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Role of Electronics in Industry 4.0

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Abstract: *Industry 4.0 is the fourth generation of Industrial Revolution which is majorly focused on automating the processes in an industry and making the work flow more efficient. This paper is designed to present a literature review on the role of Electronics in realising this revolution and provides explanation with examples that how electronics is in the core of Industry 4.0. Industrial automation is a technology that is growing continuously and a lot of research & development work is going on in this field. The process of automating various machineries and processes in any industry with the help of control systems such as robots or computers, which reduces the need of human resources, is known as Industrial Automation. This paper also describes the evolution of smart factories from Industry 1.0 to Industry 4.0.This paper also explains the technologies which form the backbone of Industrial Revolution and these are Internet of Things, Machine Learning, Embedded Systems, Artificial Intelligence and Robotics. All of these mentioned technologies require electronic circuits to form the hardware which is incorporated with the software to make the machines do desired operations by giving instructions from a normal device like Smartphone and remote controls from any corner of the world. Since new technologies such as augmented reality are being used in Industry 4.0, the employees of the companies will require good skills and qualifications for the controlling and maintenance of the machines. So, with Industry 4.0, there also comes some new risks and a new concept of Skill set and Education will be required that will connect the real world and the virtual world.*

Keywords: Industry 4.0, Smart factories, Industrial Automation, Internet of Things

1. INTRODUCTION

In every country, there are certain sectors which drive the growth and employment in that country and those sectors requires industries for the manufacturing of those well furbished products. Therefore, the industrial sector is important to every country's economy. As we know, Industry, as we see it today, was not the same at the beginning. Instead, it has undergone over a time, a series of "Industrial Revolutions" with increasing complexity and productivity that changed the existing paradigm. The first generation of industrial revolution was named as "Industry 1.0" and since then it has continuously evolved and the current version of this revolution is termed as "Industry 4.0". The first industrial revolution that occurred in last few decades of seventeenth century was orchestrated by the invention of steam and water powered engines and machines. The second industrial revolution happened by the starting decades of 20th century, when the primary source of power was electricity and machines were developed with their own power sources to make them more reliable and transportable. Around 1970, due to the invention of electronic devices, such as the integrated circuit chips and transistors, it became possible to automate and secure individual machines to increase the performance of operators.

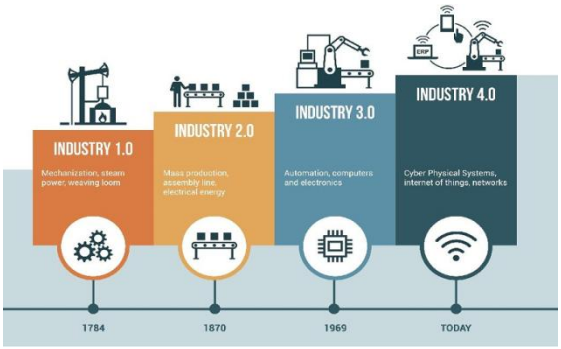

Figure 1. Industrial Evolution

This was termed as the third industrial revolution in the manufacturing process. The term "Industry 4.0" came into public in the year 2011, when this initiative was done by a coalition of spokespersons from business, academia and politics to strengthen the German Manufacturing Industries. Industry 4.0 is rooted primarily on Internet of Things and Cyber Security and therefore, "Industry 4.0" is also associated with "Industrial Internet of Things" which is being used to transform established factories into smart and autonomous factories.

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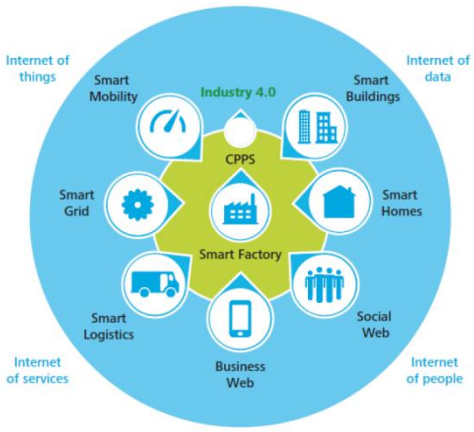

Figure 2. Industry 4.0 Environment

Industry 4.0 targets at vanquishing modern day challenges, like unstable markets and demands, decreasing innovation, much needed customization and product life cycles. Though Industry 4.0 was initially started by developed countries, it is also necessary to involve developing countries into this process. Industry 4.0 is of utmost priority for all the industries, research centres and organizations.

