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Technological Advancements in Industry 4.0

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Abstract: ***The purpose of this paper is to identify the applications for assessing the Industry 4.O readiness by discussing all industrial revolutions. Nevertheless there has been a lot of research in Industry 4.O, this paper includes the main applications Industry 4.O. Industry 4.O is introduced in this paper with the initiative taken by the German Government with the goal of digitalization and industrial manufacturing. While we are adapting to new changes, it is becoming clear that digitalization is becoming a key factor in the Industrial Revolution. In this review paper, we present recent technologies and their applications like IoT, additive manufacturing, lean manufacturing, robotic, the and cloud computing.***
Keywords- IoT, Industry 4.O, additive manufacturing, cloud computing.

I. INTRODUCTION

A. Industry 4.0

Today living in the 21st century we are experiencing the fourth industrial revolution called industry 4.0. Industry 4.0 or the fourth industrial revolution also refers to the next phase in digitalization. It is leading to smarter components and machines. It is transforming the organizations into digital form. It changes the way of work in the organization completely. The sustainability impacts of Industry 4.0 and the way it can contribute towards sustainable economic, environmental, and social development is increasingly gaining attention. It adds value to the manufacturing industry to realize a low-volume, high-mix production in a cost-efficient way. It also involves the management and organization of the entire value chain process of the manufacturing industry.

The concept was originally initiated in Germany, followed by acceptance by other countries. Industry 4.0 includes many technologies, which include the Internet of Things (IoT), Internet of Service (IoS), cloud-based manufacturing, radio frequency identification (RFID), enterprise resource planning (ERP), and social product development. The popularity of these new technologies has made the fourth industrial revolution one of the most discussed research areas in this decade.

II. HISTORY

There are four stages in the ongoing process called the Industrial Revolution. Getting an insight into them might give us a perspective on how this revolution in particular is different.

At the beginning of the 20th century, the Second Industrial Revolution happened during the introduction of conveyor belts and mass production, to which the names of icons such as Henry Ford and Frederick Taylor are linked.

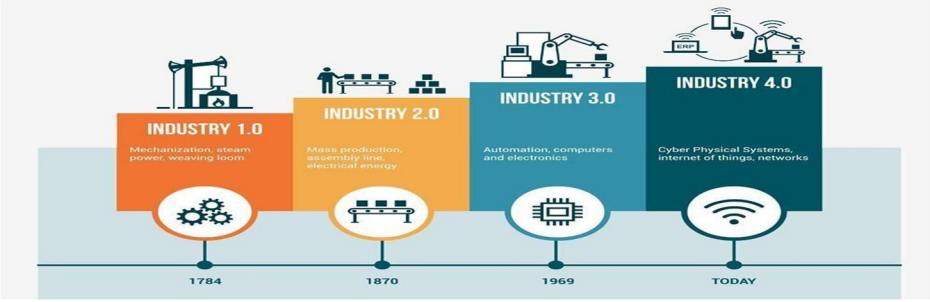


Fig: History of industrial revolutions

A. First Industrial Revolution

The 1st industrial revolution introduced machines into production by the end of the 18th century (1760-1840). It all started in Britain and then spread all over the world. This revolution Introduced in manufacturing was the invention of new machines, improvement in transportation and communication, reliance on new energy sources such as coal, the use of new raw materials such as steel, Division of Labor, and worker specialization. This included the use of steam-powered engines and water as a source of power. This helped agriculture greatly. One of the industries that benefited a lot from such changes in the textile industry was the first to adopt such methods.

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B. Second Industrial Revolution

The second one dates between 1870 and 1914 (although some of its characteristics date back to 1850) and introduced pre-existing systems such as telegraphs and railroads into industries. At this time, manufacturers began to experiment with more synthetic materials and machines evolved to play an even more important role in the industry. The two key features of the second industrial revolution are mass production and the use of electricity.

