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HUMAN-ROBOT INTERACTION – WHAT IT MEANS FOR HUMAN RESOURCE MANAGEMENT

INTERAKCJE CZŁOWIEK-ROBOT – CO TO OZNACZA DLA ZARZĄDZANIA ZASOBAMI LUDZKIMI

Abstract

Development of robotics and growing use of robots in many areas of the economy and social life require research which will identify problems related to the use of modern technologies and the development of human-robot interaction (*HRI, H*uman-Robo*t Interaction).* Robotics, autonomous systems and artificial intelligence also create a number of new legal and ethical challenges. Research in this area has been expanding in recent years, but there are still issues that require in-depth scientific exploration. The objective of this paper is to systematize knowledge about interactions between people and robots, with particular emphasis on interactions in the work environment, and to identify research gaps in the analysed problem area. The following research questions were formulated: 1) What determines people's attitudes towards robots? 2) What are the key challenges in human-robot communication? 3) What ethical challenges determine human-robot interaction? In the studies the the method of narrative literature review has been used. The latest scientific publications on the researched issue were analysed. The results of the study indicate that the main factors which determine people's attitudes towards robots are apart from demographic variables and experiences gained by people from contacts with robots, the perceived usefulness of using robots, the image of robots created in the mass media and religiousness. The key challenges in human-robot interaction apart from effective communication is the reflection of emotions. The research results enable the identification of further directions of scientific research on human-robot interaction. They can also enrich practitioner's perspective in the studied area.

Keywords: *human-robot interactions, human-robot communication, roboethics*

Streszczenie

Rozwój robotyki i coraz szersze zastosowanie robotów w wielu dziedzinach gospodarki i życia społecznego wymaga badań, które pozwolą na identyfikację problemów związanych z wykorzystaniem nowoczesnych technologii i rozwojem interakcji człowiek-robot (HRI, Human-Robot Interaction). Robotyka, systemy autonomiczne i sztuczna inteligencja stwarzają również szereg nowych wyzwań prawnych i etycznych. Badania w tym obszarze rozwijają się w ostatnich latach, ale nadal istnieją kwestie, które wymagają dogłębnej eksploracji naukowej. Celem niniejszego artykułu jest usystematyzowanie wiedzy na temat interakcji między ludźmi a robotami, ze szczególnym uwzględnieniem interakcji w środowisku pracy, oraz zidentyfikowanie luk badawczych w analizowanym obszarze problemowym. Sformułowano następujące pytania badawcze: 1) Co determinuje postawy ludzi wobec robotów? 2) Jakie są kluczowe wyzwania w komunikacji człowiek-robot? 3) Jakie wyzwania etyczne determinują interakcję człowiek-robot? W badaniach zastosowano metodę narracyjnego przeglądu literatury. Przeanalizowano najnowsze publikacje naukowe dotyczące badanego zagadnienia. Wyniki badania wskazują, że głównymi czynnikami determinującymi postawy ludzi wobec robotów są, poza zmiennymi demograficznymi i doświadczeniami wyniesionymi przez ludzi z kontaktów z robotami, postrzegana użyteczność korzystania z robotów, wizerunek robotów kreowany w środkach masowego przekazu oraz religijność. Kluczowym wyzwaniem w interakcji człowiek-robot oprócz efektywnej komunikacji jest odzwierciedlenie emocji. Wyniki badań umożliwiają identyfikację dalszych kierunków badań naukowych nad interakcją człowiek-robot. Mogą również wzbogacić perspektywę praktyków w badanym obszarze.

Słowa kluczowe: *interakcje człowiek-robot, komunikacja człowiek-robot, roboetyka*

Introduction

Human-robot interaction is a multidisciplinary area of research drawing on, among others, the achievements of psychology, cognitive science, sociological sciences, robotics, mechanics, electronics and computer science, as well as management and quality sciences. Studies in the field of human-robot interaction focus on the conditions of human-robot interaction and communication, as well as on understanding, designing and assessing this interaction in order to best design and implement robots capable of performing interactive tasks in the human operating environment, including work environment (Goodrich and Schultz, 2007, pp. 203-275; Rodriquez-Guerra et al., 2021, pp. 108557-108578, Gajsek et al., 2020, 6590). The complexity of human-robot interaction in terms of methodology is significant and does not come solely from the multi-disciplinary nature of research. It also results from the specificity of this interaction itself, where on the one hand, there is a complex technical artefact characterized by a specific intelligence, and on the other hand, there is a human who, as the subject of this interaction, perceives it, feels it and has certain expectations towards it, usually higher than those towards own washing machine, car or printer. Hence, the subject of research is not only the technical capabilities of robots, but also the needs of users, their ideas, fears, expectations, and, in a broader perspective, also the ways of using robots in the context of lifestyles, models of societies, and questions about the patterns of the so-called good life (Małek-Orłowska, 2015, pp. 93-105; Scheutz et al., 2021; Dautenhahn, 2013), as well as enhancing administrative processes (Solarz, 2023, pp. 230-252).

