

Human-Robot Co-Working in Enterprises - A Security Walkthrough

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ARTICLE INFO <i>Article history:</i> Received 03 May 2026 Accepted 25 June 2026 Available online 12 July 2026 <i>Keywords:</i> Industry 4.0 Industry 5.0 Enterprise Architecture Framework Human-Robot Co-working Artificial Intelligence	ABSTRACT <i>It is widely believed that the fourth industrial revolution is just around the corner. During Industry 4.0, there was a theme of "Smart Manufacturing for the Future". Some futurists are already discussing what the theme will be of the fifth industrial revolution. It is emerging that humans and robots can work together. A significant amount of progress has been made in the field of robotics and artificial intelligence (AI) in the last few years. A promising example of this trend is testing autonomous cars in traffic. There are Enterprises with robots or AI applications that keep employee records. Despite the abundance of studies on human-robot collaboration for low-level tasks with a focus on robot development, only few studies examine organizational issues arising from the collaboration of humans and robots. The purpose of this study is to discuss possible issues related to human-robot co-working from the perspective of both the Enterprise and the workforce. Several studies focusing on organizational robotics are expected to be influenced by the issues identified in this report.</i>
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1. Introduction

A major purpose of an industrial revolution is to separate human workforce from that of the machines. Machines will eventually do the hard, boring, or dangerous jobs that human cannot handle. These machines can also be referred as "robots". Cleaning robots, for instance, can easily take care of cleaning a room or an office in an Enterprise. In the near future, all cleaning jobs will be performed by robots. While we are at a point where both robots and human are able to do cleaning, past experiences suggest that human will do less cleaning in the future than robots. Technology level and human acceptance of robots play a major role in the pace of automation diffusion in Enterprises [1]. Studying the interactions between humans and robots, as well as the implications of their effects on organisation, is crucial because of the possible significant impacts of robots on Enterprises. A lot of research interest has been generated by Industry 4.0 since its introduction in 2011 [2]. Additionally, a number of scholars and futurists have already begun discussing the concept of Industry 5.0. A number of different visions have been presented for Industry 5.0. Human-robot collaboration is one of the emerging themes. There can be no certainty as to what the theme

of Industry 5.0 will be at this time. In spite of this, human-robot co-working will be a significant innovation for Enterprises and will have an impact on organisations in a significant way [3].

In the past three centuries, organisations have experienced three industrial revolutions. Most people now believe that we are in the midst of the fourth. These revolutions are depicted in figure 1 as a timeline. In the past few decades, the time span between revolutions has shortened. The first three revolutions happened 100 years apart. The fourth one was only reached after 40 years from the third. Within 40 years, there is a possibility of reaching the fifth level. The German government initiated Industry 4.0. During Industry 4.0, there was a theme of "Smart Manufacturing for the Future". As with previous revolutions, its objective is to increase productivity and achieve mass production through innovative technologies. Several trending technologies help make Industry 4.0 a reality. The internet of things (IoT), robotics, and artificial intelligence (AI), as well as big data and cloud computing are among the most trending trends today. Additionally, Industry 4.0 is supported by other technologies. Some of these technologies include 3D printing, virtual and augmented reality, smart

factories, smart logistics, and ambient intelligence. The technologies described here were not developed specifically for Industry 4.0, rather these technologies are brought together to create smart manufacturing as part of the vision for Industry 4.0. Industry 4.0 has also

been criticized for being a top-down government initiative with a predefined concept [4].

