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Mechatronics to Industry 4.0 and its Implications: Concept, Opportunities and Future

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***Abstract*- In recent years, Mechatronics has evolved much to a level, that it has become an integral part of our daily lives. Sensors detect an object & alarm us to take action, 3-D printers are used to print 3-D objects, manipulator robots are used to move an object from one place to another. With the advancement in Industrial Revolution, we have come to the 4th Industrial Revolution or Industry 4.0 where technologies like Blockchain, Cyber-Physical Systems & Robotics play a crucial role. This article mainly focuses on the current development, application and future development in the trends of mechatronics and Industry 4.0.**

Keywords*- *Mechatronics, Industry 4.0, Sensors, robots, 3-d printers, Blockchain, cyber-physical systems.

I. INTRODUCTION

The term 'Mechatronics' was invented by a Japanese engineer Tetsuro Mori who worked at Yasakawa in 1969, as a combination of 'mecha' from mechanisms and 'tronics' from electronics. So, the term 'MECHATRONICS' means the 'mechanisms of electronics. It encompasses of Mechanical, Electrical, Electronics, Computer Science. The aim of Mechatronics is to improve the functionality of technical systems and the creation of new concepts of machinery and equipment.

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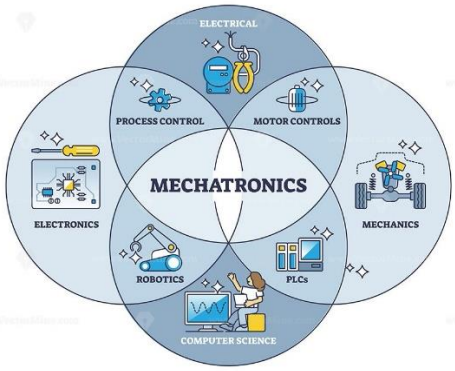

Fig 1: Mechatronics

INDUSTRY 4.0

Industrial Revolution a.k.a I4.0 is the greatest technological improvement in the era of mankind. A group of people from different fields including business, politics, technology and academics came together to discuss about the future development which happened to be in Germany in the year 2011. In 2003, they developed and published their first set of recommendations. Their vision was:

"These Cyber-Physical Systems comprise smart machines, storage systems and production facilities capable of autonomously exchanging information, triggering actions and controlling each other independently. This facilitates fundamental improvements to the industrial processes involved in manufacturing, engineering, material usage and supply chain and life cycle management."

This gave birth to the Industrial Revolution 4.0. A team was implemented to further advice on the implementation of Industry 4.0. It led to new terms in the industrial sector such as Artificial

Intelligence (AI), Machine Learning (ML), smart automation, robotics, smart sensors, Augmented Reality (AR). It refers to digitalization of things that have the potential to enhance the industry. Its motto is- "low-volume, high- mix production in a cost-efficient way".

Photo credits: - https://www.ti.com/applications/industrial/industry-4-0.html

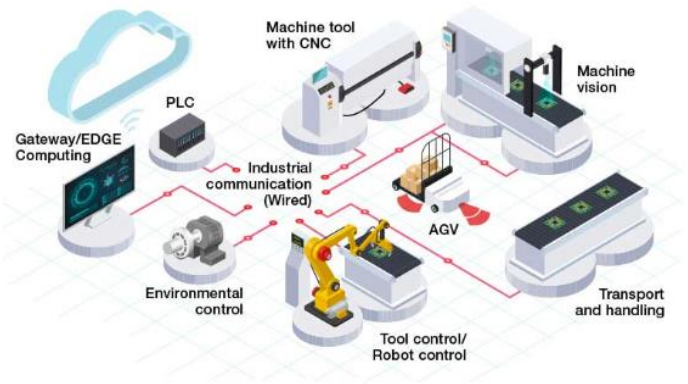

Fig 2: Industry 4.0

II. HISTORY

To understand the jargon 'Industry 4.0', perhaps going back into history might help us gather up bits of information that led us here. This is as follows:

1ST INDUSTRIAL REVOLUTION

The British introduced machines by the end of 18th century (1760-1840). It included mechanization, steam and water power. Thus, it helped agriculture in a tremendous way. The textile industry benefitted a lot from this. It also helped the British economy to prosper.

2ND INDUSTRIAL REVOLUTION

The second one dates between 1870 and 1914 (although some dates back to 1850). It gave rise to mass production and assembly lines using electrical power. Mr. Henry Ford used this opportunity to create mass production of his cars. Mass production of steels helped introduce railways into the system. Innovations like the synthetic dye was the best in the fields of chemistry.