The objective of this paper is to is to systematize knowledge about advanced interactions between people and robots, with particular emphasis on interactions in the work environment, and to identify research gaps in the analysed problem area. This will allow the identification of further desired directions of scientific research on human-robot interaction. The article uses the method of narrative literature review. The following research questions were formulated.

- What determines people's attitudes towards robots?
- What are the key challenges in human-robot communication?
- What ethical changes determine human-robot interaction?

The paper is organized as follows. The first section presents the research problem of human-robot interaction. In the second section determinants of attitudes towards robots the research methodology were described. The context was demographic variables was highlighted. The third section was dedicated to human-robot communication process. Following this ethical aspects of the human-robot relationship were presented. The paper ends with conclusions, limitations, and implications for further research.

Human-robot interaction

The word *robot* was first used in 1920 in the play *Rossum's Universal Robots* written by Czech Karel Capek (Kurniawan et al., 2006, pp. 83-98). A robot can be intelligent or autonomous if it has the potential to move freely and the ability to avoid physical barriers found in a relatively unknown and unpredictable environment. The most frequently cited definition of a robot indicates that it is a *multifunctional, reprogrammable manipulator designed to move materials, tools, specialized devices or parts, through movements integrated with programming variables in order to perform a task* (Ren, 2004, p. 1151). The mobile robot performs a freely defined task using an artificial intelligence algorithm. It is a special type of software-controlled machine that uses sensors and other technologies to recognize the environment and perform predefined tasks. An autonomous robot usually performs a task in three stages: perception (identifying the meaning of the activity), planning and interpretation (process), and movement (action).

Advanced HRI, human-robot interaction, has become an indispensable resource in Industry 4.0 (Moczydłowska, 2023). In particular, the implementation of collaborative robots (cobots) has changed the way modern, smart factories operate. These robots support human operators by working side by side with them on a collaborative task (Lin et al., 2021). Because cobots are designed to be collaborators rather than tools, smooth interaction between them and their operators is crucial for the implementation of tasks and, therefore, for their high efficiency and work efficiency (Paliga, 2022, p. 104191). The growing popularity of robots and robotics means that we are dealing with a constantly growing ecosystem of robots surrounding us (Palomäki et al., 2018, pp. 3-4). This ecosystem includes both real robots, such as industrial robots, autonomous cars, cleaning robots and assistive robots, but also robots appearing in film productions, animations, games or as virtual assistants (e.g. Google Assistant, Siri). Robots are, of course, a part of a larger whole which creates the technological reality surrounding us. At the same time, they are an exceptionally interesting element because they are intended to (to a greater or lesser extent) reflect people.

There are many robot typologies in the literature. One of the simplest, based on the nature of the performed tasks, is the one proposed by A. V. Libin and E. Libin (2004, pp. 1789-1803). It includes a division into assistive robots (industrial, research, military, rescue and service) and interactive robots (social, recreational, educational, rehabilitation, therapeutic). The basis for the division in this case are tasks performed by robots, but also differentiation of robots in terms of appearance and behaviour due to these tasks. Assistive robots resemble machines in appearance and expand the motor or sensory capabilities of humans, while interactive robots usually have anthropomorphic features, i.e. they resemble humans in appearance and behaviour. They are characterized by the ability to simulate emotions and greater complexity of gestures and facial expressions. It is worth mentioning that this is not an exhaustive typology, because the appearance of robots cannot be described only using a one-dimensional continuum of similarity to a machine or a human. Nowadays, robots which resemble animals but perform completely different functions are also being designed (examples include the BigDog transport robot and the Paro robot, a therapeutic seal). Undoubtedly, the appearance of robots is the first feature we notice when interacting with them, which is why it is important for shaping further interaction. It evokes specific emotional reactions and, consequently, also determines attitudes towards the robot. For this reason, research on human preferences regarding the appearance of a robot is an important area of research and provides information which may prove particularly useful in the robot design process (Rudnicka, 2014, pp. 53-60).

In the context of the subject of this article, humanoid robots and social robots are particularly important. A social robot is an autonomous machine which can recognize other robots and people and engage in social interactions (Fong et al., 2003, pp. 143-166). Social robots are designed for anthropocentrically understood interaction with people, as well as operation in a human environment. Research (Prescot and Robillard, 2021, pp. 1-5). provide evidence of the positive impact of social robots across five overlapping dimensions: (1) physical comfort; (2) emotional comfort; (3) direct social interactions and reinforcement of social interactions, and (5) behaviour modelling. Their common feature is that they invite users to interpersonal interactions, communicating with them and coordinating their behaviour using various verbal, non-verbal and affective modalities (Breazeal et al., 2008). Robots of this type are designed to serve people; therefore, they often act as guides, assistants, companions, caregivers, teachers or equivalents of pets (Broadbent, 2017, pp. 627-652). In addition to playing the role of helpers and companions in various areas of human life, social robots can also be scientific tools for studying the human social cognition system. In particular, they can provide information about the flexibility of this system in humans. As it appears, the social cognition system is in many cases able to use the same mechanism both in interactions with another human and with a robot. This happens, among others, when recognizing movement, identifying gestures or attention mechanisms (Wykowska, 2020, pp. 1203-1211). A social robot may also be a fully virtual robot (Wasielewska and Łupkowski, 2021, pp. 165-187).

