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Substantial Capabilities of Robotics in Enhancing Industry 4.0 implementation

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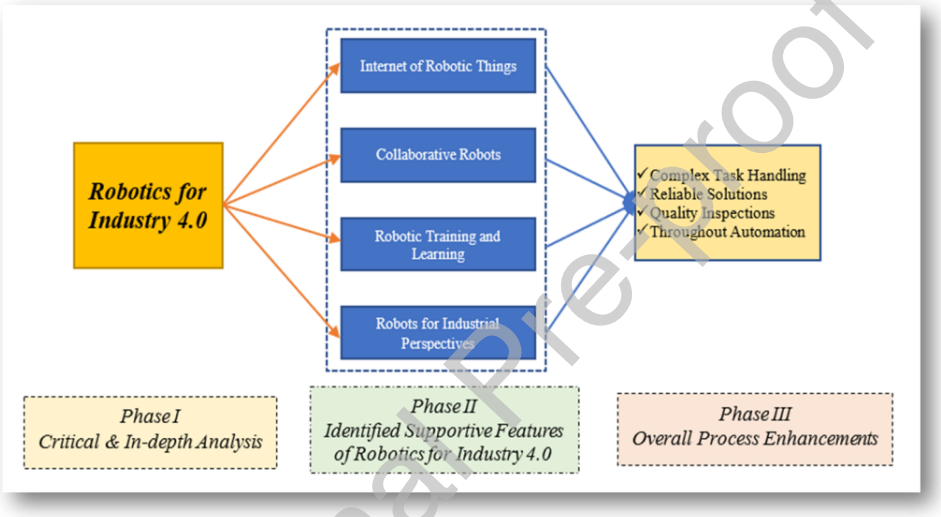
Graphical Abstract



Abstract
There is the increased application of new technologies in manufacturing, service, and communications. Industry 4.0 is the new fourth industrial revolution, which supports organisational efficiency. Robotics is an important technology of Industry 4.0, which provides extensive capabilities in the field of manufacturing. This technology has enhanced automation systems and does repetitive jobs precisely and at a lower cost. Robotics is progressively leading to the manufacturing of quality products while maintaining the value of existing collaborators schemes. The primary outcome of Industry 4.0 is intelligent factories developed with the aid of advanced robotics, massive data, cloud computing, solid safety, intelligent sensors, the Internet of things, and other advanced technological developments to be highly powerful, safe, and cost-effective. Thus, businesses will refine their manufacturing for mass adaptation by improving the workplace's safety and reliability on actual work and saving costs. This paper discusses the significant potential of Robotics in the field of manufacturing and allied areas. The paper discusses eighteen major applications of Robotics for Industry 4.0. Robots are ideal for collecting mysterious manufacturing data as they operate closer to the component than most other factory machines. This technology is helpful to perform a complex hazardous job, automation, sustain high temperature, working entire time and for a long duration in assembly lines. Many robots operating in intelligent factories use artificial intelligence to perform high-level tasks. Now they can also decide and learn from experience in various ongoing situations.

Keywords: **-** Artificial Intelligence; Cobots; Industry 4.0; Manufacturing; Robotics; Robotics Applications

1. Introduction

Industry 4.0 technologies enable connected computers, equipment, applications, and individuals to communicate in a connected network and provide producers with timely insight into critical processes. The right staff will access the details they need at the right time, preventing unnecessary downtimes and reducing processing times. Robotics is an innovative technology used to perform various tasks in the industry. When manufacturing issues can be corrected proactively, and all related workers input the production details, it can be constantly improved to minimise costs while increasing production performance. Comprehensive insight into what holds the company increases overall competition and will help to boost efficiency. In Industry 4.0, all appliances, equipment, and computers are related to an industrial production method. It provides an atmosphere fertile among many other possibilities for large-scale data processing and self-correction. Businesses are testing the limits of what is feasible today concerning robotics and the realisation of the future of business 4.0 [1-3].

Industry 4.0 is transforming how factories work globally, also known as the Global internet of things. The ability to capture, interpret and operate on the data collected in granular output transforms the operations, notably concerning efficiency and continuous optimisation. Although some of Industry 4.0's wildest forecasts appear impractical, many solutions today are available to drive Industry 4.0, especially in industrial robotics, through established processes. Robot vendors have also built options for manufacturers to enhanced Industry 4.0. The digital platform helps consumers integrate and aggregate their data safely, combined with more extensive industrial data, incorporate big data and predictive analyses and create insights to optimise performance and productivity. It provides a twin to digital, physical assets or structures to allow engineers to see what happens in their factory. This allows the installation of new product lines quicker and speedier up without surprises to provide producers with vital expertise with the current mass customisation and a shorter product life cycle [4-7].

With a range of easy-to-use devices that caters to large and small manufacturers of various industries, Industry 4.0 is emerging to make the application and implementation of robots simpler. Digital technologies encourage openness of knowledge through their ability to gather data and send it on to other systems for research, modelling.

Industry 4.0 technology also allows factories to use more autonomous mobile robots (AMRs) on their assembly lines. Unlike standard autonomous guided vehicles, AMRs do not need an external system to localise themselves and are equipped with sensors and cameras to handle their environments. AMRs are going to become more than just a managing system over time. They will become predictive data systems that will allow manufacturers to make smarter choices when they proactively develop their plants. Industry 4.0 acceptance is increasing because of the enhanced computing capacity & automation that ubiquity has stimulated many to see as yet another industry revolution [8-10].

Industry 4.0 links embedded manufacturing technology with smarting production processes. Technology departments can fully appreciate emerging inventions' possibilities and applications once they have clarified and supported these claims at the centre. These forms will provide new opportunities and bring about business improvements. A vital starting point for creativity is understanding how various information technology interacts with the real world. The mechanism of knowledge generation, communication, and intervention are implicit in the development process. It results in a tangible entity. The production eventually starts with information: drawing, design tools, or data creation by scanning the physical object. The data was moved from the digital to the real world to the designing devices. The development data are recorded ideal, and the digital and physical worlds are continuously intertwined [11, 12].

There is already a considerable range of quickly evolving embedded devices, including high-quality sensors, stable and efficient networks, high-performance computing, robots, artificial intelligence, computational technologies, and increasing fact. They will transform the market thoroughly together. The transition to Industry 4.0 is rising industrial efficiency, with technologies such as the Internet of Things, automation, artificial intelligence (AI), and cloud computing. Many manufacturing processes often cost more than a robot. The cost is often more significant for an individual. It will also free staff in other industrial fields such as manufacturing, programming, and maintenance for their skills and experience. Industrial robots are generally incorporated into several activities [13,14].

This paper consists of 11 sections. The section 1 introduced about paper, need for the study, research method, Industry 4.0, Robotics and its benefits, Internet of Robotic Things (IoRT) and Cobotics. Section 2 discusses Various Key Robotics Aspects for Industry 4.0 Implementation. Section 3 represent different Industry 4.0 Perspectives for Robotics Solicitations. Section 4 identified major potential capabilities of Robotics in different fields/ industries. Section 5 states different Robotics variants for Industry 4.0 Employments at Ground Level. Section 6 identified and studied significant applications of Robotics in context to Industry 4.0. Section 7 studied about 3D Printing and Robotics. Section 8 provides discussion on the proposed study. Section 9 studied some Limitations of Robotics. Section 10 states some Future Scope/Future research direction. Finally, conclusion of the paper is discussed in Section 11.

