IoT Based AI and its Implementations in Industries

Sherif El-Gendy
School of Information Technology and Computer Science
Nile University
Cairo, Egypt
s.elgendy@nu.edu.eg

***Abstract*—The Internet of Things (IoT) is an Internet revolution that is increasingly used in business, industry, medicine, the economy and other modern information society. IoT, particularly transport, industrial robots and automation systems are supported by artificial intelligence in a wide range of daily implementations with dominant industrial applications. IoT is an interconnected network of physical objects, which enables them to gather and share information, using software, sensor units and network connectivity. In industries; IoT brought about a new revolution in industries. In the field of IoT, the term "INDUSTRY 4.0" has been used where industrial devices and machines are connected over the internet and interacting to make decisions via Artificial Intelligence (M2M communication). This paper focuses on IoT and AI integration worldwide, addressing current and future uses for social-value.**

***Keywords*—Industrial IoT (IIoT); IoT- based industrial automation; Internet of robotic things (IoRT); IoT- based robotics.**

I. Introduction

There are many commonalities among various IoT and AI systems. Driven by the rapid changes in technology and significant increase of operational efficiency, several businesses integrate AI into their IoT systems workflow from Data improvement, activities automation to final decision making in relation to machine learning, intelligent reasoning and others.

Recently, Industrial Internet of Things (IIoT) has tremendously provided several machine-to-machine interfaces for authorized stakeholders to efficiently collect, process, evaluate and visualize their IoT-connected data and applications. The advances in both wired and wireless communication and smart connected devices have a major impact on many IoT architecture [1]. Previously, both Bluetooth and Radio Frequency (RF) offered limited connectivity ranges for monitoring and surveillance in different industrial applications [2]. IoT-based automation has much to offer in this regard [3].

The main objective of this paper is to provide an overview for the integration possibilities of AI / IoT, focusing on its implementation in automation and robotics, specifically:

a) Outlines an overview of History, present and future of IoT enabled by AI.

b) Presents fundamental issues about the integration between both of IoT and AI.

c) Explains the principles of the "Industrial Internet of Things" (IIoT), "Industrial Automation Internet of Things" (IAIoT), and "Internet of Robotic Things" (IoRT).

d) Summarizes a variety of case studies in many industries.

e) Summarizes applications of IoT-based robotic.

f) Discusses an application of IoT-Based Industrial Automation.

II. History, Present and Future

Previously, industrial automation was first demonstrated in Steam and water power as shown in Figure 1. In 1712, Thomas Newcomen's" used it as the first safe and efficient steam power plant. Electricity was then applied in the mass production industry.

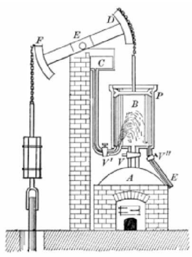

Fig. 1. Newcomen's atmospheric steam engines [26]

When computers were first created and developed for specific computing applications. Afterwards, they have eventually provided cheaper and faster solutions for industrial automation. Several advances in Bluetooth and RF technologies have been used in connection over the close distance [4] [5].

Fig. 2. Automation in industry based RFID[27]

IoT-based solutions have a major impact on both long distance communication and automation of many industrial applications [6]. Figure 3 demonstrates that IoT can help make life easier for business and other industries.

2020 15th International Conference on Computer Engineering and Systems (ICCES) | 978-0-7381-0559-8/20/$31.00 ©2020 IEEE | DOI: 10.1109/ICCES51560.2020.9334627

978-0-7381-0559-8/20/$31.00 ©2020 IEEE

Fig. 3. IoT in different fields [28]

III. IoT BASED AI

Driven by the continuous improvement of both AI and IoT technologies, such integration has been introduced in many business areas as the catalyst of the fourth revolution over the next few years [7]. AI solutions are expected to revolutionize

IoT-based implementations in certain ways such as Machine Learning (ML), reasoning and software programs. The integration between AI technologies and Big Data analytics has much to offer for IoT. AI helps us understand and analyze such huge amounts of data patterns obtained from IoT practice for better decision making. The interaction of these systems in devices such as (Amazon's "Alexa") and "Google Home" are already obvious at a personal level [7].

In the AI / IoT data analysis, the operations needed are as follows [7]:

a) Data preparation (defining and clean data pools).

b) Data discovery (find useful information in given data pools).

c) Data streaming visualization (dealing with flying streaming data, smart and fast discovering and visualizing for data, such as making quick decisions without delay).

d) Data reliability (maintain high confidence in high data quality and honesty in the collected data).

e) Accurate / advance data analysis (make accurate decisions based on data collected).

f) Real Geospatial time and location (smooth and controlled data flow) "Logistic data".