3RD INDUSTRIAL REVOLUTION

It is the fundamental building block for the Industry 4.0. This is known as the Information Age. An age where computers, electronics, calculators, semiconductors fueled the development of technology. It had a change from analog and mechanical to digital systems. A plethora of new technologies came into the picture. Rise of computers made everyone use it for daily purposes. Phones became an integral part of our lives.

Photo credit: - https://blog.isa.org/what-is-industry-40

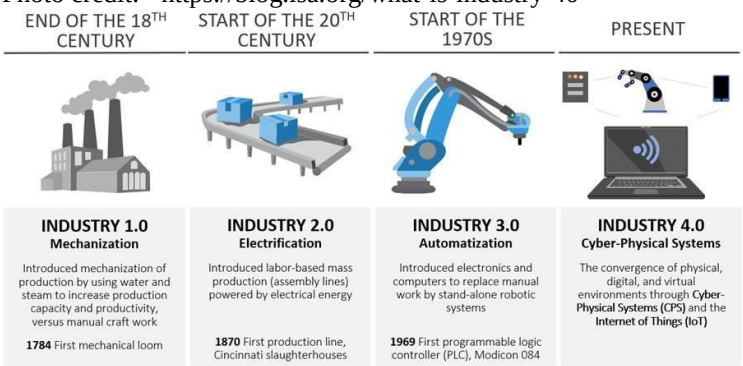

Figure 3: Industrial Revolutions

SCOPE OF TECHNOLOGY IN INDUSTRY 4.0

Before diving into the core aspects of the technologies involved in the I4.0, it is necessary to remember that this revolution is not about technology alone. It also benefits the society and the workers in general. For example, collaboration between man and robots. Moreover, Industry 4.0 has a strong emphasis on security of the data.

Not only of the data, but also the protection and security of workers, infrastructure and 'physical security'.

THE INDUSTRY 4.0 EFFECT

Due to digitalization, a lot of businesses are going digital. Factories are implementing I4.0 technologies on a large scale to enable smooth functioning and effective manufacturing.

USE CASES:

- **Iphone Factories**

Iphone's parts is manufactured in Foxconn factories in Shenzhen, China. These factories are highly advanced, having robotics, automation. They have the nickname – 'Light off' factories because they can function without light been turned on.

- **Agriculture**

Technology currently used in the agriculture sector include smart sensors, 3-d printing, drones and data analysis. One example is the Seqouia from Parrot, a system that uses drones and smart sensors to evaluate requirement of the crops. Drones are also used to spray pesticides on the crops.

- **Pharmaceuticals**

This industry faces intense audits to ensure that the medicines produced are up to date and are strongly effective. By utilizing smart sensors and data analysis techniques, each record is processed accurately.

IMPACT ON WIDER BUSINESSES

Since so many businesses are dependent on manufacturing and supply of goods, Industry 4.0 will cause a ripple effect. This will include:

- Lower cost of goods.
- Improved efficiency of manufacturing goods
- Faster production and delivery
- Improved Quality
- Increased use of sensors, data and automation
- Transparency. By tracking the process, stakeholders can be better informed.

Table 1. Pros and cons of Industry 4.0

Advantages	Disadvantages
Profitability	High Initial Cost
Improved safety & quality	Need for highly skilled labor
Improved Operations	Cybersecurity
High Customer Experience	Data Sharing
Growth of new markets	High risk of failure

As we see in the above table, with each upcoming revolution, it presents itself both the positives as well as the negatives. Our goal is to focus on the positive aspects.

INDUSTRY 4.0 TECHNOLOGIES

1. CYBER-PHYSICAL SYSTEMS

Cyber-physical systems are the integration of using sensors, computation, control and networking into physical objects by connecting them to the internet. In general, a commonly accepted definition of cyber-physical systems refers to systems where software and hardware components are seamlessly integrated into performing well defined tasks.