1.1. Need for the study

Industry 4.0 and the revolution in the factory floor is driven by autonomous mobile robot technology. Paradigm Electronics has deployed robotics to enable metal polishing by using a noisy speaker and a subwoofer maker. So, the need for this technology arises in the manufacturing industries. The network of robots linked to painting, dispensing, and welding is smart enough to know when maintenance is required so that they do not break down. If technology advances, the device will become more of an in-process adaptive platform, where robots will track and dynamically adjust their performance for optimal efficiency. Robotics systems for specific manufacturing industry sectors may be a comparatively recent phenomenon, though it has existed for decades. By mixing conventional manufacturing with higher technological types, plant managers and company owners will increase their production volumes and exponentially improve their profits. The effect of automated development stretches broadly for the whole business, maximising efficiency and success [15,16].

Robotics generate an undeniable upward change in the activity of a company when applied correctly. It positively affects routine operations, streamlines the overall assembly workflow, and even works to manufacture food. Many occupations are unsafe or contain high quantities of content that can hurt people. The repetition of their jobs can cause them to make mistakes and cause workers frustration or distract themselves within the short term. However, robots should avoid making those errors due to their dexterity and high machine learning levels [17, 18].

1.2. Research method

This study is carried out by identifying and studying a vast number of related papers, blogs, and books on Robotics for industry 4.0, its benefits, roles, features, applications and other connected themes. These are searched through Google Scholar, Scopus, ResearchGate, ScienceDirect and other research platforms. The comprehensive study is carried by reading more than 150 good papers, which have given us a better grasp of the research in this area. We have attempted to demonstrate how this technology provides unique approaches to interpret past research in the area of Industry 4.0. This literature-based review assessed the significant applications of Robotics in the Industry 4.0 environment. This work also summarises several important studies published in reputed journals and provides newer information in a technical context.

1.3. Industry 4.0: An Overview

In industry 4.0, several main elements, including networking and big data, apply to robotics. The fundamental factor is connectivity. If the devices are not linked, and data is obtained from different sensor systems included in controls, robot arms and end-of-arm tools, it is difficult to obtain any value. It is also necessary to do something about these numbers. To promote maintenance activities, engineers can consciously respond to historical reports and pattern thresholds [19,20].

Industry 4.0 has been able to prosper in recent sensor technology advances. In order to detect anomalous behaviour, sensors are used manufacturing plants. This assumes that machinery faults can be detected and fixed before downtime occurs in a system. The pressures and financial strains associated with failures are also saved for plant operators and administrators. The position of equipment repair engineers has also changed because predictable maintenance allows them to visit a site before purchasing the appropriate components. They will collect sensor data from any position and use it to classify the problem into the necessary parts to make their job more efficient and successful [21, 22].

The intelligent factories of tomorrow will rely on modern computer models, such as mobile and interactive systems interconnected. Artificial intelligence, cloud computing, and data processing can also increase the reliability of industrial robotics. The Industry 4.0-enabled robots aim to achieve optimum performance and zero downtimes. When robots use more sensors, they become even less vulnerable to interference and are digitally linked. Unprogrammed plant downtime is one of the most common sources of today's production inefficiency. The automation of previously manual activities with an in-place set of real-time AI and computer networking is being increased by Industry 4.0. Industry 4.0 converge to help factories obtain better investment returns [23-25].

The inclusion of Industry 4.0 characteristics would allow understanding the business's overall impact and automation importance. The mechanical component makes Industry 4.0 vital because it allows manufacturers to understand better how automation can enhance process performance, product quality and safety. Furthermore, the capacity to consider what will happen when it does is predictive prediction. AI will play an important part in this phase in the future. The knowledge level imparted to robots varies, such as gripper friction, arm location, engine temperature, or vibration. Industry 4.0 is significant to the robotics industry because of the changes in its output to end-users. These perspectives will further increase performance and reliability across the whole manufacturing chain, from engineering and commissioning to running and maintenance. Industry 4.0 is just about making business decisions based on data collected by networking. Engineers need to make sense of the data and implement AI to enhance the process [26-28].

Human feedback and customisation are important for industrial power automation, and Industry 4.0 makes this simpler. With portable devices such as smartphones and tablets, supervisors can direct robotic operations and circumvent mainstream technologies. It encourages manufacturers to stay flexible in a fast-paced processing world

where they were historically linked to a computer or stationary data system. Industry 4.0 is a giant step ahead in equipment growth and development that has already seen pioneering productivity strides in life quality for several hundred years. Industry takes on any digital change and increases intelligent manufacturing, intelligent factories, and IoT applications. Web access is increased for machines, and they are linked to the whole supply chain visualisation scheme. Rapid developments in automation technologies contribute to increased productivity and more mobile workflows. We have moved to the modern industry 4.0 era, which will redefine the advantages promised by Industrial IoT with smarter robotics and computer vision technology [29,30].

In connection to new technology and developments with automation and production data sharing, industries hit the next milestone. The fourth industrial revolution is concerned with mainstreaming cyber-physical technologies and putting them at the forefront of production. Industry 4.0 develops cyber-physical structures to monitor the physical world digitally and make decentralised choices within scalable and organised mills. The technology behind industrial automation and efficiency is vital to consider and help humans harmonise with their computers. Fully autonomous robotic systems assemble components, direct them in the factory, and ensure quality levels are met [31,32].

1.4. Brief about Robotics

Robotics modules such as pumps and motors are installed at high speeds in many car plants. Robots also perform tasks such as the installation of windshields and wheel assembly to maximise performance. Robots are made suitable for removal procedures such as trim and cuts by their high accuracy and repeatability. This could take the form of cutting materials, plastic mouldings and die castings. Mobile autonomous robots, which are an extension of the autonomously driven vehicles (AGV) that have historically been used in manufacturing centres, use vision systems and proprietary algorithms to manoeuvre through areas such as factories and warehouses. Receiving and order delivery have always been manual operations. To make matters worse, many suppliers and dealers have changed their logistics policy in recent years. TIt moves in-store jobs to a factory or delivery centre, where order fulfilment costs increase [33-35].

For real-world motion and manipulation tasks, robots depend on actuator systems such as DC engines, servo motors, steppers, etc. The chosen components must satisfy robots' operational specifications and architecture requirements. Robot designers currently focus on a trial approach and error when sizing the drive. In order to fulfil the performance criteria, the part size is iteratively increased. A single point of running speed/ operating torque is used to size the actuators. Including the newest intelligent technology, mobile robots have been provided with new features that can increase collaboration. It enables the client/user to monitor positioning, locating, and navigation operations directly from any robot network computer [36, 37].

The automotive industry has long been the primary consumer of robotic solutions, owing to high demand and a small production unit range. However, electronics are growing, as used in metal, rubber and plastics, food manufacturing, and even pharmaceuticals, owing to robotics technology developments.

Autonomous mobile robots are located in moving packages around the warehouse. These mobile vehicles that do not need facilities to manoeuvre are available in various sizes and payloads. It transports the right location at the correct time through various arrangements, onboard information, and complex preparation of the route [38,39].

A robot may be used to load and unload CNC machines when they are working and unsafe. If done regularly, they can also be an enormous efficiency source with lesser downtime. Robots have been used for a long time in the automotive industry and are used in many areas today. The manufacture of robots and products is a natural collaboration. The role of robotics in the production landscape today is significant. A core element in any operation aimed at optimum performance, protection, and competitive advantage should be automated manufacturing solutions. Production robotics automate routine jobs, minimise mistake margin to nominal rates, and enable people to concentrate on the business's more profitable areas [40,41].

