Development Of Health And Safety Management System Based On Collaborative Robots

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Abstract

The era of the society 5.0 is a concept that defines technology and people to improve the quality of human life in a sustainable manner. One of these technological advances is Society 5.0, which was initiated by the Japanese. This concept allows us to use modern science-based such as Internet Of Things (IoT), Artificial Intelligence (AI) and Robots for human needs in order to live comfortably and more effectively. This article aims to create a strategy for expanding the characteristics of occupational safety and health in the era of the society 5.0. This strategy creates new technologies to make it easier for humans to do industrial work that focuses on the safety and health of employees in the workplace from accidents and exposure to hazardous substances. One of the technologies used in society 5.0 is Cobots, which is designed to make programming simple through a Human-Machine Interface (HMI). The use of cobots also enables companies to achieve a faster Return on Investment (RoI) as it provides rest time for workers and allows them to handle higher productivity processes and ultimately acquire new skills. So that this concept will make management and strategies more effective, efficient, and innovative, in creating high worker performance so that it can support the success and improvement of the company's quality to protect workers from accidents and occupational safety and health in the era of society 5.0.

1. Introduction

Collaborative robots, also referred to as cobots or co-robots, are robots or robot-like equipment designed to safely work directly with human workers to complete tasks that cannot be fully automated.

1.1 Literature Review

The The cobot's flexibility and reprogramming capabilities make it even more worth the investment as it can be programmed to have a wide range of applications in a wide range of sectors, from manufacturing to healthcare.

In recent years industrial robots have been widely used in the manufacturing industry, and they have replaced humans in various tasks, freeing workers from repetitive, unhealthy or hazardous work. The direct result of the application of robots in industry is the emergence of new accident risks for workers. In order to prevent accidents, the selection of a safety system should be based on the above-mentioned risk analysis. Generally in the past, safety systems have separated robots and human workspaces. One example of this separation is reflected in the UNE-EN 755:1996 standard which stipulates that sensor systems must be combined to prevent the entry of people in hazardous areas, where the operating state of the robotic system may pose a hazard to workers. By standard Traditionally, authorized personnel can only be inside the robot's workspace if the robot is not in automatic mode.

To overcome these shortcomings, Collaborative Robots is the best solution for these shortcomings. Unlike traditional robots, Collaborative Robots will work as co-workers and collaborate and interact further from a predefined list of tasks. This robot is easier to use and flexible to use. Most importantly, limiting and force sensors that can put humans and robots working in the same place without the need to install shields. With all the diversity created by this collaboration between humans and robots, humans will gain a higher share in the industry, especially in controlling in society 5.0.

So in the era of society 5.0 it can be easily said that humans will manage and operate the industry as before in industry 4.0 but with differences. And this difference is the availability of Collaborative Robots for humans. Now the human workforce can better manage things, ensuring the technical precision of robots to produce customizable products. In addition, it allocates tasks such as lifting heavy and high-risk objects to robots without compromising human intelligence and human strength.

The pursuit of more flexible and more efficient manufacturing is driving significant changes in the industry. The transformation from automatic manufacturing to Industry 4.0 which is mostly promoted from Germany, or to smart factories fostered from the United States, is based on the emergence of a new generation system that introduces the latest technological advances in the field of information and communication. Technology (ICT), data analysis, and devices such as sensors or robots. This transformation means that the tasks performed by industrial robots are no longer limited to moving objects, or other repetitive actions. In contrast, there is an increasing number of tasks in which humans and robots combine their skills in collaborative work.

Society 5.0 is currently conceptualized to harness the unique creativity of human craftsmanship to collaborate with powerful, intelligent and accurate machines. Many technical visionaries believe that society 5.0 will bring the human touch back to the manufacturing industry. It is hoped that society 5.0 combines high-speed, accurate machines, as well as critical thinking and human cognitive. Man-machine collaboration aims to increase production at a high speed. society 5.0 can improve production quality by assigning repetitive and monotonous tasks to robots/machines and tasks that require critical thinking for humans.