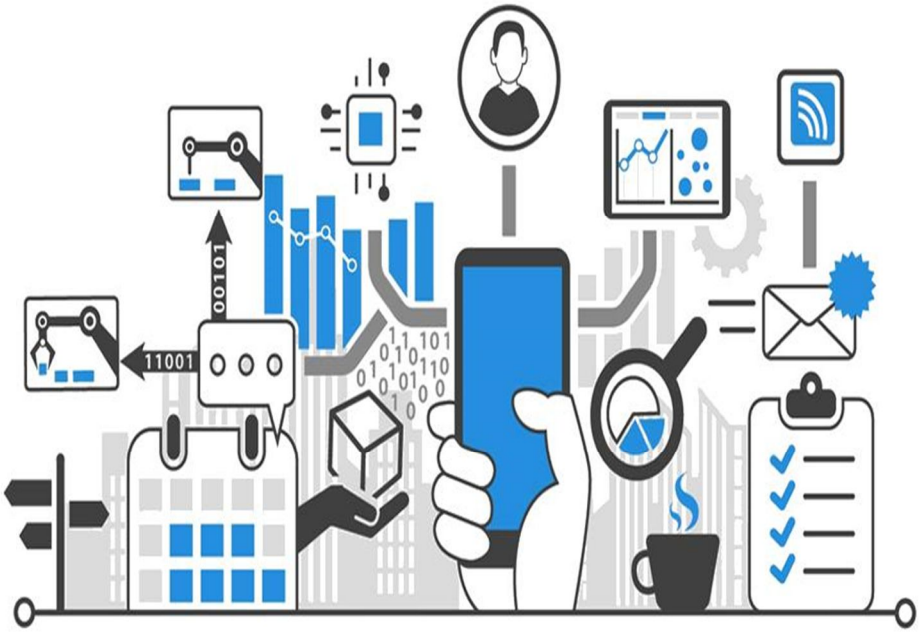
C. Third Industrial Revolution

The Third Industrial Revolution is very much familiar and identifiable in the industries nowadays too. The Third Industrial Revolution was termed by the American sociologist and economist Jeremy Rifkin to describe the technological and social transformations that took place. Also, many industries have continued and been using the third industrial revolution only. The third industrial revolution was marked in the late 20th century. It can be called a digital revolution since all the mechanical operating systems were transformed into digital systems which reduced the time of the workers and made the system much more efficient.[8] Information technology was also introduced to the world in the same era, businesses led it too. Mechanical technology started transferring itself into electronics with the adoption and growth proliferation of digital computers and digital record-keeping, which continues to the present day.

D. The Fourth Industrial Revolution

Industry 4.0 has been referred to as the new buzzword of the manufacturing industry. As the suffix indicates, this is the 4th wave of distinct industrial advancements, and has thus been titled “The Fourth Industrial Revolution”. Although the concept is not yet widespread, there is great potential that it will penetrate and improve many aspects of human life and today’s manufacturing. However, at the same time, it will be accompanied by many challenges. [4]

The need of industry 4.0 is to convert the regular machines to self-learning machines to improve their overall performance and maintenance management with the surrounding interaction. Industry 4.0 aims at the construction of an open, smart manufacturing platform for industrial-networked information applications industrial-networked information applications. Real-time data monitoring, tracking the status and positions of products as well as holding the instructions to control production processes are the main needs of Industry 4.0.[2].



The 4th Industrial Revolution which started in the 21st century takes automation even further and revolves around cyber-physical production systems. It overlaps largely with the technological advancements known as IoT, additive manufacturing, Lean Manufacturing, Robotics, Cloud Computing, etc.

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III. THE IOT (INTERNET OF THINGS)

The IoT addressed objects that can communicate with the help of standard programs. Internet of things consists of a varied concept which mostly includes Internet of Services, Internet of People, Internet of Manufacturing Systems, Internet of Information Technology, etc. IoT refers to sensing the environment or an object and immediately responding to the changes, to keep the system balanced. [2]

Due to the use of smart sensors and intelligent machines, it has become very much useful to track and control everything in the industry, with the use of smart IoT devices, minute observation over each activity takes place which leads to accuracy and development of the company. Due to the use of various software's process planning efficiently takes place.