Manufacturing robots play a wide variety of functions. Autonomous robots in development are required for repetitive operations of high volume, where a robot has unrivalled advantages in its speed, precision, and durability. Robot technologies used to assist humans with more complicated activities provide other industrial automation solutions. The robot performs heavy parts so that heavy packs are lifted, held, and moved. Manufacturing robotics process automation enables businesses to stay competitive internationally, providing an affordable, sustainable alternative to offshoring and fulfilling capability gaps in locations where recruiting required staff may be challenging. Development robots allow workers to concentrate on creativity, productivity, and other dynamic processes, which lay the basis for growth and prosperity. This enhanced staff's safety and satisfaction and resulted in a dedicated production automation solution in operation [42-44].

Robots defend staff from dull, worldly, and unhealthy repetitive activities and provide more suitable roles, such as engineering, programming, administration, and machinery repair. Robots free up labour, allowing businesses to leverage employees' talents in other aspects of the market. Domestic businesses can compete on price with companies by automation. Manufacturing robots offer higher efficiency, enabling businesses to survive on more

significant contracts. In an environment where green manufacturing becomes increasingly necessary, robots save resources, as climatic regulation or luminaire are not needed, and cleaner areas are generated [45,46].
Industry 4.0 is an automated system of development guided by the Internet of Things principle, which interacts with each other through a linked mesh of objects, equipment, and computers. The robots' activities can be orchestrated and automated more than ever by linking to a central computer, database, or programmable logic controller. They can intelligently complete assignments with no human feedback. Material can be transported around the plant using autonomous mobile robots, preventing barriers, coordinating with fleet mates, and detecting where takeovers and drops are required in real-time. This open connectivity is the keeper of Industry 4.0, particularly for advanced machinery. Industry 4.0 transcends the traditional notion of connectivity with machines. This is an exciting opportunity for producers as it provides automation opportunities that enable automation to be incorporated into a well-tuned process [47,48].
Opening doors may be the simplest example of autonomous mobile robots. Through the shipment of components and objects, doors that a human may have opened and closed must now be linked to allow robots to interact with them and unlock them while carrying the items. Factory workers using autonomous mobile robots could transfer materials between the production plants with pallets into elevators; these elevators can now attach and open automatically via wireless communications using robots. Robot systems, including fire warning systems, can now be wholly incorporated into the plant and respond to emergencies.

1.5. Major benefits/utilities of Robotics

Multiple functions can be carried out simultaneously by industrial robotics. Facility administrators can efficiently leverage industrial floor space and minimise hardware footprint by replacing a heavy multi-core computing capacity with an existing programmable logic controller (PLC). Robots have been integrated into the food processing facilities by major food corporations. The robots carry on various tasks in development with vision technology, cameras, and AI. They are capable of cutting, measuring, packing, and palletising everything. Industries with a wealth of sensors will track machinery and manufacturing processes in real-time to avoid aberrant output and services. Machine vision robots can perform complex optical processes with precise precision. Microscopic structural defects or minor colour differences may be detected and corrected immediately to uphold performance quality [49,50].
Automation is becoming much more reliable than staff. Robots are precision designed such that the output and services can be sustained continuously without the human error factor. The industry has been using robots on floors for decades. The robots come fitted with lasers and cameras, which allow high-precision welding. The reliability of automation enables producers to reduce total waste in the manufacturing chain. Replacement costs are lowered when robotic systems can be upgraded or reassigned as the market model progresses to complete new activities. Although they might seem to be an extravagant initial investment, industrial robots return on investment quickly through lower labour costs and shorter production cycles. The long-term costs of operation and servicing would be lower than an employee doing the same duties.
At the end of a robotic arm, the mounting of a smart camera opens up a vast range of applications as the arm will move over the examined component to monitor several parameters. Machine vision incorporates various innovations to provide practical results from image acquisition and interpretation for robot-based inspection and guidance. The fast-growing machine vision inspection is used to assess surface flaws, colour or presence/absence. The automobile industry has been a major driver of industrial robotics, using most of the robots in use today. The most common robotic activity in car manufacturing has been body welding. Two metal fragments are fused at a point in this process to form a combined fusion of both components. A high electrical current and low voltage are transmitted between two opposite electrodes, between which the parts to be connected are mounted [51-53].
Robots programmed to operate the whole time in a day in almost any situation to help manufacturing companies achieve greater productivity, higher throughput, and greater profits. Though automation alters the essence of work, it has created enormous profit opportunities in the manufacturing industry. A collaborative robot is one of the most commonly used forms of automation robots. With the maturing technology behind it, collaborative robotics can become more flexible in production and carry on innovative tasks. Alternatively, modern sensor designs and algorithms have improved to ensure that early robots are better suited for high volumes, minimal variants so that they can be used for new uses. Robots are thus used in a growing variety of sectors and even in the factory increasingly. Automation has become standard in numerous sectors over the last couple of years [54,55].
Robots are commonly used in several industries to apply sealing material cords or adhesives. The substance to be applied is in the shape of a liquid or paste. It is placed in a tank and pumped up to the application gun, which holds the robot that controls the projected flow of material. Furthermore, robots are used to screw, assemble, mark, manipulate, and control quality in the automotive industry. Industrial robotics helps different manufacturing sectors maximise efficiency and boost product quality by automating production. Picking, packaging, and palletising are all tasks that must be done correctly. Hand-in-hand, labour-intensive and time-consuming work may be done. It is

impractical to expect humans to operate with limitless energy reserves. Besides, people will make mistakes during assignments [56,57].

1.6. Internet of Robotic Things (IoRT)

The IoT is also linked to connected devices such as surveillance cameras or wearable heart monitors. IoT integration of manufacturing robotics is considered the Internet of IoRT. This integration can help track activities around them, fuse their sensor data, use local and distributed information to decide on courses of action, and influence objects in the real world. With IoT, the robot can be intelligent on its own, gathering data and values from its sensors and storing or relaying live data collected [58-60].

Robotics and the Internet of Things have been motivated by several ambitions that are all interconnected. IoT focuses on ubiquitous sensing, control and recording services, while robotic societies concentrate on development, engagement, and autonomous behaviour. Combining both and establishing an Internet of Robotic Things will add a substantial benefit. It can be emphasised that machine vision is being used, and robotics minimises production lines errors and increases efficiency. It creates a major competitive edge and to go beyond industry 4.0 with self-correction, continuous learning and ever-improving workflows [61,62].

Technological developments in robotics continue to make robotics more available and affordable. Robotics is a helpful method when computer learning, simulation, and computing can be applied to a single machine that achieves a greater target. Across the smart technology continuum, all computers and vehicles to heavy equipment are getting smarter every day. With modern artificial intelligence algorithms, the technology around us continuously adapts to our desires and habits to better support us.

1.7. Cobots

Collaborative robots are known as cobots which are capable of interacting with humans. This partnership is designed to increase human capacity healthily. In contrast, robotic deployments that do not presume human-robot cooperation usually work independently of humans and remain in an enclosure. They can also be designed to interrupt when a person approaches a robot operating facility. It leads to unnecessary delays in service or output, which can be prevented by using cobots. Collaborative robots can control the world and co-exist with humans in the same facility without losing efficiency or protection [63, 64].

A cobot in a human-free facility would not require as much care as a cobot close to a human being. The need for high signalling, high bandwidth, low latency, and rapid decision-making capability by robust computation is, therefore, required for cobot in more safety-critical environments. 5G provides effective network allocation, ensuring the required level of operation, thus optimising mobile networks' use of resources. Much research is underway on how robotics can imitate human gestures and choices. On the other hand, algorithms of artificial intelligence can find answers superior to those found by people. Robots' are used to make human work more effective, and cooperation between human beings and robots more successful will be quite exciting [65, 66].