Robot programming requires experienced programmers. Programming robots through humans has been intended as a flexible framework that reduces the complexity of robot programming tasks and allows end users to control robots in a natural and easy way without the need for explicit programming. The way it works is to let the robot passively interact, while humans control the movement of objects. For human- robot collaboration to be efficient, robots must be able to perform active and passive interactions, just like humans. However, in terms of physical interaction and collaboration in the assembly or setup of service robots, the work available is still somewhat limited.

In order for a robot to be active in interaction to be able to plan and execute the exact trajectory of an object and its own movement, it must have knowledge of its internal state and what constraints will occur if a human imposes it on the object. In contrast to the conventional program development process, when programming robots through demonstrations, users may not be familiar with the syntax and semantics of the programming language. Therefore, we need a methodology to study and code the tasks of some demonstrations and basic learning in both explicit communication (natural language) and implicit communication (motion).

However, there are still a number of challenges to be faced such as interaction modalities such as the need for speech, gaze or movement based on formalism that can be interpreted by robotic control algorithms and disambiguity that needs to be resolved, planning and motion control. must be done in real to ensure workflow and interaction. natural ones. This is something that cannot be done with the classic sense-plan- act architecture that forms the current state of the art in applied robotics. Furthermore, the task of manipulating the robot requires a model that captures the dynamics of the interaction. This cannot be obtained by rare human demonstration alone. The most promising approach to this dilemma seems to be exploratory learning.

Here, the robot interacts with the environment and tries to build a suitable model (or directly control policies) using the information collected. However, data collection in robotics is time consuming and random exploration is potentially dangerous for robots and their surroundings. Therefore, the main objective lies in an efficient sample reinforcement learning method to find local models and control policies. The way to generalize the results lies in the active area of the research. The purpose of this article is to highlight these challenges as well as suggest a framework for human-robot collaboration that leverages the ideas mentioned above using explicit communication, exploratory learning and reactive control-based approaches to motion generation.

2. Research Methods

A. Human-Robot Interaction (HRI)

The need for effective human-robot interaction (HRI) continues to present challenges in the field of robotics. As new technologies are integrated into human robot teams across multiple application domains, robot exposure and expectations grow rapidly. The limiting factor in the success of human robot teams is the lack of metrics to assess HRI effectiveness.

The need for validated testing methods and metrics for human robot teams is driven by the desire for repeatable and consistent evaluation of HRI methodologies. Such evaluations are critical to advancing the HRI baseline model, as well as establishing traceable mechanisms for HRI technology vendors and consumers to assess and ensure functionality.

Methods and metrics for evaluating the performance of human robot teams across many human-centric application domains, including industrial, social, medical, field and service robotics. This article will focus on establishing a diversity of approaches to addressing HRI metrology across various robotics domains, and identifying the issues underlying traceability, objective repetition, and transparency in HRI metrology.

B. Internet of Things (IoT)

The Internet of Things (IoT) has arrived, and its future is deep. Billions of devices are connected to the Internet, enabling the capture, manipulation and processing of signals from multiple sources. Everyday objects and devices use sensors to capture information and then connect to a network for better connection and visibility. Collecting analog data from the outside world, the network encodes it into digital signals and transfers it across time and space with the Internet. Information is managed at the device, edge, and cloud levels.

One of the main benefits of IoT is the increased coordination and control of automation, which is increasingly being used in industry. In this setting, this subset of IoT is known as the Industrial Internet of Things (IIoT). This relates primarily to the use of most automated equipment and networks in manufacturing or other industrial production systems. The availability of large amounts of data brought to the network via IoT-enabled devices allows large amounts of data to be processed quickly and efficiently, providing insight and better decision making and process control for industry.

IoT is fused with another major industrial technology: robotics. Robots have long been used in industrial processes. The most famous example is robotics used on manufacturing lines, such as for automobile assembly. Semiconductor manufacturing also makes excellent use of robots for stable and reliable process control and handling of sensitive products that require high attention and consistency.

The growth of IIoT enables the emergence of industrial cobots. Cobots are collaborative robots that have been adapted to work synergistically with humans. The use of cobots is increasing as IIoT allows robots to be coordinated with human activities, achieving higher levels of collaboration and efficiency. While traditional robots are programmed to work largely independently of human-specific interactive activities, cobots engage with humans. They work with them cooperatively and synergistically.

