Human Robot Interaction: Applications, Challenges and Future Directions

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Abstract – Human-Robot Interaction (HRI) has grown over the years and is now used in a wide range of contexts including medicine, manufacturing, physical therapy, customer care, agriculture, and education. HRI is utilized in many workplace settings that entail co-manipulating tasks as well as picking and placing operations in production lines, welding processes, painting and parts assembly. It is also used in assistive robotics for people with physical and cognitive impairments. This study explores HRI as applied across different fields such as industry, health care, rehabilitating agricultures, service and education. The paper analyzes several types of HRI including geographically or temporally separated interactions, distant ones or those that are social in nature. Finally the research shows the advantages of HRI on productivity increase in quality enhancement competitiveness increase and improved working conditions. Lastly, this research delves into a number of challenges along with future prospects regarding issues such as safety precautions required while engaging in HRI activities; acceptable social behavior; distribution of work among others; there are other possible downsides to some of these emerging technologies on general well-being as well. To ensure safe and effective human robot systems more human factors investigations must be conducted in this area

Keywords – Human Robot Interaction, Assistive Robots, Unmanned Aerial Vehicles, Social Robots, Socially Interactive Robots, Smart Manufacturing.

I. INTRODUCTION

Currently, the field of Human-Robot Interaction (HRI) is undergoing a rapid expansion in academic research that holds great promise for advancing robotics and integrating it more effectively into various aspects of human lives. HRI research cuts across numerous areas and disciplines such as educational environments, industrial settings, agricultural practices, service industries, rehabilitation facilities, medical contexts etc. Many scholars have demonstrated excellent performance with co-manipulation tasks such as picking up and placing operations inside production lines, welding processes, assembly of parts and painting jobs among others. In addition to this, HRI recognizes assistive robotics as an important area of study. These systems allow robots to offer assistance to individuals with physical and cognitive disabilities thus giving them chances for active participation and curative benefits.

Moreover, HRI has been shown to occur in medical settings, specifically in hospitals, where it has exhibited its capacity to assist in endeavors aimed at mitigating the effect of the COVID-19 [1]. In the agricultural domain, the implementation of approaches associated with HRI holds promise for effectively tackling a range of complex difficulties. The aforementioned issues pertain to the imperative tasks of providing security, minimizing workload, improving comfort, and optimizing productivity within the agricultural processes. Furthermore, HRI assumes a crucial function in various agricultural tasks, including but not limited to packing, harvesting, sorting, planting, mowing, pruning, phenotyping, spraying, weed identification, transporting, and fertilizing. In an educational setting, robots have the potential to assist in various aspects of the learning process within classrooms. Moreover, these devices have the potential to facilitate the promotion of education among typically developing youngsters in both home and school settings. Robots have the potential to assist young students in developing empathy and gaining various abilities. Furthermore, HRI has been observed in several domains such as service industries, residential applications, mining operations, household administration, space exploration missions, and Unmanned Aerial Vehicles (UAVs).

Furthermore, they may be geographically or chronologically distant from one another. An illustrative instance within this classification is the Mars Rovers, which are spatially and temporally detached from Earth. Within the proximate classification, both humans and robots cohabit within the same physical vicinity. An illustrative instance within this category pertains to the utilization of service robots in shared environments where they coexist with humans inside the same physical space. These categories can aid in differentiating between applications that necessitate social interaction, physical interaction, or mobility. The concept of remote interaction via mobile robots encompasses the practice of supervised control or tele-operation. The term "remote interaction physical manipulator" pertains to the practice of tele-manipulation [2]. The utilization of mobile robots facilitates proximate engagement through the presence of a robot assistive device. Proximate interaction integrate physical types of interaction. Social interaction encompasses various components, including the social, affective, and cognitive aspects of interaction.

During social interactions, robots and human engage with one other as equals, assuming the roles of peers or companions. Significantly, the social interactions involving robots primarily occur through close physical proximity rather than through remote means. This publication focuses on the proximal interaction within the specified categories. This paper highlights various practical implementations of HRI in diverse settings such as industrial environments, hospital and rehabilitation facilities, agricultural sectors, educational institutions, and other relevant contexts. These applications demonstrate the significance of the interactions occurring between human operator and the robot in real-world scenarios. The exponential expansion of HRI across diverse sectors underscores the imperative need for a thorough comprehension of its practical implementations, obstacles, and prospective trajectories.