A review is given in [8] of the technology possibilities and paths for integrating AI, cyber-physical systems (CPS) and IoT, with a technical forecast based on extensive field explanations and advances as well as communication traits. The convergence of IoT and AI is known by the "cognitive IoT" [9], according to Sudha Jamthe. There are several examples for the interaction of AI and IoT in [10]. One of these examples buildings' air conditioning appliances, and investigates what happens on an extremely hot day when the local utilities having brownouts. The system could flow robustly in this case, and the service personnel would need to expend extra time and money on clients who are irate about restoring the service. When the buildings' thermostats and the appliances are related to an IoT network, the service personnel will be able to identify how many conditioning appliances are attached to the grid and respond by switching the thermostat of all 3 degrees up, thereby avoiding a brownout. An optimized AI system would automatically do the same work; a more complex AI program would proactively transform thermostats 3° in homes and non-essential enterprises, while retaining balanced thermostats in hospitals or cooled warehouses.

Big data generated by IoT is believed to be strong on its own as well as AI, but together they are turned to be the superpowers in the digital existence. Researchers in the area of information expect the scale of the digital world to increase every couple of years by double, which results in fifteen times higher increase between years 2010-2050. AI technology needs for bigdata to achieve meaningful results. In addition, the big data analytics problem can be fixed by AI.

With the continuing growth of AI integration with IoT, IoT will be driven six drivers which become the most important factors for big-data and cloud computing [11]:

- Decreasing cost of CPU, memory and storage.
- Convergence of IT and operational technology.
- Advent of big data and cloud.
- Increasing device proliferation.
- Decreasing the cost of megabit/second
- Increasing in venture capital spend and investment.

In IoT world, AI faces challenges such as:

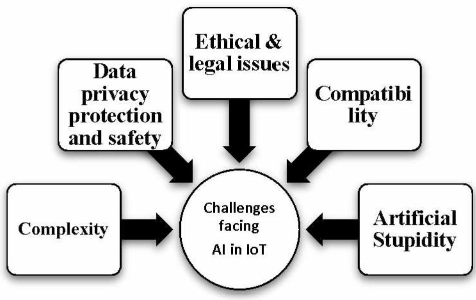

Fig. 4. Challenges facing AI in IoT

IoT applications can be categorized as one of the below [12]:

a) House or personal data (sensor's unit data is gathered and processed by those who own the network).

b) Enterprise (including IoT in working environments, such as offices, companies, organizations, etc.)

c) Utilities (to automate services such as surveillance of the water networks, smart assessment and measurement.

d) Movable logistics (including but not limited to; road traffic, smart transportation, smart city traffic, and smart logistics).

There are many industries that adopt AI-IoT including smart automotive, healthcare, education, security and others. Connecting various devices with minimal processing, storage and energy resources in many powerful applications such as; Home automation, Wearable related technology, Medical and Healthcare "MHCs", Retail, Banks, Transportation and others.

IV. INDUSTRIAL INTERNET OF THINGS "IIOT"

The Internet of Robotic Things (IoRT) concept is an outcome of the integration of robotics and IoT. IoRT deals in fact through the communication between robots and devices by Machine to Machines (M2M) in ecosystems in which data is used to perform analytics and get actionable results. The Robot is a smart machine that activities can be tracked, and the information from multiple sources can be combined so as to decide and execute the best possible course of action, for example, walking around and controlling the physical environment in this environment. Possible IoRT implementations include:

a) To test if a vehicle can use a specific parking lot in a parking area using a robotic device

b) IoRT and humans are involved in making operational and other actions in one processing unit.

c) Use the IoRT principle to make intelligent transport systems (ITS) more versatile and efficient.

d) Using IoRT to assist older people and to wash the kitchen.

Intelligent industrial automation is an important technology field of IoT. Conventional industrial automation has been fully modernized with IoT technology support, such as M2M communication, sensor networks integration, and wireless connectivity. Many small and large companies have already implemented IoT innovations and are using them. The present automation status, named Industrial Automation 4.0 or the Industrial Automation Internet of Things (IAIoT), is reflected by the IOT-based industrial automation. The word ' Industrial Internet of Things' (IIoT) encompasses both IoRT and IAIoT. IIoT also includes applications for industrial automation and development. IIoT requires smart devices that function as a component of a wider network, or as one of the systems that include the intelligent industrialization system (machines, engines, robots, actuators, power grids, sensor cloud, etc.). Connected resources are able to monitor, capture, interpret, share and respond on data / information immediately so that their output or behavior changes automatically and intelligently. The IIoT devices analysis framework [13] offers a functional identification scheme that relates to the safety issues of IIoT. IIoT provides reduced costs and improved operational efficiency, followed by higher product quality (less defects, better material availability, etc.).

