

A survey of merging the Artificial Intelligence Applications with Internet of Things infrastructure different fields

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Abstract:

This study provides a survey of real life application examples that uses the arena of merging the smart systems along with the infrastructure of the IOT.

The applications presented in this study has been built for the fields of healthcare and smart hospitals, industry, smart cities, transportation and the field of the civil engineering.

Results: This surveying-study has shed the light on the growing demand on using such combination on different and critical aspects of people's everyday life, thus, combining the artificial intelligence with the internet of things is considered as one of the modern technologies that are going to be potentially necessary in the future of building the smart societies.

Keywords: Internet of Things (IOT), Artificial Intelligence (AI), Smartness, Machine Learning, Big Data Analysis (BDA), Internet of Every Thing (IOE), Information and Communications Technology (ICT), Machine to Machine connection (M2M).Artificial Intelligence of Things [AIoT].

دراسة مسحية عن المجالات التي يتم فيها دمج تطبيقات الذكاء الاصطناعي مع البنية التحتية لأنترنت الأشياء

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المستخلص :

في هذه الدراسة، تم عرض التطبيقات التي يتم بنائها من خلال عملية دمج تقنيات وتطبيقات الذكاء الاصطناعي مع انترنت الاشياء، ودراسة مدي تأثير هذه التقنية التركيبية على تغيير نمط الحياة العصرية اليومية للناس. اتبعت هذه الدراسة الاسلوب الوصفي المسحي وذلك من خلال استعراض مجموعة من التطبيقات الموجودة علي ارض الواقع والتي تستخدم الذكاء الاصطناعي وتعتمد على البنية التحتية لأنترنت الأشياء. التطبيقات المستهدفة في هذه الدراسة هي التطبيقات التي لها تأثير مباشر على الحياة اليومية في مجالات الصحة وبناء المستشفيات الذكية، الصناعة، بناء المدن الذكية، النقل والمواصلات ومجال الهندسة المدنية. تهدف هذه الدراسة الي تسليط الضوء على مدي اهمية استخدام هذه التقنية المركبة في العديد من المجالات التي تسهم في اثراء المجتمعات المتعدنة بالعديد من التطبيقات الذكية التي بدورها تساهم في توفير العديد من سبل الراحة والامان لمستخدميها، كما تسهم في عملية جمع وترتيب البيانات والمعلومات المطلوبة لأنشاء المجتمعات الذكية. من خلال دراسة ورصد الازدياد الملحوظ في عدد المجالات التي تستخدم

تطبيقات الذكاء الاصطناعي-انترنت الاشياء نجد بان استخدام التزاوج بين التقنيتين قد ساهم بشكل كبير في تطوير المجتمعات الذكية، وبالتالي، فان استخدام التزاوج بين الذكاء الاصطناعي وانترنت يعتبر بنية تحتية اساسية لبناء أي مجتمع ذكي.

الكلمات المفتاحية: انترنت الأشياء، الذكاء الاصطناعي، الذكاء، خوارزم تعلم الالة، تحليل البيانات الضخمة، انترنت كل الأشياء، تقنية المعلومات والاتصالات، اتصال الاله بالاله، ذكاء الأشياء الاصطناعي.

I. INTRODUCTION

The tremendous use of the Internet Technology all around the world has led to a growing interest to connect more and more systems and items that have a direct contribution to the people's everyday life.

The internet now days is not just a network that connects bunch of computer systems to each other for the sake of sharing the information, other items are now connected through the IP technology such as house hold devices, smart phones, and automotive applications. The smart nature of these items provides an inevitable merging between the artificial intelligence and the so called the IOT (Internet of Things).