The synthesis of cobots in the industry is underway in many different fields. Faster response time, more accurate patterns of movement, alignment capacity, human imitation capability – all of these factors lead to the advancement of cobot production. Besides, brain-computer interfaces are an engaging environment that has seen considerable strides in recent years. When brain impulses can be interpreted with high accuracy and transmitted to robots, they will work with them in a whole different way. Cobots provide the most benefit in cases where humans need to be in close contact with robots. It involves human-robot partnerships in which a human directs robots, controls the process, or even learns from robots. There is a precise fit when it comes to cobots and 5G devices. One of the main features of cobots would be the consistency of service specifications, which differ in time and meaning. Protection zones differ, depending upon the location of barriers, the proximity of humans to the same facility, and the speed at which the robot moves. For the control system to respond and take timely decisions, such as stopping the cobot movement, fast and effective communication is critical [67-70].

Significant use of any modern technologies is an issue in the industry since the industry is deploying cobots. Both robotics automation in the design process has been traditionally configured and calibrated. In a best-case situation, a data-driven method was modified in a runtime. Here, cobots provide process engineers with the opportunity to teach cobots how to do tasks and adapt activities in time, enable artificial intelligence to progress.

Cobots also decide on several issues in real-time and can look for much space. This involves crossing large diagrams that require computing resources, a trustworthy network and modern machine architectures. Recent technology such as data-connectedness, parallel processing, edge computing and artificial intelligence distribution allow fast decision making through cobots and stable and efficient delivery [71-73].

A problem with cobots' commercial use is to impede cobots' market introduction by inadequate technological sophistication. Cobot technology comprises hardware architecture, sensors and actuators, effective information transmission, video processing and preparation, and technology for guaranteeing security, predictability, and security of the solutions in a wide variety of artificial intelligence fields. Cobotics is one of the leading intelligent factory innovations that make the global production market competitive and productive. Cobots are lightweight and

easy to configure, unlike conventional robots. The cobots' prominent role is to cooperate with humans to ensure stable, cost-effective production automation improvement [74-76].
Cobot is commonly used in a range of sectors, as life science, automobile, engineering, electronics, aerospace, packaging, chemicals, and healthcare, to name a few. The opportunity to retain sustainable shares of human machinery can benefit many of these businesses over rivals. The fact that cobots are simple to use while being dependable, safe, and accurate is also advantageous. Overall, cobots are less costly than their counterparts and can yield more stable effects. In comparison, some robotics integrators do not fear the cobot revolution [77,78]. Cobotics incorporation into Industry 4.0 is plain to conclude that it will be one of our lifetime's most destructive events. Advanced robotics and their machine vision ties are important to Industry 4.0 and affect every manufacturing process stage. In industrial robotics, machine vision has played a crucial role, and both became interconnected. The principal explanation for this development is that cameras have become more powerful and precise in industrial environments. Although robotic technologies have advanced, cameras can allow robots to see what is around them, giving some of the most lucrative and efficient benefits [79-81].

2. Various Key Robotics Aspects for Industry 4.0 Implementation

Figure 1 is reflecting about the numerous key robotics aspects for realising Industry 4.0 philosophy in practical terms. It includes real-time features, historical trends, up and downtime monitoring, PLC and several other alarming, critical performances, etc. These proposed robotics-based aspects further enable the robotics utility while implementing industry 4.0 culture throughout. These special functions also provide a fundamental base to materialise industry 4.0 culture effectively and precisely [82,83].

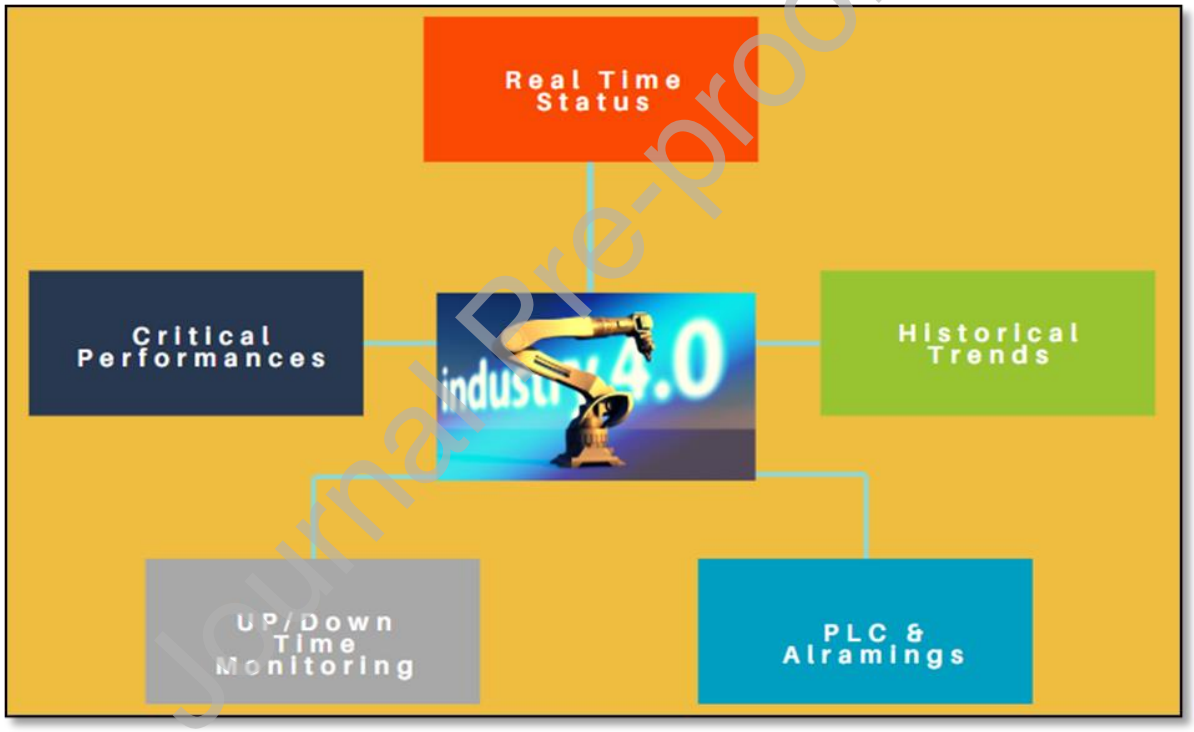


Figure 1: Various key Robotics facets for Industry 4.0

Advances in robotics render new operations more reliable and more secure. Autonomous robots, cobots, interactive autonomous smart robs, humanoids, mobile robots, cloud robots, pick and place robots, and robotic swarms comprise the most influential robotic technology that impacts development. The use of robotics provides greater accuracy and endurance and improves the capacity to build personalised robots quickly.
Robots often encourage human capital to concentrate on other high priority or non-repeatable activities. In Industry 4.0, the flow of information due to networking raises questions about stability, openness and privacy. As production processes become more personal and adaptable, data processing activities can significantly impact the brand's attraction outside and within the shop floor. Thus, to deter cyberattacks on important industrial infrastructure, the transfer and retrieval of confidential industrial data must be performed safely using robotics technology. The latest advances in this area include software ethics and protection, privacy-enhancing technology, intelligent encryption,

zero-trust security, end-to-end contact security [84-86]. Cyber protection must be matched with integrity and confidentiality. Industry 4.0 developments are fundamental which can be enhanced by robotics.