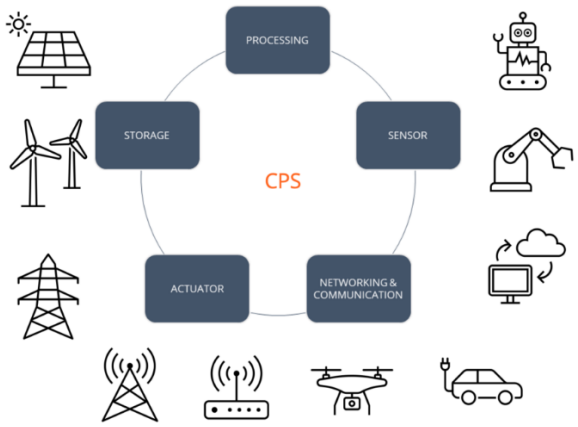

Figure 4: Cyber-Physical Systems

Photo credits:- https://www.cleantech.com/data-security-and-cleantech-the-future-of-cyber-physical-systems/

They are capable of making their own decisions.
Here are few of its applications where CPS can be applied:

APPLICATIONS:

- Intelligent Computing like Machine Learning.
- Information Acquisition and processing of CPS.
- Automotive
- Industrial Automation
- Home Automation

2. INDUSTRIAL ROBOTICS

This are the robots used in the industries, especially for welding and painting. They are also used to stock shelves in warehouses. Elsewhere, they are also used for cutting, grinding, moving objects. Robots play a huge role in making things easier and more efficient for humans.

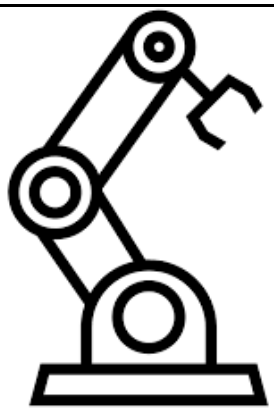

Figure 5: Industrial Robotics

Photo credits: - https://www.nvidia.com/en-us/learn/

APPLICATIONS:

- Industries
- Automotive
- Complex Medical Surgeries
- Home

3.BLOCKCHAIN

Blockchain is defined as a decentralized and distributed technology that can be used to store information. No person or entity has control over it. It is nearly impossible to hack or attack the entire system. (Kushwaha & Singh, 2020). *"Unlike the Web or Internet alone, blockchains are distributed, not centralized; open, not hidden; inclusive, not exclusive; immutable, not alterable; and secure. Blockchain gives us unprecedented capabilities to create and trade value in society" (Tapscott & Tapscott, 2017).*

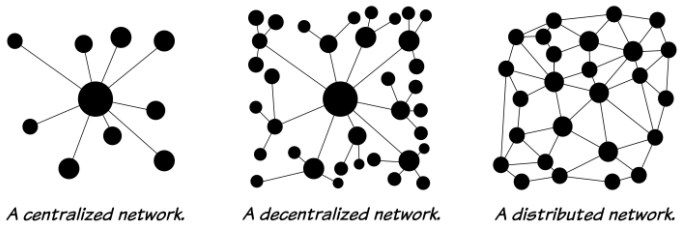

Fig. 6: A comparison of the topography of centralized, decentralized and distributed networks *(Source: Baran, 1964)*

APPLICATIONS

- Cryptocurrency: - One of the many advantages of cryptocurrency is it can be used for transactions all around the world. This option is much better than regional payment apps.
- Internet-of-Things (IoT): - Most common example is Smart Home where all home appliances such as lights, thermostat, AC, smoke alarm can be connected together on a single platform.
- Online Identity Verification: - It is useful in the banking and financial industry. Users also get the right to choose their identity verification methods.
- Cybersecurity: - Using blockchain, it's easy to prevent malicious attack. Let's have a look at a real-life application of this blockchain application. Mastercard is using blockchain for sending and receiving money. Also, it allows exchanging the currency without the need of a central authority.

THE CRITICAL ROLE OF INTERNATIONAL COLLABORATION

The international community should come together to help countries harness this new technological wave. The risk is to perpetuate the gaps seen in previous technological revolutions.

In this regard, the five critical areas are:

1. Sharing knowledge, and conducting research.
2. Help design policies, strategies, and implement initiatives.
3. Help build capacity of the innovative system on Industry 4.0
4. Promote technology transfer through new innovative collaborative approaches, addressing market,
5. Helping to set legal frameworks, norms, and standards.

FUTURE DEVELOPMENTS IN MECHATRONICS & INDUSTRY 4.0

With the rapid increase in technologies like AI, ML, Robotics it is easier to implement this and get our tasks done. The future is bright for Industry 4.0. If sensors are put inside our body, they can sense what's happening inside our body by giving us real time data into our phone or PC.
This will help us to understand if there are any diseases in our body and if there is, then what diagnosis is required can be obtained from it.

IV. CONCLUSION

Thus Industry 4.0 is a light for the future. It holds tremendous possibility to uplift mankind in ways, that cannot be imagined.

The amount of innovation that are happening everyday proves that we can uplift humanity on a better level.

ACKNOWLEDGMENT

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