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Human-Robot Interaction

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ABSTRACT

Human–robot interaction (HRI) is essentially the field of study of interactions between humans and robots. It exists at the overlap of several academic disciplines such as psychology, philosophy, anthropology, cognitive science, the social sciences, artificial intelligence, computer science, robotics, engineering, and human-computer interaction. It is dedicated to understanding, designing, and evaluating robotic systems used by humans. The goal of HRI is seeking to better understand the nature of interaction between humans and machines. Long-term human-robot interaction is important in several areas such as for companion robots, rehabilitation, and education. This paper introduces human-robot interaction and critically reflects on some of its key challenges.

KEYWORDS: *robots, robotics, human-robot interaction, human-robot collaboration*

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INTRODUCTION

Humans have been fascinated by robots, what they are and what they can do. A robot is essentially a machine designed to do something, Today, robots are everywhere. They are increasing used in our society, creating some concern about their relationship with humans. Some lifelike robots can carry on simple conversations. Some people who think highly of their robots and treat them as an extension of themselves. Lonesome individuals appreciate robots keeping them company [1]. Robots are increasingly being developed for real-world applications such as healthcare, rehabilitation, manufacturing, social assistance, surveillance, and education. Behaviors and appearances of robots have been changing dramatically.

While autonomous robots are good at repetitive tasks in controlled environments, the world in which most humans live is messy, constantly changing, filled with other people, and is unstructured environment. Robots are getting closer to the humans and the boundaries between human and robot workspace are getting blurred. In recent years, robots are being used in close proximity with humans in a variety of settings such as homes, schools, workplace, and hospitals.

New robotic systems are intended to play the role of teammates and partners with humans to perform operations. Poor interaction between human operators and robots will be progressively costly and calamitous. Human-robot interaction (HRI) is an interdisciplinary effort aimed at understanding and improving all aspects of interactions between humans and robots. It is the science of studying people's behavior and attitudes towards robots. The goal of HRI is to develop robots that facilitate the human-robot interactions while meeting the social and emotional needs of individual users as well as respecting human values.

HRI can take many forms. Picture a school teacher using an assistive robot to help students when they get stuck. Imagine an elderly being reminded to take

his medicine. Think of a robot helping you to cook or clean at home [2]. Robots provide entertainment and companionship for people. A doctor may use robotic technology in order to find out about the nature of a particular medical condition.

WHAT IS A ROBOT?

The word "robot" was coined by Czech writer Karel Čapek in his play in 1920. Isaac Asimov coined the term "robotics" in 1942 and came up with three rules to guide the behavior of robots [3]:

1. Robots must never harm human beings,
2. Robots must follow instructions from humans without violating rule 1,
3. Robots must protect themselves without violating the other rules.

Robotics has advanced and taken many forms including fixed robots, collaborative robots, mobile robots, industrial robots, medical robots, police robots, military robots, officer robots, service robots, space robots, social robots, personal robots, and rehabilitation robots [4,5]. Robots are becoming increasingly prevalent in almost every industry, from healthcare to manufacturing.

Although there are many types of robots designed for different environments and for different purposes/applications, they all share four basic similarities [6]: (1) All robots have some form of mechanical construction designed to achieve a particular task; (2) They have electrical components which power and control the machinery; (3) All robots must be able to sense its surroundings; a robot may have light sensors (eyes), touch and pressure sensors (hands), chemical sensors (nose), hearing and sonar sensors (ears), etc. (4) All robots contain some level of computer programming code. An autonomous robot must have a basic body structure (the chassis), sensors, a central control system (microprocessor), actuators (motors), a power supply and an overall program for its behavior. Programs are the core essence of a robot since they provide intelligence. There are three different types of robotic programs: remote control, artificial intelligence, and hybrid. Some robots are programmed to faithfully carry out specific actions over and over again (repetitive actions) without variation and with a high degree of accuracy.

The advantages of robotics include heavy-duty jobs with precision and repeatability. Despite these advantages, there are certain skills to which humans will be better suited than machines for some time to come. Humans have the advantages of creativity, decision-making, flexibility, and adaptability. Figure 1 illustrates the design space of robots [7].