3. Different Industry 4.0 Perspectives for Robotics Solicitations

It includes various industry 4.0 issues: aspects of agile assembly and manufacturing, training and learning processes, energy maintenance issues, etc. Figure 2 is exemplifying the several Industry 4.0 perspectives towards robotics applications. It further explores enhancing tact: quality check, effectiveness, error-free functioning, soft gripping, satisfaction, fast processing, downtime reduction, etc. [87,88].

Figure 2: Industry 4.0 Perspectives for Robotics Solicitations

By integrating complex real-time sensing and simulation data, digital twin technology produces simulated industrial asset models. Any of the promising cases of digital doubles involves model-driven programming, virtual prototyping and virtual machine validation. The use of digital twins leads to hyper integration of the production sector. Digital twins offer valuable insights into every stage of the production process. Industry 4.0, also known as Connected Industry, whereby people and robots can work together safely and exchange knowledge to refine their operations, thereby improving decision-making. Mobile robots and mobile manipulators provide the modular and automated industrial automation required to build Smart Factories. The most valuable commodity is the knowledge sharing enabled by introducing cutting-edge intelligent technology into robotics, such as the Internet of Things, Artificial Intelligence, and Big Data. In the age of mobile robots, the convergence of ICT and intelligent technology has led to features extending their industrial applications; these abilities can process data, execute measures and respond to various working environments [89-91]. This resulted in significant improvements in mobile robotics application in metrology, quality management, service on large parts or packing, washing, polishing, screwing or drilling.

4. Major potential capabilities of Robotics in different fields/ industries

Advanced robotics and their connections to machine vision are important to the progress of Industry 4.0 initiatives and influence every step in the production process. Machine vision played an integral role in the development of industrial robotics, and both became more and more intertwined. The key explanation for this development is that cameras in robust manufacturing environments are more powerful and reliable than ever before. In comparison, robotic technologies have increased, which is the most profitable and effective ways. In a robotic arm, the mounting of a clever camera opens up many applications, as the arm will move the examined component to verify a range of requirements. Machine vision brings together various tools that produce practical results from image acquisition and interpretation for robot-based inspection and guidance. To create a surface defect, colour, presence/absence, the inspection, a high growth zone, uses machine vision [92-94].

Computer vision technologies offer to build blocks to create effective product testing, quality management, fault detection and data collection solutions. These features are perfect for producers to improve efficiency and perform processes with minimal human interference. The work of a car painter is not easy, and booting is extremely poisonous. Finding trained, competent painters is often tricky due to a lack of work. The robotic arms will fill the vacuum, as each coat of paint needs durability. Robots should follow a planned course that covers vast areas and reduces waste reliably. Machines for adhesives, sealants, and other applications are also helpful. This job type is suitable for massive manufacturing robotics. Besides, smaller cobots for more minor production activities also carry out machinery tenders and loading/unloading duties. Robots will navigate a dynamic course without fail many times, making it ideal for cutting workers. This style of work is ideally suited for light robots with force-sensing technology [95-98]. Major potential capabilities of Robotics in different fields are as under:

4.1. Manufacturing

During, this technology provides a significant role in manufacturing to perform all ongoing processes. The rolling of hot metal ingots into final forms such as coils and strips is an example of electronic process management in the metals industry during manufacturing processes. This was first used in the steel industry, but similar manufacturing is now done for aluminium and other metals. Hot rolling is carried out under machine control in a modern steel factory using robots. The rolling process entails moving a large, hot metal billet through a rolling mill composed of one or more sets of large cylindrical rolls that squeeze the metal and reduce its cross-section. In order to progressively reduce the ingot to the correct thickness, several passes are necessary. After each pass through the rolls, sensors and automated instruments determine the ingot's measurements and temperature, and the control computer measures and controls the roll settings for the next pass.

4.2. Agriculture

The agriculture industry has been aggressively working to implement various robotic technology types to improve productivity while lowering total costs. Farmers have also started to use GPS-guided tractors and harvesters. There has recently been an increase in the experimental use of autonomous systems that automate operations such as pruning, thinning, mowing, watering, and weed repulsion.

4.3. Kitchen and household applications

One of the most extravagant robot technology advances in the kitchen is due soon to be made. It can be operated by a smartphone, allowing the robot to cook the pre-determined meal quickly and efficiently after selecting a recipe and arranging pre-packed containers of ingredients. Robotics also creates a consumer-friendly version of a smart dishwasher and refrigerator that includes a smart kitchen robot.

4.4. Robotics for healthcare practices

Robotics advances can transform a wide range of health care practices, including surgery, recovery, counselling, patient companionship, and regular tasks. Robotic instruments used in health care are not intended to replace health care workers but rather make their jobs simpler. During the COVID-19 pandemic, this technology is used to deliver medicine, food and other essential items for the infected patient.

4.5. Competing with human skill

Industrial robotics is on the brink of revolutionising manufacturing as they become noticeably more sophisticated, faster, and less costly, and they are being asked to do more. They compete with more human skills and qualities such as detection, experience, memory, and trainability. As a result, they are competing for more jobs, such as picking and packing. For a long time, robots in manufacturing industries have ensured speed, efficacy, and performance. Robots are transforming the way we think of assembly and manufacturing. This built to transfer components and execute a range of changed tasks in production and manufacturing environments. Robots are often used to carry out dangerous or unsatisfactory human labourers activities, such as monotonous work that induces exhaustion and can result in wounds due to the nebulous nature.

4.6. Automotive industry

The automobile industry is now among the world's most advanced, which further raise its automation standard by integrating collaborative robotics for the first time in its assembly. Strengthening workers at factories are used to embrace interactive robotics. Modern robotics can help improve efficiency for workers and compete the competitors. In the auto industry, the number of robots in automobile production is anticipated to rise even higher. The automotive business is the first organisation in Industry 4.0, implementing collaborative small-scale robotics on the mounting side. Robots previously substituted staff for single or dangerous activities. Car manufacturing industries are now introducing robots that work with human beings and serve as assistants. The car industry has long been and continues to be one of the fastest, greatest adopters of industrial robotic technology. Robots are used in one manner or another in virtually any aspect of car production and prove to be one of the most heavily automated supply chains in the world.

4.7. Logistics and warehouse

Robots have expanded around manufacture since their first use in die casting. Today in many different fields, they execute a wide variety of tasks for logistics and warehouses. The list of robotics applications in manufacturing is continuing to expand with sensor technology and software advancements. In factories, warehouses and delivery centres, some of the latest and most interesting robots are included. Robots are more straightforward and useful for setting up plug and play in warehouses. They are designed to connect much more quickly to each other and make development less demanding, provided that the following systems are stronger and more adaptable. Robots can do additional tasks while working to deliver multi-faceted consistency and robustness in different assembly environments.

5. Different Robotics variants for Industry 4.0 Employments at Ground Level

Industries utilise robots for a variety of applications and functions. These intended functions further enhance the overall effectiveness of the process being implemented/explored for enabling industry 4.0 philosophy throughout. Figure 3 explores various robotic variants which are particularly employed while implementing industry 4.0 culture at several levels. Some major domains are welding robots, material handling, pick and place type, and other miscellaneous applications robots [99,100]. The collaborative, dispensing, plasma, spot welding type robots, vision, press robots, assembly, paint, and routing robots are few examples of various robots that enable the various needs at industry 4.0 implementation.