Determinan ts of attitudes towards robots – research review

The key factor analysed in the context of human-robot interactions are attitudes towards robots. The concept of attitude is one of the most important concepts in social sciences (Grzegorczyk, 2017, pp. 34-44). Attitude is defined as *an individual predisposition to evaluate an object or a certain aspect of the world in a favourable or unfavourable way* (Robinette et al., 2017, pp. 129-155), which translates as liking or disliking products, services, people, thoughts, behaviour and other attitude items. Some authors add that it may be *durable* (Solomon, 2006, p. 242) or *relatively durable* (Wojciszke, 2011, p. 200). Such a definition emphasizes the importance of the affective (emotional-evaluative) aspect of attitude. It is also a factor constituting attitude, which may (but does not have to) also include other components: cognitive and behavioural. The behavioural aspect comes down to how we would like to behave towards the object of the attitude. However, the cognitive aspect of attitude concerns what we know and think about a given subject. Opinions should be treated as activation of attitudes consisting of evaluative and cognitive aspects. This means that the respondents' knowledge about robotics may significantly influence the constitutive, emotional-evaluative aspect of their attitudes (Robert et al., 2020, pp. 107-212). Therefore, the attitude towards robots is most often defined as a relatively persistent tendency to evaluate them positively or negatively. It can manifest itself through emotions, evaluations, automatic and controlled reactions. Attitude allows to predict behaviour towards robots, willingness to cooperate with them, subjective or objective treatment, e.g. readiness to expose them to the risk of destruction (Różańska-Walczuk et al., 2016, pp. 15-24).

Research by A. Wasielewska and P. Łupkowski (2021, pp. 167-169) shows that there are many factors which influence human-robot interactions, in particular people's attitudes towards robots. These include: sex, education, age, culture, nationality, experiences related to robots, as well as the type of robots, the context in which they appear, the perceived usefulness and ease of use of robots, and finally the belief in uniqueness of human nature and the willingness to attribute positive human traits to robots. Beliefs about robots based on fictional characters from science fiction works and the image of robots created in the mass media also appear to be important (Bruckenberger et al., 2013, pp. 301-310), as well as the degree of similarity of robots to humans or broadly understood appearance of robots (Nomura et al., 2006, pp. 437-454) (Table 1).

Table 1. *Demographic variables and attitudes towards robots*

Demographic variables	Attitudes towards robots
Sex	Research conducted in various cultural circles (in Japan, Portugal, Poland) on representative samples of people of different ages confirmed statistically significant differences in attitudes towards robots resulting from sex. Men have more positive or less negative attitudes towards interacting with robots than women. The main reason is that men and women associate robots with different contexts of use (and, consequently, imagine different contexts of interaction with them). Men tend to imagine interactions with industrial robots in work contexts, and women tend to imagine interactions with robots in home contexts. Moreover, women have a stronger belief in the uniqueness of human nature and anthropomorphize robots to a lesser extent than men.
Age	Research has confirmed that age is a variable that significantly influences attitudes towards robots. People under 25 years of age have ambiguous ideas about robots and their use. People in the 26-50 age group expect that robots will cover functions other than communication (e.g. household chores, dangerous tasks). This age group reported the strongest fear of interactions with robots. Respondents in the 51+ age group expect robots to perform more communication tasks (i.e. public service, home care, social services) and are more concerned than other age groups about the physical and ecological damage that robots may cause.
Nationality and culture	Cross-cultural research on people's attitudes toward robots found that Japanese people had more negative attitudes toward interacting with robots than Americans. Mexicans had more negative attitudes towards interacting with robots than Germans. No differences were observed in attitudes towards interacting with robots among Germans, Dutch, Chinese and Japanese. Moreover, Germans, Mexicans and Japanese had more negative attitudes towards the social influence of robots than did the Chinese, Dutch and Americans. Germans and Mexicans, however, had more negative attitudes toward emotions in interactions with robots than the Japanese. And the Japanese themselves had more negative attitudes towards emotions in interactions with robots than Americans. Such results contradict popular opinion suggesting that Japanese people love robots more than other nationalities. It appears that they are concerned about the impact that robots may have on society. Americans have the most positive attitudes towards robots, which may be explained by their familiarity with technology.
Education	Higher education is associated with greater acceptance of technological solutions and greater openness to interactions with robots.

Source: own study based on: (Wasielewska, Łupkowski, 2021), (Piçarra et al., 2016), (Różańska-Walczuk et al., 2016).