BACKGROUND ON HUMAN-ROBOT INTERACTION

The role of robots in our society is expanding, bringing up a lot of issues surrounding the relationship between robots and humans. In recent years, human-robot interaction (HRI) has become an important field of robotics. HRI has received considerable attention in the academic community, industries, government, and the media.

HRI is a multidisciplinary field with contributions from human–computer interaction, artificial intelligence, robotics, natural-language processing, design, sociology, and psychology. It is a new discipline that has attracted a lot of attention in recent years. Ideally physical HRI should offer the users robotic systems that are easy to handle, intuitive to use, ergonomic and adaptive to human habits. Figure 2 shows a framework for conceptualizing HRI [8].

It is widely believed that "good" interaction with a robot must reflect natural interaction and communication as closely as possible. The workspace between robots and humans is explicitly shared, and direct interaction with each other is desired. Interaction between robots and humans can be separated into two general categories [9]:

- **Remote Interaction:** The human and the robot are not co-located and are separated spatially or even temporally. Remote interaction with mobile robots often is referred to as teleoperation or supervisory control, and remote interaction with a physical manipulator is often referred to as telemanipulation.
- **Proximate Interactions:** The humans and the robots are co-located. Service robots may be in the same room as humans. Proximate interaction with mobile robots may take the form of a robot assistant, and proximate interaction may include a physical interaction. Social interactions with robots appear to be proximate rather than remote since the humans and robots interact as peers or companions.

An important aspect of human-robot interaction/collaboration is the presence of the human or the human element. Autonomous robots have their own understanding of a situation and use that to make decisions independently from their human counterparts. The human behavior, on the other hand, is usually highly unpredictable and difficult to model. Robots designed to work with humans will face a variety of emotions, such as anger and frustration. As shown in Figure 3, robots are likely to affect humans emotionally [10]. Human communication incorporates plenty of social cues – from facial expressions to body language. By understanding these

social cues, robots can enable collaborative scenarios with humans.

Trust is one of the necessary factors for building a successful human-robot interaction.

It is regarded as a social glue that connects people and promotes collective goals. Trust is not limited to only inter-personal interactions, and it can affect different forms of interaction, including relationships among human individuals and robots. Relation-based trust implies the acceptance of a robot as a trusted social agent. A robot should have some features such as being sincere and ethical to the person with whom it interacts. Affective HRI is emerging as a necessary field of study as robots become more commonplace in operating in social environments and domains, such as caring for older adults, companionship, and education [11].

APPLICATIONS OF HUMAN-ROBOT INTERACTION

Several current applications of robots require them to work alongside people as capable members of human-robot teams. Applications of human–robot interaction/collaboration include industrial manufacturing, medical technology through rehabilitation, autism intervention, elderly care devices, hospital care, entertainment, human convenience, social robotics, service robots. assistive robotics, robot-assisted search-and-rescue, telepresence robots, companionship, education, agriculture, space exploration, military battle, bomb detection, and law enforcement. Some of these application areas are discussed as follows [3]:

- **Industrial Robots:** These robots have been implemented to collaborate with humans to perform industrial manufacturing tasks (such as welding, gluing, or pick and place) Traditional industrial robots are programmed to accomplish a fixed and repetitive task. Lightweight robots are replacing the traditional industrial robots due to their advantages: they are less dangerous and their compliance allows the users to work in close proximity [12]. In industrial robotic, assembly-line robots can perform versatile grasping tasks. In the industrial setting, a lot of tasks can be executed automatically using robots, such as picking, placing, welding, assembly, and inspection.
- **Collaborative Robots:** Robots are specifically designed to work with people. These robots are marketed as "collaborative" in that they are supposedly safer. Humans who build more accurate robot are often better collaborators. A physician may use robots to find out about the nature of a particular medical condition or impairment. The demand for collaborative robots is growing due to their safe design, versatility, productivity, and low prices. As shown in Figure 4, an industrial robot arm collaborates with a human operator [13].
- **Rehabilitation Robots:** The medical community employs robots for increasingly complex tasks such as robotic-assisted surgeries. Rehabilitation robot is an example of a robot-aided medical system. Robots can be configured as collaborative robot and can be used for rehabilitation of users with motor impairment. They may help elderly users at home with physical tasks, reminding them of appointment/events or the need to take medicine, and bring up their favorite topics when they appear sad.
- **Social Robots:** This explores important issues in designing a robot system that works with people in everyday environments. Social robots interact and communicate with humans or other agents by exhibiting social behaviors and following norms. They are typically robotic systems deployed in people's homes, hospitals, or other care settings. They are often equipped with tactile sensors to allow the robot to respond to human touch. Social robots are used in daily life such at a school, train station, shopping mall, and science museum. A social robot may understand the meaning of human body gestures, facial expressions, and verbal language. Social robots have exploded in popularity in recent years due to their various uses at home, in customer-service, education, and healthcare settings. People's relationships with such robots will cover a range from "funny toy" to "long-term companion." Interactive scenarios for social robots require not only the ability to find and track humans, but also to understand their gestures and actions [14].
- **Service Robots:** These can assist people in their homes or at work, and they may join this field in order to find out how to handle situations when these robots need to interact with people. Robots may play the role of service providers, companions and "helpers."
- **Manufacturing:** Robotic automation has drastically changed the way manufacturing is planned and performed. A new manufacturing paradigm is emerging with shorter product life cycles, mass personalization, and interactions between humans and robots in close proximity. If the human and automation can be combined, the advantages of production flexibility, product mix, and reconfiguration can be achieved [15].