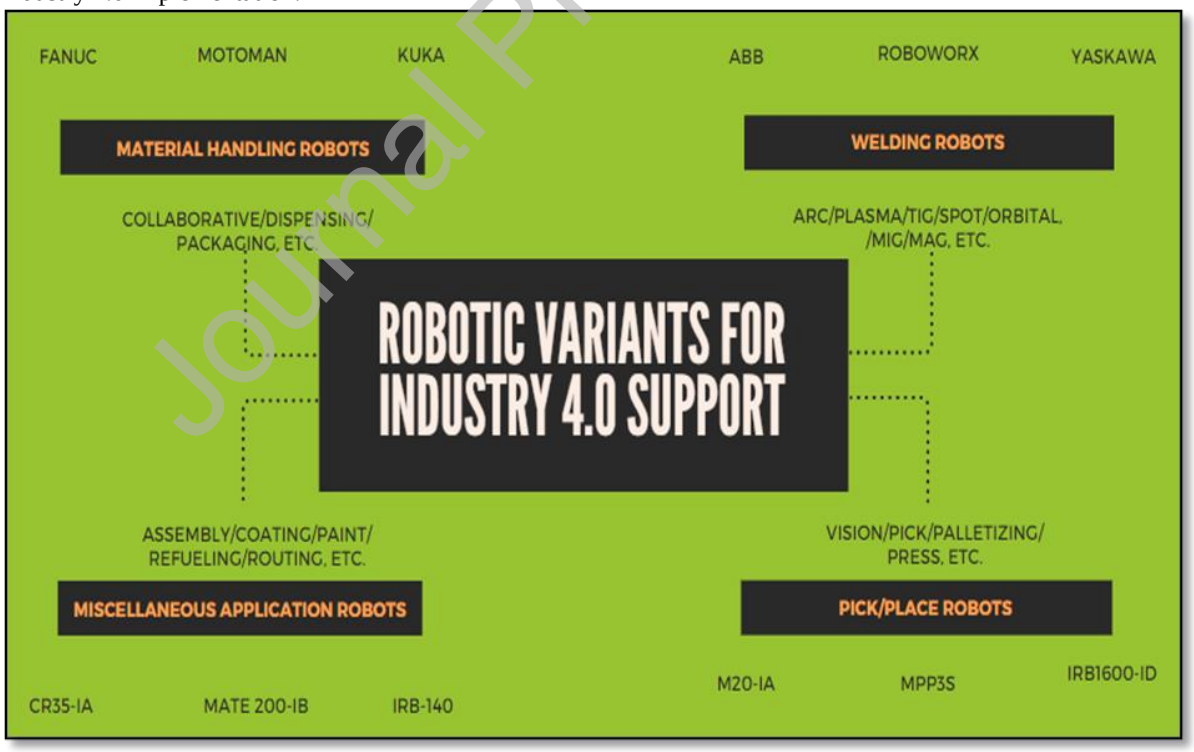


Figure 3: Varieties of Robotics for Industry 4.0 Implementation

Montage and inspection are the major application field for industrial robotics. Due to the high cost of manual labour to these activities, robotics in assembly is expected to grow. As robots may be programmed, one technique in assembly tasks is to manufacture multi-style batches and reprogram robots. An alternative approach is to combine different product types in a single mounting cell that each robot needs. A digital computer is used to guide the processes of a production process in computer process control. While computer control over other automatic device processes commonly involves continuous processing of materials. Products are usually manufactured in the gas, liquid, or powder phase in these operations to allow material movement across the different stages of the manufacturing cycle using robotics [101,102]. Furthermore, these goods are usually mass-produced. Because of the simplicity of managing the commodity and the large quantities involved, these businesses have reached a high degree of automation.

6. Robotics applications in context to Industry 4.0

Robotics is an innovative technology used for various development industries. Owing to their duties' repeat and monotonous nature, many employees on the floor experience exhaustion, weakness, and other physical discomforts. This technology helps the floor, helps employees effectively perform their duties, and reduces or removes all physical stress. Network and connectivity are two of the most critical considerations in facilitating Industry 4.0. A variety of advances in technology such as edge-to-cloud, gigabit ethernet time-sensitive networks, wide-area low-power networks, 5G machine-to-machine connectivity, real-time determinist ethernet networking, omnipresent radio access and unified IoT platform, and zero-touch networks are enabling factories to introduce IIoT to turn into facilities for Industry 4.0 [103-107]. Machine-machine and human-machine connectivity and data transfer are continuously enhanced to create developments in modern industries. Network and connectivity are two of the most critical considerations in facilitating Industry 4.0. Technologies used in this revolution helps for data transfer, are continuously enhanced by these developments. Table 1 discusses the significant applications of Robotics in Industry 4.0.

Table 1: - Significant types of applications of Robotics in Industry 4.0

S No	Applications	Description	References
1	Complex job	Human beings are also studying the fitness of robots and their function in production. Robotics use electronic devices to perform physical, tough activities to improve their employees' health and welfare. In the 'factory of the future, automation will automatically understand and change the material to deliver a specific and reliable operation. The machine's onboard knowledge then autonomously tracks variations to the regular procedure to assess when the component is finished. Finally, the tough transportation of the goods would be required to proceed to the next level. Professional painters are hard to come by, and the work is particularly dangerous. This makes it ideal for robotics, but paintwork has to be very precise over a wide area of paint, and avoiding waste can save a lot over time. This technology can easily carry out all difficult jobs which are not possible by the human. For a long time, robotic welding has been the most common robotic application in the automotive industry, as any car demands many welds before it is completed. Due to the high demand for the final product, automation efficiency is huge. To save time and money, use industrial robotics to simplify applications in an assembly line. Robots can also perform the most repetitive and risky production applications, keeping the employees clean, secure, and inspired.	[108-112]
2	Smoother production	From preparation to real activities, production can become smoother. Supply chains can get closer and more effective by supplying finished products for sale in warehouses by automated machines. Most of all, interactive tasks for robotic machines are reduced, more flexible and easier to programme. They will understand to become artificially intelligent, smarter, more self-sufficient and self-optimising. This enhanced the predictive maintenance for a smooth production system. The rational and expected product of Industry 4.0 is smart factories. Intelligent plant automation will be powered by artificial intelligence and smart robotics.	[113-116]
3	Enhance productivity and reliability	Robotics is being used in many fields of manufacturing to enhance productivity and reliability while lowering production costs. Robots work together with employees to do routine, single or complicated work under employees' supervision and direction. The development of robotics is also increasingly secure. Robots can detect and avoid humans in the workplace using cameras, alarms, and automated shut-off capability. Robotics is being used in a wide range of applications in the public safety industries to enhanced productivity.	[117-119]