It is a mutually beneficial engagement, arrangement, and relationship, which benefits human workers and industry as a whole. This article will discuss the technologies that are enabling these changes, as well as some of the applications of cobots in industrial environments.

Cobots engage with IoT as technology enables robots to be transformed by acquiring new skills that were previously outside the domain of traditional robots. This technology serves to improve human-robot interaction, improve worker safety, and reduce costs. Enhanced sensor, actuator, control, and computing technologies power cobot perception, data fusion and processing, artificial intelligence, and actuation. The technology also drives ease of use, adaptability, and lower costs. Technology used :

1. Artificial intelligence and machine learning

Artificial intelligence (AI) is a technique for processing digital data in a way that seeks to mimic human functioning, behavior or thinking. Machine learning (ML) is a subset of AI that uses algorithms that are automatically improved through experience and data usage.

Cobots, on the other hand, incorporate AI. Cobots can to some extent sense their surroundings. Programming a cobot to operate in a new environment is not always complicated and can involve a human operator manually walking through the desired motion by moving the cobot arm through the desired trajectory.

AI and machine learning are enabled through high-speed computer processors and software that can incorporate technologies such as fuzzy logic, probabilistic methods, neural networks, and expert systems. This technology provides cobots with human-like qualities that promote human-robot interaction and collaboration.

Cobots retrieve and process large amounts of raw data from various sensors. This data is integrated, processed and interpreted, enabling cobots to make accurate and informed conclusions about the environment so that appropriate action can be taken. This should be done in virtual real-time to avoid latency issues in cobot operations with humans. Machine learning algorithms effectively integrate all data from different types of sensors, which may come from different locations in the workspace or can be sensed at different times to make precise and accurate conclusions about the environment and situations. AI and ML enable cobots to have forms of cognition that mimic human behavior, enabling them to more successfully engage with humans in the IIoT environment.

2. Computer/ machine vision

Sight is one of the most significant human senses, and is usually the primary way humans perceive the outside world. Similarly, cobots can be made to see through a process called computer or machine vision. Machine vision enables cobots, by mimicking human vision, to detect and identify objects, spaces, scenes, orientations and locations in visible (30nm–730nm), infrared (>730nm), and ultraviolet (<430nm) wavelengths. Light and range detection (Lidar) is a detection system that works on the principle of radar but uses light from a laser. Most of the focus on machine vision has to do with solving problems related to adequate differentiation and correct categorization of objects, so that decision making and object handling do not become bottlenecks of industrial processes. Machine vision enables increased accuracy, higher throughput, collision avoidance, and situational awareness.

3. Intelligent edge computing

Cobots themselves are built from edge devices, which are linked together in IoT. These edge devices are constantly improving in technical capabilities and intelligence. They become smarter, with the ability to understand and respond to more things and communicate and process them accordingly. Cobots represent the next step of autonomy for robotics, giving them more ability to operate and decide how to perform their specific tasks in their work environment, even as they work together and interact with humans. Enhancing complex interactions between machines and humans requires a way to handle and coordinate large amounts of data closest to where the operation is. The preference is for intelligent data processing to be done locally rather than remotely or at a hub or gateway.

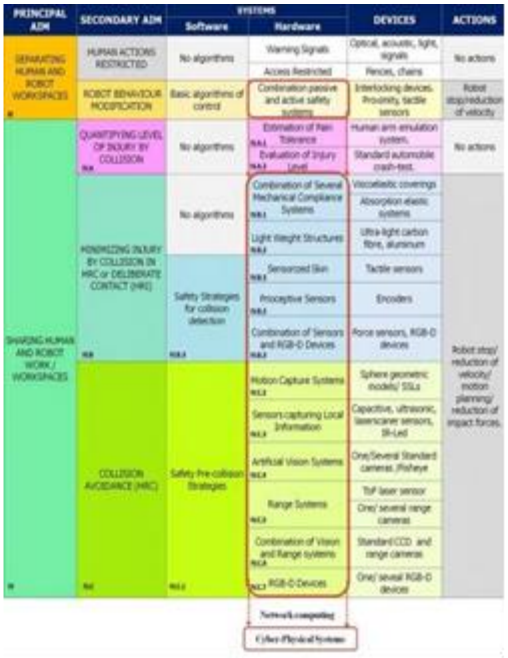
Intelligent edge consists of network systems and technologies that are built and customized to meet local data management needs. It must have adequate data capacity, proper system performance, system bandwidth, security, and reliability. Further development of edge computing will enable the creation of a new generation of cobots with increasingly autonomous capabilities.