2. TECHNOLOGICAL REVIEW

In Industry 4.0, the internet of things (IoT) are interconnected with Cyber Physical Systems (CPS) in a way where things are made to have the potential to feed information into it and add value to manufacturing process by the combination of sensors, processor, software and communication technology. The technologies that are the pillars of Industry 4.0 are Internet of Things, Cyber Security, Cloud Computing, Robotics, System Integration, Augmented Reality, Big Data Analytics, Simulation and Additive Manufacturing (3D Printing).

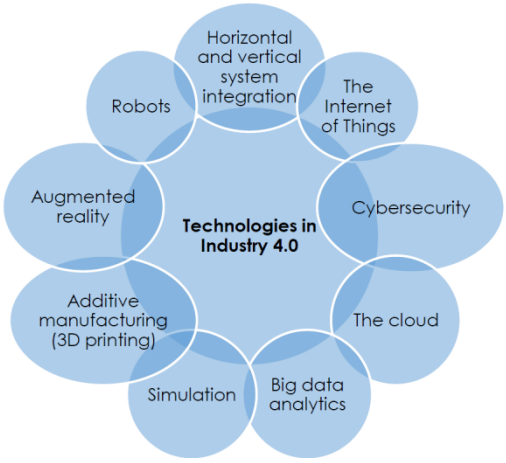

Figure 3. Technologies related to Industry 4.0

2.1 Industrial Internet of Things

The phenomenon of connecting everyday things embedded with electronics, software and sensors to the internet enabling them to collect and exchange data is known as Internet of Things or IoT in short. IoT can also be known as Internet of Everything that is Internet of Services, Internet of People, an embedded system and Integration of information and communication technology (IICT).

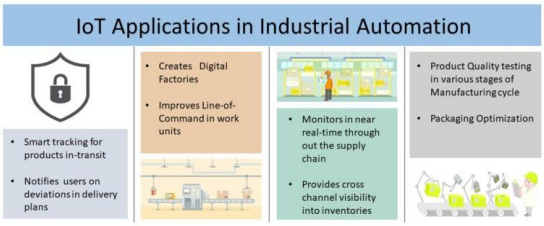

Figure 4. IoT Applications

2.2 Cyber Security

Since we use standard communication protocols and more increased connectivity in Industry 4.0, it is mandatory to secure fragile industrial units, machines and manufacturing assembly lines from cyber security risks that come with it. This is why a secure and robust communication system is needed to provide intricate recognition and retrieval management of systems and users. Cyber Physical Systems (CPS) is the term given to the systems in which traditional and artificial systems are tightly consolidated with computation, storage and communication. The main features of Cyber Physical Systems are localization and autonomous behaviour of the production processes. CPS is similar to IoT in terms of sharing the basic architecture, but the former offers a higher organization between computational and physical elements.

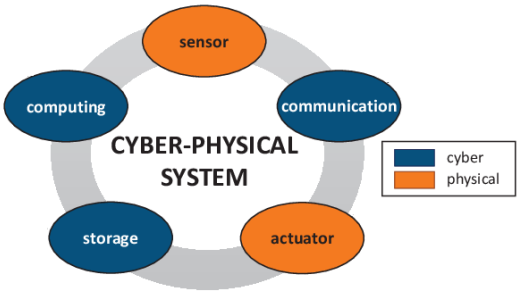

Figure 5. Cyber Physical Systems

2.3 The Cloud

In cloud computing, “the cloud” is referred for “the internet”. Basically, the cloud works as a technical backbone for the communication and connection in Industry 4.0 since there is a need of advanced sharing of data across the sites and industries to make the time of reaction faster. So, different devices are connected to same cloud for sharing information to each other and hence cloud-based IT-platforms are widely used. Cloud is also associated with IoT and many German companies like Bosch provides an open source IoT and cloud services to accelerate this industrial revolution.