This research endeavors to provide insights into the optimization of human-robot interactions for enhanced productivity, safety, and user happiness by examining the advantages and constraints of HRI. Furthermore, gaining insight into the ramifications of emerging technologies, such as advanced robotic systems, on the employment landscape and overall quality of life can provide valuable guidance to policymakers and researchers in defining the trajectory of HRI in the coming years. The remainder of the article has been arranged as follows: Section II discuss the applications of human-robot interaction (HRI). Section III reflects of human administrative controls of robots for various repetitive industrial tasks. Section IV presents a discussion of human-robot social interaction focusing on HRI research classification, and the definition of social robots. Section V discusses the research focusing on human factors. In this section, the task dynamic analysis, teaching robots and eliminating unintended consequences, and discussions about robots in education, and lifestyles, fears, and human values, are provided. Lastly, Section VI conclusion to the article.

II. APPLICATIONS OF HUMAN-ROBOT INTERACTION

HRI Industry

Human-Robot Interaction (HRI) finds extensive utilization in various industrial domains, including but not limited to production lines, welding operations, components assembling, and painting. Fig. 1 to 4 illustrate several instances of HRI within firm applications. The robot workstation is operational within the BMW facility located in South Carolina. Its primary function is to assist human operators in the assembly process of the final door component. In the process of door installation, both human operators and robots collaborate. The BMW plant has successfully developed and implemented a system of direct human-robot interaction and cooperation inside its series manufacturing operations. Human-robot collaborations are also observed within the context of flexible manufacturing lines. In the depicted illustration, the robotic manipulators and human operators engage in a collaborative effort to handle the workpieces. Safety is of utmost importance in such circumstances due to the close closeness between the human operator and the robot, which may result in potential harm.

Suitable positions of the human body enable the performance of repetitive co-manipulation activities. The utilization of specific poses has the potential to mitigate the adverse impacts of excessive joint torque. Moreover, individuals have the ability to optimize the potential for influencing human behavior. The utilization of a multi-robot system with collaborative capabilities has been shown to aid workers in the handling of bulky and large components during welding operations, as depicted in Fig. 4. Two robotic systems are employed to facilitate the alignment of components for the welding process. Subsequently, a human operator undertakes the welding activity in a habitat optimized for ergonomic considerations. When comparing the typical welding bench to the proposed alternative, it is evident that the human operator is relieved from assuming awkward postures or doing overhead tasks. The robot is capable of executing all essential tasks related to the positioning and orientation of the workpieces. This also encompasses the arrangement of components in an appropriate position to facilitate the welding process and ensure a smooth flow of the welding bead. The implementation of HRI in welding operations significantly reduces the handling duration, which accounts for approximately 1/3 of the overall process time. This reduction is attributed to the quick robotic repositioning motion.

The study done by Hoffman [3] focused on exploring the dynamics of human-robot collaboration within industrial contexts, with specific emphasis on safety protocols, interaction patterns, and the establishment of trust between robots and humans. During the course of the study, participants were solicited for their perspectives regarding the potential ramifications of implementing robots in industrial settings, as well as the critical factors necessary for achieving successful integration. The responses to the initial inquiry (refer to Fig. 5) aligned with the anticipated outcomes. The prevailing viewpoint that we have found is that the introduction of robots would lead to a decrease in job opportunities. Contrary to opposing viewpoints, there was a widespread agreement regarding the advantageous outcomes that its implementation would yield in terms of productivity, production quality, competitiveness, and the overall working conditions of employees.

HRI in Farming

The collaboration between robots and humans in the field of agriculture facilitates several duties, including but not limited to harvesting, sowing, mowing, fertilizing, spraying, weed detection, and hauling. In the context of precision farming, as depicted in **Fig 6,** the utilization of robots assists human operators or farmers in the process of hydroponics. In this scenario, it is imperative to incorporate measures to ensure the safety of both the robot and the human operator. Moreover, the robot was operated from a remote location by an operator who was physically present at the same site.

Fig 1: Robot Helping Humans to Complete Final Door Assembly of BMW plant.

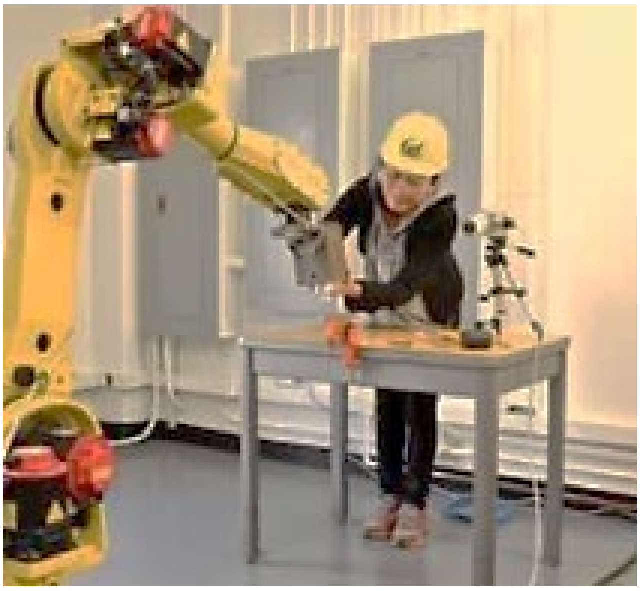

Fig 2. The Human and the Robot Employee Collaborate in Handling Different Pieces of Work