C. Cyber-Physical System (CPS)

This article provides a structured framework for further and deeper discussion, the classification of the main security systems in the robot environment is provided in

Fig 1, including: the goals pursued by the security system, the systems used i.e.shows the section of the paper in which each subject is covered.

Fig 1. Safety classification in environmental industrial robot collaboration.



PRINCIPAL AIM	SECONDARY AIM	SYSTEMS		DEVICES	ACTIONS
		Software	Hardware		
SEPARATING HUMAN AND ROBOT WORKSPACES	HUMAN ACTIONS RESTRICTED	No algorithms	Warning Signals	Optical, acoustic, light, signals	No actions
			Access Restricted	Fences, chains	
	ROBOT BEHAVIOUR MODIFICATION	Basic algorithms of control	Combination passive and active safety systems	Interlocking devices. Proximity, tactile sensors	Robot stop/reduction of velocity
SHARING HUMAN AND ROBOT WORK / WORKSPACES	QUANTIFYING LEVEL OF INJURY BY COLLISION	No algorithms	Estimation of Pain Tolerance	Human arm emulation system.	No actions
			Evaluation of Injury Level	Standard automobile crash-test.	
	MINIMIZING INJURY BY COLLISION IN HRC or DELIBERATE CONTACT (HRI)	No algorithms	Combination of Several Mechanical Compliance Systems	Viscoelastic coverings	Robot stop/ reduction of velocity/ motion planning/ reduction of impact forces.
				Absorption elastic systems	
			Light Weight Structures	Ultra-light carbon fibre, aluminum	
		Safety Strategies for collision detection	Sensorized Skin	Tactile sensors	
			Proprioceptive Sensors	Encoders	
			Combination of Sensors and RGB-D Devices	Force sensors, RGB-D devices	
	COLLISION AVOIDANCE (HRC)	Safety Pre-collision Strategies	Motion Capture Systems	Sphere geometric models/ SSLs	
			Sensors capturing Local Information	Capacitive, ultrasonic, laserscaner sensors, IR-Led	
			Artificial Vision Systems	One/Several Standard cameras /Fisheye	
			Range Systems	ToF laser sensor	
				One/ several range cameras	
			Combination of Vision and Range systems	Standard CCD and range cameras	
			RGB-D Devices	One/ several RGB-D devices	

In addition to these elements, the term Cyber-Physical System (CPS) has been included because recent developments in intelligent manufacturing have important implications for the application of robotic security systems. In this way, the incorporation of network computing, connected devices, and data management systems in manufacturing processes, including active security systems, has resulted in examples of CPS. Cyber-Physical System is defined as physical devices equipped with technology to collect data about themselves and their environment, process and evaluate this data, connect in communication with other systems and initiate actions to achieve their goals.

The use of the CPS framework in the manufacturing industry has helped bring the division of the workspace between humans and robots from concept to reality. This has contributed to achieving flexible, adaptable, reliable and high-performance production. CPS can be considered as a concept work from which variations such as Cyber Physical Production System (CPPS) emerged. CPPS is seen as a more specific concept geared towards manufacturing, and not as generalist as CPS covering various fields of transportation, infrastructure, healthcare, defense emergency response, energy, or manufacturing.

Taking into account that, along with other applications, security issues fall within the scope of Cyber Physical Systems (CPS), in CPS-based security systems for human robot collaboration teams are implemented. To this end, several safety approaches, allowing for different HRC levels, have been proposed. For each proposed strategy, different types and combinations of sensors are used including laser scanners, proximity sensors, vision systems, or force sensors. The results of the study indicate that there are technological limitations on the sensor data rate and the number and types of sensors that are suitable for use in system implementation. This shortcoming highlights the limitations and technological challenges associated with implementing real-time CPS applied to human robot collaboration.

In a smart manufacturing context where all interconnected devices share information and make decisions and take action, safety is closely linked to security. In understanding that the concept of security is related to cyber threats or attacks that CPS can suffer, the possible interdependence between safety and security must be taken into account to achieve stronger hazard management.