The first emergence of the internet used the simple paradigm of connecting computers with each other. Later, the emergence of the social media and the virtual societies has increased the scope of the parties from just machines to machines to interconnected systems that provides the digitization of relationships between people and the collection, processing and application of personal data. Thus, has been called the Internet of people. The following figure may further describe the concept of the Internet of people:

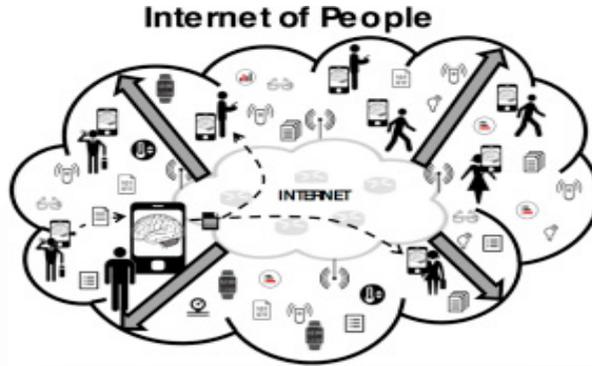


Fig. 1 the Internet of People [12]

Due to the rapid improvement in the ICT, the internet paradigm has taken the term M2M (Machine to Machine), the M2M technology communications refers to technologies that allow

Mechanical or electronic devices to connect with other devices and freely automate

data transmission and measurement using the wireless networks [1].

The same paradigm was recently used to connect the smart objects such as the smart phones, thus, unlike the traditional M2M technologies, the human intervention has become a part of the operation of such paradigm, that is why a new term has been added to this technology and so called the Internet of Things. The following figure illustrates the concept of the IOT and its potential components:

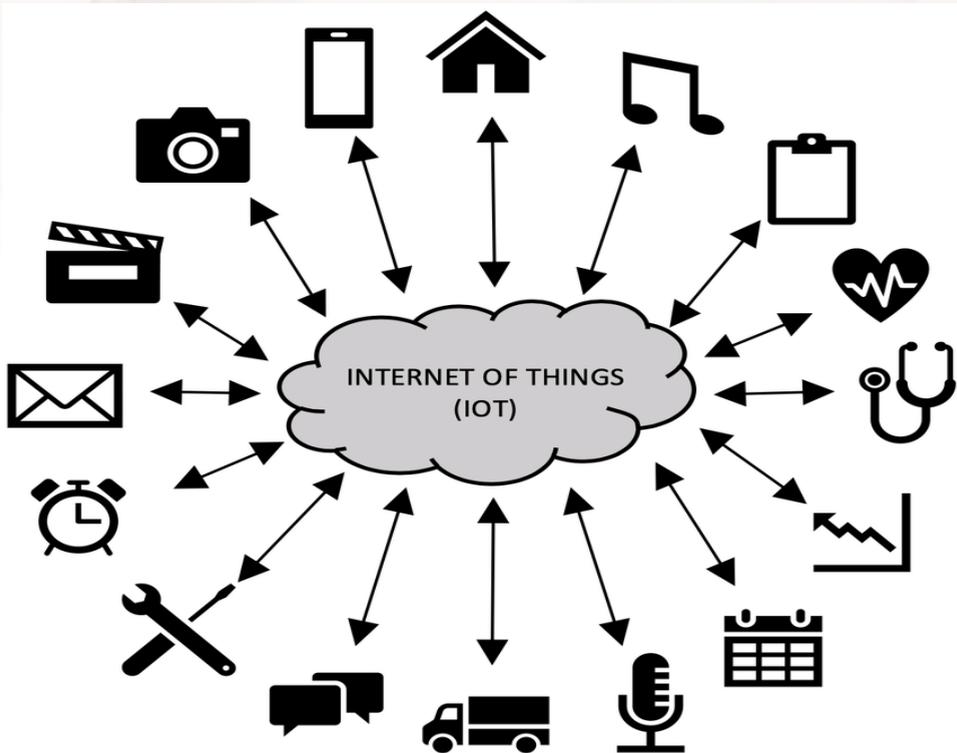


Figure 2: Internet of Tings Diagram [14].

Cisco defines the Internet of Everything (IOE) as the networked connection of people, process, data, and things. The benefit of IOE is derived from the compound impact of connecting people, process, data, and things, and the value this increased connectedness creates as “everything” comes online [13]. therefore, the term IOE (Internet Of Everything) is a more comprehensive term in which the IOT is embedded along with the connection of people, process, data, and things.