Figure 5 provides a pictorial example of the components of industry 4.0 and the output of the' intelligent factory' IoT / IoRT, cyber-physical networks and cloud computing are the primary elements. The chatbot is strong interface will support engineers, easy to use, provides real-time communication with IoT and robotics, has a question-and-answer layout, and is a great framework to AI. Figure 6 [14] shows a typical IoRT-based robot factory floor.

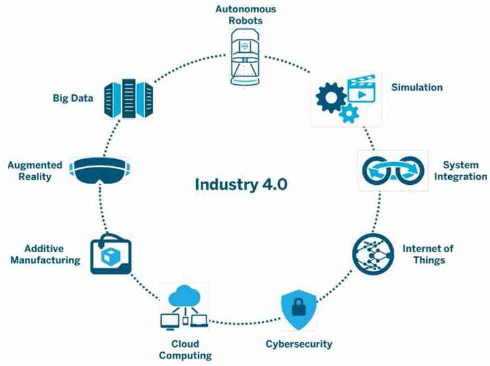

Fig. 5. "industy 4.0" constituent parts. A ' chatbot ' is a new interface for communication between people, sensors, robotics and big data. [29]

Fig. 6. Intellegent IoRT-based industrialization line. [14]

There is a discussion about the IoT challenges and technological solutions for industrial automation in [13], including defining problems to long-term and evolving IoT-based industrial automation. The following are some of the IIoT challenges taken into account in [15]:

a) Latency and information scalability (can be dealt with via computing localization).

b) Criticality mixing (can be handled by segmenting of the system).

c) Secure collaboration in real-time (can be handled by using the method of "zero configuration networking").

d) Tolerance to failure (can be handled by redundancy of networking or local flaw detection near the terminal devices).

e) Functional safety (separation of the safety issues from IoT will fix this).

V. CASE STUDIES

A collection of case studies and implementation examples, especially in automation and robotics, give us a better understanding of the scope of IoT / IIoT usages.

Oil field production

IoT has helped maximize oil and gas field production. The collected data is approximately 18,900 per day. Oil production levels, temperature, well pressure and other parameters for approx. 21,000 wells are assessed.

Further data analysis and transformation are performed to determine the costs related to IoT data analysis. The collaboration between the IoT industry analytics has led to significant progress [16].

Home appliances automation

Home appliances automation monitoring and control system based on IoT is defined in [17]. This is an integrated system that uses an intelligent energy conservation PIC microcontroller. Many domestic appliances can be managed and programmed by an easy-to-use mobile GUI, such as lights and a fan on / off. The units are integrated to the embedded micro-web server over LAN or WiFi for use in Android-based mobile apps with connectivity, tracking and control of devices and appliances. The system also tracks computer activity.

ABB Smart robotics

In order to develop an effective maintenance system, this multinational robotics company has adopted IIoT. Many connected sensor units monitor their robots' maintenance requirements (with five continents) and start the repair of their components prior to interruption. IoT is also the basis of the company's collaborative robotics. Its YuMi model is able to work with people via Ethernet and industrial protocols (Profibus, Device Net, etc.) [18].

Fig. 7. ABB Smart robotics “YuMi model” [30]

Boeing smart industrialization

The global aviation corporation "Boeing" adopted IIoT technology in its factories and supply chains in an attempt to improve productivity and constantly increases the number of embedded sensors with its aircraft. Boeing is currently working for a very important range of services whilst at the top of the aviation information providers [18].

KUKA connected robotics

The company has an IoT program covering entire factories. As stated in [18], Jeep asked from KUKA to help build a facility, which could manufacture a car body every 77 seconds. Through helping the company create an IoT-based factory with 100 robots connected into a private cloud by KUKA. Thus, it is possible to produce more than 800 vehicles every day.