Another important aspect to achieve effective and safe co-workers in a smart factory is the psychological state of the operator. It is important to ensure that the operator feels comfortable and safe when working with the robot, and the mental strain associated with this task is bearable. An assessment of the mental tension of a human operator working in a mobile manufacturing system was conducted through an experiment in which three influential factors in operator mental tension, including distance, speed and motion warning, were varied to determine design criteria to improve operator comfort.

Proper training of operators clearly has an impact on their confidence and their stress levels and safety as suggested. Training can considered a security measure that does not depend on the particular technology used in the robotic system, so it falls from the classification of Fig 1.

3. Result and Discussion

The introduction of Collaborative Robots in society 5.0 has had an impact on the dimensions or scope of industrial technology. Collaborative Robots embody interoperability, decentralized decisions. Figure 2 :

Fig 2. Completely new IoT hardware ESP8266 ESP-05 with antenna (green small square) and old IoT hardware WiFly RN-XV 171 (red big square) placed in low level robot control system (Color figure online).

IoT and information transparency. Society 5.0 together with Collaborative Robot will bring a tremendous holistic impact. The respective impacts of these results are:

1. Economi impact

   Job allocation to robots makes humans unemployed. So, the collaborative report concept will prove helpful in this regard, as it will encourage the use of human labor again with positive robotic power.

2. Consumer impact

   Taking into account the consumer's point of view, it is now possible to make whatever your customers want. No longer tied to an industrial standardization approach. In an Industry 4.0 setting, companies cannot manage a variety of products for individual customers no matter how much they want. The use of robots has problems. But with generation 5.0, it's not impossible.

   Now, customers will be in a better position to control the market. At the same time, Collaborative Robots will give companies the opportunity to take a competitive advantage in terms of greater customization.

3. Social impact

   Service value and overall career value will be much higher for humans working in the industry, bringing more job security and higher salaries. The result is an increase in people's living standards. In addition, the risk-oriented activities that humans have to perform initially can be easily transferred to this Collaborative Robot. In addition, humans will be in a better position to devote their energies to creative work – work they will enjoy.

In Industry 4.0, both robots and humans have their respective roles, but both work independently. They don't collaborate on a large scale. This is what is different in Society 5.0. Now, you will see robots and humans working together, delivering higher quality and perfection in the results. Figure 2 :

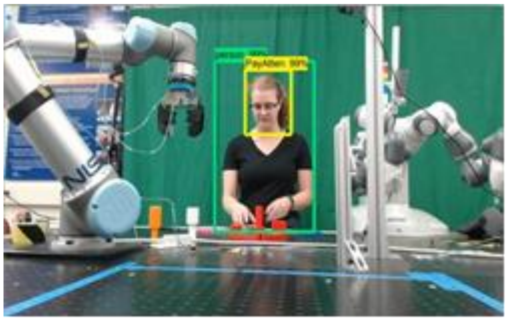


fig 3. conduct metrology test of human conscious visual system for robot situational awareness.

thus, no advanced programming or engineers are required, as robot software is so advanced that it allows robots to learn new work paths simply by imitating. Another collaborative model learns new work routines by having the operator draw a route on the software's graphical user interface.

Because collaborative robots are easy to teach, it opens up new usage scenarios. Unlike industrial robots, collaborative robots are not locked into a specific task for the rest of their lives. This means getting more value from the investment in terms of both use and financial return.

Discussion

This review provides insight into the evolution of Occupational Safety and Health systems in the era of society 5.0 and their application in robotic environments, enabling collaborative human robot work, including tasks involving interaction tasks. Due to the shift in human-robot relations reflected in international standards aimed at the industrial robot environment, changes in the relevant standards have been discussed, which involve the inclusion of new definitions and consideration of new risks. To illustrate the type of safety system under consideration, a matrix is designed to briefly relate the objectives of the various safety systems, the software, hardware systems and devices used, and the behavior of the robot in each case. A description of each safety objective and the appropriate systems and devices is provided. The inclusion of cyber-physical systems in this matrix provides a connecting link between various systems geared towards achieving a shared workspace between humans and robots. The use of the CPS approach in human-robot collaboration has been discussed, highlighting the limitations and current technological challenges associated with real-time implementation of this approach in human-robot collaboration.