Fig. IoT

A Human-Machine Interface is nothing but a user interface that connects a person to a machine, system, or device. While the term can technically be applied to any screen that allows a user to interact with a device, HMI is most commonly used in the context of an industrial process. So with the use of this technology, we can connect a Human with a computer which will help and make our work faster and accurate in an Industry. Another example is Decentral controlled production based on Smart Products which was demonstrated by Smart Factory KL at Hannover Messe 2014 in Germany. The presented working stations are produced autonomously according to a work schedule on the product. Although it was push-controlled production, this concept could be adopted for an order-oriented control system. [5]

IV. ADDITIVE MANUFACTURING

Additive Manufacturing, in common terms, is referred to as 3D printing. It is a type of new manufacturing technique that allows us to create three-dimensional (3D) objects using metal or plastic. This process involves a framework that uses additive or layer development technology.

This technology requires digital innovation and also flexibility in the production process. The digital models made by this technology can also be altered or customized. As digitalization is growing, companies find an increasing need to involve IT and the networking of products in their manufacturing processes. The production also needs to be faster and cheaper. Hence Additive Manufacturing methods such as fused deposition method (FDM), selective laser melting (SLM), and selective laser sintering (SLS) are used. Additive Manufacturing supports sustainable production. As it involves only one process, it generates less waste or byproducts. This technology is best suited for the production of small batches of products, which are complex and light-weighted. However, we cannot yet implement Additive manufacturing for large-scale productions due to its low throughput speed. Thus this "Smart Production" largely influences the whole Business revolving around it, which involves the design and simulation of the 3D product, the automation, and tools required for product control and supply, supply chain management and logistics as well as the recycling. The most benefited industries from Additive Manufacturing are automotive and aerospace. By 2023, the 3D printing market is estimated to be worth $32.78 billion.

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V. LEAN MANUFACTURING

Lean Manufacturing is an idea of combining automation technology with Lean Production. In the previous decade, this idea was mostly overlooked, but as Industry 4.0 is in full progression, new technologies and automation are providing us with the required solutions to solve difficulties related to Lean Manufacturing. Combining Lean Production and Automation can be easily done using Industry 4.0 solutions. As a result, the product is comparatively more standardized because of the less complexity.

Lean Manufacturing aims to increase productivity mainly by shortening the time required for the production i.e the responsiveness has to be increased by reducing the lead time Also, in Lean Manufacturing the efficiency increases as the automation involved allows greater flexibility, reduced production cost, better quality, and more energy efficiency. To increase the energy savings, the robots can be switched off while the material is being processed. This method can save up to 15% of electricity consumption.



Fig. Lean manufacturing

The Advancements in these technologies lead to the development of embedded systems involving various sensors, actors, and autonomous systems. This connection of systems controls the prime tools and systems in the companies such as various equipment and conveyors. Also for increasing efficiency, we can have feedback mechanisms for the information collected from all the physical processes. Hence Lean Manufacturing involves Smart Operator, Smart Product, Smart Machine, and Smart Planner. Combining this gives us a “Smart Factory”. Here the Smart products can collect precise data from individual products and analyze it before or after the production process.

The demonstration for Smart Factory was given at Hannover Messe 2014 in Germany. There a vendor-independent technology was initiated by the German Research Center for Artificial Intelligence (DFKI). The main challenges they faced were with high variety and low production qualities.

RFID (Radio Frequency Identification) uses the theoretical approach for smart factory technology. In recent years RFID has given the benefits such as a contactless, simultaneous collection of data, and high accuracy.

VI. ROBOTICS

Autonomous robots or Robotics are used to replicate human labor, in a manufacturing unit. The factories have a network of autonomous robots working in unison with the men. These robots are now improved and enabled with sensitive sensors that detect the slightest signals. Depending on different requirements, it can be robotics arms, a whole assembly line, vehicle-type rover, android, or legged patrol robots. We find the use of robotics in fields of chemical processing, pharmaceutical manufacturing, food and beverage productions.