The study by J. C. Giger et al. (2017, p. 509) allow the conclusion that an important element influencing attitudes towards robots is the belief in the uniqueness of human nature, as well as religiousness. A strong belief in the uniqueness of human nature is associated with negative emotions towards robots and, consequently, with more negative attitudes towards interactions with them. The same study also found that higher levels of religiousness are associated with more negative attitudes towards interacting with robots. Similar conclusions were formulated by M. Różańska-Walczuk et al. (2016, pp. 15-24). As a result of their research, the belief in the uniqueness of human nature appeared to be a significant predictor of attitudes towards robots with human characteristics and attitudes towards interactions with robots. The weaker the belief in the uniqueness of human nature, the more positive the attitude towards robots. Moreover, an interesting predictor of attitude towards robots was the willingness to attribute positive human characteristics, such as nice, pleasant, agile, strong to them. The presented regularities apply to both adults and adolescents. In a study conducted on students of the last grades of primary schools, attitudes towards interactions with robots correlated with the belief in the uniqueness of human nature – these were positive relationships of moderate or low strength (Wasielewska and Łupkowski, 2021, p. 174). The variable which influences people's attitudes towards robots is the experience gained from contacts with them. This concerns both real and virtual contact, through various types of media and with fictional robot characters. Research results confirm that people who have ever seen a real robot in action or in the media had more positive attitudes towards interacting with them (Nomura, 2014, pp. 460-464; Łupkowski, Jasiński-Mały, 2020; Riek, Adams, Robinson, 2011).

Attitudes towards robots are also influenced by the extent to which a human is the creator of the robot. V. Groom and her team designed a study in which participants built a robot from the Lego Mindstorms NXT set and then controlled it on a designated board while playing a simple game. The groups were divided according to the type of a robot being built (car robot or humanoid robot) and according to the information they received after assembling the robot. Some of the subjects were told that they would operate a robot built by themselves, and others that it would be a robot with the same appearance as theirs but built by someone else. The main goal of the study was to measure the extent to which subjects extend their *self-concept* to the robot (they feel that the robot is a kind of representation of themselves) which they control. The researchers observed a greater expansion of a self-concept on the robot which the subjects assembled themselves. Participants preferred its *personality* and were more attached to it than to a robot they believed was assembled by someone else (Groom et al., 2009, pp. 31-36; Wasielewska and Łupkowki, 2021, p. 175).

Attitudes towards robots depend largely on their appearance. This is one of the most frequently studied aspects of human-robot interaction. It is usually mentioned in the context of the so-called uncanny valley hypothesis which was proposed already in the 1970s by the Japanese roboticist M. Mori (Mori et al., 2012, pp. 98-100). According to this concept, the observation of humanoid robots which are difficult to distinguish from humans causes a negative emotional reaction (Kwon et al., 2016, pp. 463-464). It is about a situation of high, but still imperfect resemblance to a human being. We can imagine models ordered by increasing similarity to a human on the X axis and the level of perceived comfort on the Y axis. As similarity to a human increases, we observe increasing comfort until a limit point is hit where the comfort level drops sharply. For example, we like a doll-shaped robot toy better than a mechanical arm that turns screws in a factory. However, after crossing a certain limit of realism, the robot's strong resemblance to a real human begins to give rise to a rather unpleasant feeling of concern. The determinants of the uncanny valley effect have not been fully explored, and what follows, there are voices questioning its validity (Kätsyri et al., 2017, pp. 149-161). M. Mori himself attributed this condition, among other things, to the fact that humans associate movement with life, therefore if something resembles a person (or part of it), but theoretically has no right to move (like shop mannequins), it is associated with something dead. However, the sight of something that is *dead* but moving, subconsciously brings to mind the association with a corpse that suddenly came alive and started to walk (Sestino and D'Angelo, 2023; Gibbs et al., 2022). The reasons for the uncanny valley are sought in the religious concept of a man, the sense of their own mortality, the conflict between what is human and non-human, in the fear of potential failure to recognize what is truly human and what only pretends to be human.

In the light of the concept of the uncanny valley, it seems that in the face of the imperfections of technology it would be safer to produce robots that are not humanoid. However, we are observing clear trends towards designing robots which look similar to humans. Although research (Waytz et al., 2014, pp. 113-117) did not confirm a universal preference for hominid robots, it was proven that their subtle anthropomorphisation, e.g. by giving them a name, determining their sex, or providing vocal communication, influences a higher level of trust of robot users (Waytz et al., 2014). More anthropomorphic robots are perceived as more likeable, friendly and intelligent than functional robots. Humanoid robots are also considered more useful and better understood by people. This is manifested, for example, in the fact that people are more likely to perceive them as having their own identity and are more inclined to notice the desires and intentions of such robots (Kätsyri, et al., 2015, p. 390).

From the viewpoint of management theory and practice, an extremely important element is the readiness of people to cooperate with robots while performing professional tasks (Goetz et al., 2003). Thanks to this solution, it is possible to combine the strengths of the machine, such as reliability, endurance and repetition accuracy, with the strengths of humans, such as dexterity, flexibility and the ability to make decisions. In the case of close cooperation between a human and a robot, the workspaces of the human and the robot overlap both spatially and temporally (Cohen et al., 2019, pp. 4037-4054). These robots can work side by side with humans on physically strenuous or monotonous tasks (Vido et al., 2020, pp. 1-21). Typical areas of application are *pick and place* tasks, object handling between different production stages and *follow the line* applications, where the robot must precisely follow a designated movement path (e.g. for contour tracing or gluing work) (Kulik , 2015, pp. 102-103).