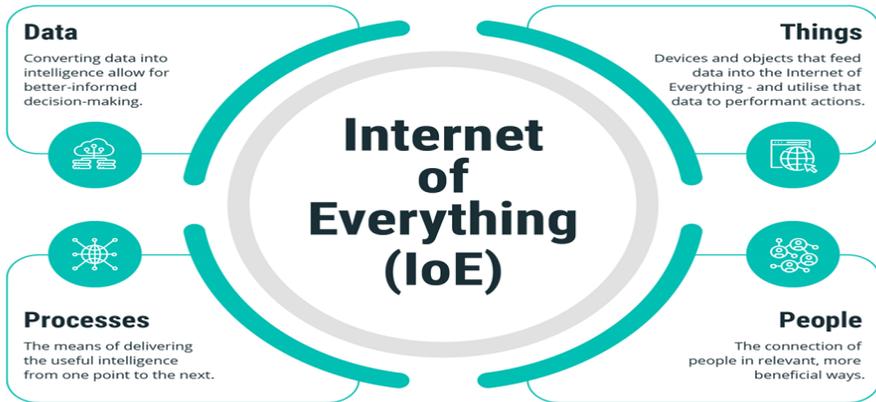


Figure 3: Internet of Everything [13].

The Artificial intelligence of Things is the combination between the Internet of Things and the smart systems, which uses the AI techniques. This kind of combination makes a powerful and important tool for many applications like Drones Manufacturing Traffic, Autonomous Vehicles and robot and smart retail [2]. The following figure reveals the main components of the AIoT:

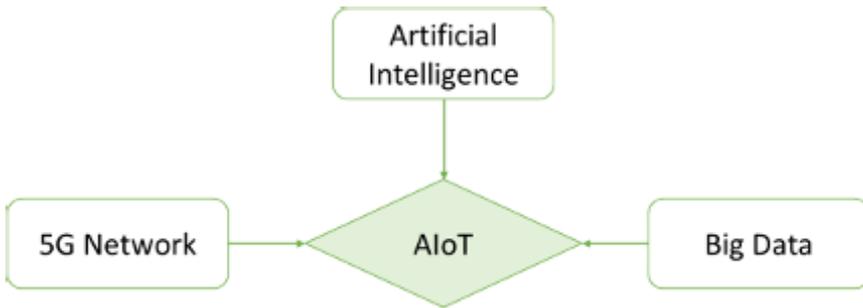


Figure 3: The AIoT main components [2].

II. Combining the Internet of Things with the AI [AIoT] in the Field of Industry

THE fusion between the Internet of Things and the Artificial intelligence affects the field of the industry through the segment of the smart Industries [2], according to the study presented by (Nasreddine et al, 2022), "Smart industries are the industries that rely on the digital transformation to become more efficient and reduce human error. From real-time data analysis to supply chain

sensors". The AIoT such as the smart city, autonomous cars, and the wearable devices also affects other segments. They all use the sensors technology to gather the necessary information that may provide a good contribution in the arena of cost reduction and human-error reduction [2].

The integration of the communication infrastructure and the smart objects along with the computational devices, humans and physical environment forms the term CPS (Cyber Physical systems).

The term Cyber Physical systems has been introduced by Helen Gill at the national science foundation in the United States of America [3]. The term defined by the National Science Foundation (NFS) as "engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components" [3]

Computers are efficient in doing the exhaustive jobs of counting and mathematical stuff, while human efforts are required to do the job of logic and reasoning, this kind of cooperation is applied in real life in order to emerge the artificial Intelligence enabled (IoT-CPS) [3]. The following are real life examples of systems in which the Artificial Intelligence is used to shape the paradigm of IoT-CPS [3]:

