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Human-Robot Co-working Improvement via Revolutionary Automation and Robotic Technologies – An overview

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Abstract

The Fourth Industrial Revolution, prevalently dubbed "Industry 4.0", is currently in full swing. "Smart Manufacturing for the Future" is considered "theme" of Industry 4.0. Some futurists are said to be arguing what the theme of the fifth Industrial Revolution should be. Collaboration between humans and robots is a common thread that goes across all of the concepts. In the disciplines of robotics and artificial intelligence research, there has been significant advancement in recent years. For a variety of reasons, robots are becoming more widely available, and we will soon be in frequent contact with them as we go about our daily lives. While there are several investigations and research on low-level human-robot collaboration and activities, findings on human-robot collaboration at higher and more direct levels are lacking. This work focuses on new and automation technologies to improve human-robot collaboration in this study.

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Keywords: Automation; Human; Intelligence; Revolution; Robotics; Work.

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1. Introduction

The major goal of industrial revolutions is to separate human labour from that performed by machines or robots. Machine or robot works are those jobs that humans consider demanding, dangerous, or dull. Cleaning jobs can be done by humans or robots, but it is unquestionably better to utilize a robot for cleaning. This is an example of how robots are becoming more prevalent in our daily lives. Human-robot co-working is a concept that brings humans and robots together in a variety of tasks, whether they be industrial or domestic. The rate at which our technology improves and the level at which it reaches determines how quickly this may be accomplished. According to reports, some futurists are even disputing what the topic for the fifth Industrial Revolution should [5] all of the concepts have one thing in common: human-robot collaboration [5]. In recent years, great progress in the fields of robotics and artificial intelligence research has been made. Robots are increasingly readily available for a number of reasons, and we will soon be in everyday contact with them as we go about our daily lives. While there are several investigations and research on low-level human-robot collaboration and activities, there are very little amount of investigations on higher and more direct levels of human-robot collaboration. We will focus on new and automation technologies to improve human-robot collaboration in this project.

1.1 The Fifth Industrial Revolution (Industry 5.0)

For Fifth Industrial Revolution, a variety among different visions have developed (Industry 5.0). While Industry 4.0 is mainly concerned with the inter-connection of devices together, some futurists argue that Industry 5.0 foresee collaboration between human beings and machines or robots in manufacturing locations [1]. Instead than employing programming languages and compilers, this may entail programming robots to perform a certain activity using direct speech, similar to providing instructions to a worker. Collaboration can also be thought of as having a bench companion or lab attendant who will take care of all of the labour-intensive tasks without tiring you out and with great precision and accuracy. Automation and robotic technologies are required for human-robot collaboration. The idea which involves a fully automated "lights-out factory" with just the programming of the machine and its maintenance has proven to be a lost cause. The running of a factory necessitates a considerable lot of human creativity, learning as well as adaptation [1]. As different products vary a lot and are customized to the request of local markets as well as consumer demands and specifications, the economics of full automation are not any longer sustainable. The massive technical investments and duration of time needed to erect a fully automated line for a product of complex nature, will never be recouped before product replacement. The optimum option is combining the strength of industrial robots', their precision, as well as speed with human workers' intelligence, their judgment, and their dexterity. This permits the human workers to concentrate on activities which demand flexibility, while robots perform tasks, requiring the most strength and speed [2]. When robots and humans collaborate in performing work as well as duties together, manufacturing processes become more efficient and cost effective [3]. Working cooperatively with a human-aware robot reduces idle time by 85 percent in comparison to working in different all-human teams, according to a research done by MIT's Julie Shah [3] In a case study carried out using Advanced Robotics for Manufacturing (ARM), it was discovered, a collaborative path reduces cycle time by nearly two-thirds in comparison with a totally manual approach [4]. Furthermore, although today's retooling is proven to be a complex and time-consuming process due to heavy as well as inflexible automation, the flexibility of human and robot collaboration/co-working permits businesses quickly respond to changing demands on novel products and procedures [5]. In our case study, we discovered reprogramming and fitting new fixturing to a fully automated process might be a duration of days or even weeks—this downtime is costly [5]. The collaborative path takes advantage of human workers' innate adaptability, in which it just takes a day or maybe a few days to reprogram the palletizing robot arm [6].