		Unmanned drones are one influential example.	
4	Automation	Robotics allow for more leverage of variable output costs by maximising the distribution of capital and workforce. The security of workers is improved in factory automation. Robots remain focused on their jobs, while smarter versions are used and tailored to the situations around them that could damage the protection of working environments. It provides flexible automation in which a material-handling system connects many machine tools, and a central computer operates the whole system. A flexible manufacturing system's ability to process more than one product type concurrently differs from an automatic production line. Each computer in the system can be processing a particular component form at any given time. A flexible manufacturing system will also address adjustments to the product mix and production schedules as market conditions shift over time in the various goods produced on the device. Robotic technology makes the system more flexible, which enhance efficiency.	[120-122]
5	data Extraction	The everyday activities of robots will give a wealth of data. Many of these data can be formatted, submitted regularly and often backed up for data consistency and availability. Based on detailed performance results, companies are encouraged to make more efficient choices. In Industry 4.0, industrial robotics technologies improve innovation and enable unparalleled efficiency levels. Intelligent and automated plants are smart factories where the machinery networks can gather and analyse big data in real-time and detect and fix problems.	[123-125]
6	Sustain high temperature	Human staff may use robotics to perform too risky or difficult activities. High temperature operating conditions, dangerous contaminants, and extended exposure to noisy noises can constantly impair. Delegating hazardous robot activities removes employees from the plant floor risks. The level of automation should be adapted to fulfil market needs to sustain a prosperous worker community.	[126-129]
7	Performing boring and difficult jobs	Robotics will take unsafe, boring and complex jobs, which people do not like. Thus, it helps employees should concentrate on more important, fulfilling opportunities. They will learn how to configure and maintain machinery or benefit from advanced training. It helps to develop skills that contribute to the progression of their careers by training robots. Staff will remain in the company with greater pleasure and inspiration. The robot incorporates new and reconditioned robot solutions for a wide range of applications. Using this technology production line can run as quickly as possible, and industries will determine the right robot solution for particular application specifications.	[130-133]
8	Higher output efficiency	Industrial robotics can have a higher output efficiency and greater precision and reliability than other technologies, including the Industrial Internet of Things and 3D printing robots. Reduced processing cycles and real-time reporting are both added advantages to increase preventive maintenance. An industrial robot raises production speed, partly by continuous operation. Robots finally decrease cycle time and optimise performance. Repetitive robots mean less risk of injury to staff, especially in aggressive situations where manufacturing needs to occur. Supervisors may also track the procedure electronically or remotely.	[134-136]
9	Self-management and decision making	A mobile robot can not only execute a mission without human intervention, but it can also self-manage and make decisions due to its ability to view, produce, and process information. This means that the mobile robot can undertake routine or hazardous operations and, by tests, it can re-establish and predictive models it creates from the data it receives in real-time. It can determine either to adjust its path and to modify its omnidirectional movements. This makes communication possible from machine to machine. The development of decentralised systems and the possibility of robots communicating with humans through integrated interfaces simplify collaborative work. This also facilitates the cooperation of other elements, such as artificial vision systems or robotic arms, which can also be built into mobile platforms.	[137-140]
11	Working entire time and for long duration	The robots work seven days a week in the factories. The implementation and evaluation of control logics and human-computer interface is also a big challenge in robotics engineering. The department automation monitors the validation of applications to perform the entire working process. The consumer advantage is that the virtual start-up process in a risk-free environment is reduced using a dependable virtual prototype. One straightforward solution is mobile robots that make it possible to automate internal flows of products simply, dynamically and cost-effectively.	[141-143]
12	Materials movement	Highly trained staff frequently manually handle internal transportation to the detriment of performance. Robotics are used to handle all internal transportation in the industries.	[144-147]

		Industry 4.0 involves solutions that serve as a versatile connection between the production processes. Autonomous robots can navigate independently in a complex environment to their sensor systems and protection algorithms without interfering with production facility infrastructure. This allows them to work around people safely. Top devices, such as shelf units, gradually turn the robot colleague into a powerful platform capable of automating almost any transport mission. For material movement, Robot shift materials and workpieces from place to place. Many of these tasks are relatively straightforward, and robots need to collect and position parts from one transporter. Other transfers, such as positioning parts in an arrangement that the robot has to measure, are more complicated. A robot is used to charge and discharge parts in a manufacturing machine for the loading and discharge process. This means that the robot must be fitted with an inflator capable of seizing bits. The gripper must typically be precisely built for the unique geometry of the component during material movement.	
13	Inspection	Robotic technologies have advanced applications in inspection and quality control. It used cameras to allow robots to see what is around them, giving some of the most lucrative and efficient benefits. At the end of a robotic arm, the mounting of a smart camera opens up a vast range of applications as the arm will move over the examined component to monitor several parameters. Machine vision incorporates various innovations to provide practical results from image acquisition and interpretation for robot-based inspection and guidance. The fast-growing machine vision inspection is used to assess surface flaws, colour or presence/absence.	[148-150]
14	Surveillance	Robotics and IoT are motivated by separate but closely connected priorities. IoT focuses on services promoting pervasive sensing, surveillance and recording, and the emphasis on processing, engagement and independent activity in robotic societies. The development of an Internet of robotic things will add a strong benefit to using Industrial robots. Artificial intelligence, robotics, and other automation technologies are evolving rapidly and delivering major performance and growth gains to businesses. This evolves massively in the process of digital transition and is different in the future.	[151-153]
15	Control entire processes	Today car manufacturers are exploring many processes using robotics. This technology makes a more powerful, precise, scalable, and reliable environment. The car industry has remained one of the world's most automated production chains and among the biggest consumers in robotics with this technology. It takes a complicated assembly process to bring materials to thousands of wires and parts in every car.	[154-156]
16	Production Feedback	The laser and camera array of the robot wrist provides the system with immediate production feedback. This can create a large manufacturing environment with long arms and higher payload capacities. Smaller robots will still place in the industry to perform precise work. It achieves good welding standards in any fabrication. Industrial robotics minimise waste and manufacture jobs with higher-quality materials with consistent accuracy.	[157-160]
17	Assembly lines	On vast assembly lines, collaborative robots collaborate with other big manufacturing robots. Thus, to keep the assembly line running, robotic welders and handlers must work together. Robot handlers must precisely position themselves so that the entire task can complete in lesser time and cost. Light robotic arms can be used to assemble smaller components such as engines and pumps at high speeds. Robots also perform other functions such as screw driving, wheelsets, and windshield installation. A significant feature of the robotic installation is the complex nature of the product. Assembling human-satisfactory approaches are not inherently robotic such manual assembly is simple to do with a screw and nozzle as a repairing tool, but a single-arm robot has pretty much the same operation. The robot provides a replacement for human labour in almost all commercial robotic applications. Certain human industrial workers define work as a possible robot application.	[161-163]
18	Welding, soldering, brazing, painting and joining	The robot manipulates a method for processing the job component of robotic processing operations such as welding, soldering, brazing, painting, joining processes and spray painting. Vehicle spot welding is one of the most frequent applications for industrial robotics. Here, a spot welder is placed against automotive panels and frames to finish the basic vehicle body assembly. Arc welding is a continuous procedure in which the welding rod is moved around the seam to be welded by the robot. Spray painting means that the spray-painting weapon is manipulated on the surface of a covered object. Other operations in this group include grinding, polishing, and routing, in which the robot's instrument is a revolving spindle.	[164-167]

New design types will be put into manufacturing with a flexible manufacturing system as long as they are part of the product selection to be processed by the device. Therefore, such a system is suitable for low to medium demand for goods and demand shifts are expected to occur. The versatile manufacturing method is highly automated, but people are still required for system management, loading and unloading components, adjustment tools, and machinery maintenance and repair. Robotics is used in manufacturing industries to create flexibility in manufacturing [168-173]. Inspection is another sector in which robots are being used more and more in the factory. When the robot places a sensor in a standard inspection task concerning the workpiece, it decides that the component conforms to consistency requirements. The individual end of arm tools, basic reach and payloads are required and flexible in each industrial robot application. It maintains a vast inventory and work cells, allowing us to integrate easily. The industrial sector has long been excellent in its serious use of modern technologies [174-177].