1. Energy Utilization: Algorithms have been developed to reduce energy consumption in a coffee machine, or used in temperature control systems of houses, which can make them efficiently consume the local energy.
2. The machine learning of routing and traffic management that gets the parameters of traffic, weather condition, and road condition and decides which routes are the best.
3. Cost savings machine learning that collect information from different sensors to keep track on the usual running conditions of the machines and raise the alarm in case of detecting any unusual anomalies that may occur to the machine, this helps avoiding the accidents and in order to save the cost of troubleshooting those accidents.[3]

When it comes to the software, AIoT uses the intelligent platforms such as the machine learning, deep learning, and the Natural Language Processing (NLP), the following figure illustrates the interconnection between those components:

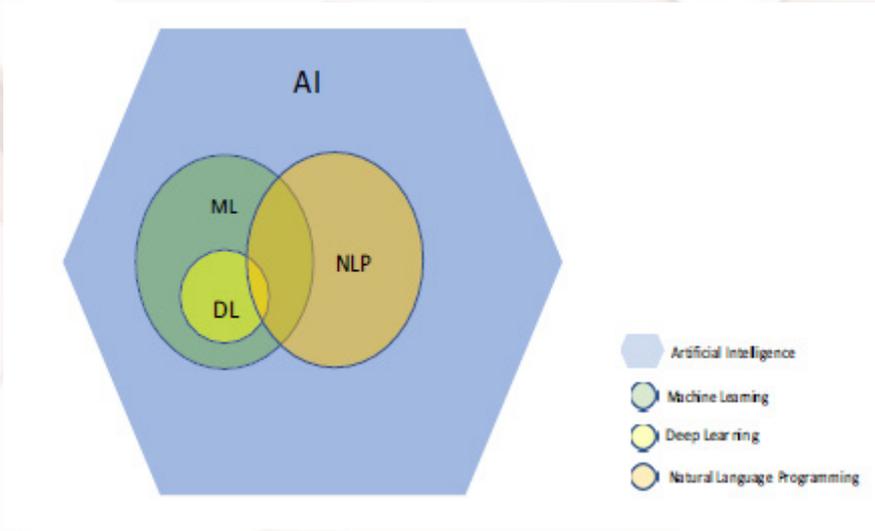


Figure 4: the Interrelation between the artificial intelligence, deep learning, machine learning and Natural Language Programming. [2]

The massive data content that is generated through this interconnectivity called Big Data. The Machine Learning algorithms do the processing and the analysis of this Big Data, this process is called BDA (Big Data Analysis) [3].

Deep Learning is an advanced form of the Machine Learning, it is based on the structure and the function of the human brain specifically the neural networks, neural networks simulates the functionality of the biological neural networks structure of the human brain [7].

According to Russu Loan, and Kolomiets Alona, “The links between AI and IoT are very similar to the relationship between the brain and the human body. Through the senses, our body collects sensory information: we see, hear, feel, and touch. Further, this information enters the brain for processing, and the brain gives a signal for further action” [7].

III. Combining the Internet of Things with the AI [AIoT] in the Field of the Supply Management

The Term Supply chain usually refers to managing the connectivity between the company and its supply provider. This connectivity may involve different items such as people, entities, information and resources.

A real life example that implements the technology of the AIoT in the domain of the supply chain management is the Amazon Alexa [4]. Amazon Alexa is an AI application service provided by Amazon™, according to Amazon developer’s website,

Alexa is a voice interaction assistant software agent that is used to connect the different household devices into a single cloud; Alexa may be available in Amazon devices such as Amazon Echo, Echo Dot, Echo Spot, Echo Show, or Amazon Fire TV; also it may take the form of software application that can be downloaded and installed in smart phones.

Other applicable examples in the field of the supply chain management like a drone with numerous sensors that can obtain the data about the environment required to fly an unmanned vehicle. Also smart household devices such as smart refrigerators that is capable of ordering the grocery without the human intervention [4].

The connected smart warehouses also are good examples of using the AIoT, its robotic nature is smart enough to deliver the right inventor to the right place, thus, the order fulfillment process will become faster, safer, and more efficient [6]

IV. Combining the Internet of Things with the AI [AIoT] in modern society

Modern society is a generic form that involves so many items concerns the life style of the modern societies such as smart cities, smart agricultures, life style and health monitoring wearable devices [5].

