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The Role of Robotics Technology and Internet of Things for Industry 4.0 Realization

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ABSTRACT

Robotic systems can already proactively monitor and adapt to changes in a production line. Nowadays, internet of things and robotic systems are key drivers of technological innovation trends.Major companies are now making investments in machine learning-powered approaches to improve in principle all aspects of manufacturing. Connected devices, sensors, and similar advancements allow people and companies to do things they wouldn't even dream of in earlier eras. For realizing it time series feature extraction approach is selected.Industrial internet of things solutions are poised to transform many industry verticals including healthcare, retail, automotive, and transport. For many industries, the industrial internet of things has significantly improved reliability, production, and customer satisfaction. The internet of things and robotics are coming together to create the internet of robotic things. Industrial internet of thing is a subset of industry 4.0. It can encourage smartness at a bigger level in industrial robots.

Key words: -Industrial Internet of Things, Internet of Robotic Things, Robotics, Internet of things, Industry 4.0

1. INTRODUCTION

Robotics and IoT have been driven by varying yet highly related objectives. IoT focuses on supporting services for pervasive sensing, monitoring and tracking, while the robotic communities focus on production action, interaction, and autonomous behavior[1].

A strong value would be added by combining the two and creating an internet of robotic things. Cloud robotics is distinguished from the general field of electromechanical automation through its use of teleportation as well as reliance upon various cloud computing technologies such as computing and storage as well as the emerging cloud-based business models enabling robotics as a service. In addition, cloud robotics will benefit greatly from edge computing technologies, such as mobile edge computing, as well as commercial introduction of 5G. One of the important advantages of the cloud robotics market is the ability to make robotics and industrial automation equipment available to a much wider spectrum of users. One of the ways in which this is accomplished is via open APIs, which enable abstraction of the robotics control plane from the application user interface. This means that customers do not need to use proprietary user interfaces for robotic controllers[2].

The industrial internet of things is a branch of the larger type of technology collectively known as the internet of things. Connected devices, sensors, and similar advancements allow people and companies to do things they wouldn't even dream of in earlier eras. There are particularly fascinating things in store for the IIoT and its effect on the robotics sector. One significant benefit of IIoT-ready robots is that the people overseeing production at a plant or similar facility can often sync the movements of numerous pieces of equipment and have them work together to achieve tasks faster than one machine could alone. In the past, company executives often invested in pieces of robotic equipment without assessing whether

those products were compatible with other assets already in the environment. The advancements of the IIoT, it's possible to find industrial robots that communicate with each other in the cloud. Then, people can set up several robots to handle particular needs and watch the statistics of each machine on a dedicated dashboard. As such, this kind of industrial automation improves overall efficiency and cohesiveness. People often hear about the Internet of Things (IoT) regarding connected devices like security cameras and wearable fitness trackers, but what about combining IoT with robotics?This combination is likely to shape the future of robotics and is already disrupting the norm in many cases.From collaborative robots in the automotive industry, to autonomous mobile storage for the retail industry, to robotic personal assistants in your day-to-day activities, Interment supports the robotic industry across the new industrial revolution[3].Working together with robot manufacturers, we deliver extensive risk assessment and compliance evaluations to ensure that standalone robots, or robotics as part of an overall automated system, comply with global safety and performance standards.Thanks to more powerful software and falling hardware costs IIoT is poised to revolutionize manufacturing through smart technology. Also known as industry 4.0, it brings greater automation through the internet of things, machine-to-machine learning, robotics, and artificial intelligence, and cyber-physical systems.The internet of Things, the technologies, architectures, and services that allow massive numbers of sensor enabled, uniquely addressable “things” to communicate with each other and transfer data over pervasive networks using internet protocols, is expected to be the next great technological innovation and business opportunity. It will exceed in size and importance both the personal computer and mobile communications markets, and even the development of the Internet itself[4].