7. 3D Printing and Robotics

The combination of 3D printing with industrial robotics is promising for Industry 4.0. These emerging technologies provide better solutions towards digitisation and smart manufacturing. Industrial robotics and 3D printing are possible by equipping a robotic arm with a material deposition head and industrial robot aid in 3D printing at various manufacturing stages. These devices are automated for enhancing factory floor productivity. Robotics can also be used to automate the post-processing of 3D printed products. These technologies have great capability to produce large-scale items [178-181]. A robotic 3D printer with a multi-axis robotic arm can be moved in different directions and 3D print at varied angles and produced complicated designs. Better material management is also aided by the combination of robotics and 3D printing. As a result, robotic enabled 3D printing represents a more sustainable manufacturing method. The construction industry could benefit the most from robotic 3D printing. This allows designers and architects to experiment with diverse shapes [182-185]. Thus, to build huge metal three-dimensional objects, a 3D printer is combined with an industrial robot holding welding equipment. Nowadays, advanced technologies become more effective, adaptable, and precise. Several improvements have been made on assembly lines to support workers' day-to-day tasks in the last few years [186-189].

8. Discussion on the proposed study

The Fourth Industrial Revolution and the new intelligent technologies were the constant transformations of conventional production processes and the market. The main focus is on using big machines communication devices, such as machine to machine and IoT, to enhance automation, enhanced communication and tracking, and smart machines that can evaluate and diagnose problems without any human involvement. The aim is to better communication and self-monitoring. The hardware includes services robotics, all-around networking and communications technology, construction control and management systems, a power management system fitted with sensors, cloud and leading-edge infrastructure, smart device governance, wearable networks, and a clever application. Remote diagnostics, inspection, and even repairing of products related allows for more loyal customer connections, improves value and makes it possible for suppliers to maintain productivity expectations and consistency. It creates early notice, identifies and input from closed loops that can guide potential product quality changes.

Industry 4.0 undertakes and extends the robotics and intelligent possibilities such as businesses start incorporating intelligent manufacturing in their production. This exponentially incorporates robotics into factories. It brings unbelievable accuracy, efficiency and versatility. Factories are now seeing a spike in the number of autonomous robots that can operate together to increase productivity and performance. The precision of robots decreases the number of errors of quality, lower disposal costs and reprocessing. Automation leads to the largest productivity with the lowest expenditure. A business will draw more buyers with the decrease in schedule and prices. The industry will increase the number of goods provided by incorporating an industrial robot into manufacturing. Robots improve safety and ergonomics in the workplace by eliminating risky or repeated activities for employees.

The first robotic procedure was implemented for injection moulding. Here the substance is used in a liquid state and inserted under pressure into the mould in this process. The above model comprises two halves held together during the metal injection by the strain exerted by two cylinders. The mould can be reused after it has been washed of metal residues and well lubricated. Robots are solely used to finish objects by painting them with a specific substance such as paint, enamel, metal flakes, etc., for cosmetic or protective purposes and are an essential aspect of many production methods. The problem to be solved is similar in both painting and metallic applications. It is widely used in the production of cars, electronics, and furniture, among other things.

In the automotive sector, they incorporate industrial equipment to perform a range of applications, as automatically; welding, material processing, packaging, palletising, dispensing, cutting, etc. Automation makes many applications feasible with one robot. The execution of various functions, pace adaptation, alternate routes, and changes to parts is well beyond a smart-navigated mobile robot's capacity. Manufacturing and marketing specialists with all the capabilities required to respond to their own needs in all industries have developed and built innovative, tailor-made

solutions to improve and enhance mobile robots' industrial applications by close cooperation with various industries. Many people believe that the interactions between cobotics and IIoT would be one of the most transformative factors in the modern world. Investments in industry 4.0 by manufacturers, utilities, and transport are currently the key driving force for IoT development.

Many analysts characterise industrial automation and even the spark for the next industrial revolution as cobotics. Cobots are the next generation of robots packed with new sensors for effective human interaction. The standard dynamic programming, with learning skills, is also a central focus of Cobotics. Floor operators will now train cobots, log and view the operation repeatedly through a series of movements. In a plant setting, autonomous mobile robots and other automated vehicles may transport the goods from the storage areas to the factory floor. In Spain, the newly adopted Mobile Industrial Robots are to be delivered to separate robot stations on the ground and replace a man to supply industrial and soldering materials. The production and assembly of components in the car industry are some of the most important robot users. The robot employee's design and deployment are more available today than they had been a decade ago, and montage lines have since become more effective.

Several orders for rolled goods with varying requirements can be in the mill at any given time in a large factory. Control programmes have been produced to schedule the sequence and pace at which hot metal ingots are fed through the rolling mills. The production management role of scheduling and tracking the various orders necessitates swift, massive data collection and analysis. This role has been combined with machine control of rolling mill operations in modern plants to achieve a fully automated production system. There has been an increasing movement in manufacturing companies toward using computers to execute specific design and development functions. This trend's technology is CAD/CAM, which stands for computer-aided design and computer-aided manufacturing. It is now generally accepted that computer software's reach would expand beyond design and development to cover its corporate functions. This broader use of computers is known as computer-integrated production.

9. Limitations

Automated machines can perform challenging and demanding activities, which human beings cannot accomplish. However, humans can also do much more things than robots can do. One way people win over robots is by their decision-making ability. More importantly, they are also more robust problem solvers, and they can think out of the box and respond more flexibly. Also, many companies depend upon imagination, ingenuity and personality, which an organisation powered entirely by robotics will lack. Therefore, human feedback will continue to be needed even after Industry 4.0 gets wholly developed. Many fears and misunderstandings have been expressed about robots that steal humans. The robots usually need substantial investment at an early stage. The industry has to weigh all the prices, including installation and setup, when searching the business case for buying. The sophisticated operation, maintenance, and programming are necessary for industrial robotics. While the number of individuals with these abilities increases, it is small at present. Therefore, the industry must consider staffing and get current employees this skill or tool to take care of the mission.

10. Future Scope/ Research Directions

For a long time, the factory of the future has been taking shape. Digital systems are being used, people and machines are work in daily work, and product innovations have become increasingly productive. Also, creative ideas are needed for intralogistics for the increasingly automated processes. Industry 4.0 will only perform optimally if manufacturing and logistics systems are related effectively. In future, Robotic Automation will make its way into a wide variety of industrial applications. Welding, fabrication, distribution, raw material processing, assembly and packaging will be efficiently performed by robotics. Robotics automation will be growing with a large number of suppliers for a wider variety of applications. This technology will be commonly used in the automotive industry and have become an essential feature in many production processes. Industrial robotics will enable integrating multiple challenging activities on the manufacturing line while improving operation versatility. By applying these technologies, the essence of people's work will be changed. Electronic machines will carry on physical and demanding jobs to improve employee’s health and safety.

11. Conclusion

Industrial manufacturing is constantly evolving to help producers meet rising customer demand and remain competitive in the global market. Robotic machines are now making inroads into several industrial markets. As robotic devices become affordable, they will soon be available in a range of formats for customers, with the potential to affect our lives in various ways. Robotics applications in manufacturing have produced more protection, quality, and sustainability for enterprises. With the advent of Industry 4.0, robotics integration is beneficial to the manufacturing industry for various reasons, including reliability, precision, performance, and resistance to hazardous environments. It can be used to allow more rational decision making for Industry 4.0. It can also be combined with business processes to make collaboration between many data platforms more effective. It provides a

more effective and reliable production process. Many manufacturing processes in the industry have been streamlined by intelligent robots that operate with great precision and speed. The existing demand necessitates highly adaptable systems that allow for regular product adjustments at a low cost. As a result, factory robots have emerged as the optimal option for assembly automation. Thus, in the upcoming days, automation will bring substantial profit opportunities to the manufacturing industry.

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