A real life example of the smart cities is the city of Chicago; they have an array of things with many sensors that are used to keep track of the city fitness, it is done by sensing the information about the changes in the weather state. The city of Las Vegas also have sensors that gathers information about the traffic and the air-conditions in order to control the quality of the breathable air and avoid the air pollution accidents, other smart cities may sense the weather fluctuations and the rise in the sea water for the sake of issuing early notifications that helps the citizens to avoid the natural disasters [5].

Another example of the smart IOT contributions in the arena of the modern society is the smart agriculture, using the sensors that collect data about the weather conditions for example will help in improving the quality of farm produce by sensing the suitable environment for the growth of certain crops.

In the health industry, using the smart wearable trackers that collects information about the patient's blood pressure and oxygen level and other vital measurements may help the medical staff to provide a quality service to their patients and keep an updated and accurate record sets about their health state [5].

Smart homes, as a part of smart cities are home buildings that are equipped with the network of sensors, devices, and appliances that are accessed and controlled by smart phone application, smart home services are essential because it allows the house

owners to remotely control the house, and also to help them keep track of the security stuff [9].

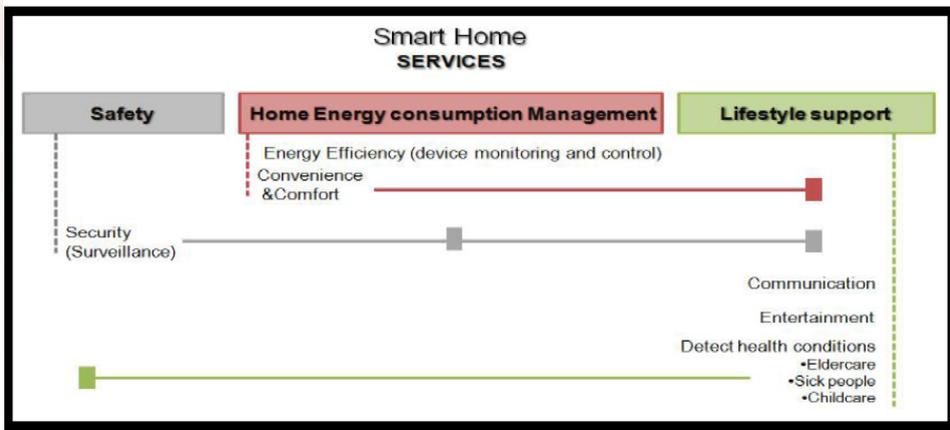


Figure 5: Smart Home Services [9]

v. Combining the Internet of Things with the AI [AIoT] in the field of Transportation

The internet of things and artificial intelligence interconnection may play a key role on ensuring the safety of using the roads in the smart cities [8]. This AIoT fusion also helps the drivers to avoid the accidents through controlling the traffic by using the machine learning algorithms that collect the information from the intelligent sensors.

Using dynamically deep learning technology such as the Deep Reinforcement Learning module can be used to solve the problems of path planning and other continuous control problems, for example, designing an autonomous path plan model for unmanned ships.

In the study presented by (Siyu Guo et al, 2020), a Deep Reinforcement Learning model (DRL) is proposed to realize the intelligent path planning of unmanned ships in the unknown environment [8]. Using the Deep Deterministic Policy Gradient (DDPG) algorithm to do a continuous evaluation job of the surrounding environment and make the proper interaction method based on the historical experience data [8].

Moreover, a study presented by (Kh Tohidul Islam et al, 2020) proposes a vehicle license plate recognition; the proposed system is a Vision Based machine learning method that is installed in a barrier access control [16]. This system is a computer vision effective real time system consists of two stages, detection and recognition.