Fig 3. Example for the Repetitive Co-Manipulation Tasks

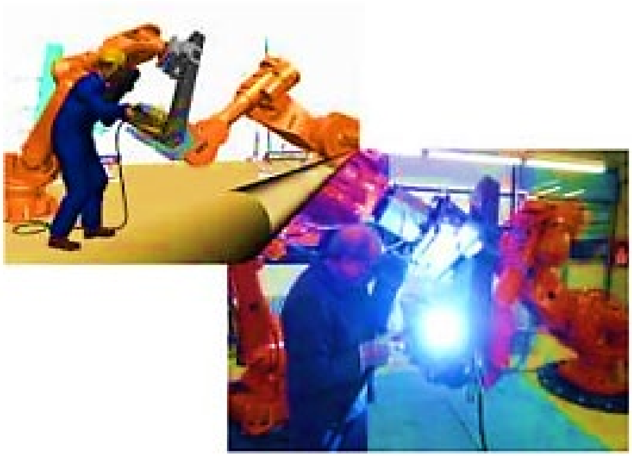

Fig 4. The Multi-Robot Model Helping Workers in the Process of Welding

The objective assigned to the individual was to effectively guide the robot towards the designated positions of the pickers upon their request, facilitate the loading of the occupied crates onto the robot, and subsequently convey them to the designated storage space.

In the study conducted by [4], a sophisticated robotic system was implemented within a greenhouse environment to provide assistance and support to farmers in the process of melon harvesting. The concept of HRI is readily apparent in Scaffold Mode. The collaborative system involves the robot and the human operator working together in a unified manner. In this system, the car autonomously goes along the structured rows of trees, while the humans on the car focus on engaging in various activities, including thinning, pruning, harvesting, and tying trees to wire.

Hu, Lum, Mastrangeli, and Sitti [5] presented the concept of tree trimming tasks and conducted a comparative analysis of the performance of individuals operating a robot in Scaffold Mode versus those employing the conventional ladder-based technique. The findings indicated that participants who utilized the Scaffold Mode of the robot exhibited a significantly higher efficiency in tree trimming, with a pace that exceeded twice the speed of persons employing the ladder approach.

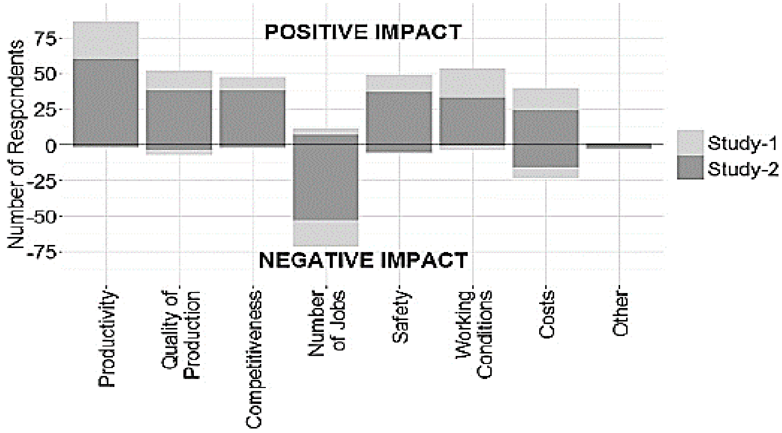

Fig 5. Positive and Negative Effects of Introducing Robots at Work

Fig 6. The Robot Integrated in the Greenhouse for Hydroponics

HRI in Clinical and Rehabilitation Applications

Assistive robotics is considered to be one of the most prominent and widely recognized fields within the domain of HRI. Robots possess the potential to offer individuals facing physical and mental problems the chance to engage in interactive experiences and therapeutic interventions. The investigation of this study focuses on the engagement of children diagnosed with autism, as discussed by Jahromi, Bryce, and Swanson [6]. A significant proportion of individuals have limited proficiency in interpreting and appropriately reacting to social cues, yet demonstrate notable proficiency in engaging with mechanical gadgets. Robots have a potential therapeutic function in utilizing mechanical devices to enhance social relations. Robotic applications are being explored across various sectors, including those that cater to the well-being of youngsters, such as those who have undergone traumatic experiences.

The inclusion of the social dimension in HRI is essential not just in assisting duties, but also in various domains and contexts of close engagement. The embodiment of robots offers distinct advantages for individuals with physical limitations that are not achievable through alternative forms of technology. The researchers are currently engaged in the development of robots that offer assistance and aid in the field of physical therapy. Significant efforts encompass the provision of the required force and the manipulation of mobility trajectories in order to facilitate the restoration of both strength and flexibility. Additional research on identifying the motivational state and adapting therapeutic interventions to optimize their efficacy is discussed in [7]. Smart wheelchairs are a category of robotic devices that utilize exterior sensors to facilitate course planning and collision avoidance or individuals in need of wheelchair assistance.

