car traffic in metro cities or highways and deploy diverse services that offer traffic routing guidelines to avoid traffic jamming. In this outlook, cars will be perceived as representing 'smart'.

With smart learning, one of the most popular trends is Autopilot in driving or most commonly known as self-driving cars. Autopilot or self-driving means that the car itself drives without any human assist while keeping all aspects of driving like, traffic and traffic rules in consideration. Self-driving cars is a very new domain and it is still under development. Self-driving cars today are only for assist/ to relax the driver during long drives and we still cannot fully rely on the self-driving systems.

- Smart parking devices system: By using information provided by RFID and sensors we can find the free parking space available.
- Safer and automated transportation:
- With the help of sensors, we can monitor the traffic and collect the important parameters of highway traffic
- Sensors may observe the run of vehicular traffic on highways and gather aggregate facts such as average speed and numbers of cars.
- One example is Google's self-driving car takes advantage of Machine Learning approaches to predict the behavior of cars and pedestrians in various circumstances.
- Environmental monitoring: Important environmental parameters would be collected such as temperature, humidity, soil conditions and pollution level of air which can be further used by health agencies. Information provided by the sensors can be used by law agencies to identify the violator or to analyze any accident scene. With this data we can analyze and compute the environmental changes at a very minute level which helps in generating precise reports and can help in taking necessary actions well in advance.
- Smart homes and offices: It makes our lives comfortable and easier. For example, by using smart phones we can adjust the temperature of home, control and automation of lightings, and lock the doors when you are not present in home. With these IOT devices we can save energy as well as time.
- Security and Surveillance: It is an important necessity for today's perspective. In buildings, shopping malls, car parking and diagnostic centers, cinema halls and many other public places we can monitor the suspicious behavior of the people. With the facial and emotion recognition techniques of Artificial Intelligence, behavior monitoring is very easy.

4) Healthcare

The healthcare industry generates showers of data. Sensors from medical devices, healthcare mobile apps, fitness trackers and digital medical records have been producing and collecting patient's data for years.

The AI and IoT approach can help predict diseases, suggest preventive maintenance and provide drug administration. When it comes to health protection or disease control, patients and hospitals would welcome the benefits that come with the AI and IoT approach.

5) Agriculture

With the introduction of AI in agriculture, the process and eased a lot and the yield and increased drastically. The most popular uses of AI in agriculture are:

- Predictive Analytics – Machine learning models are being developed to track and predict various environmental impacts on crop yield such as weather changes
- Agricultural Robots – Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers.
- Crop and Soil Monitoring – Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.

VII. CONCLUSION

As defined Internet of Things is called as the future of human evolution and with AI the future is smart as well. This paper gives a brief overview of IoT and importance and uses of AI in

IoT. We see various applications of this technology being implemented and development in this field is also very rapid. And hence AI and IoT will play a vital role together in the near future.

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