The detection stage is the image processing stage that identifies the area of interest by collecting the segments of the license plate. The recognition stage is the

stage of detecting an identifying the character of the vehicle's driver, thus, an optical character recognition system (OCR) is used to fulfill this stage. The stage of collecting the license plate segments and localizing the plate is based on deep learning method for object detection, while the character recognition stage is using an Artificial Neural Network (ANN) [16].

v. Combining the Internet of Things with the AI [AIoT] in the field of Civil Engineering
Developing countries and the third world countries suffers from the lack of experience and skilled workers[10], applying the IOT with the Artificial Intelligence (AI) can solve this problem, "The application of artificial intelligence (AI) and internet of things (IoT) has the potential to reform structural designing, construction practices, quality assurance, construction management" [15]. This can be achieved by using meta-heuristic algorithms coupled with machine learning (ML), meta-heuristic algorithm minimizes multi-objective function while the machine learning reduces the time of processing and thus, reduce the cost associated. Machine learning can be also used to adjust the potential errors caused by an unexperienced designer [10]. The heuristic multi-objective function must include all the parameters concerning the practicality of the construction, further; this will decrease the waste in the construction materials such as the concrete [10]. Using the IOT and the AI in construction building can also add the advantage of the real time monitoring of construction and detect the human and non-human errors during the activity of construction. Using the real time monitoring has the advantage of saving money and saving lives by minimizing the errors that may cause the loss of the property or even worth the loss of lives duo to occurrence of the disasters.

v. Combining the Internet of Things with the AI [AIoT] in the field of Healthcare (Smart Hospitals)

According to a study presented by (Mann, Suman et al, 2020), Smart Hospital is defined as "a hospital that relies on optimized and automated processes built on an ICT patient care procedures and introduce new capabilities" [11]. This achieved by wired or wireless sensors incorporated into ECG monitors, smart thermostat, and blood pressure monitor. The advantages of using the concept of smart hospital are big, it involves the comfort of the patient's life, increase the efficiency of the patient health monitoring, provides less power consumption thus, decreases the cost charged on the patient, beside, it is easy to use and understandable for both the patient and the doctors.

Dr. Maharaja's paper propose a two phase Smart Hospital Framework as follows:

1. Phase 1:installing an IOT device in the hospital's main circuit board, the function of his IOT minicomputer-single board device is to monitor and control all the sensors that are installed in the building, one of the following brands can be used to fulfill this phase:

- a. Raspberry Pi.
- b. PcDuino.
- c. Beagle bone Black.
- d. Cubie Board.

The IOT device will receive the wireless signal from the router to get into the interconnectenetwork and do the storage in the database cloud [11].

The sensors that are required to be available in the building in order to feedback the IOT device are the following:

- a. Heart Rate sensors.
 - b. Temperature Sensor.
 - c. Air Bubble detectors.
 - d. Humidity sensors.
 - e. Sleep sensors.
2. Phase 2: developing a mobile application to act as an out front of Stage one, also the application is responsible of sending the alert signals form patient to nurse and from nurse to doctor in case of emergency [11]. This will make the quality of care to the patients more efficient. Thus, this application will make patient safer and connected to nurses and doctors [11].

vi. Conclusion

The combination between the Internet of Things (IOT) and the Artificial Intelligence (AI), is pretty much important in the evolution of many fields, this technology is a truly life changing technology and it forms the characteristics of the future of computing and internet technology.

The increasing demand on this paradigm may take a big step forward in the both domains of the Internet technology and the artificial intelligence. The shape of the Internet of Everything will become more and more comprehensive by applying this fusion of IOT and AI, thus, it will affect almost all the parts of everyday life especially for the nations that have the eager to apply the concept of the smartness and intelligence in their lifestyle.

In this paper, a surveying study presenting the way of how this fusion between the Artificial Intelligence and the internet of things (AIOT) has been applied on the fields of Industry, modern society, supply management, transportation, civil engineering, and the health care.

The examples presented and surveyed in this study exist already on real life. Those are not only the fields that uses the merging between the AI and the IOT. Nevertheless, using the IOT in those critical fields clearly manifest the importance of this technology to the humankind.

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