At this time, most IoT initiatives are focused on using connected devices with simple, onboard, passive sensors to manage, monitor and optimize systems and their processes. This alone will be hugely impactful; however, it is not too soon for forward-thinking companies to explore the more advanced and transformational aspects of ubiquitous connectivity to, and communication among, smart devices. The concept of the internet of robotic things , where intelligent devices can monitor events, fuse sensor data from a variety of sources, use local and distributed “intelligence” to determine a best course of action, and then act to control or manipulate objects in the physical world, and in some cases while physically moving through that world. It will also examine the many ways IoT technologies and robotic “devices” intersect to provide advanced robotic capabilities, along with novel applications, and by extension, new business, and investment opportunities[5].In the industry 4.0 future, smart factories using additive manufacturing such as 3D printing through selective laser sintering and other computer-driven manufacturing systems are able to adaptively manufacture parts on demand, direct from digital designs. Sensors keep track of needed components and order them based on patterns of demand and other algorithmic decision trees, taking "just-in-time" manufacturing to a new level of optimization. Optical sensors and machine-learning-driven systems monitor the quality of components with more consistency and accuracy than potentially tired and bored humans on the product line. Industrial robots work in synchronization with the humans handling more delicate tasks or replace them entirely. Entire supply chains can pivot with the introduction of new products, changes in consumption, and economic fluctuation. And the machines can tell humans when the machines need to be fixed before they even break or tell people better ways to organize the line all because of artificial intelligence processing the massive amounts of data generated by the manufacturing process[6].

a. Applications of Internet of Robotic Things

the concept of the internet of robotic things , where intelligent devices can monitor events, fuse sensor data from a variety of sources, use local and distributed intelligence to determine a best course of action, and then act to control or manipulate objects the physical world, and in some cases while physically moving through that

world.Applications of internet of robotic things can range from warehouse automation to parking lot management to elderly care. In parking lot management, an internet of robotic things technology device can check if a corporate parking lot is only used by authorized cars, and raise an alert in the event of unauthorized cars enter the lot. Internet of robotic things also finds application in warehouse automation fulfillment center. This is where mobile robots move bins and pallets and can coordinate their movements.Some other new phenomenon where internet of robotic things is poised to find application is the personal robot space. This involves taking real physical action by learning and combining sensor data, which can range from garden maintenance to support of the elderly or cleaning.Internet of robotic things can also find applications in physical security and healthcare[12].

Robotics and automation have been commonplace in industrial manufacturing for decades, but we are seeing a new wave of opportunity driven by declining technology costs, growing functionality, and an expanding range of environments in which robotics can be safely and effectively deployed. Introducing new robotic technologies in product assembly, warehousing, and logistics can improve the productivity, quality, and safety of operational processes. Applications include autonomous guided vehicles in distribution centers, automated warehouse management systems, and cobots (collaborative robots) working on assembly processes in conjunction with humans[8].

b. Industry Internet of Things

This new wave of technology and innovation offers companies opportunities not only to drive a step-change in productivity and efficiency, but also to capture strategic business value by establishing competitive advantage in the way they operate their entire “make to deliver” value chain. The nature and scale of the opportunities will vary from sector to sector and company to company, depending on factors such as value drivers, market dynamics, and operational maturity. However, we routinely see successful technology-enabled transformations dramatically shifting individual value drivers[3]. Advanced analytics and artificial intelligence can be applied to large data sets to generate new insights and enable better decision making in predictive maintenance, quality management, demand forecasting, and other areas. Machine-learning algorithms are growing more powerful as computing power advances and big data proliferates. However, the full potential of artificial intelligence has yet to be captured in production environments, which at present use only a small fraction of data for decision making. Internet of things provides a strong platform to connect objects to the internet for facilitating machine to machine communication and transferring data using standard network protocols like TCP/IP. IoT is gaining rapidly day by day and till date, billions of devices are already connected and in the coming few years, the number can even touch trillions. With consistent advancements, lots of areas like military, agriculture, industry, healthcare, robotics, and nanotechnology are adapting IoT for advanced solutions. The research papers proposes a comprehensive view of the new concept of IoT especially proposed for robotics i.e. Internet of robotic things. IoRT is a mix of diverse technologies like cloud computing, artificial intelligence, machine learning and internet of things. The industrial internet of things is the use of smart sensors and actuators to enhance manufacturing and industrial processes. Also known as the industrial internet or industry 4.0, IIoT leverages the power of smart machines and real-time analytics to take advantage of the data that dumb machines have produced in industrial settings for years. The driving philosophy behind IIoT is that smart machines are not only better than humans at capturing and analyzing data in real time, they are better at communicating important information that can be used to drive business decisions faster and more accurately. IIoT applications, on the other hand, connect machines and devices in such industries as oil and gas, utilities and manufacturing. System failures and downtime in IIoT deployments can result in high-risk situations or even life-threatening situations. IIoT applications are also more concerned with improving efficiency and improving health or safety, versus the user-centric nature of IoT applications[13].

c. Robotics and Industry 4.0

Today, we're at a juncture: industry 4.0 is on the rise due to automation and the ubiquity of computing power and has spurred what many consider yet another industrial revolution.Industry 4.0 refers to the use of automation and data exchange in manufacturing. According to the Boston consulting group there are nine principal technologies that make up industry 4.0: Autonomous robots, simulation, horizontal and vertical system integration, the industrial internet of things, cyber security, the cloud, additive manufacturing, data and analytics, and augmented reality. These technologies are used to create a "smart factory" where machines, systems, and humans communicate with each other in order to coordinate and monitor progress along the assembly line. Networked devices provide sensor data and are digitally controlled[14].