An illustration of rehabilitation robotics was demonstrated in a previous study [8]. The study involved the development of a robotic system capable of accurately executing exercises commonly performed in conventional physiotherapy, specifically shoulder flexion. The system was designed to mimic the actions typically carried out by a physiotherapist while co-manipulating using the KUKA LWR robots. By combining the exceptional attributes of humans, such as decision-making capability, with those of robots, including precision, work capacity, and repeatability, it is possible to enhance the outcomes in musculoskeletal arm rehabilitation. In addition, the secondary purpose was to assess the normal shoulder behavior during shoulder flexion movements.

The etiology of the infectious ailment referred to as COVID-19 can be attributed to a novel strain of the coronavirus that has been found in recent times. The range of symptoms associated with COVID-19 might vary in terms of their severity, encompassing both mild and severe manifestations. The collaborative efforts of humans and robots contribute to the collective response against the emerging epidemic. Two instances of human-robot collaboration can be employed within healthcare facilities to combat the spread of the Coronavirus. The robot has the capability to perform more tasks and offer solution to nasopharyngeal swabs evident in patients, which is essential for the detection of genetic material associated with the coronavirus. The positive test result suggests that the individuals have been infected with the coronavirus. Specimens, in this case (obtained from the oral cavity, nasal passages, and throat of people) are submitted for laboratory examination with the objective of detecting the existence of genetic material linked to the coronavirus. The extent of the duties assigned to laboratory workers is limited to the task of placing samples onto the tray. Following this, the responsibility of performing pipetting is taken over by the COVID-19 testing robot. In the second scenario, the manipulator is equipped with a portable device. The mobile robot actively collaborates with the human operator, leading to a significant level of accuracy throughout the alignment process with the workpiece.

The mobile robot possesses the capacity to provide nourishment and medication to individuals in need. In addition, the robotic system possesses the capacity to precisely evaluate the body temperature of patients. This approach would reduce the extent of physical interaction between patients and healthcare personnel, as well as other individuals, hence mitigating the risk of infection. The robot is capable of assisting humans in tasks such as cleaning and washing floors and walls. Additionally, this practice serves to reduce the likelihood of viral transmission.

III. HUMAN SUPERVISORY AND TASK CONTROL FOR ROBOTS

A wide range of robotic systems are employed for assembly line operations, encompassing duties such as picking and positioning objects, welding, painting, and other related activities. It is widely recognized by readers that there are production lines for autos and various other commodities that exhibit a complete reliance on automation. According to Longo, Nicoletti, and Padovano [9], machines that rely on human operators for tasks such as supervisory control, including learning from experience, planning, performing repairs, monitoring of automatic control, and teaching, can be classified as telerobots.

The Baxter assembly robot is a commercially available product developed by Rethink Robotics; a company based in Boston [10]. The subject of extensive discourse is a robot that has been specifically engineered to ensure operational safety in close proximity to humans by including mechanical compliance, akin to the human body. One notable advancement in the Baxter robot involves the incorporation of a visual display of eyeballs. These eyes serve the purpose of conveying information to the human operator regarding the specific task or object that the robot's software is presently focused on, rather than functioning as a means for the robot to see its surroundings. Moreover, Baxter possesses mechanically responsive arms, which allows programmers to manipulate its hand while training it to perform a manipulation or working task in close contact to others.

In order to enhance human-robot interactions in industrial environments, particularly in the context of airplane assembly, Prus and Jorgensen [11] have presented methodologies for the observation of human participants engaged in manipulation tasks. The process of observation involves the utilization of markers placed on the human limbs, which are subsequently detected and analyzed by computer vision techniques. The aforementioned information is employed to deduce a comprehensive strategy for fostering a strong partnership with a robot, whereby the human is relieved of specific task components that can be executed more effectively by the robot. The approach is also capable of distinguishing between different task styles exhibited by human workers. In a study conducted by Pierno, Mari, Lusher, and Castiello [12], it was shown that participants exhibited a preference for the robot's ability to antedate their actions, as opposed to manually instructing the robot to assume control over specific task components. The participants also assessed the strategy as being more effective compared to the approach of having a professional to program the assignment of responsibility.

The existing problems in HRI for routine jobs have expanded beyond the traditional scope of factory assembly lines. These challenges now encompass a wide range of activities such as retrieving and delivering packages and parts in warehouses, collecting and distributing mail within office buildings, transporting supplies and medicine in hospitals, performing floor cleaning tasks, and carrying out automated agricultural activities. The topic of safety, namely collision avoidance, remains an ongoing concern in the field [13]. The primary areas of focus for human aspects research encompass planning, training, display, control, and supervisor monitoring of automated actions, which are seen to be of utmost importance.