Research provides evidence that people are generally willing to cooperate, for example they are willing to give up some of their own particular interests if it contributes to achieving the collective interest (Wang et al., 2018, pp. 315-327). In the context of the subject of this article, an important question arises: does this readiness also apply to cooperation with robots? The answer to this question is very difficult. Robots perform their tasks in various social systems, and the analysis of human-robot interactions in terms of the number of human and robot participants in a given team and the nature of the relationship between them (e.g. direction of information flow, autonomy) is the basis of the H. A. and Yanco and J. L. Drury taxonomy (2004, pp. 2841-2846) covering eleven aspects of human-robot interaction, which clearly indicates the level of complexity of this interaction (Table 2).

Table 2. *H. A. Yanco and J. L. Drury taxonomy of determinants of human-robot interaction*

Determinants of the human-robot interaction	Characteristics
Task type	The task which the robot is to perform gives a specific character to the interaction with a human, who may be a beneficiary of the robot's work (e.g. caring for the elderly) or a co-performer of the task (e.g. in the production process).
Critical nature of the task	The criticality of a task is measured by analysing the potential negative consequences that a human may experience, for example, the failure of a robotic wheelchair may result in the loss of health or even life.
Robot appearance	People react to robots differently depending on their appearance. There are three possibilities here: anthropomorphic (human-like robot), zoomorphic (animal-like one), and functional (having an appearance that is neither human nor animal, machine-like robot).
Proportions between the number of people and the number of robots in the team	Human-robot interactions are influenced by whether humans or robots predominate in the team.
Composition of the robot team	Human-robot interactions are influenced by whether the robots are of the same type or different.
The level of coordination in the team	How many robot controllers are there? How are commands issued? What is the flow of messages between people and between people and robots? How are conflicts resolved when different commands go to the same or different robots?
The role of a human in the interaction with a robot	There are five roles which a human can play interacting with a robot: supervisor, operator, teammate, mechanic/programmer, and observer. The supervisory role is taken over by a human when it is needed to monitor the robot's behaviour, but there is no need to control it directly. For example, a supervisor of an unmanned vehicle can tell the robot where it should arrive, and then the robot plans and performs its task. An operator needs to have more interaction with the robot because they need to control it, e.g. by changing its behaviour. A teammate works with a robot to complete a task. An example would be a production robot that did part of the work while a human worked in another part of the assembly. A mechanic or programmer must physically change the robot's hardware or software. An outsider does not control the robot, but must have some idea of what the robot is doing in order to share the same space. For example, a person who enters a room with a vacuum cleaner robot must be able to get around the robot safely.
A type of physical proximity between a human and a robot	Depending on the task characteristics, humans and robots need to interact at different interpersonal distances, such as avoiding, passing, following, approaching, and touching.
Decision support for operators	In this criterion, the essence is the types, quality and diversity of robot performance measures which can be used by humans.
Spacetime	The space-time taxonomy is divided into four categories depending on whether humans and robots use computer systems at the same time (synchronous) or at different times (asynchronous) and while being in the same or different location.
Level of autonomy/number of interventions	The criterion here is the number of human interventions necessary for the robot to work: from continuous intervention to full autonomy. Autonomy level measures the percentage of time needed for a robot to perform a task "on its own"; and the number of interventions is indicated by the percentage of time during which a human operator must be involved. These two measures add up to 100%.

Source*:* own study based on: (Yanco, Drury, 2004).

In the case of cooperation between humans and robots in manufacturing and production processes, interactions are most often analysed with respect to four fluency perspectives: human emotions-oriented, human contribution-oriented, robot-oriented and team-oriented (Paliga, 2022, p. 104191). The human-oriented fluency perspective of HRI is based on the assumption that people interact with robots as they would with other humans, not with tools. It reflects the cognitive and affective states of the human operator experienced while working with the robot. As such, it refers to a person's emotional state and is therefore referred to as a human emotions-oriented perspective. In particular, this perspective describes the level of confidence in the robot and the feeling that the robot commits to the team's success (Paliga and Pollak, 2021, p. 102698). According to M. Bergman et al. (2019), trust is the most important success factor in human-robot teamwork. The reliability and predictability of the robot can influence the level of trust. It is worth noting that confidence in a robot is only a human factor in this interaction, and the emotional states of robot operators may influence robot operation (Bauer et al., 2008, pp. 47-66). Therefore, a human-oriented perspective should also reflect the operator's contribution to the fluency of human-robot interactions. Collaboration between a human and a robot can be implemented through the individual actions of each collaborator, including the human and the robot, and the operator's contribution supports the robotic system. Therefore, the description of the human-oriented perspective in HRI fluency by M. Paliga and A. Pollak (2021) is expanded to include human performance of joint tasks with a robot, involvement and contribution to human-robot interaction. This fluency perspective is referred to as human contribution-oriented. Research (Paliga, 2022, p. 104191) confirmed the significant impact of each perspective on the work efficiency of the team consisting of a robot and its operator.