Industry 4.0 involves the heavy use of automation and data exchange in manufacturing environments, encompassing areas such as cyber-physical systems, the Internet of Things (IoT) and cloud computing, among others. With Industry 4.0, manufacturers will be able to operate "smarter" factories, in which they can more easily tailor products for specific customers.This new phase in manufacturing is so named because it follows the previous manufacturing phases of water/steam power, electric power, and computing power. A lot of the technologies organizations are deploying today, such as big data/analytics, cloud services, and augmented reality, will also have a part in industry 4.0.[15]. The trend is gathering force, the firm said and advised executives to carefully monitor the coming changes and develop strategies to take advantage of the new opportunities. It sees the trend being driven by four disruptions: the dramatic increase in data volumes, computational power, and connectivity; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3D printing. Robotics is part of the industry 4.0 picture. One significant benefit of IIoT-ready robots is that the people overseeing production at a plant or similar facility can often sync the movements of numerous pieces of equipment and have them work together to achieve tasks faster than one machine could alone. In the past, company executives often invested in pieces of robotic equipment without assessing whether those products were compatible with other assets already in the environment[16].

2. THE APPROACH USED

The term 'Internet of robotic things' itself was coined in recent research reports to denote a concept where sensor data from a variety of sources are fused, processed using local and distributed intelligence and used to control and manipulate objects in the physical world. We believe that automation and IoT simplify the day-to-day routine and accelerate business processes. Being adherents of automation and implementation of smart things into the business workflow, we do a step-by-step implementation of Industry 4.0 elements into our clients' infrastructure. Some scenarios of IoRT are applicable to a connected factory where in the robot data is monitored in real-time in the cloud as well as the robots maintenance is and performance optimization takes place well in advance. Another scenario which has been implemented by some companies is the concept where the Robot data from the factory is synced in real-time with the cloud and the actuation happens accordingly so that the productivity is high and no robot remains idle in the production line, this way it is ensured that the process of manufacturing never comes to a halt even because of the slightest of the error or faults in the robot. One of the most challenging scenarios in the industry is to develop a software platform, which is independent of the robot being connected to it i.e. different robots but all connected to one software platform on the cloud, via this the user experience and remote monitoring solutions become simplified to leaps and bounds in this. The fourth industrial revolution is characterized by the creation of intelligent factories that implement and integrate state of the art technologies such as cyber physical systems (which combine tangible assets with digital twins), IIoT, data analytics, additive manufacturing, 3D printing and artificial

intelligence. Applying these technologies make possible to achieve the necessary optimization and automation to reduce costs and manufacturing times. This will allow us to produce thousands of different product configurations and to manufacture very small batches of goods at a very low cost[19].Industrial big data, IoT (IIoT), robotics and other information sources are known to generate large volume of variety information in huge velocity with variability (inconsistent) and veracity (imprecise). Such data needs to be carefully merged and integrated for predicting the system state by analyzing and extracting the most meaningful features from different time intervals[19]. This are do with time series feature extraction approach for easily extracting analyzing the feature.

a. Reasons for the selected approach

Feature extraction remains one of the most preliminary steps in machine learning algorithms to identify strong and weak relevant attributes. While many feature extraction algorithms are used during feature engineering for standard classification and regression problems, the problem turns increasing difficult for time series classification and regression problems where each label or regression target is associated with several time series and meta-information simultaneously.Feature extraction controls selecting the important and useful features, by eliminating redundant features and noise from the system. In the context of time series data it aims to[20]:

1. Extract characteristics feature from time series, such as min, max, average, percentile or other mathematical derivations.
2. Consolidate feature extraction and selection process from distributed heterogeneous sources of information lying on different time-series scale for predicting the target output.
3. Allow time series clustering (un-supervised learning) from extracted features based on its relevancy.
4. The extracted relevant and non-relevant features can help us to identify new insights at time series properties and dimensions in both classification and regression modeling.