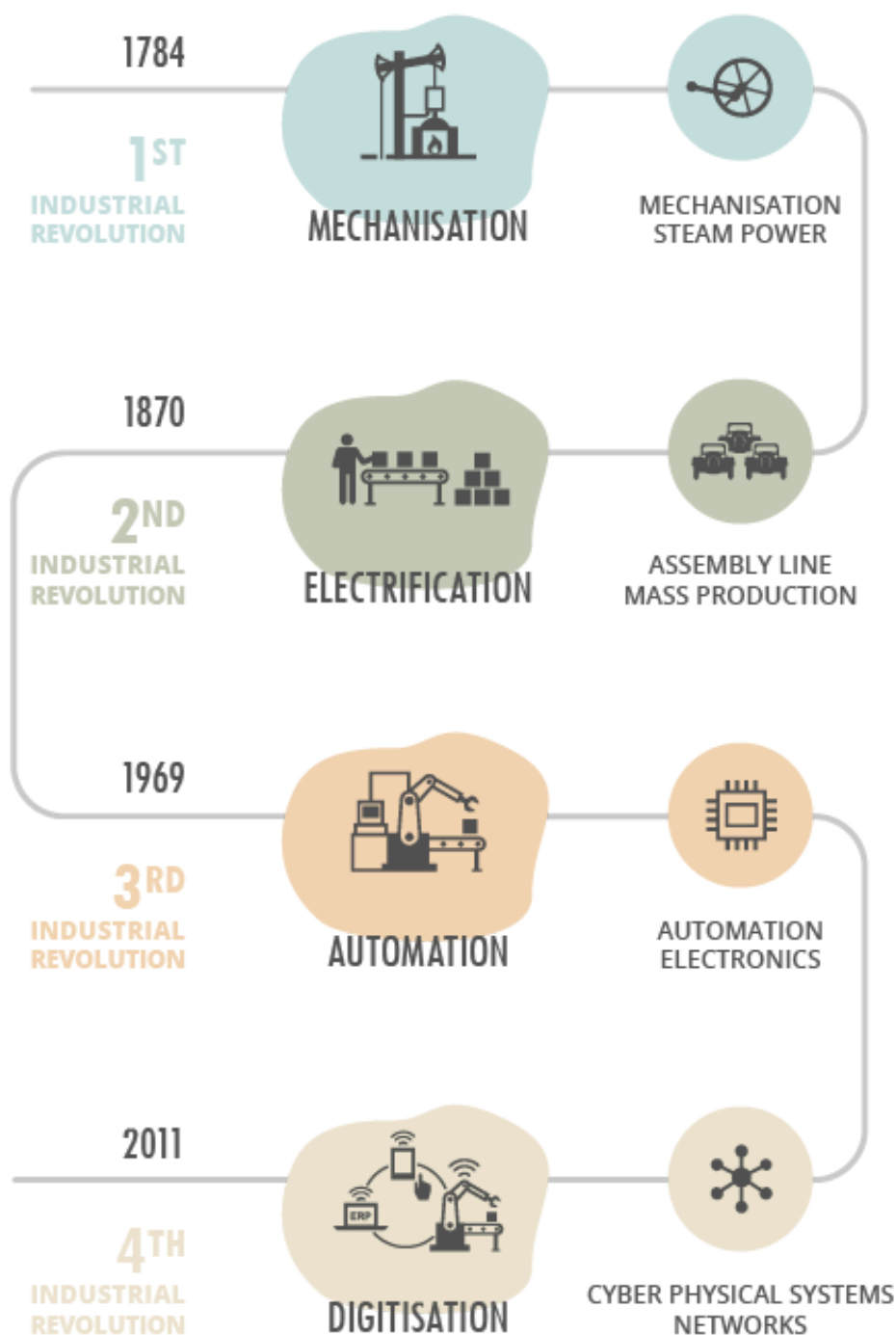


Figure 1: Will the 5th Industrial Revolution be the next Renaissance? [5]

Currently, two visions for Industry 5.0 are emerging. One of them is “human-robot co-working”. The goal with this vision is to have robots and humans work together whenever and wherever possible. Efforts requiring creativity will be handled by humans, while the rest will be taken by robots. A second vision for Industry 5.0 is the bioeconomy [6]. An eco-friendly, industrial, and economic balance can be achieved by using biological resources for industrial purposes. Biological economy is defined by the European Commission as “the production and conversion of renewable biological resources and waste streams into value-added products, such as food, feed, biobased products, and bioenergy.” Agricultural production, forestry, fisheries, food, pulp and paper production, chemical production, biotechnology production, and energy production are all included in this category. Since they utilize a wide range of scientific disciplines (life sciences, agronomy, ecology, food science, and social sciences), enabling and industrial technologies

(biotechnology, nanotechnology, information and communication technologies (ICT), and engineering), as well as local and tacit knowledge, its sectors are highly innovative [7].

The bioeconomy is based on the principle of biologization, which has the potential to change industries fundamentally. In consequence, it is possible that bioeconomy will play a major role in the next industrial revolution. In Table 1, we compare the concepts of Industry 4.0 and Industry 5.0. An important distinction is that Industry 5.0 may apply to both human-robot co-workers and bioeconomists [8]. Furthermore, other topics like space life, space industries, and space mining, may also occur in the near future. Space resource utilization is already being cautioned by scientists. It might become the next “gold rush”.