IV. HUMAN–ROBOT SOCIAL INTERACTION

Classification of HRI research

Human-Robot Interaction (HRI) study can be categorized into three distinct directions, each of which is not mutually exclusive, as outlined below.

Robot-centered HRI places emphasis on perceiving a robot as a sentient being, possessing autonomy and driven by its emotions, desires, and own motivations. In this perspective, the robot's interaction with humans is aimed at satisfying its identified "needs" as determined by the robot implemented through the internal control architecture. For instance, social needs can be fulfilled through interaction, even in the absence of a specific task. The primary focus of this method is on the skills that allow the robot to effectively adapt to its surroundings and meet its own requirements, such as motives, urges, and emotions. Research inquiries encompass many aspects, such as the advancement of sensorimotor control and the formulation of frameworks and models pertaining to motivation and emotion that govern interactions within the (social) milieu.

Human-centered HRI primarily focuses on the ways in which a robot can effectively do its designated tasks while ensuring that the methods employed are acceptable and comfortable for humans. In this context, scholarly investigations focus on examining individuals' responses to and interpretations of a robot's physical appearance, irrespective of the underlying behavioral architecture and cognitive mechanisms employed by the robot. The challenges encompass several aspects, such as achieving a harmonious and coherent design of both the behavior and physical appearance of robots, ensuring socially acceptable behavior, advancing novel approaches and methodologies for studying and evaluating human-robot interactions (HRIs), recognizing the specific requirements of individuals and groups that robots can adapt to and interact with, and mitigating the phenomenon known as the "uncanny valley."

The uncanny valley refers to the point at which highly human-like robots may elicit feelings of unease and disgust in humans, as described by Faudzi, Ooga, Goto, Takeichi, and Suzumori [14]. The perception of machines is subject to the influence of anthropomorphism and the inclination of individuals to attribute social characteristics to machines. This phenomenon has been extensively examined in studies conducted by Burgoon et al. [15], which demonstrated that humans tend to interact with computers in a manner that resembles interpersonal interactions, employing social norms and cognitive shortcuts typically associated with human-human interactions when engaging with machines. The concept of the "media equation" that has been put forth, which posits that media is equivalent to real life, holds particular significance in the field of robotics research. This is especially true in cases when individuals engage with robots in various capacities such as friends, designers, patients, users, clients, observers, collaborators, assistants, or rivals.

The concept of robot cognition-centred HRI places emphasis on the robot as an intelligent system, following the classical principles of artificial intelligence (AI). This means that the robot is able to independently make decisions and finding solutions to the challenges it encounters while carrying out activities within a certain application domain. The research inquiries within this field encompass the advancement of problem-solving techniques, machine learning, and cognitive robot architectures.

Frequently, a common practice entails the division of responsibilities in the examination of various aspects of HRI research, with each aspect being investigated within distinct disciplines. Only subsequently are these aspects integrated, such as the separate advancement of the robot's physical structure from the advancement of its observable behavior and cognitive processes as perceived by humans. There is a potential drawback associated with this approach, as it may lead to an imbalanced robot design characterized by a fragmented system without cohesive integration. The successful development of a synthetic method necessitates ongoing collaboration across the entire life cycle of the robot, encompassing various stages such as specification, design, and implementation. However, this endeavor presents a significant difficulty due to the conventional demarcations between disciplines and financial frameworks. Nevertheless, it is crucial to adopt a comprehensive multidisciplinary approach that integrates the perspectives of robotics, humans, and robot cognition in order to effectively address the projected increase in the presence of robots in our domestic spaces.

The establishment of socially acceptable conduct, such as the formulation of social norms that govern a robot's conduct during its interactions with individuals, while also considering the unique characteristics of human beings, has the potential to result in machines capable of adjusting to a user's specific preferences, inclinations, and aversions. This could manifest in the form of an individualized and personalized robotic companion. According to Tombropoulos, Adler, and Latombe [16], the implementation of such a robotic system would enable the treatment of individuals as unique entities rather than as mechanical objects. In Section 4, the concept of a robotic companion is further expounded upon.

Definition of social robots

Multiple definitions of social robots or related ideas have been employed in scholarly literature, encompassing the following (Table 1). Socially interactive robots possess a range of notable attributes. These include the ability to perceive or express emotions, engage in high-level dialogue, acquire knowledge about or identify other agents, sustain and establish social connections, utilize natural prompts such as gestures and gaze, demonstrate unique personality traits and characteristics, and potentially acquire and enhance social skills. According to accounts by Burnham and Hare [22], Kismet, developed by MIT, is a robot head that possesses "social intelligence" and exhibits expressive behavior. Kismet uses computerized facial and vocal analysis to generate suitable gestures in response. The classification of this technology as social intelligence is subject to discussion; however it undeniably raises intriguing philosophical inquiries. The available evidence indicates that these technologies have been found to be efficacious in facilitating typical social contact among young infants.