3. RESULTS AND DISCUSSION

The internet-of-robotic-things is an emerging paradigm that brings together autonomous robotic systems with the internet of things vision of connected sensors and smart objects pervasively embedded in everyday environments.Applying the IIoT to robotics offers real-time supply chain visibility and other insights that guide business intelligence. The IIoT even allows plant managers to assess the performance of multiple robots across numerous business locations. Having access to informative updates when desired also makes it easier for plant managers to assert it's time to invest in more robots to complement the ones currently in use. Then, since the dashboards that give robotics' metrics are typically extremely detailed, the effects of adding another robot or changing business operations in another way are easy to see without delay. Industrial internet of things solutions are poised to transform many industry verticals including healthcare, retail, automotive, and transport. For many industries, IIoT will significantly improve reliability, production, and customer satisfaction. While, IIoT will initially improve existing processes and augmented current infrastructure, the ultimate goal will be to realize entirely new and dramatically improved products and services.Using IoRT, intelligent devices can monitor events, fuse sensor data from different sources, use local and distributed intelligence to determine a best course of action. This follows by an act to control or manipulate objects in the physical world[19].

The global internet of robotic things market is driven by a number of favorable factors. Expansion of the e-commerce industry and increasing application areas due to integration of robots with various technologies is serving to boost the use of internet of robotic things. Increasing use of smart devices, automation in manufacturing processes, and proliferation of e-commerce are some factors driving the IoRT market.On the downside, lack of awareness of

internet of robotics technology and high cost factor for research of internet of robotic things are some factors challenging the market's growth. Nevertheless, increasing adoption of industrial robots by small and medium enterprises is likely to create opportunities for vendors in the internet of robotic things market[21].

IoRT has three intelligent components:First, the robot can sense that it has embedded monitoring capabilities and can get sensor data from other sources.Second, it can analyze data from the event it monitors, which means there's edge computing involved. Edge computing is where data is processed and analyzed locally instead of in the cloud, and it eliminates the need to transmit a wealth of data to the cloud.Third, because of the first two components, the robot can determine which action to take and then take that action. As a result, the robot can control or manipulate a physical object, and if it was designed to, it can move in the physical world. The bigger idea for now is collaborations between machine / machine and between man / machine. These interactions could move toward predictive maintenance and entirely new services.With a higher degree of automation in a smart factory fewer workers will be needed. Lower skilled workers like drivers, and cleaners will face redundancy. In contrast there will be a premium on employ more skilled workers especially software engineers and programmers[22].The introduction of more robots in production plants will change strategic geographical considerations. Relocating facilities in search of cheap labor will be less of a priority as this approach will have much less impact on final cost hence packaging manufacturers can relocate plants closer to their customers and realize new time and logistics savings[23].

4. DISCUSSION

Industrial things are intelligent machines, devices, and systems that generate copious amounts of measurement data; from the operation of single devices to entire production processes, energy consumption, operating environment and production quality. Measurement data analysis allows functions to be controlled, prepared and automated**.**The incorporation of the robotics aspect into the wider IoT transforms the landscape currently dominated by business models built upon passive interaction to dynamic and physical relationships between the digital and physical world.The integration of smart technology into the manufacturing sector will allow for machines and processes to be wirelessly interconnected, providing for greater communication and information gathering, more accurate data, and better decision making than ever before.The internet of robotic Things is an emerging vision that brings together pervasive sensors and objects with robotic and autonomous systems. This survey examines how the merger of robotic and Internet of Things technologies will advance the abilities of both the current Internet of Things and the current robotic systems, thus enabling the creation of new, potentially disruptive services **.**Though many people often think about internet of things and robotics technology as separate fields, these two niches seem to be growing simultaneously as we find new ways to engineer each one[20].The IoT and robotics communities are coming together to create The internet of robotic things . The IoRT is a concept in which intelligent devices can monitor the events happening around them, fuse their sensor data, make use of local and distributed intelligence to decide on courses of action and then behave to manipulate or control objects in the physical world.The IoT is a network of things that are connected to the internet, including IoT devices and IoT-enabled physical assets ranging from consumer devices to sensor-equipped connected technology. These items are an essential driver for customer-facing innovation, data-driven optimization, new applications, digital transformation, business models and revenue streams across all sectors.IoT devices are usually designed to handle specific tasks, while robots need to react to unexpected conditions. Artificial intelligence and machine learning help these robots deal with unexpected conditions that arise[24].Both IoT devices and robots depend on sensors to understand the environment around them, quickly process data and determine how to respond. Robots are able to handle anticipated situations, while most IoT applications can only handle well-defined tasks.The main difference between the IoT and the robotics community is that robots take real action and are in the physical world.