2. Literature Review

2.1 Cobotics

Cobots are collaborative robots that allow interactions between themselves and humans in an automated work environment. This evaluation looks at works that used collaborative robots for manufacturing or assembly tasks between 2010 and 2021. We disregarded articles that only evaluated the problem in simulation and did not include an actual experiment with a collaborative robot doing a manufacturing or assembly task [6,7]. This requirement was added since only real-world trials with real hardware can often reveal both the limitations and benefits of robots. In the robotics sector, the concept of collaborative robot is considerably new, yet there are already various types. Their initial breakthrough in a variety of industries prompted speedy product development, culminating in four of the major categories for given collaborative robots [7]. Many varieties of cobots are distinguished based on safety features, programming features, as well as the manner how they avoid/reduce possibly hazardous interactions alongside human co-workers (See Figure 1). To ensure a safe operating space, each type/kind of the cobot uses different techniques as well as different technologies, which determines which surroundings they are most suited for. Some characteristics that guide the categorization of cobots available are as discussed below;

- Safety monitored stop, separation and speed, force and power limiting as well as hand directing present the four kinds of cobots described by ISO 10218 part 1 and part 2 [7].
- Safety Monitored Stop: For the sake of safety, I'm keeping an eye on you. Stop collaborative robots are specially designed for applications that do not demand a lot of human-robot interaction. As a person enters the work envelope, collaborative robots typically use an industrial robot equipped with a set of sensors that disable the robot [8].
- Separation and Speed: Collaborative robots of these kinds are akin to safety monitored stop collaborative robots since an industrial robot is in use. Collaborative robots with higher separation and speed make use of more advanced vision systems for the effect which slows down activities when a human worker approaches, and also to entirely halt operations if a human worker gets too close in proximity to the robot [6].
- Force and Power Limiting: When collaborative robots come into contact with a human worker, they have rounded corners as well as a variety of smart collision sensors that sense and stop them in their tracks. Cobots, that make do of collaborative robot arms, have force constraints built in them for the prevention of injury in the case of a collision [9].
- Hand Guiding: In automated mode, these collaborative robots contain a hand-guided device that allows an operator, ability to control the robot's mobility directly. Hand-guiding collaborative robot only responds to the operator's direct control input in automated mode. It permits the robot to hold the heavy work piece while the operator directs the work piece into place, lowering danger of repetitive-stress injury to the operator. Hand directing is done as a collaborative activity during normal production when the robot is in automated mode, but programming isn’t done in automatic mode neither is it used during production [10].

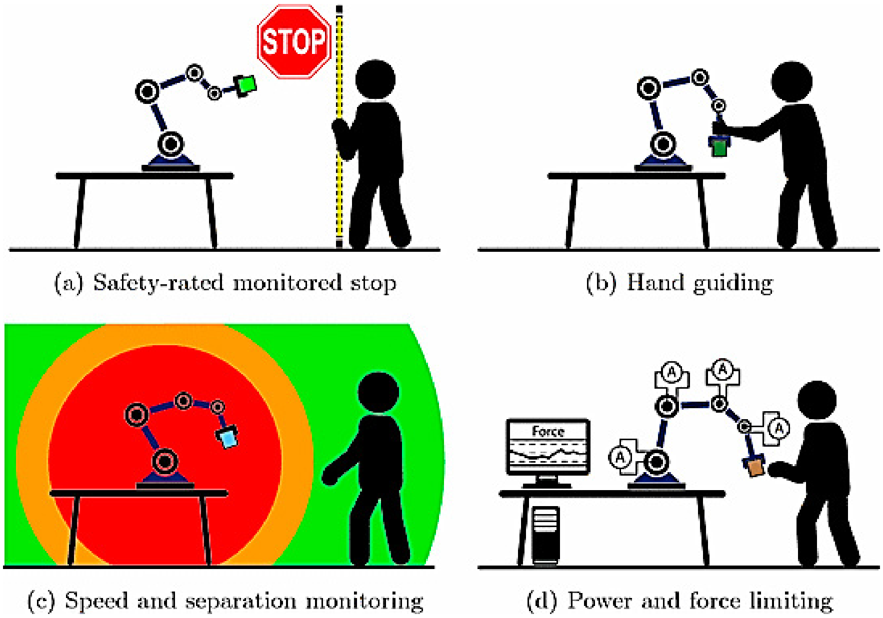

Fig. 1. Safety-Related Risks and Opportunities of Key Design-Aspects for Industrial Human-Robot Collaboration. [3]

If robots can express their decisions, the underlying beliefs, and the experiences that inspired these convictions, they can interact more effectively with humans [11]. The robot frequently makes decisions based on a variety of uncertainty and incomplete domain descriptions [11]. Smart businesses are attempting to create an environment in which robots aid workers. Collaborative robots, often known as cobots (See Figure 2), can aid warehouse workers in picking merchandise and carrying cargo. This shows that, rather than replacing humans, machines are augmenting their abilities and relieving them of difficult tasks [12].

The Global cobot market, is expected to develop at a compound annual growth rate (CAGR) of more than 44% between 2019 and 2025, according to a report. The affordability of this technology is a major factor in its adoption. Many cobots cost less than $45,000, making them a viable alternative for businesses of all sizes in a variety of situations [13].When people and robots collaborate to achieve a common purpose, they create “a team”. A team is described as a relatively small group of partners with each complementary skills who are committed to a single objective, result target, as well as plan and hold each other accountable for it. The same may be said about human-robot teams, in which both humans and machines are dedicated to working together to accomplish a common goal [14].