- **Healthcare:** The integration of robotic systems in healthcare settings is accelerating. Robots are used as diagnostic aids, mobile assistants, physical rehabilitation providers, cognitive assistants, social and cognitive skills trainers, or therapists. Arguments for using robots healthcare include increased cost-effectiveness, protections for the healthcare workers, urgent need to supplement the declining numbers of available caregivers [16].
- **Automatic Driving:** From driving directions to choosing the food we eat, machines/robots are influencing our decisions daily. A specific example of human–robot interaction is the human-vehicle interaction in automated driving. There is a lot of trusts a human needs to have in the self-driving car that it can safely transport them from point A to point B.

Other areas of applications of HRI include search-and-rescue mission, teleoperation, military, transportation, logistics, agriculture, construction, entertainment, and space exploration

BENEFITS

Human-robot interaction research is an inter-disciplinary field with enormous future societal benefits. Improving the way humans and machines collaborate can help democratize robotics. Providing the right interface can put the power of robotics in the hands of regular people. Robots would fulfill better human-like tasks. Different disciplines have used HRI approaches for solving complicated problems, where humans and robots interact in some way to obtain advantages from their collaboration.

CHALLENGES

As robots transition into human environments, a variety of technical, ethical, psychological, and legal challenges are arising. In reality, robots are far from showing any truly human-like abilities in terms of physical activities, cognition or social abilities. Building humanoids which operate and behave like human is technologically highly challenging and costly. Designing robots and prototyping of scenarios for HRI properly remains a difficult task. Human culture is changing and people's attitudes towards robots is also changing.

Other challenges facing HRI include the following [3]:

- During initial interactions, people are more uncertain, anticipate less social presence, and have fewer positive feelings when thinking about interacting with robots, and prefer to communicate with a human.
- It has been observed that when the robot performs a proactive behavior and does not respect a "safety distance," the user sometimes expresses fear.
- Supervised exposure to a social robot can decrease uncertainty and increase willingness to interact with the robot
- Interacting with a robot by looking at or touching the robot can reduce negative feelings that some people have about robots before interacting with them.
- Developing complex robots for human-robot interaction requires substantial amount of resources, equipment, know-how, and funding. The development may take years until it is fully operative and functioning.
- Although children are encouraged to participate in robotic competitions, robots are often designed from an adult perspective, largely ignoring children's perceptions and attitudes about robots.
- Human safety is a key requirement for robots to work alongside humans in any environment. Bringing robots and humans spatially together leads to the fundamental concern of how to ensure safety of the human.
- There is still much skepticism from potential users towards the increasing deployment of robots in domestic environments and workplaces.
- People tend to anthropomorphize the world around them, and they react socially even to non-humanoid-looking technology.
- Since the adoption of robots raises substantial ethical, legal, societal, and regulatory issues, the field of robotics is now receiving attention from political and regulatory actors.
- We need to consider legal questions of robots' responsibility for their actions, cultural questions about racial profiling, and economic questions about the future of labor market in an increasingly automated society.
- There can be no real love or genuine friendship with a robot. The relationship will always be based on programming.