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2.4 Robotics

The study, designing and development of robots come under a branch termed as "Robotics". Robots are nothing but machines that can be used to do various desirable tasks or assigned jobs. The invention of Robots is not new. The thing that is new is the development of autonomous, flexible and cooperative robots which does not need a human to constantly give instructions to them. Autonomous robots can work in the places where there is no possibility of human workers to work and can finish any given task intelligently and efficiently within given limited time. In Industries, robots are also being developed to interact to each other and work alongside humans and learn from them by observing them. There are certain autonomous human-like robots which have been developed in the recent years. Some of them are "Sophia", a social humanoid robot developed by Hanson Robotics Company in Hong Kong and "Vyommitra", a half-humanoid robot developed by ISRO which is planned to be sent into space.

2.5 System Integration

System Integration is broadly classified into Horizontal and Vertical System Integration which are the very backbone on which the smart industry is built. Vertical integration refers that the production floor is strongly coordinated with processes such as procurement and quality control whereas Horizontal integration refers to the well-integrated processes as production floor as well. The horizontal integration takes place at many levels such as production floor, multiple production facilities and across the entire supply chain. The vertical integration, on the other hand, is done to bring together all the logical layers right from the field layer up through research and development, quality assurance, IT, sales, management, marketing and so on.

2.6 Augmented Reality

Augmented Reality is the technology of experiencing real-world environment in which real-world objects are enhanced by computer-generated information. Some of the examples of AR are Snapchat lenses and Instagram lenses. The industrial systems based on augmented reality facilitates a vast category of services, like sending repair instructions over mobile devices by scanning the machine with a camera or selecting parts in a warehouse. Augmented reality is similar to virtual reality in the objective of drowning the users, though AR helps in interacting with virtual objects by residing in real world while VR provides isolation from the real world and drowns users in completely fabricated world.

2.7 Big Data Analytics

Big Data Analytics is a very complex process in which large analogous and varied data sets, termed as "Big Data", is examined to derive or uncover information like hidden pattern, market trends, unknown correlations or customer preferences and use that information in predicting future trends and accordingly make accurate business decisions. The decision is based on the four dimensions of Big Data which are: Value of Data, Variety of Data, Volume of Data and Velocity of generation of new data and analysis. The biggest challenge in Industry 4.0 is to extract value from manufacturing big data since these data sources can be structured, semi-structured or unstructured; therefore, Big Data Analytics plays a very important role in the ongoing industrial revolution.

2.8 Simulation

Simulation is extensively being used in industrial operations to attach real time data to examine the real physical world in a virtual replica of machines and systems resulting in decreasing setup times of systems and improving the quality. Simulation technique is probably one of the most widely used approaches to design and analyze production units in Industry 4.0.

2.9 Additive Manufacturing

Additive manufacturing is a technology that has the ability to develop personalized or customized products with lesser production costs, shorter lead times and lesser energy and material consumed or wasted. This technology can be used to manufacture complex parts on demand and reduce the supply chains. It also enables manufacturers to reduce inventory and create smaller decentralized manufacturing environments. This additive manufacturing is nothing but another name given to 3D printing technology through which we can create small or big complex products in the exact quantity that is required.

3. ELECTRONICS INDUSTY

Industry 4.0 not only refers to the change in production and extension of technologies but it also means that there is a growing need to develop new business models. In today's signal chain, industries use a node with a sensor in some form and link them to the real world. In such cases, the signals travelling to and from these devices are of very low range and frequency and have much noise. So, there is an extra need to process, convert and forward the next link in the signal chain.