VI. IoT-BASED ROBOTIC APPLICATIONS

The array of IoT-based robotic systems includes robotics for the automotive industry, health services, military, space exploration, deep-sea reconnoitering, rescue, and security operations. IIoT helps resolve a variety of industrial related issues, such as; monitoring of production machine’s temperature and pressure, electrical grid monitoring, and so on. Includes boundary intruders in ship ports, air ports, railroad stations identified by IoT applications. IoT combined with AI for successful communication of human robots (perception, understanding of natural languages).

In the activation of robot features such as agility, sensing, simulation, etc.., cloud robotics play a major role. For advanced, ubiquitous ecosystems, robotic systems based IoT often have applications for communications of close distances technology, designing the network and maintaining security. Autonomous vehicles are one of examples of robots connected to the cloud internet that allows access to the map and satellite image server. A driverless vehicle can precisely localize its location (within centimeters) through sensor fusion, to take advantage of broadcasting their camera and the global positioning system (GPS) with 3D sensors. Figure 8 shows the driverless vehicle capabilities accomplished by proper sensors. The vehicle also has an IoT platform connection.

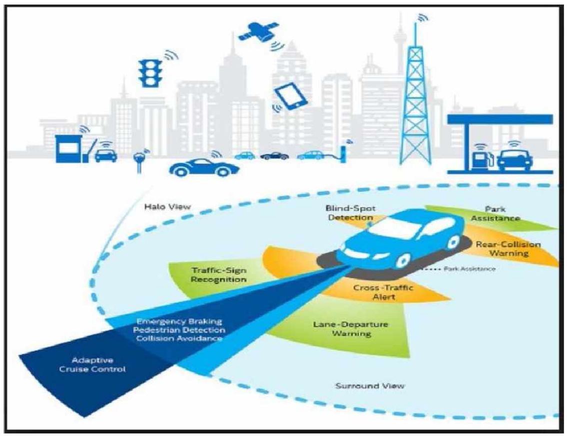

Fig. 8. 360° awareness driverless vehicle connected to the Internet of Things. The vehicle has sensors for safe traffic. [31]

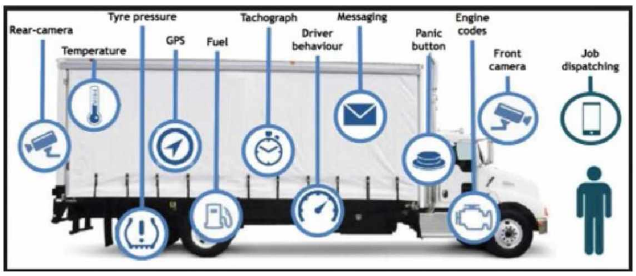

Fig. 9. IoT connected truck [32]

A typical IoT / AI enabled truck with sensors is shown in Figure 11. When the vehicles are linked to IoT and drive on intelligent highways, the mobility advantages are:

a) Performance of transportation (transit and parking information are generated for maximum efficiency and lowest congestions).

b) Lower cost of operation (by providing preventive maintenance based on accurate operating and diagnostics information that increases assurance and efficiency).

c) Better security (the linked vehicles allow for cooperation and guarantee the avoidance of collisions and protection).

It should be noted that any vehicle connected with the cloud internet have vulnerabilities to possible cyber-attacks, as the case with IoT-based usages often, and special controls should be taken. Home security is one of the important uses of IoT / AI enabled robotics. As an example, "AppBot" is an intelligent robot for safety at houses, the internet-managed robot (Figure 10).

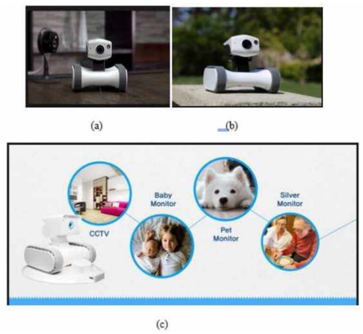

Fig. 10. The intellegent house robot “AppBot”[33]

The intelligent robot has the following information:

a) Distant control and live stream.

b) Videorecording and snapshot.

c) Recognition of movement and monitoring.

d) The interaction conversation is clear

e) The house router can be connected and access from all over the world.

f) The robot can spontaneously rotate itself if intruders appear in a house to capture them and send alarm messages in seconds.

VII. IoT-Based Industrial Automation

In this case, the IOT / AI-based industrial automation systems define a symbolic system that generates warnings and notifications and makes intelligent decisions. The IIoT allows remote sensing and device tracking across the network. Figure 11 shows the structure of this method.