Effective collaboration/co-working necessitates a unified plan for all partners involved. In order for development of shared aim, those involved must understand the objectives and activities of the other members of the team. Based on this knowledge, a robot can plan its own movements, which eventually will in the end bring about the fulfilment of the mutual intention and achievement of a common goal [15]. Human emulation (HE) as well as Human complementary (HC) are two paths to human-robot collaboration. Despite the disparities between these systems, there are research initiatives underway to establish a unified strategy based on potential convergences, such as Collaborative Control [16].

Fig. 2. (a) A human working (collaborating) with a human being (b) SIASUN is a collaborative robot that assists the automotive sector in changing its manufacturing process [8].

In order to work with humans, human emulation technique tries to give computers the ability to act or behave like humans or have human-like abilities. It focuses on formalizing human-human cooperation models and applies them to human-computer collaboration. Humans are considered as rational agents who make as well as carry out plans to achieve their distinct goals as well as infer the plans of other people in this approach. Agents must deduce the aims and plans of other agents and collaborative conduct entails assisting other agents in achieving their objectives [17].

The human complementing method aims at improving human-computer interaction by making computers smarter partners who complement and work with humans. The argument is that human and computer capacities are essentially unequal. As a result, researchers create interaction paradigms that divide or share responsibility between human users and computer systems by assigning separate roles or duties that take advantage of both partners' strengths and weaknesses [18].

HRC being Human-Robot Coordination is used in a variety of fields and situations, resulting in a wide range of activities and joint actions. Robots can travel to specific locations, to fetch, hold, and even support objects, carried by humans with them in a cooperative manner, speak or interact in other ways, and seek for something or someone [19].

The following are some examples of robots that can collaborate with humans; Leonardo is a typical humanoid robot that can work together in order to complete a button-pressing activity while communicating with gestures at the same time comprehending human speech and movements. In partnership with a human, the mobile robot helper can share a weight and handle an object, both the Leonardo robot and Mobile Robot Helper are shown working with humans [20]. RHINO and MINERVA are tour guide robots for museums (See Figure 3) that communicate with visitors and guides them. Jijo-256, a robot for the office, moves around and asks humans for instructions and information to understand where offices and people are located.

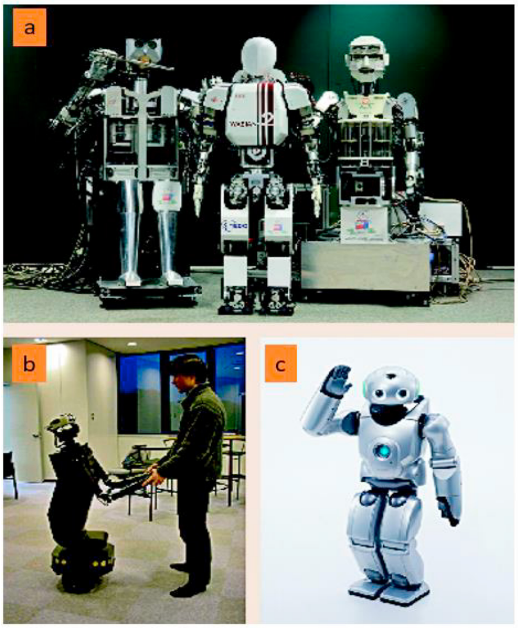

Fig. 3. Interacting robots in the museum

Human-robot collaboration has a wide range of applications, with the most common having being in healthcare, as well as construction, inter-stellar use applications, search and rescue, tourism, home service, also even entertainment [21]. Each of stated sectors has its own set of needs, and the degree to which they are all intertwined differs. Robotic walkers and wheelchairs for the blind, senior care robots, and robots for the rehabilitation of autistic youngsters are all being created. Because these robots are all designed to assist sick or frail individuals, they must be meticulously built and tested. Ethical considerations are especially important in the disciplines of healthcare and medicine. As a result, despite the fact that these sectors are a hotbed of research, few collaborative-robotic solutions are commercially available [22].