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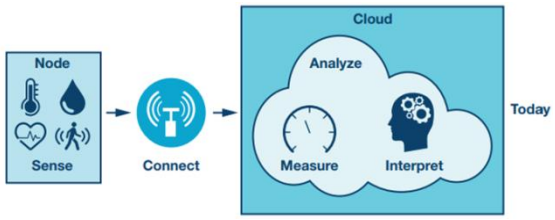

Figure 6. Today's signal chain

Due to those issues in the present signal chain, it was necessary to make changes in the chain.

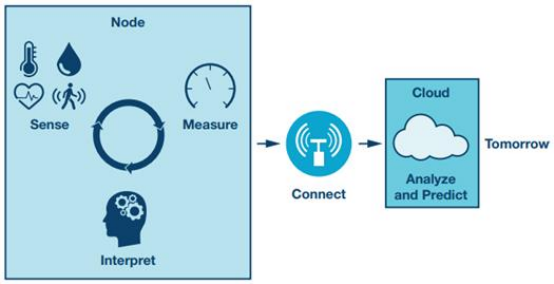

Figure 7. Tomorrow's signal chain

In tomorrow's signal chain, the data processing gives more insight and generates intelligible knowledge at the node, therefore reliable information is extracted. At cloud, this information is then used to analyze and predict trends.

Due to the evolution of Industry 4.0, the semiconductor industry itself has undergone transformation from traditional production lines to smart and fully automated factories.

3.1 Electronic Sensors

An electronic sensor is a piece of hardware that is used to sense physical activities happening in real world and translating it into digital data for processing. An electronic sensor is used in nearly every IoT device, so it can be interpreted as the sensory organs of IoT. These sensors allow IoT devices to collect and analyze data by itself without human intervention and thus make the device fully autonomous. Some of the commonly used sensors in the industrial IoT are Temperature sensor, Pressure sensor, Proximity sensor, Accelerometer and Gyroscope sensor, IR sensor, Optical sensor, Gas sensor and Smoke Sensor.

Figure 8. Bosch CISS kit

Recently, the German conglomerate "BOSCH" developed a small and robust multi-sensor device for harsh and unbearable industrial environments. It has been named as the "Connected Industrial Sensor Solution" or CISS in short. This all in one sensor consists of temperature, pressure, humidity, accelerometer, magnetometer, and gyroscope, acoustic and digital light sensors.

3.2 Wireless Communication

Wireless Communication technology like Wi-Fi, Bluetooth and ZigBee is used in most IoT devices to send and receive data over internet or radio frequency. This technology enables an IoT device to connect with another device without being physically connected by a wire. The description of Wi-Fi, Bluetooth and ZigBee technology have been given below.

3.2.1 Wi-Fi

Wi-Fi is the shorter name given to wireless fidelity which is a wireless technology based on the 802.11 standard that transmits data through the atmosphere by using radio frequency. The standard 802.11 have further been classified into four types which are 802.11a, 802.11b, 802.11g and 802.11n. The comparison of these four standards has been shown in the below given table:

Table 1. 802.11 Wi-Fi Standards

Parameter	802.11 a	802.11 b	802.11 g	802.11 n
Frequency (in GHz)	5	2.4	2.4	5 or 2.4
Typical Data Rate	23 Mbps	4.5 Mbps	19 Mbps	74 Mbps
Max Data Rate	54 Mbps	11 Mbps	54 Mbps	300 Mbps
Range	30m	95m	95m	190m
Cost	High	Low	Low	High

3.2.2 Bluetooth

Bluetooth is a short-range wireless technology created by telecom vendor Ericsson in the year 1994 that facilitates in connecting computers, mobile phones, and handheld devices to each other. It can be used to create secure Personal Area Networks having average date rate of 1 to 3 Mbps. Its range is between 2 to 10 meters and it communicates at a frequency of 2.4 GHz. Bluetooth uses the Frequency-Hopped Spread Spectrum (FHSS) technology to transmit the low-power radio waves and it uses point-to-multipoint or star topology for connecting to other Bluetooth systems.