Knowledge and quantification of human limits in terms of pain and injury levels, through the impact of simulated or controlled human robots, have contributed to achieving active safety in the industrial robot environment. With regard to measuring the degree of injury by collision two different points of view have been discussed. The former provides an estimate of the human tolerable level of pain, while in the second approach, several indices that have been used by the automotive industry have been discussed. Although this index is not entirely appropriate in the context of industrial robots, it is useful for evaluating new safety systems. It should be pointed out that with the latest ISO-TS 105066:2016 standard, appropriate procedures for setting a robot speed limit to avoid major injury to humans in the event of a human-robot collision are now available.

Since collision avoidance cannot always be guaranteed in human-robot collaboration, different mechanical systems and safety strategies for collision detection have been described that minimize injury in the event of a human-robot collision. The literature reviewed indicates that some of these mechanical systems have been tested using numerical models or actual experiments, and their benefits have been measured using the most appropriate injury indices. The results of the review show that the viscoelastic cover appears to be sufficient to absorb the impact energy. However, this cover in combination with an elastic absorption system has resulted in much better results. These ideas have been implemented in commercial lightweight robots that seek to enable the safe work of collaborative human robots. In addition, software development has been proposed and tested in combination with mechanical compliance systems as a method that not only helps to minimize injuries, but also enables intentional human-robot contact in human-robot interactions, opening up a wide field of research.

While mitigating the consequences of human-robot collisions is very important, prevention of accidental contact is most recommended. As a result, various safety systems focused on collision prevention have been proposed. Various pre-collision strategies have been presented in this paper. Their main characteristic is that, based on information about the movement and configuration of the robot, together with information about humans obtained from the vision system and other sensing modules, alternative pathways for the manipulator robot are calculated, keeping the robot out of harm's way. the zone at which the collision was predicted.

A way to gather information about unknown or uncertain parts of the environment is to use motion capture systems and simulated environments. Using this information, geometric representations of humans and robots are generated. This representation is usually based on volume constraints. Using this simulated representation, the distance between the human and the robot can be estimated and incorporated into the pre-collision strategy. When the risk of impact is identified, safety protocols are activated to generate alternative trajectories and keep industrial robots away from humans.

Another way to get information about the robot's surroundings is to rely on contactless devices such as sensors that capture local information or devices that enable global retrieval of information from the work area. Infrared proximity sensors, capacitive sensors, ultrasonic sensors, or laser scanning systems were among the first types of contactless devices and were used in some of the early work in this field. However, the constraints associated with capturing information about the robot's environment make this approach unsuitable by itself. However, some researchers have found a way to avoid the occlusion problems associated with sensors located in fixed placements through the use of this type of device.

Although the use of motion capture systems in conjunction with a simulated environment has yielded good results in the reported implementations (and to overcome the limitations of local sensors), fixed devices monitoring the work area appear to be a viable alternative for this acquisition. system. . Using standard cameras and range systems, there is no need to place markers on the human body. In addition, they can provide information about unexpected objects that may enter the work area. The section on artificial vision systems of this review paper discusses methods that have been proposed to prevent human-robot impacts using standard cameras and computer vision techniques.

Collaborative robotics has shown great promise for bringing potentially complex tasks in frequently changing settings closer to automation. In that regard, especially tasks involving contact between the robot and the environment such as assembly remain challenging. This is due to the fact that the contact state is difficult to detect and to the difficulty in modeling the effects of the robot's actions. Strengthening local control policy learning has proven to be a promising method for obtaining control policies for interaction tasks. Of particular importance here is sample efficiency because exploratory measures are expensive and potentially dangerous. An open issue remains a generalization of a learned policy for a new setting. when viewing. potential to address this using a-priori (partial) knowledge of the performance of learning robot models in the task-invariant operational space. Recent policy learning approaches have also achieved a close relationship with perception.

From a perceptual point of view, effective and flexible use of real-time multisensory data will be required. Although sensor functionality has been demonstrated in other areas (mapping and localization), physical interactions experience the challenges outlined in the previous paragraph and many existing methodologies for sensor function do not meet all the challenges of physical contact and deformable objects.