Autonomous Mobile Robots (AMRs) are a very important part of the Smart Factory. They are responsible for connecting the factory. The Siemens Electronics Works in Amberg, Germany primarily uses these AMRs. ARMs are used for transporting material across factory floors. They receive signals from real-time production systems and hence their physical movements are digitally connected. They avoid obstacles, coordinate with fleet mates, and identify where the pickups and dropoffs are needed.

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The leading example of an autonomous robot is the Kuka LBR Iiwa. Iiwa stands for intelligent industrial work assistant. It is a lightweight robot designed for safe close interaction between humans and robots. They are used for highly sensitive tasks. It can independently check, optimize, and document the results when connected to the cloud. Bosch has also introduced the AP, including for increasing efficiencyS family robot system which includes APAS assistants, APAS inspector, and APAS base.

Robots have gained more precision, which increases productivity and reduces the potential risks. These robots are of two types:

1) *Automation Robots:* They make a manufacturing process automated. It includes Smart Manufacturing. They can complete a given task with precision and intelligence within time constraints. For example, Nextage robots from Kawada Industries
2) *Collaborative Robots:* These robots work with humans and provide them with flexibility and productivity. It includes Smart Working. For example, the dual-arm YuMi robot from ABB.

Top notable Autonomous Robotics Companies

NAME	TYPE	DESCRIPTION
Nuro	Autonomous Vehicles	They make fully autonomous, on-road vehicles, robots for running different errands such as dry cleaning or delivering groceries.
CANVAS Technology	Industrial, Logistics	They make autonomous robots for usage on factory floors and factory processes. They have stereo cameras and LED lights systems.
Piaggio Fast Forward	Logistics, Computer Vision	Lightweight mobility solutions. Their robot named “Gita” follows people and can carry loads up to 45 pounds.
Diligent Robotics	Healthcare	“Moxi” robot can help patients to set up the wards and also restock their supplies.
Sphero	Education, Gaming	Robotic balls named Sphero 2.0 and Sphero Mini is used in classrooms to teach through fun and play
Ouster	Sensor manufacturing	They manufacture 3D lidar sensor technology. They work in fields of robotics, autonomous vehicles, mapping technology, security systems
Tempo Automation	Prototyping	Process data related to production and expected costs. Used in organizations such as aerospace, medical, and other manufacturing industries.
Vicarious	Robotics	Provide advanced assembly lines, including palletizing, assembling kits, machine tending, bin packing, sorting, and advanced packaging.

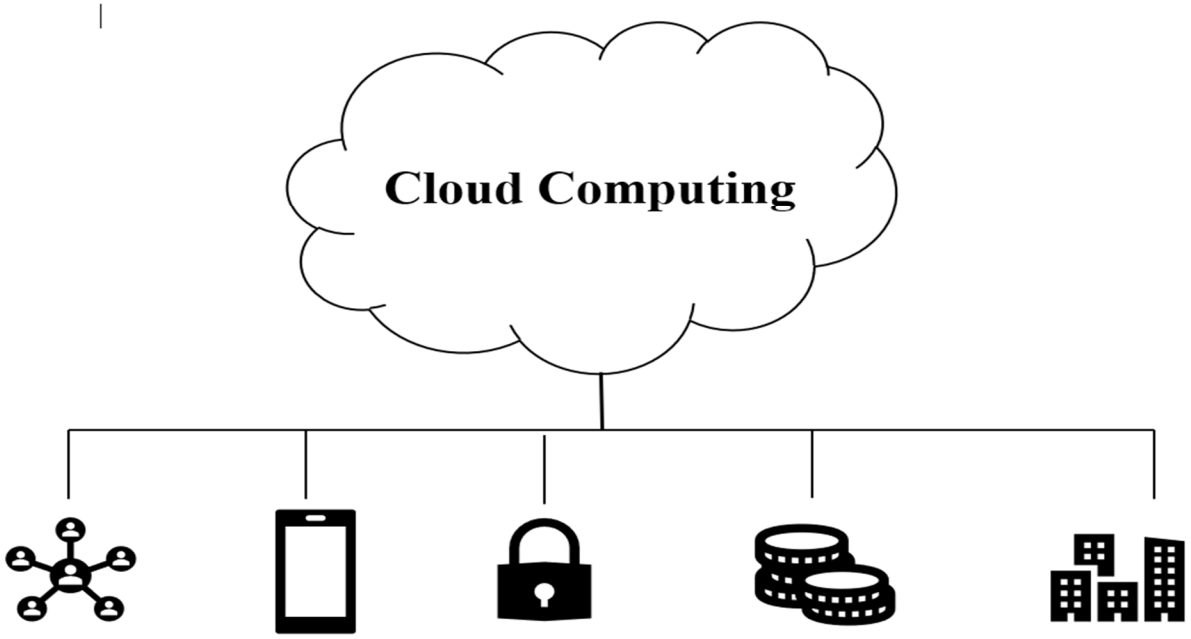
The upcoming technology may have self-optimization processes. They may also have better adaptability towards business production and the network environment. This new generation robot will actively interact with the surrounding environment and robots. This will improve the design and servicing of the equipment. Various markets and Commercial applications including healthcare to rental consumers will adapt to use Autonomous robots in their manufacturing or processing systems.