Table 1. Definitions of Social Robots or Related Concepts

Concept	Definition
Socially evocative	Robotic systems that use the innate human inclination to anthropomorphize and leverage the emotional responses elicited when individuals engage in nurturing, caring, or interacting with their 'creation' [17].
Socially situated	Robotic entities that are situated inside a social context, wherein they possess the ability to observe and respond to their surroundings. According to Broz, Nourbakhsh, and Simmons [18], socially situated robots possess the capability to differentiate between different social agents and items inside their surrounding environment.
Sociable	Robotic systems that actively interact with humans with the intention of fulfilling internal social objectives, such as urges and emotions. The development of social cognition models is essential for the functioning of these robots [19].
Socially intelligent	Robotic systems that exhibit characteristics of human-like social intelligence, drawing upon potentially intricate models of social aptitude and human cognition [20].
Socially interactive robots	Robots that prioritize social contact are distinct from other robots that engage in "conventional" HRI, such as those utilized in scenarios of teleoperation [21].

Nevertheless, it is worth considering if these devices impede the development of a healthy imagination, as exemplified by children engaging in play with inert dolls, rather than fostering its growth. Therapeutic animal and several toys or human figures that are being introduced to the market incorporate decision-making software, speech recognition, and computer-based speech. One illustrative instance involves the development of a novel Barbie doll by Mattel, which has a comprehensive lexicon for voice and language recognition. This doll is interconnected with the organization`s server through the Internet. The doll has been specifically built to engage in in-depth conversations with young individuals, including girls and boys, pertaining to subjects that capture their attention.

In [23] provide an in-depth analysis of a case study that involves the use of a comprehensive methodology for acquiring knowledge from human feedback in the context of an interactive robot. This application is purportedly the initial showcase of the capacity to instruct different behaviors in robot learning solely through unstructured input provided by humans, without the need for additional instruction or evaluative feedback. The establishment of trust and avoidance of alienation among hospital patients, particularly the elderly, towards robots involved in tasks like meal tray delivery and fitness coaching, is a pertinent research area within the domain of human factors professionals.

Nevertheless, Yagoda and Gillan [24] raises doubts regarding the extent to which trust in robots can be justified. The utilization of robot collaboration in the education sector is not a novel concept. An instance of this can be observed in the LOGO language developed by Qiang et al. [25], wherein robotic entities referred to as "turtles" were employed as a pedagogical tool for youngsters to acquire fundamental programming skills. The aforementioned endeavor has undergone a transformation, resulting in the development of the present-day LEGO Mindstorms product, which is primarily targeted at children in a commercial context. There exist issues pertaining to human factors in the context of both robot-to-human instruction and human-to-robot instruction. Historical evidence indicates that the optimal scenario involves the simultaneous occurrence of both factors

V. HUMAN FACTORS RESEARCH IN HRI

Task Dynamic Assessment

Task analysis is a crucial element within the human factors toolkit. An alternative avenue of inquiry within the field of human conditions study is to the assignment of duties between human operators and automated systems. The renowned Fitts [26] taxonomy delineating the optimal capabilities of both humans and machines is considerably antiquated and has not yet undergone a comprehensive and authoritative revision. The advancement of machine capabilities is seen through the development of hand-bandwidth communication, AI, and miniature sensors. If one holds the belief that ergonomics might be perceived as a traditional approach to human aspects, it may be worth contemplating the concept of developing a robotic system that can delicately assist elderly and disabled individuals in transitioning between their beds and the toilet.

Currently, a significant number of individuals engaged in the role of human caretakers are prone to experiencing back injuries throughout the course of their duties. The current era presents an unprecedented level of complexity in the realm of simulation and task planning, particularly in relation to cost, time, force, space, and energy. This problem is further compounded by the potential integration of virtual-reality envisioning aids. The matter of whether general-purpose robots in humanoid configuration are logical also arises, as empirical evidence indicates that the optimal physical design of a robot is contingent upon the specific requirements of the work at hand. Analyzing HRI activities in order to anticipate the optimal physical manifestation presents an inherent difficulty.

Training a Robot and Eliminating Unplanned Consequences

The act of imparting geometric instructions to a robot hand can be achieved by a person. However, the process of providing detailed guidance regarding the manner, timing, and avoidance of certain movements necessitates the use of symbolic language rather than analogic means. The rapid progression of computer-based voice understanding, shown by Apple's SIRI, holds the potential to greatly facilitate the process of commanding robots. Nonetheless, it is significant to acknowledge the potential for unexpected outcomes. One potential solution could involve human supervisors utilizing real-time virtual reality simulation to examine the anticipated actions resulting from verbal directions, prior to authorizing the robot to proceed. The proposed methodology can be considered as an expansion of predictor displays, which involve the continuous updating of process models to anticipate future outcomes by model extrapolation.