Human-robot communication process

One of the key challenges in human-robot interaction is effective communication (Murphy and Peschel, 2012, pp. 53-62; Cominelli et al., 2021, p. 9687). As we know, interpersonal communication is based, on the one hand, on verbal communication, i.e. on conducting conversations, but in many situations, it takes place using other means of expression. These are primarily gestures, changes in body position, static facial expressions and dynamic changes of facial expressions (Bonarini, 2020, pp. 279-285). The way a human communicates with a robot depends on the type of signal used to transmit information (electrical, mechanical, sound, optical). It is also necessary to determine the method of producing this signal (generator) and its reception. A human being uses own senses to communicate. In interactions with other people or animals, a person naturally uses vocal communication (sound signals), which requires the sense of hearing. It should be remembered that natural language is not always used for voice communication. What is often used are other sound signals whose meaning is understood by both parties to the dialogue. Such a set of sound signals is created, for example, by an owner and their dog.

In the case of robots, work on attempts to generate emotions expressed by changing *facial expressions* is very advanced (Islam et al., 2019, pp. 1581-1618). Most often, sets of artificial markers are used for this purpose, with the help of which, by changing their geometry, synthetic images with symbolic meaning are generated. Therefore, the quality of the message is somewhat limited and may cause consternation, fear or signs of disappointment (e.g. in the case of a robot communicating with small children). In such a situation, the problem of robot-human communication becomes particularly important. For the elderly and sick, as well as children isolated due to an illness, and also for autistic children, a properly constructed robot can effectively change the conditions of their functioning and help break down existing barriers to communication with the surrounding. In this situation, interpersonal communication patterns may be a good starting point for work on improving human-robot communication.

Psychologists believe that most interactions in interpersonal communication are carried out non-verbally (Leathers, 2009). For this reason, robot designers try to implement both verbal and non-verbal communication mechanisms into humanoid robots. Such robots are equipped with the ability to interact with each other and implement social behaviours. Moreover, they should have mechanisms for understanding human behaviour and some kind of empathy that allow them to express their behaviour in an appropriate way. Currently, there is great interest in the so-called personal robots. Such robots can be used in everyday life to perform heavy work or to help elderly and disabled people. Both applications require robots capable of communicating with people in a natural way, without limiting only to verbal and written communication, for example instructional communication (Hambuchen et al., 2021, pp. 265-272). It should be emphasized that additional aspects such as gestures, facial expressions and movement also play a very important role here. In terms of construction, meeting these expectations is difficult because it is not easy to make a lightweight structure, for example a life-size eye mechanism with cameras inside the eyeballs with comparable movement capabilities and appropriate dynamics as in humans (Zhang et al., 2021, p. 13319 – 13327). Integrating both special artificial sensory systems and facial expression creation components is a very complex problem (Vasconez et al., 2019, pp. 35-48).

Another important feature of the human-robot communication process is the correct interpretation of human emotional states. It is necessary to identify movements of the trunk, neck, eyes and especially the face (Luo, Amighetti, Zhang, 2019). Correct recognition and interpretation of such movements using sensory systems is an important research and design problem. In addition to the design of the robot's mechanical systems, which should ensure clear human-robot and robot-human communication and an appropriate sensory system for collecting information about the environment, the robot needs an efficient and effective control system that ensures dynamics adequate to the conditions of the task being performed (Randell et al., 2014, p. 52; Levine et al., 2018, pp. 421-436). Work in this area is very advanced (Raj and Kos, 2022). Due to the fact that emotions are integral components of human interactions, significant efforts have been made to develop emotionally responsive robots. An example is a robot called Ameca, which is able to imitate human facial expressions in a very realistic way. Ameca can smile, frown, blink, and open and close its mouth. It may also show surprise, frustration or amusement (Boque, 2022, pp. 667-671). It should be clearly emphasized here that there is still an asymmetry between the ability of robots to generate spoken language and expressive behaviour compared to their ability to capture the situational context, follow and participate in natural dialogue or read people's intentions (Lee et al., 2020, pp. 612-616). Their capabilities in this area are in contrast to the trajectory of human development in which social understanding usually precedes speech. A social robot can talk like an adult and yet have less situational understanding than a two-year-old. This imbalance, which can be confusing for users, will decrease as the robot's social sensitivity to context improves. Meanwhile, verbal human-robot interactions are most effective in limited conditions, with clearly defined interaction goals. Reducing the production capacity of social robots to better match their cognitive advancement may also be an effective strategy. For example, animaloid robots can serve in therapeutic roles, while most are non-verbal and have limited situational awareness. An animal-like appearance may also generate significantly lower user expectations compared to humanoid robots (Prescot and Robillard, 2021, pp. 1-5).