TABLE 1
A Comparison of Industry 4.0 and Industry 5.0 Visions [9]

	Industry 4.0	Industry 5.0 (Vision 1)	Industry 5.0 (Vision 2)
Percept	Smart Manufacturing	Human-Robot Co-working	Bioeconomy
Stimulus	Mass Production	Smart Society	Sustainability
Energy Supplier	Electrical power Fossil-based fuels Renewable power sources	Electrical power Renewable power sources	Electrical power Renewable power sources
Applied Mechanism	Internet of Things (IoT) Cloud Computing Big Data Robotics and Artificial Intelligence (AI)	Human-Robot Collaboration Renewable Resources	Sustainable Agricultural Production Bionics Renewable Resources
Experimentation Domain	Organizational Research Process Improvement and Innovation Business Administration	Smart Environments Organizational Research Process Improvement and Innovation Business Administration	Agriculture Biology Waste Prevention Process Improvement and Innovation Business Administration Economy

2. State-of-the-Art

The integration of robots into organizations has been discussed in previous studies. There are a number of issues to consider, including evolving organizational behaviors, structures, workflows, ethics, and work environments. A number of important matters need to be addressed, including: acceptance of robots in the workplace, discrimination against robots or people, privacy and trust in co-working spaces for humans and robots, re-designing the work environments for robots, education, and training. A significant amount of change is anticipated in organizations as a result of the issues identified. Issues related to integrating robots into organizations are elaborated in figure 2.

Working with robots presented organizational

challenges to Bagdasarov and her colleagues [10]. There were three sets of factors discussed: individual, organizational, and robotic agents. According to the authors, various factors should be considered under each set. An employee's age, gender, level of education, knowledge and experience of technology, their expectations, and their social perceptiveness/interpersonal sensitivity are factors that affect them as individuals. There are a number of organizational factors to consider, including workflow, physical environment, social/emotional context, training, and employee-robot goals alignment. Factors that determine the performance of robotic agents include the robot's appearance, behavior, ability to interact, and safety.



Figure 2: Issues related to integrating robots into organizations

3. Identified issues in Human-Robot Co-working

The authors identified 11 emerging issues in enterprises related to human-robot co-working. It is important to note that some issues have implications for both the organization and the individual. Clearly distinguishing organizational issues from personal ones

can be difficult. All the 11 issues are described in subsequent subsections.

3.1. Issues related to Administration

In one definition, a robot is a machine that responds to stimuli, thinks about them, and acts on them. Despite its simplicity, this definition is problematic. What does being a robot mean when it comes to thinking and acting? A robot, according to the Oxford dictionary, is a machine that performs complex actions

automatically, especially one programmable by computers. According to the Merriam Webster dictionary, a robot is a machine that imitates the functions of a human being (such as walking or talking). Furthermore, these definitions pose problems as well. One relies on vague concepts such as carrying out complicated actions automatically. Similarly, another group assumes robots look like humans [11]. These vague definitions reveal that we haven't yet come up with a satisfactory definition. Co-working between humans and robots will be fraught with problems if the necessary regulations are not in place. Defining what a robot is from a legal standpoint is the first step.

While there are scientific definitions for the robot, only a legal definition of a robot is binding the businesses to adopt it. An automated machine can be of many different types, and a robot is also one of them. Additionally, each machine has a defined level of automation. Co-working between humans and robots should be regulated by laws that clearly distinguish automated machines from robots. Similarly, drones and cyborgs also play a significant role. Furthermore, robots, drones, and cyborgs should all be distinguished from one another [12]. A law and other relevant regulations should not only include a clear definition, but also a list of robots that are allowed to be used in workplaces, robots' roles and responsibilities, their ability to make decisions involving humans, types of robot malfunctions, who is responsible for robot malfunctions, how robot malfunctions are handled, whether a robot's software follows hard-coded instructions or learns and evolves over time, the certifications robots must have, and the responsibilities of the certification authorities.

3.2. Employees Inclination towards Robots

Each individual has a different preference for whether to use or not to use a particular technology. In addition to people who are eager to work with robots, there are others who strongly oppose it. These personal preferences should be considered by organizations planning to integrate human-robot co-working into their workplaces. Co-working environments between humans and robots are unlikely to be successful if employees who enjoy working with them do not have

a positive attitude toward them. Since human-robot co-working does not yet exist, the media shapes people's opinions more than first-hand experiences when it comes to working with robots [13]. A number of famous movies and TV shows have been made about robots taking over the world or fighting humans. Robotics is negatively portrayed in media, and this affects people's preferences when it comes to working with them.