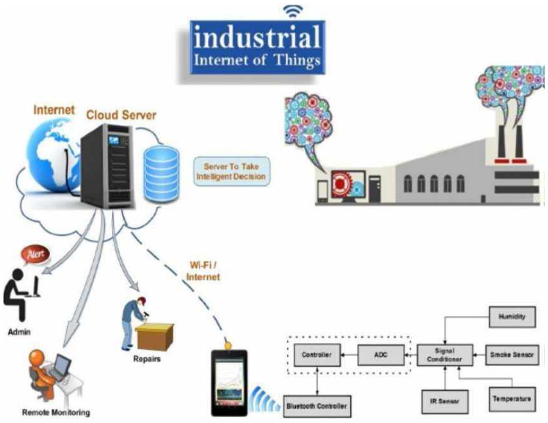

Fig. 11. IoT/AI based automation system diagram. [22]

The unit is fitted with sensors for the perception of atmosphere and environments (e.g., temperature, pressure, humidity, noise, interference, etc.). The anlogue signals are inserted in the Android control unit which checks the system administrator's defined thresholds and compares them to incoming anlogue signals. If an irregular or anomalous situation happens, the network operator can be sent warning or alerts with specific equipment (e.g. Buzzer, Alarm Fan, etc.).

The program will then take appropriate steps to solve the problems with the help of AI based on previous knowledge and identical situations contained in the database, the cloud is ideal as a scalability database. Industrial IoT in cloud computing provides services such as storage, servers, networking, applications, databases, analysis etc. The cloud storage permits the distant database not to keep files on a local storage device but to save data files. The network shares within cloud computing is quicker than access through other networking services. The cloud computing applications in the industrialization sectors are shown in Figure 12.

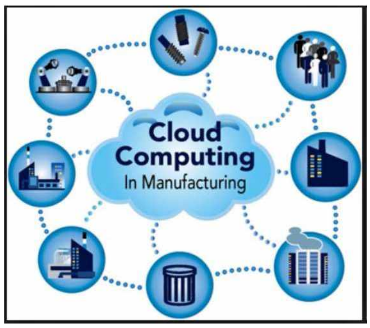

Fig. 12. Cloud computing in manufacturing sector. [34]

VIII. Conclusions

Recently, IoT has a major contribution to humanity in many aspects and multi-disciplinary design as well as complicated and large-scale systems. The integration with AI has already shown considerable success. The continuous development along with many unforeseen beneficial consequences are expected to revolutionize many industries in the near future.

In this paper, I addressed the advent of intelligent things on the Internet with more capabilities than mere sensors, including

AI processing and actuation. This makes possible a new Internet of things that integrated with AI in robotic and industrial automation applications; such as intelligent agents and potentially future living beings. IoT enables the successful management of the facility management, monitoring production flow, inventory control, logistics, supply chain management and robotic operations in industrial / robotic automation. While IoT protection gained significant attention from the beginning, the approaches which have been developed and used to date have not been fully successful. In reality the greatest challenges in IoT and IIoT implementations still remain protection and confidentiality.

Globally, the development of decentralized and multifarious IoTs is still a challenging procedure. New forms of interconnectedness, interrelation, and interdependence need to be developed for IoT-based solutions alongside shared and collaborative resources. The ethical aspects and standards of both IoT and AI systems and applications have to be considered in the actual practice and implementations [19 - 25].

REFERENCES

[1] Mark D. Sengupta (2014), CSIA Executive Conference San Diego.

[2] M. Kim and K. Kim, (2012) *"Automated RFID-Based Identification System for Steel Coils"*, Progress in Electromagnetics Research, Vol. 131, 1–17.

[3] S.d.t. Kelly, n.k. Suryadevara and S.C. Mukhopadhyay (2013), *"Towards the Implementation of IoT for Environmental Condition Monitoring in Homes"*, IEEE Paper.

[4] Jinsung Byun, Insung Hong, Byoungjoo Lee, and Sehyun Park (2013), *"Member Intelligent Household LED Lighting System Considering Energy Efficiency and User Satisfaction"*, IEEE paper.

[5] Gopinath Shanmuga Sundaram, Bhanuprasad Patibandala, Harish Santhanam (2013), *"Bluetooth Communication using a Touchscreen Interface with the Raspberry"* Pi 978-1- 4799-0053-4/13/31.00 IEEE.

[6] Li Da Zu (2014), *"Internet of Things in Industries: A Survey"*, IEEE Transactions on Industrial Informatics, vol. 10, no. 4.

[7] Ahmed Banafa (2017), *"Internet of Things: Why IoT needs AI"*, IEEE. https://medium.com/@banafa/why-iot-needs-ai-4c5759d17c23 (visited 1/12/2019).