They do something. Focus has been shifting from the cyber component of IoT to the physical aspect, and that's where the efforts are combining.With the rise of robotics technology and industry spending, it's a great opportunity for those who are interested in artificial intelligence and robotics. A career in robotics technology offers a wide variety of options, and a number of jobs fall under this category.This type of field can offer jobs like service and repair as well as designing and creating the interfaces and systems. It's a multi-disciplinary field with growing opportunity as the industry expands. Many perceive benefits of this type of work to be in the distant future but are unaware of how much robots already play a role in society and how fast they're evolving[22].The internet of things is a recent revolution of the internet which is increasingly adopted with great success in business, industry, healthcare, economic, and other sectors of modern information society. In particular, IoT supported by artificial intelligence enhances considerably the success in a large repertory of every-day applications with dominant one's enterprise, transportation, robotics, industrial, and automation systems applications[21]. Being essential to the success of Industry 4.0 initiatives, advanced robotics and their relationship to machine vision is making an impact on every step of the manufacturing process. Machine vision has played a vital role in the evolution of industrial robotics, and the two are becoming increasingly integrated. The main reason for this trend is that cameras have become more powerful and more accurate in rugged industrial settings than ever before. While robotic capabilities have certainly improved, it's been the ability of cameras to let robots see what's around them that has provided some of the most profitable and productive benefits. Mounting a smart camera at the end of a robotic arm opens up a wide variety of applications because the arm can traverse around the part being inspected to check a variety of criteria. Machine vision combines a range of technologies to provide useful outputs from the acquisition and analysis of images for robot-based inspection and guidance. Inspection, the fast-growing area, uses machine vision to determine surface defects, color, or presence/absence[17].

Robotic systems can already proactively monitor and adapt to changes in a production line. By networking multiple machines, each robot will increasingly be able to adapt dynamically not just to its work, but that of other robot and humans within the smart factory. Major companies are now making investments in machine learning-powered approaches to improve in principle all aspects of manufacturing. It is projected to grow noticeably and in the coming five years this will spread for specialized industries into mainstream sectors, including packaging. To realize machine learning's full potential however, companies must break down data silos. Pooling data for advanced synthesis across companies is key to creating new, performance-based business models[18].

5. CONCLUSION

Nowadays, Internet of things and robotic systems are key drivers of technological innovation trends. Leveraging the advantages of both technologies, IoT-aided robotic systems can disclose a disruptive potential of opportunities the present contribution provides an experimental analysis of an IoT-aided robotic system for environmental monitoring. To this end, an experimental test bed has been developed.The internet of things and robotics cannot be considered two separate domains these days. The internet of robotics things is a concept that has been recently introduced to describe the integration of robotics technologies in IoT scenarios[9]. Industrial internet of things solutions are poised to transform many industry verticals including healthcare, retail, automotive, and transport. For many industries, IIoT will significantly improve reliability, production, and customer satisfaction. While, IIoT will initially improve existing processes and augmented current infrastructure, the ultimate goal will be to realize entirely new, and dramatically improved products and services. Successful companies will be those that understand how and where IoT technologies and solutions will drive opportunities for operational improvements, new and enhanced products and services, as well as completely new business models.The industrial internet of things is a network of physical objects, systems, platforms and

applications that contain embedded technology to communicate and share intelligence with each other, the external environment and with people. The adoption of the IIoT is being enabled by the improved availability and affordability of sensors, processors and other technologies that have helped facilitate capture of and access to real-time information. Industry 4.0 will generate enormous quantities of data. Gathering, analyzing and processing such big data will generate new insights, support decision-making and create a competitive advantage[10].We closed out by looking at how robotics and IoT can be integrated. Point to highlight is that machine vision is being used along with robots to help reduce defects in manufacturing lines and improve productivity, to establish a significant competitive advantage, and to move beyond industry 4.0 with self-correcting, continuously learning, and ever-improving workflows. Industry 5.0 has already appeared on the horizon.

Abbreviations: Artificial Intelligence (AI), intelligent manufacturing (IM), Industrial Internet of Things (IIoT), Cyber Physical Systems (CPS), Internet-of-Robotic-Things (IoRT), Machine to Machine (M2M), Internet of services (IoS) and Internet of Things (IoT).

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