3.3. Cognitive Issues

Humans are subject to certain psychological effects as a result of advanced technology. An increasing number of people are becoming aware of the psychological disorder of video game addiction. Moreover, there are people who are extremely attached to their smart-phones. A new type of phobia emerged for them called "nomophobia" or "phobia of not having a mobile phone [14]." Nomophobia is defined by the Collins dictionary as a chronic stress caused by not having access to a mobile phone or being unable to use one. At the moment, there is no information about whether there will be "robophobia" or "norobophobia". Nevertheless, many employees are likely to experience many unprecedented psychological effects as a result of advanced technologies such as robots [15]. Organizational robotics will develop research topics regarding the psychological effects of working with robots and the impact they have on organizational climates.

3.4. Societal Consequences

The addition of robots to workplaces could have unprecedented effects on social interactions in the workplace, regardless of the number of human employees. The social behavior shown by robots may be preferable to some humans, while others may believe that such social behavior is fake and just computer programming. There will be different perspectives on social interaction with robots among employees. It becomes more difficult when robots hold positions of authority or management. The average employee shows respect for his or her superior or manager, but in this case employees could be unsure about respecting a robot manager [16]. As it is a fact that robots won't care about respect, because they don't

understand it. It will be new, confusing, and even frustrating for many people to deal with these kinds of issues. The way children treat robots is the same as how they treat their real pets, according to numerous studies. In the future, robot-human interaction may be similar to the human-smartphone interaction today, just as the latest generation of consumers has more interaction with smartphones and they view phones as an integral part of their lives. Hence, research on human-robot collaboration appears to be integrated with social studies.

3.5. Varying Employee-Employer Relation

Among the important responsibilities of human resources departments are analyzing work, developing job descriptions, and hiring the right people with the right qualifications. The vast majority of organizations currently employ people, with the exception of industries that use industrial robots. In a world where robots are becoming a part of every organization, human resources departments face a number of challenges. Additionally, they will have to identify which jobs can be handled by robots on top of their current duties. There are businesses and companies today advertising themselves as "green" and claiming to be environmentally friendly.

Businesses and organizations that practice "green" practices try to act responsibly towards the environment despite the fact that these initiatives increase costs. In the future, there might be businesses claiming to be "human". Despite being a "human" organization, these organizations may employ only humans even if using robots would be more economical. Organizations that claim to be human will assert that they are socially responsible and create jobs for people [17]. Among the most important responsibilities of the human resources department are analyzing work, creating job descriptions, and identifying business processes. It will take a lot of work for human resource departments to rethink most of what they have been doing when it comes to robots before they can integrate them into their organizations.

3.6. Business-IT Alignment

The importance of information technology (IT) increases as technology is becoming an inevitable part

of organizations' operations. It will be necessary for organizations to find a way to purchase and maintain robots in order to realize the vision of human-robot collaboration. The IT department is likely to be assigned this task at first. Eventually, organizations may create robotics departments that are responsible for acquiring and maintaining robots within their facilities. Maintaining and upgrading robots should be done in a safe and secure manner since robots take on a lot of responsibility. It will also be important to ensure the information security of robots. It will be much more challenging and complicated to secure data acquired by robots than to secure current IT infrastructures within organizations. Workplace information assurance and privacy assurance will likely be complicated by human-robot collaboration. Information security researchers will likely find this topic to be important [18].

3.7. Morality in Robots

The ethical behavior expected of human employees includes honesty, diligence, and helpfulness. It is certain that the work ethic values we hold dear will change if robots with selfless motives, without ambition, without laziness, and without lying are introduced. As far as reaching a good ethical standard in this regard goes, humans may not be able to compete with robots. As a result of a co-working environment involving humans and robots, it is hard to predict the development of work ethics. The interaction between humans and robots will also likely be governed by an ethical norm. Apparently, humans can feel sorry in the face of events such as robots behaving badly toward each other, according to a study. Hence, it will be necessary to determine the ethical status of robots in the workplace [19].

3.8. Learning Issues

The development of robots that can learn is an area of research that receives a lot of attention. There is, however, a possibility that robots with machine learning capabilities will behave in an unpredictable manner. People may be discouraged from assigning important tasks to robots if they experience this unpredictable behavior frequently. Robots may even be refused by some people depending on their

behavior. In contrast, robots that follow a set of rules are predictable. In spite of this, their learning capabilities will be limited. Therefore, co-working environments involving robots and humans will probably involve tradeoffs in robot types [20]. A robot with the capacity to learn but limited capability to do so may need to be chosen between a learning robot that is susceptible to unpredictable behaviors and a predictable rule-based robot that isn't capable of learning.