3. Challenges of the Cobot and possible solutions.

3.1 Legal and Regulatory Issues:

Definition of a robot in various contexts is man-made electromechanical device that senses, thinks, and acts [12]. This definition is relatively straightforward, yet could also be difficult. What does it mean for a robot to think and act on its own? A robot, according to the Oxford dictionary, is "a machine able to perform a range of complex acts autonomously, in particular one that can be programmed by a computer". A robot, according to Merriam Webster, is a machine that resembles a human being and can perform complex human-like actions (such as walking or conversing). These various definitions have the potential to be problematic as well. The former alludes to a concept as undefined as "carries out a series of complex acts automatically", while latter is an assumption that a robot takes on a humanoid form. In the end, the lack of realness of these definitions provides a semantic problem. It is as such necessary for a legal, clear definition to be provided for the term – robots [19]. Scientific definitions exist for the term but a legal definition would be binding for businesses and organizations. Automated machines do well in a variety of categories, robots being one of those. The difference between automated machines and robots ought to be clearly provided in laws that regulate human and robot collaboration. There also exists devices closely connected - cyborgs and drones. The rules should include a differentiation between robots and these. Besides providing a clear definition of terms, the law ought to include;

- Types of robots that are commonly utilized and encountered in the workplace.
- Their responsibilities as well as obligations.
- The kinds of choices robots are permitted to make with regards to human beings.
- The types of robot malfunctions as well as entities that are to be held responsible in the event of any of these malfunctions.
- Whether the robot software is programmed to follow strict restrictions or is given the freedom to learn and adapt.
- The certifications required by a robot as well as the authorities of certification and their obligations.

Discussions around the legality and ethics of robots use have to be discussed before their deployment for public or industrial use. As such, these are expected to be a part of the research work that goes on before their approval for use.

3.2 Personal Preferences Towards Working with Robots:

The acceptance of use for various technologies varies from person to person. While some people would be eager and accepting of the use of robot, there will inevitably be others who are not. Industries and organizations that intend to utilize and benefit from human-robot co-working have to take cognizance of this. Organizations whose personnel comprises mostly of people who aren't accepting of robot technologies would have a hard time with the transition to human-robot co-working systems [22]. The solution to this problem lies in the reorientation and re-education of people with the regards to the benefits of the incorporation of these technologies. Because human-robot collaboration is not yet a reality, people's knowledge and perceptions of the topic are mostly molded by the media rather than firsthand experience. Many very popular movies and TV shows feature the idea of robots/artificial intelligent machines taking over the world or fighting humans. The media should also improve their portrayal of the benefits to be accrued when these technologies are in place [23].

3.3 Psychological Issues Which are Caused from Human Robot Co-working:

The introduction of new technologies will inevitably have certain psychological effects on the humans using it. For example, addiction to video games, people developing strong attachments to their smart phones [24]. We are as yet unaware of the potential psychological effects that human-robot co-working industrial systems will have on people, but it is fair to assume that there will be some. This needs to be the subject of research for organizational robotics [25]. However, the development of job descriptions and charts for work analyses could go a long way in resolving some of these challenges [26].

3.4 Data privacy:

Despite the fact that technology interconnectivity is regarded to be critical for full IoT integration, there are still worries about data privacy and security. There are also concerns about the security of communication via cloud computing platforms, as well as how data should be managed and maintained [27]. However, we the help of emerging technologies such as edge computing (a system of data processing at close proximity to data generation point) and blockchain (a technology that reduces incidence of data manipulation), privacy is gradually been preserved. Some methods proposed to reduce incidence of data privacy leaks include, perception limitation which involves image manipulation [28] and manipulation limitation which involves the control of what the robot can access or touch [29].

3.5 *Recent Advances in Cobotics*:

Research indicates that new materials for a new generation of soft robots, or "smart materials," may be available in the coming years. These materials will allow robotics to gain new capabilities and characteristics.
The new materials, like piezomaterials, can be tough [30]. The objective of research in the area of new materials is to replace the metallic and stiff robots with smooth, soft robots that might be more amiable while collaborating and engaging with humans [31]. One interesting trend in the use of cobots is the development of new sensors and actuators. The increasing use of collaborative robots is driving the development of cutting-edge tactile skin sensors

that will be affixed to the robot's surface to ensure the operator's safety [32]. Recent developments in proximity skin sensors, such as capacitive sensors or robotic skin modules that can detect an object before any physical contact occurs are being made in order to increase safety [32].

4. Conclusion

The fifth Industrial revolution is all about Collaboration between humans and robots and this will bring about a series of changes for multiple organizations. This involves technology similar to man in more aspects than normal. The possibility that that these robots will bring about significant change to the human race in its entirety is extremely high. There are a lot of mixed opinions about this as of now and there will be more in the future as many will find this appealing and others will find it threatening to their livelihood. This negative approach toward robots, although mostly unfounded is highly biased and boosted by the presentation of the robots by the media. This negative perspective is the initial and most prominent of the views of the society at large and until humans really co-habit and co-work with these robots, there is no assurance of how humans will react to the robots. A difference in the generations will definitely affect the perception of the robots as the next set of the human generation will grow up interacting with these robots as part of their daily lives, routine and most especially at work and this is highly likely to affect them in a positive manner. With regard to this, it is necessary to ethically construct a system in which human and robots interact in many ways. Here, we spoke on significant and probable events that may arise from Collaboration between humans and robots and all these are subjects for further debate, inquiry and observation.

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