Integrating Mutual "Mental" Frameworks to Limit Operating at Cross-Purpose

The concept of robots or humans possessing internal cognitive representations of each other has been proposed for a considerable period. The field of computer vision has made significant advancements in its ability to observe and analyze human actions. This includes the capacity to capture and retain data in the form of stick-figure models, as well as using Bayesian analysis and prediction techniques. The challenge of HRI lies in the process of extracting mental models from humans on the capabilities and expectations of robots. Integrating this knowledge with the model of of a computer that is essential for effective conflict and planning avoidance in HRI scenarios. Previous encounters with artificial intelligence (AI) in the domains of language translation and visual pattern recognition have indicated that achieving a level of performance comparable to the first 90% of human competence. However, attaining the remaining 10% proves to be exceedingly challenging due to the wide breadth of human experiential knowledge.

Role of Robots in Education

The field of robotics has made significant contributions to various disciplines, resulting in substantial advancements. The field of education presents a diverse range of difficulties that can be addressed through the utilization of robotics technologies and methodologies. Robotics offers a distinctive educational opportunity, presenting advantageous solutions tailored to the individual learning requirements of each student. Thus, Robotics in Education (RiE) comprises a diverse range of established sub-disciplines within the field of robotics. When examining the various uses of robotic devices within the realm of education, it becomes apparent that there are four primary domains: educational robotics, assistive robotics, socially assistive robotics, and social robotics. Each of these categories is employed within the domain of education for certain purposes.

The integration of assistive robots in educational environments has promise for mitigating physical constraints that may impede the educational process, hence fostering inclusivity and enhancing general well-being. Social robots in the realm of education fulfill two primary functions: they can function as tutors, offering students guidance and support, or they can serve as companions, promoting engagement and transforming conventional classrooms into networked and interactive learning environments. Research has demonstrated that socially assistive robots can effectively assist students in addressing social deficits by offering support through social interaction rather than relying solely on physical assistance. ER is grounded in the educational framework of constructionism and use programmable robotic kits that frequently comprise many disassembled elements. The objective of this strategy is to enhance the acquisition of diverse technology and subject-specific proficiencies among students. Experiential learning exercises have the potential to foster the development of both soft skills and hard skills, including but not limited to teamwork and communication.

The proliferation of robotic devices presents a multitude of prospects as well as novel complexities. It is imperative to undertake an assessment of their efficacy in fostering student engagement and cultivating competencies, as well as provide pedagogical and technology training for educators. The presence of technological openness in social and assistive robots can be seen as a benefit, since it allows users to effectively control and readily embrace their technology. Conversely, there exists a potential drawback associated with ER.

Lifestyle, Fears, and Human Values

The investigation of factors that contribute to and are associated with an individual's level of life satisfaction has gained significant traction in contemporary social sciences and economics literature. Research has demonstrated a positive association between both absolute income and relative income and individuals' levels of life and job satisfaction. Notably, studies have indicated that satisfaction levels tend to increase to a greater extent in response to relative income improvements, as evidenced by several sources (e.g., [27, 28, 29]). Individuals who are faced with unemployment tend to express diminished levels of life satisfaction, as supported by empirical findings that indicate a lasting negative impact on their overall sense of well-being (e.g., references [30], [31], and [32]). The significance of interpersonal relationships with family and friends in an individual's overall life happiness has been substantiated in the scholarly contributions of Weinstein [33]. The significance of governance quality and economic and social institutions and norms in relation to life happiness has also been emphasized.

An area of research that has received relatively limited attention is the impact of emerging technology on individuals' life satisfaction. This observation is intriguing, as it aligns with the widely acknowledged notion in the field of economics that technical advancements have historically played a pivotal role in instigating industrial revolutions, thereby significantly impacting labor markets and populations at large. The consensus among scholars is that technology and its progression tend to favor those with higher levels of skills, leading to increase in the skilled labor demand and a decrease in the unskilled labor demand. In his 2013 publication, Feldmann [34] posited that the phenomenon of technological unemployment would arise because of our increasing ability to optimize labor utilization surpassing our capacity to identify novel labor applications.

This form of unemployment is an inherent component of the technologically-driven phenomenon known as creative destruction, as described by [35] and incorporated into Kondratieff's theory of long waves in economic expansion. It is not unfounded to postulate, then, that the introduction of technical advancements may, in the beginning stages, potentially have a negative implication on individuals' overall satisfaction of life by leading to a significant increase in unemployment rates. It is conceivable that individuals may experience a sense of threat and subsequent impact on their life happiness, even if they are not directly affected by technology advancements. In contemporary times, scholars have regained interest in examining the dynamic between individuals and technology, particularly in light of the emergence of the fourth industrial revolution, sometimes referred to as I4.0.