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3.2.3 ZigBee

ZigBee is a technology standard that declares a set of communication protocols for sending or receiving information having low-data rate and short-range through wireless networking. The devices based on ZigBee technology operate in three frequency bands which are – 868 MHz (used in Europe), 915 MHz (used in North America) and 2.4 GHz bands (used worldwide). The data rate in ZigBee wireless communication limits at 250 kbps.

3.3 Electronic Brain of IoT Device

There are varieties of electronic devices that are in trend which can be used as the brain or controller of an IoT device. These can broadly be classified into three types of Microelectronics Devices which are Microprocessor, Microcontroller and Microcomputer. One example of each of these three is Intel 8080 processor, Arduino Uno and Raspberry Pi respectively.

3.3.1 Arduino Uno

Arduino Uno is a microcontroller board equipped with sets of digital and analog input/output pins based on the Microchip ATmega328P developed by Arduino.cc. “Uno” means one in Italian and this word was chosen to symbolize the release of Arduino software (IDE) 1.0. It has a 16MHz quartz crystal, a power jack, a USB connection and 14 digital input/output and 6 analog input pins i.e. a total of 20 input/output pins.

Figure 9. Arduino Uno Board

3.3.2 Raspberry Pi

Raspberry Pi is the general name given to the series of single-board microcomputers developed by the Raspberry Pi foundation which is a charity based out of United Kingdom that aims to provide education to all in domains like computing. Raspberry Pi is used in hardware projects and systems in home automation and industrial applications and generally the programming is done in Python language. Raspberry Pi 4 is the latest version of Raspberry Pi Board. It has better Central Processing Unit for better performance speeds and can support 2 4K monitors. It has both USB 3.0 and USB type C power supply and other more ports also for various applications.

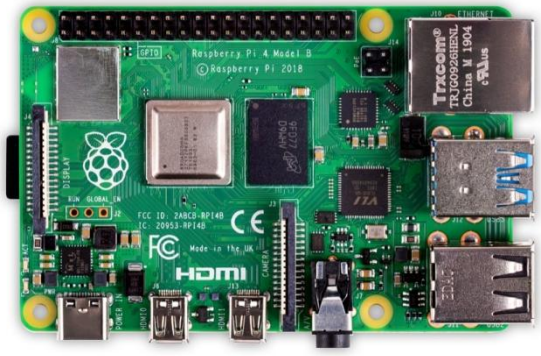

Figure 10. Raspberry Pi

4. CONCLUSION

Summing up all the above discussions, we conclude that Industry 4.0 signifies the digitization of manufacturing through the connected networks of robots and humans in which they work and interact together with each other. It allows smart, effective and efficient production at a very reasonable cost. However, this industrial revolution is still in the initial phase for most of the companies around the world and a strong leadership and management will be required to overcome the barriers and restrictions for its successful implementation. This paper reviews the concepts of industrial Internet of Things, Robotics, cyber security, cloud, big data analytics, augmented reality, system simulation and integration and additive manufacturing in Industry 4.0. The description of how the electronics industry is in the heart of Industry 4.0 and what changes are being done day by day to improve it has also been discussed. The three major electronics domains that are electronic sensors, wireless technology and the processing units have been discussed briefly to explain about the importance of these domains in the reliability of Industry 4.0. In electronic sensors specifically for IoT, we have temperature sensors, pressure sensors, humidity sensors, proximity sensors, water-quality sensors, smoke and gas sensors, liquid-level sensors and medical sensors. The global market for the sensors used in IoT had reached 7.3 billion dollars in the year 2015 and is expected to reach 50 billion dollars till the year 2021. There are various alternatives of Raspberry pi also which are being used in various IoT projects some of which are Odroid XU4, Banana Pi M64, Asus Tinker Board and BeagleBone Black. So, in final words, we can say that Industry 4.0 brings a vast opportunity for the growth and advancement of electronics industry.

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