Since the second half of the 1980s, the concept of embodied intelligence has revolutionized artificial intelligence. Instead of logical architectures and knowledge representations, the embodied view argues that intelligent behavior arises naturally from interactions between motor and sensory channels. Reflecting neural and social engagement along with the physical constraints imposed by the environment enable and challenge the way humans learn and interact with the environment and collaborate with one another. Although there are difficulties in conveying and generating new knowledge, the process is simplified considering that very similar body shapes and imitations can be used to achieve a goal. Policies or ways to achieve goals can then be refined through training and experimentation. So how can we achieve the same mode of interaction between humans and machines when different perceptions and actions are, and probably will, remain different Perhaps, in the future, we will be able to build mechanical structures that are superior to humans in perception and action, and developing collaborative arrangements will result in a series. which is really a new challenge to complete.

4. Conclusions

Collaborative robots are meant to work side by side with human employees, they are designed to be safe to interact with. As such, it is standard for collaborative robots to have intelligent built-in safety measures that make them stop completely if they collide with anything other than the workpiece.

Some collaborative robots can also be installed to slow down the pace of work when human employees are nearby. The safety aspect is not only seen in the robot's features, but also in its design. Many collaborative robots are designed with rounded edges so as not to pose a hazard to humans working around them.

Cobots already work with humans and are increasingly involved in the world of IIoT. IIoT drives new relationships between humans and technology that enable digital and robotic technologies to improve performance and meet human needs. The future of industrial automation is not robots invading the workplace, but engaging with the workplace to make it better.

Cobots can provide careful inspection or inspection of items and never get tired, bored, or distracted. This makes it an important asset for improving IIoT processes related to safety, quality and productivity. Cobots can be easily programmed to recognize and count items on conveyor belts, apply packaging materials and labels, and place them into appropriate cartons. Human workers may still work with cobots while performing higher skill level tasks such as supervising related quality control inspections. Programming for cobots can be easily modified to adapt to changing product configurations or packaging requirements.

5. References

Talita Gustiyana (2022). The Next Industrial Evolution. In book industrial 5.0 Federico vicentini, Gurvinder Singh Virk, Paolo Barattini, Tamas Haidegger (2019). Safety Standardization and Benchmarking .In book Human-Robot Interaction.

Collaborative Robot and Industri 5.0. In bespoke Robotic & Automation. Avaible from : Collaborative Robots And Industry 5.0 | Bespoke Robotics & Automation (bespokeroboticsautomation.com).

Paul Golata (2021). Cobot and IIoT create a synergistic eorking relationship. In Wevolver. Avaible from : Cobots and IIoT Create a Synergistic Working Relationship (wevolver.com).

Enrico Krog Iversen (2020). Collaborative Robot. In On Robot. Avaible from : What are collaborative robots? | OnRobot.

Siarhei Herasiuta, Uladzislau Sychou, Ryhor Prakapovich (2003). Distributed information system for collaborative robots and IoT devicess. In Robotics. Avaible from : Distributed Information System for Collaborative Robots and IoT Devices (robotics.by).

Editorial Team (2022). Cobots : Types of Collaborative Robots and The Future of Teamwork. In Aiplusinfo. Avaible from: Cobots: Types of Collaborative Robots and The Future of Teamwork - (aiplusinfo.com).

Adamant Namiki Precision Jewel Co., Ltd. (2021). Collaborative Robot. In Orbray. Avaible from : What is a collaborative robot? An introduction to the functions and performance of collaborative robots - ADNa Magazine - Adamant Namiki Precision Jewel Co., Ltd. (ad-na.com).

Mikkel Stein Knudsen, Jari Roy Lee Kaivo-Oja (2020). Collaborative Robots : Frontiers of Current Literature. In Journal of intelligent systems Theory and Application. 15, Avaible from : (PDF) Collaborative Robots: Frontiers of Current Literature (researchgate.net).

Jeremy Marvel, Shelly Bagchi, Megan Zimmerman, Murat Aksu, Brian Antonisek (2019). Test Method and Metrics for Effective HRI in Collaborative Human-Robot Teams. In Nist. Avaible from : Test Methods and Metrics for Effective HRI in Collaborative Human-Robot Teams | NIST.