Some of these problems are extremely challenging and have strong societal implications. Despite the huge investments in robot design, it will take decades for androids to develop near-human capabilities.

CONCLUSION

Many roboticists believe that robots will enrich society. They are expecting a future of work that

establishes a division of labor between humans and robots. Future robots are expected to help us perform various tasks. They will look and behave very differently from the one we have today. Human–robot interaction is an extensive topic that has been gaining importance in recent years. In reality, it seems that humans are likely to supervise robots, rather than robots being an equal in a relationship.

Students should be taught the basic concepts on robotics, how robots work, how to design them, and how to evaluate their performance. They should be introduced to current research in HRI and provide hands-on experience. More information about human–robot interaction can be found in the books in [17-27] and the following journals devoted to robot-related issues:

- Robotica
- Robitics and Autonomous Systems
- Robotics Research
- Frontiers in Robotics and AI
- Robotics and Computer-Integrated Manufacturing,
- Advanced Robotics
- Autonomous Robots
- Journal of Robotics
- Journal of Robotic Systems
- Journal of Robotic Surgery
- Journal of Robotics and Mechatronics
- Journal of Intelligent & Robotic Systems
- Journal of Mechanisms and Robotics-Transactions of the ASME
- Journal of Automation, Mobile Robotics and Intelligent Systems
- Intelligent Service Robotics
- IEEE Journal on Robotics and Automation
- IEEE Robotics & Automation Magazine
- IEEE Robotics and Automation Letters
- IEEE Transactions on Robotics
- International Journal of Medical Robotics and Computer Assisted Surgery
- International Journal of Robotics Research
- International Journal of Social Robotics
- International Journal of Humanoid Robotics
- International Journal of Advanced Robotic Systems
- ISRN Robotics
- Recent Trends in Mobile Robots
- Science Robotics
- Swarm Intelligence
- Trust in Human-Robot Interaction
- Human–Computer Interaction
- Foundations and Trends in Human–Computer Interaction

REFERENCES

[1] "The future of human-robot interaction," November 2020, https://www.techslang.com/human-robot-interaction-the-future/

[2] H. M. Khalid, M. G. Helander, M. L. Lin, "Chapter 4 - Determinants of trust in human-robot interaction: Modeling, measuring, and predicting," *Trust in Human-Robot Interaction,* 2021, pp. 85-121.

[3] "Human–robot interaction," *Wikipedia,* the free encyclopedia https://en.wikipedia.org/wiki/Human–robot_interaction

[4] R. D. Davenport, "Robotics," in W. C. Mann (ed.), *Smart Technology for Aging, Disability, and Independence*. John Wiley & Sons, 2005, Chapter 3, pp. 67-109.

[5] M. N. O. Sadiku, S. Alam, and S.M. Musa, "Intelligent robotics and applications," *International Journal of Trends in Research and Development*, vol. 5, no. 1, January-February 2018, pp. 101-103.

[6] "Robotics," *Wikipedia*, the free encyclopedia https://en.wikipedia.org/wiki/Robotics

[7] K. Dautenhahn, "Human-robot interaction," *The Encyclopedia of Human-Computer Interaction,* 2nd ed., Chapter 38 https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-robot-interaction

[8] E. C. Collins, "Drawing parallels in human–other interactions: A trans-disciplinary approach to developing human–robot interaction methodologies," *Philosophical Transactions of the Royal Society B*, vol. 374, no. 17771, April 2019.

[9] Kanda, "Human-robot interaction: A research portal for the HRI community," February 2012. Unknown Source.

[10] R. M. Stock and M. A. Nguyen, "Robotic psychology: What do we know about human-robot interaction and what do we still need to learn?" *Proceedings of the 52nd Hawaii International Conference on System Sciences,* 2019, pp. 1936-1945.

[11] Z. R. Khavas, "A review on trust in human-robot interaction," https://arxiv.org/pdf/2105.10045.pdf

[12] S. Gopinathan, S. K. Otting, and J. J. Steil, "A user study on personalized stiffness control and task specificity in physical human–robot interaction," *Fronteirs in Robotics and AI,* November 2017.