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VII. CLOUD COMPUTING

In the era of IoT and Industry 4.0, the reality is that data is being generated at high volumes, it is impossible to handle this data manually. So by using cloud computing we can store and manage this data more efficiently and effectively. Cloud computing is the major part of the connection and communication for industry 4.0. Cloud computing increased data sharing across the different sites.[2] It is a high-performance and low-cost feature that suits perfectly for information storage[14]. Cloud Computing allows us to store a large amount of data in it. The capacity of cloud computing is most important to store the data generated, machines and sensors produce more data than humans. This data is always connected to cloud computing and also reduces investment in different technologies and resources, giving huge storage space and processing capacity which provide flexibility, adaptability. Cloud enables reduced costs, since it avoids purchasing different servers, licenses, and hiring specialized personnel for their maintenance, and saves energy. In addition, it provides ease of access to storage from any place regardless of the platform and connecting devices.



CBDM (Cloud-Based Design and Manufacturing) is a service-based product development model. in which service consumers can customize products, services as well as manufacturing systems using cloud computing service models i.e. Infrastructure-as-a-Service (IaaS), Platform-as-a-Srvice (PaaS), Hardware-as-a-Service(HaaS), and Software-as-a-Service (SaaS).
Software-as-a-Service (SaaS) is the most well-known application for cloud computing. SaaS products distribute data through online mode and are accessible from a browser on any device. SaaS is one of the most attractive sectors in all of the businesses. Slack is the industry leader in cloud SaaS products. Located in San Francisco, California. Slack is a communication and collaboration tool for teams and companies. Slack channels are essentially group messages by individuals, groups, teams, etc. to ensure that everyone in the team or group is on the same page when it comes to communication. it even features video chatting, file sharing, etc. Hello Fresh, Airbnb, and NASA this major organization uses Slack to communicate and collaborate.

VIII. CONCLUSION

In this paper, the primary objective is to review the literature and analyze the areas in which Industry 4.0 technologies have implemented the background, development, and applications of the Industry 4.0 concept. The concept of the fourth industrial revolution (Industry 4.0) allows smart, efficient, effective, and customized products at a reasonable cost with the help of smarter computers, machines, sensors, and huge data storage and also make easier communication and collaboration between machines of products. It represents the current trend in automation in the organization. It includes different technologies like IoT, lean manufacturing, big data, and cloud computing, etc.