3.9. Challenges in working with Robots

The concept of robots is familiar to humans because of books and movies. The concept of co-working between humans and robots will, however, be unfamiliar to most office workers. In spite of expectations that robot interaction will be easy, the actual experience may be different from what is expected. For us to get what we really want, we may need to learn how to behave toward robots. The importance of non-verbal communication in human interactions cannot be overstated. These non-verbal communications, however, may not be understood by robots. Humans will have to learn to work with robots and will need time to get accustomed to it. As well, robots will be able to perform different tasks. Differentiating robots with different capabilities will be hard and confusing for humans [21]. There is a need for robot manufacturers to develop robots that convey information about their capabilities without confusing the user. As a result, working with different types of robots will require humans to learn new skills.

3.10. Missing Links

A study found that humans' greatest fear of robots is the loss of jobs, both personally and at Enterprise level. The negative attitude toward robots will likely increase as humans start losing their jobs to robots. Those who oppose the use of robots will argue that this will lead to increased unemployment. This view can be countered by arguing that new jobs will be created. In addition, this counterargument has been proven valid throughout history. In contrast to mundane jobs being taken over by robots, human creation, artistry, research, and development will be the focus of humans. Nonetheless, this view presents a dilemma.

It is unlikely that the people who lose their jobs will be able to fill jobs that require creativity because they lack the education, training, and skills. Let's imagine a middle-aged woman who works at a hotel as a housekeeper. Unless she has the skills required becoming a marketing campaign manager in the robotic age, it is unlikely that she will possess the necessary qualifications for such a position after losing her job to a robot. Unemployment will be strongly opposed by worker unions if robots are introduced. Having this negative attitude will lead constituents to vote for or make robotic laws and regulations based on these laws and regulations. Consequently, people may have a negative attitude toward robots in the early years of the robotic age since they cause unemployment [22].

3.11. Competition or Complementation

In the future, scientists and practitioners will discuss the positions and roles that robots will take on. A simpler solution would be to place robots in roles that complement human work. Consequently, humans won't feel threatened by robots since they won't lose their jobs. Robot assistants may even be preferred by most humans. Robots will take over the tasks in these positions so that humans will not have to worry about managing human assistants [23]. Humans will also have more time to spend on tasks requiring creativity and higher intelligence, as robots will take over mundane and cumbersome tasks. In order to create a co-working environment between humans and robots, complementing them with robots is a simpler, more straightforward, and less problematic solution. Some people, however, may advocate that robots should or may replace human employees in certain positions. The argument will be made that this will enhance the performance of human workers. It is natural for human beings to compete for positions in organizations. Management and organizational behavior will be complicated by adding robots to this competition. In fact, studies have been conducted investigating human reactions to robots that command [24].

4. Conclusion and Future Directions

It does not matter whether Industry 5.0 involves human-robot collaboration or not, it will still be an

important change for Enterprises. Humanity is likely to experience a significant change as a result to the introduction of robots into our lives. Using technology, researchers strive to create something that resembles humans in many ways. There will be some who find this innovative and exciting while there will be others who will find it outrageous, frustrating, and even dangerous. As a result of the media, people have a negative attitude towards robots. Practitioners might be biased by this negative attitude when they conduct surveys regarding robots in society. There is a negative perspective on robots reflected in one of the first scales developed to measure attitudes toward them. It is hard to predict how humans will respond to robots until they live and work with them. As humans become more familiar with robots, their attitude toward them is likely to change. There may be a difference between how the next generation reacts to robots and how this generation is doing, since the new generation will grow with robots or similar technologies. The developers must recognize the generational gap and create a robotic society that maximizes the benefits of robotic technology and minimizes its negative effects. The authors discussed possible legal, regulatory, psychological, socio-ethical, and ethical issues that may arise from human-robot co-working. In addition, the authors pointed out that the changing roles of IT and HR departments pose challenges to the co-working of humans and robots. The following issues are a few of the most prominent: personal preferences and types of robots preferred for working with, learning to work with robots, competing or cooperating with robots, and possible negative attitudes toward robots. In any case, all the topics discussed are still open to further research, investigation, and experimentation.

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