[13] J. Marvel, "The cybernetic revolution: The influence of metrology on the user experience in human-robot interaction," May 2019, https://www.nist.gov/blogs/taking-measure/cybernetic-revolution-influence-metrology-user-experience-human-robot

[14] A. Thomaz, G. Hoffman, and M. Cakmak, "Computational human-robot interaction," *Foundations and Trends in Robotics*, vol. 4, no. 2-3, 2013, pp. 105–223.

[15] A. A. Malik and A. Brem, "Digital twins for collaborative robots: A case study in human-robot interaction," *Robotics and Computer-Integrated Manufacturing,* vol. 68, April 2021.

[16] E. F. Villaronga, "Nothing comes between my robot and me: Privacy and human-robot interaction in robotised healthcare," *Data Protection and Privacy,* December 2018.

[17] L. Dez, *Human-Robot Interaction Useful Information in AI and Robotics: Artificial Intelligence for Dummies.* Blackwell's, 2021.

[18] J. Carpenter, *Culture and Human-Robot Interaction in Militarized Spaces: A War Story*. Routledge, 2016.

[19] D. Zhang and B. Wei (eds.), *Human–Robot Interaction: Control, Analysis, and Design.* Newcastle upon Tyne, UK: Cambridge Scholars Publishing, 2020.

[20] S. Kielser and P. Hinds (eds.), *Human-robot Interaction: A Special Double Issue of Human-Computer Interaction*. Boca Raton, FL: CRC Press, 2004.

[21] C. Bartneck et al., *Human-Robot Interaction - An Introduction*. Cambridge: Cambridge University Press, 2020.

[22] T. Kanda and H. Ishiguro, *Human-Robot Interaction in Social Robotics*. Boca Raton, FL: CRC Press, 2011.

[23] X. Wang (ed.), *Mixed Reality and Human-Robot Interaction*. Springer 2011.

[24] M. A. Goodrich and A. C. Schultz, *Human-Robot Interaction: A Survey*. Delft, The Netherlands Now Publishers, 2008.

[25] P. A. Lasota, T. Fong, and J. A. Shah, *A Survey of Methods for Safe Human-Robot Interaction*. Vol. 104. Delft, The Netherlands: Now Publishers, 2017.

[26] P. Barattini et al.(eds.), *Human-Robot Interaction: Safety, Standardization, and Benchmarking*. Chapman and Hall/CRC, 2020.

[27] D. Coleman (ed.), *Human-Robot Interactions: Principles, Technologies and Challenges.* Nova Science Publishers, 2015.

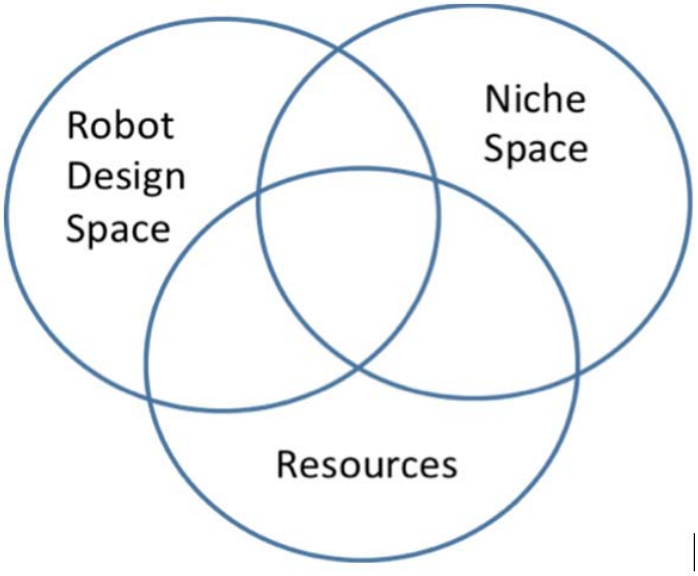

Figure 1 The design space of robots [7].