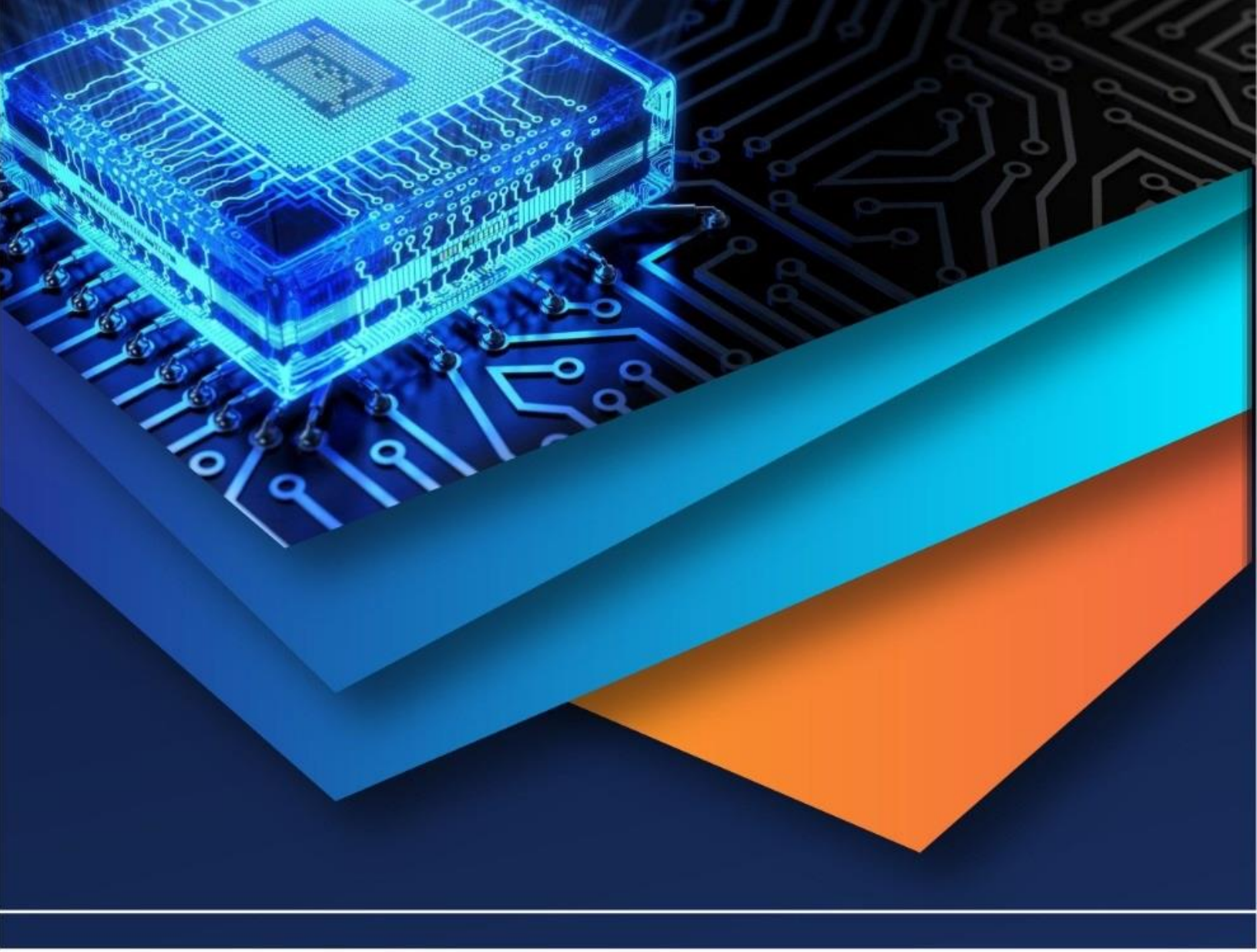
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The Industry 4.0 concept is not limited just to the direct manufacturing in the company and also includes a complete value chain from providers to customers. These technologies provide data about the state of their work. Further, these data are used for maintenance; it provides useful information to manufacturers about the readability of products or services. Industry 4.0 is the new industrial revolution of the 21st century, which authorized companies to create "smarter" products and services efficiently.12 Industry 4.0 is a combination of several technological advancements like the internet of things, cyber-physical systems, network communications, big data and cloud computing, modeling, and improved tools for human-computer interaction and cooperation. 15 Industry 4.0 is the new industrial revolution of the 21st century, which enables companies to create "smarter" products and services by increasing efficiency.

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