People can spontaneously form social-emotional bonds with robots, even those that are not specifically designed to induce social behaviour (Hoffman, 2019, pp. 209-218). This is proved by the cases of emotional attachment among owners of house-cleaning robots and soldiers who cooperate with robots to dispose of bombs (Carperter, 2015). An extremely significant event was the ceremony that took place in 2015 in a Buddhist temple in Japan. It was a ceremony of dismantling a robot dog, analogous to those which priests in Japan organize for deceased pets (Prescot and Robillard, 2021, p. 4). These are just examples illustrating the potential complexity of the human-robot relationship and the ethical dilemmas that arise in this context.

Ethical aspects of the human-robot relationship

It is reasonable to ask whether there is a need to address ethical issues arising from the interaction of robots with humans? Does dealing with these problems automatically mean the emergence of a partially autonomous subdiscipline of ethical considerations, which is roboethics? In other words, do we need roboethics today? In the authors' opinion, the answer to this question is: yes. This is mainly due to the complexity and diversity of human-robot interactions. The main areas of interest of roboethics representatives include:

- ethical systems built into robots;
- ethical systems used by robots;
- ethical systems used by engineers when constructing robots;
- ethical systems used by robot users;
- ethical systems used by robot manufacturers;
- the ways in which people treat robots (Coeckelbergh, 2022).

Human-robot cooperation is visible not only in the areas of production, cleaning and entertainment. Human-robot interaction also occurs with particularly vulnerable populations (Bryant et al., 2020, pp. 13-21). For example, robots have been used for therapeutic and/or diagnostic purposes for many years. Extensive scientific literature illustrates the use of robots in the treatment of children exhibiting autism spectrum behaviours (Feil-Seifer and Mataric, 2011, pp. 24-31). Robots are effectively used to reduce social isolation and loneliness in people who are hospitalized or in care facilities (Gulrez et al., 2016, pp. 1-2). The positive impact of robots in the process of therapy of people with mental disorders, especially in the field of emotional support, has also been confirmed (Kabacińska and Prescott, 2021, pp. 919-935; Robinson et al., 2013, pp. 661-667). The effectiveness of robots as social companions is visible also in the process of health and social rehabilitation of people with dementia (Perugia et al., 2020, pp. 926-943). Social robots can be used to support social behaviour, both between the user and the robot, and by acting as a catalyst for human-human interaction. This function was confirmed by the research results of A. K. Ostrowski et al., (2019, pp. 59-70). They proved that robots can act as companions to older people, but also as robots initiating conversations between nursing home residents and drawing them into the community space. Moreover, they can improve the quality of life of older people by positive influence on their activity and regularity of taking medications and also by minimizing anxiety and stress and reducing the feeling of loneliness (Pu et al., 2019, pp. e37-e51). Robotic assistance with everyday activities, such as bathing for example, may also be important.

The described aspects of the human-robot interaction raise a number of ethical threats. First of all, attention is drawn to the high risk of emotional involvement of people who begin to have the same feelings for the robot as for the other people, including those closest to them. We must not lose sight of the fact that robots are designed as machines, and therefore it is at least risky, if not completely wrong, to encourage people to treat them in the same way as social entities (Gu et al., 2019). Only other living beings (mainly humans and some animals) are able to establish authentic emotional relationships with humans. This is why there are increasingly frequent accusations against manufacturers of social robots of *false advertising* overtly causing social and emotional reactions in people (Sharkey and Sharkey, 2021, pp. 309-316). There are arguments that creating social bonds with robots may pose a threat of establishing a moral obligation towards them, which is contrary to the interests of human well-being. The robot's emotions are, in fact, a kind of *counterfeit* of real emotional bonds (van Wynsberghe and Comes, 2020, pp. 43-53). Meanwhile, people who, due to their physical and/or mental condition, engage in a relationship with a robot, for example children or people with mental disorders, may experience strong negative effects of such a situation, e.g. a feeling of being deeply hurt or being deceived. Therefore, feeding false expectations regarding the emotional context of interaction with a robot among representatives of sensitive groups should be considered definitely unethical. From this perspective, the most pressing ethical questions concern the balance of benefits and harms that may result from allowing robots, which humans are ready to recognize as social, into our lives (Clarke, 2014, pp. 286-305). The list of potential threats and harms continues and particularly concerns human dignity, the possibility of reducing or losing contact with other people as a result of replacing this contact with interactions with a robot, and the broader emotional social robot effects (van Wynsberghe, 2015). Particular emphasis is placed on the fact that interactions with robots are basically easier and do not require empathy and commitment, so there is a risk that they will gradually replace real, complex interpersonal relationships (Bryson, 2010, pp. 196-200). The ethical dimension of the analysed interaction also concerns the involvement of robots in particularly intimate activities, such as bathing and using sanitary facilities. Even direct physical contact between robots and humans, such as when lifting a patient from a bed and into a wheelchair, creates a high likelihood of creating an emotional bond, especially in environments where human companionship is lacking. Therefore, the use of robots that physically assist people must take into account their privacy, for example by deactivating video monitors during intimate procedures.