Current scholarly investigations have primarily concentrated on examining the ramifications of technology on society, with particular emphasis on the influence of robots and the escalating utilization of advanced robotic systems. These robotic systems have the capability to collaborate with human workers, exhibiting more adaptability in the manufacturing process by performing a variety of tasks rather than being limited to a singular function. In the study conducted by Gonzalez, Alves, Viana, Carvalho, and Basilio [36], it is said that Industry 4.0 largely depends on robotic agents that are required to adapt and carry out key tasks within the smart manufacturing setting. These robotic agents are also expected to engage in communication with human operators, clients, and various distributed partners. This observation underscores the more intimate connection between robots and humans in the realm of production, encompassing not just physical proximity but also, for the first time, cognitive integration, as robots undergo continuous advancements. Numerous economists, both within the mainstream and non-mainstream spheres, are making projections on the transformative impact of next-generation robots on the labor market. These predictions suggest that the forthcoming labor market will exhibit significant disparities compared to the post-World War II era.

VI. CONCLUSIONS

Human-Robot Interaction (HRI) is an expanding discipline that finds its application in diverse sectors including education, industrial, service, medical, agriculture, and rehabilitation. HRI is employed in several jobs, including co-manipulating tasks, selection, and placing operations in production lines, welding procedures, components assembly, and painting. Furthermore, it is employed within medical facilities to combat the spread of COVID-19, enhance safety measures, reduce the burden of tasks, and enhance overall efficiency. Robots have the potential to serve as valuable aids in educational environments, facilitating classroom activities and fostering the advancement of education. HRI encompasses several forms of interaction that can be classified based on spatial or temporal separation. These interactions can range from remote interactions facilitated by mobile robots to proximity interactions involving robot assistants. The significance of social engagement with robots is equally notable in real-life contexts. The importance of safety in the industrial implementation of HRI cannot be overstated. Extensive research has demonstrated that the integration of robots in industrial settings can yield significant advantages in terms of enhanced productivity, improved production quality, increased competitiveness, and enhanced working conditions for employees. Within the realm of agriculture, robots play a crucial role by providing assistance in various duties including but not limited to harvesting, sowing, fertilizing, spraying, weed detection, hauling, and mowing. Robotic systems offer prospects for engagement and therapeutic interventions in the context of rehabilitation and medical domains, catering to individuals facing physical and cognitive impairments. HRI is also employed in the ongoing battle against the COVID-19 pandemic, wherein robots are capable of detecting genetic material specific to the coronavirus and offering aid to individuals affected by the virus. The field of HRI encompasses several challenges that warrant attention. These challenges encompass the identification of an optimal equilibrium in the design of robot appearance and behavior, the formulation of socially acceptable behavior, the creation of novel methodologies and approaches for conducting HRI studies and evaluations, and the mitigation of the "uncanny valley" phenomenon. The assignment of tasks between robots and humans presents a significant difficulty, as does the instruction of robots and the mitigation of unforeseen outcomes. The incorporation of robots in the field of education encompasses various domains, namely educational robotics, assistive robotics, socially assistive robotics, and social robotics. The assessment of the efficacy of robotic devices in fostering learner engagement and competence development, as well as providing pedagogical and technological training to educators, holds significant importance.

The current body of research pertaining to the influence of emerging technology, such as robots, on individuals' life satisfaction remains very limited. Technological advancements exhibit a bias towards skill, hence resulting to a surge in the demand for individuals with advanced skills while simultaneously causing a drop in the demand for people with limited skills. The emergence of next-generation robots within the context of the fourth industrial revolution is anticipated to engender a novel labor market paradigm. The involvement of the human factors community is crucial for advancing human factors research in the field of HRI. Technologies such as self-driving automobiles and drones present safety and acceptability challenges. The act of eliciting mental models from operators and subsequently comparing them with computer assessments can yield safety and efficiency advantages in the context of human-robot systems. The field of HRI necessitates increased involvement from the human factors community, which has historically been limited, with the exception of certain domains like military systems and commercial aviation, where human conditions professionals have been actively engaged. The existing technological advancements in autonomous vehicles and unmanned aerial vehicles (UAVs) present significant obstacles in terms of safety and societal acceptance. In relation to the previous discussion on Task Dynamic Analysis, it is imperative for human factors specialists to enhance their comprehension of control and dynamics, even if it is only at a fundamental level.

Data Availability
No data was used to support this study.

Conflicts of Interests
The author(s) declare(s) that they have no conflicts of interest.

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