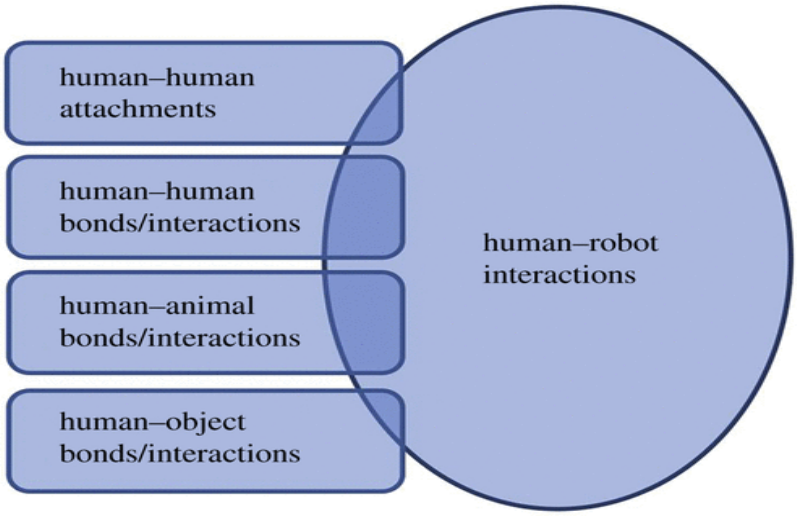

Figure 2 A framework for conceptualizing HRI [8].

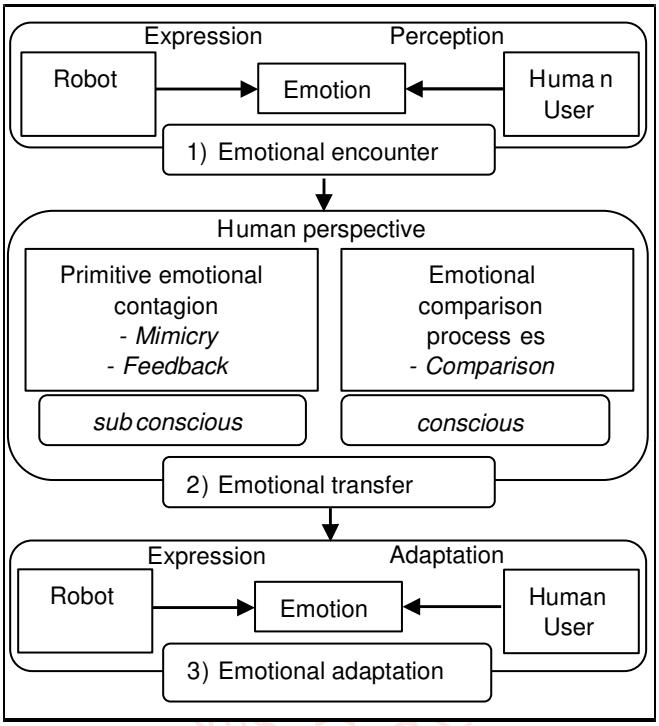

Figure 3 Emotional contagion in HRI [10].

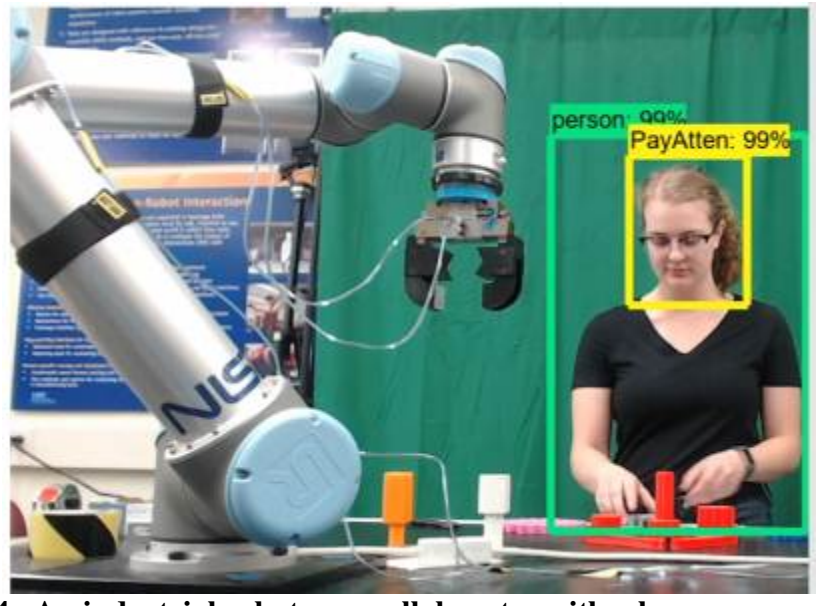

Figure 4 An industrial robot arm collaborates with a human operator [13]