The answer to ethical challenges is codes that are intended to eliminate the presented risks and threats. The most famous and at the same time one of the first proposals regarding robot ethics was developed by I. Asimov and went down in history as the Three Laws of Robotics. They read as follows:

- a robot may not injure a human being or, through inaction, allow a human being to come to harm,
- a robot must obey orders given it by human beings except where such orders would conflict with the First Law,
- a robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

In his later publications, Asimov expanded the list of principles and added a new, even more fundamental law, which he called *Zeroth Law*. It is to be superior to the other three. Zeroth Law states that a robot may not harm humanity or, by inaction, allow humanity to come to harm. (Moczydłowska, 2023).

There are robot ethics codes alternative to Asimov's. One of them was developed by an international team of scientists belonging to EURON (European Robotics Research Network). This code resolves ethical dilemmas on two levels: developing ethical principles for scientists constructing robots and *artificial* ethics that will be programmed into robots. The EURON code does not yet deal with the formulation of specific laws or principles, focusing on general recommendations that can then be used as the basis for more detailed regulations. The following priorities have been identified:

- manufacturers must build machines in such a way that they are always under human control; illegal use of machines cannot be allowed,
- data obtained by robots must be protected,
- an understandable system for machine identification should be developed, as well as a method for machine tracking (Sharkey, 2014, pp. 63-75).

In other words, these are norms intended to prevent possible immoral or illegal use of machines, or to respond effectively if they suddenly *get out* of human control (Li and Meng, 2022). As R. Campa vividly writes, *The robot is not afraid of arrest or punishment, it would have much fewer psychological and operational scruples than a human murderer, and therefore, it would definitely be more dangerous. As costs came down, more and more criminals would start entrusting the execution of their criminal plans to machines. This is why it would be necessary to inventory and catalogue all robots in circulation and at the same time shift protection and liability for their actions onto their owners, as well as establish sanctions in the event of selling or purchasing a robot not registered in the database* (Campa, 2011, p. 89).

Notwithstanding the principle of harmlessness, robotics research should be conducted in accordance with the highest standards of ethics and professionalism and ensure compliance with an additional three principles: 1) bring benefits – robots should serve the best interests of humans 2) autonomy – the ability to make a conscious, unforced decision about the rules of interaction with robots 3) equity – the fair distribution of benefits associated with robotics, and in particular, the affordability of home care and health care robots.

Conclusions

The results of the study indicate that the main factors which determine people's attitudes towards robots are apart from demographic variables and experiences gained by people from contacts with robots, the perceived usefulness of using robots, the image of robots created in the mass media and religiousness. The key challenges in human-robot interaction apart from effective communication is the reflection of emotions. Since mood and emotions are integral elements of human interactions, many efforts have been made to develop emotionally responsive robots. The increasing use of robots in the economy and in individual applications, e.g. by sick and elderly people, requires resolving ethical and legal dilemmas. Due to the spread of artificial intelligence and the operation of robots equipped with it, there is a need to develop legal standards or amend legal regulations to take into account the emergence of this technology. The most important legal challenges regarding robotics are related to civil and criminal liability. There are questions that researchers should seek answers to: how to resolve the issue of liability of technologically advanced autonomous devices, whether the traditional understanding of civil liability is sufficient in relation to self-learning machines that can make independent decisions, whether it is justified to create a new legal category – the electronic legal person? In the near future, a particularly important direction of research, according to the authors, will be roboethics as an autonomous subdiscipline of ethical considerations. The debate in this area is just beginning. In particular, future research should focus on clarifying ethical codes in the field of robotics, which would eliminate risks and threats resulting from the use of robots.

Human resource management shall be considered as an important area of robot application. Although human resource management is considered not to be very susceptible to the implementation of innovative changes, examples from many countries around the world indicate that the implementation of new technologies using robots in HR departments is becoming more frequent. The application of automation and robotisation in HR processes brings tangible benefits to companies. They include reducing the duration of particular procedures, reducing the risk of errors, improving the quality and increasing the efficiency of HR processes, which translates into the efficiency of the entire organisation. Robotisation can be used in the following areas of HR: multiposting, searching for job candidates, communicating with candidates, selecting candidates and conducting and analysing statistics in HR departments. The use of robots in HR processes brings many challenges, both technological and organisational, for HR managers. There are psychological and ethical dilemmas – concerns about the role of humans in a world dominated by modern technology. However, the implementation of modern, high-tech tools in HR should be seen as support, not competition.

Limitations and implications for further research

This study is not free of limitations. The research intention of the authors was to provide a basis for the formulation of hypotheses for such research. As a result the paper is systematic and theoretical in nature and does not include empirical research. Identifying the specifics of HRI work requires in-depth social research, including research based on the methodology of a social experiment, taking into account the influence of diverse variables, including specific psychological and cultural variables, as well as the level of competence sophistication of employees working in teams whose members are robots. Further studies are needed to narrow the indicated research gap. One of the potential directions of future studies should be the regulations in the area of robots, also in the context of responsibility of creators and users.

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