[8] Klumpp M (2018), *"Innovation potentials and pathways merging AI, CPS, and IoT"*. Applied System Innovation 1(1): 5.

[9] Jamthe S (2016), *"Business Junction of IoT and AI"*. https://www.slideshare.net/sujamthe/business-junction-of-iot-and-ai-ebusiness-2016-thailand-17-nov-2016 (visited 15/11/2019).

[10] Sappin E (2017), *"How AI and IoT must work together: R2 uses big data to develop IoT solutions for enterprise customers"*. https://venturebeat.com/2017/06/28/how-ai-and-iot-must-work-together/ (visited 18/12/2019).

[11] PWC (2015), *"Leveraging the upcoming disruption from AI and IoT: How artificial intelligence will enable full promise of the internet of things"*. https://www.pwc.com/gx/en/industries/communications/assets/pwc-ai-and-iot.pdf (visited 18/12/2019).

[12] Boyes H, Hallaq J, Cunningham, Watson T (2018), *"The industrial internet of things (IIoT): An analysis framework"*. Computers in Industry Vol.101: pp 1-12.

[13] Cubbi J, Buyya R, Marasic S, Planiswami M (2013), *"Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions"*. Future Generation Computer Systems 29: 1645-1660.

[14] Alba M (2017), *"Thing Worx and Deloitte release plans for industry specific IoT solutions"*, https://www.engineering.com/IOT/ArticleID/14453/ThingWorx-and-Deloitte-Release-Plans-for-Industry-Specific-IoT-Solutions.aspx. (visited 15/11/2019).

[15] Breivord HP, Sandström K (2015), *"Internet of Things for industrial automation: Challenges and technical solutions"*. Proceedings of IEEE Conference on Data Science and Data Intensive Systems (DSDIS) pp. 532-533.

[16] Gurav U, Patil G (2016) *"IoT based interactive controlling and monitoring system for home automation"*, International J of Advanced Research in Computer Engineering and Technology (IJARCET) 5(9): 2392-2396.

[17] Bolen A (2018), *"3 IoT examples from 3 industries: Real world implementation achieving results today"*.

[18] Buntz (2017), *"Industrial IoT: The top 20 Industrial IoT applications"*.

[19] Tzafestas SG (2016), *"Roboethics: A Navigating Overview"*. Springer, Berlin, Germany.

[20] Tzafestas SG (2018), *"Information, Communication, and Automation Technology Ethics in the Knowledge Society Age"*, Hauppauge. Nova Science Publishers, New York, USA.

[21] Chowdhury AR (2017), "*IoT and robotics: A synergy*". http://docplayer.net/65239767-Iot-and-robotics-a-synergy.html (visited 22/11/2019).

[22] Dalataela MP, Accentura N, Griego L, Boggia G, Dohler M, et al. (2013), *"On optimal scheduling in duty-cycled IoT using IEEE 802.15.4c TSCH"*. IEEE Sensor J 13(10): 3655-3666.

[23] Potter C, Haneke G, Silva B (2013), *"Machine to machine possible applications in industrial networks"*. Proceedings of IEEE International Conference on Industrial Technology (ICIT) 2013: 1321-1326.

[24] Kuffner JJ (2010), *"Cloud-enabled robots"*. IEEE RAS International Conference on Humanoid Robots, Nashville, Tennessee, USA.

[25] Manasseh E (2018), *"Combined artificial intelligence and IoT for smart sustainable cities"*, 1st Forum on Artificial Intelligence and the Internet of Things in Smart Sustainable Cities in Latin America, Buenos Aires, Argentina.

[26] https://en.wikipedia.org/wiki/Newcomen_atmospheric_engine

[27] https://www.rfidhy.com/rfid-manufacturing-sector-profitability/

[28] http://rkyadav56.blogspot.com/2017/07/iot-internet-of-things.html

[29] https://chatbotslife.com/the-role-of-chatbot-in-industry-4.0-acf2b0ac8bb6

[30] https://new.abb.com/products/robotics/industrial-robots/irb-14000-yumi

[31] https://blogs.intel.com/iot/2015/11/23/building-the-next-generation-car-with-intel-iot

[32] https://rctom.hbs.org/submission/coca-cola-original-formula-in-an-iot-world

[33] https://iot.do/devices/appbot-security-robot

[34] www.evidentsoftware.com/latest-cloud-solutions-for-it-industry