Article

Sustainable adaptation of new technology — the case of humanoids used for the care of older adults

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Abstract: The processes of an ageing population are becoming a challenge in the context of social, technological, and research policy. Also, according to the perspective 2080, Poland belongs to the group of counties with the prognosticated number of citizens over 65 to account for one-third of the population. Different strategies aimed at dealing with the mentioned demographic challenges include widespread use of humanoids in care for older people. As the research of such nature was the first in Poland, this article aimed to identify the factors and their interlinks that determine the attitude and the future use of humanoids by older people of the Polish society. Based on the specific attributes of humanoid technology, the model hypothesises that an attitude to technology can be directly predicted by four perceived technology attributes, namely an impact on the quality of life, technological impact, ethical and social problems, while user attitude towards humanoid technology is predicted to have an indirect influence on the future intention of use. A survey method was used to collect research data. An electronic questionnaire was used to conduct confidential interviews. Finally, 643 filled questionnaires were received. Results received via a regression analysis confirmed that the most important factor influencing human attitudes was a positive social impact achieved using humanoids in the care of lonely people and improving the safety of older people. Another important factor was a technological impact from the use of humanoids performing functions desired by respondents. The technology in question could be useful for reminding older people about taking medication, informing family members about the health condition of their older people and calling for help on their behalf.

Keywords: humanoids, robots, ageing population, elderly, attitude, future intention

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1. Introduction

Globally, a systematic decrease in numbers of retired active working-age people has been observed for more than twenty years. On 1 January 2017, the world population amounted to 7.55 billion [1], and that of the EU was 511.8 million [2]. Young people (0–14 years of age) constituted 25.92% of the world population and amounted to 15.6% in Europe. Persons considered to be of working age (15–64) accounted for 65.38% of the world population, and 65.00% of the EU population. On the other hand, the share of older adults (aged 65 and more) reached 8.70% globally and 19.40% in the EU (an increase of 0.3% compared to the previous year and an increase of 2.5% compared to 10 years ago). The highest share of people aged 65 or over in the total population was observed in Japan and amounted to 33.37%. In contrast, in the EU, the highest share of people over 65 in the total population was in Italy (22.0%), Greece (21.3%) and Germany (21.1%), while Ireland had the lowest share (13.2%). In turn, in Poland, young people accounted for 15.1% of the population, and people aged 15–64 accounted for 68.3% of the population. In Poland, the share of people over 65 was 16.5% in 2017, which is 0.5% more than in 2016.

The increase in the number of the post-productive age people and the declining number of the pre-working age people confirms the ageing society. The ageing population is a global phenomenon in its nature and seems to be one of the most important challenges facing the world, including the European Union and Poland [3]. The main reasons for this phenomenon include, above all, a steady increase in the life expectancy with the simultaneously low rate of the natural increase in most European countries. In addition to the factors above, the phenomenon of an ageing population is also affected by such aspects as a high level of wealth, a level of social protection, the proposed family model or the education of the population. This process is universal, unavoidable and irreversible from the perspective of at least three or four generations. It is estimated that in 2030, there will be as many as three people of retirement age for every four people of working age. According to the population forecast prepared by the United Nations until 2050, people aged over 65 will represent 15.82% of the population in the world and 27.85% in Europe (Table 1). The highest rate is expected in Japan, namely, 36.37%. By 2080, the population aged over 65 will account for 20.05% globally, and 28.68% in Europe. In the case of Poland, it is forecasted that in 2050, people aged over 65 will make up 31.64% of the population, and this number will grow by 3.61% in 2080 (35.25%).

Table 1. Population by age group (percent) (Source: [1])

	2030			2050			2080		
	0-14	**15-64**	**65+**	**0-14**	**15-64**	**65+**	**0-14**	**15-64**	**65+**
World	23.68	64.66	11.66	21.31	62.86	15.82	18.97	60.98	20.05
Europe	15.15	61.77	23.08	14.99	57.16	27.85	15.10	56.23	28.68
Japan	12.21	57.49	30.30	12.55	51.07	36.37	13.32	51.48	35.20
Poland	15.40	18.40	23.20	12.20	56.16	31.64	12.78	51.97	35.25

Such predictions as to the shaping of the age structure of the population carry certain challenges for both the global and the Polish economy. The effects of increasing life expectancy and ageing population generate burdens for the economy. It is important, however, to improve the well-being of the society, meet the needs of older people and use their potential and possibilities. Nevertheless, it should be remembered that the increase in the number of older adults is also associated with the need to provide them with institutional support in the form of care, especially in the case of a low level of independence [4]. The increasing life expectancy and ageing will also stimulate changes in a family model. A significant part of the elderly will live separately, often away from their family, and depend on themselves. Lonely people will need full geriatric care offered at home as well as in nursing homes [5]. Several researchers focused on exploring new methods to improve the quality of life of older individuals by allowing them to remain independent and healthy to the maximum possible extent.

One of the fields aiming to find answers to challenges of an ageing population is gerontechnology — an interdisciplinary field of scientific research that uses technology for the aspirations and opportunities of older people. Humanoids — robots equipped with artificial intelligence and resembling humans — will be one of the technologies supporting older people [6] in the future [7]. Robots have been proposed as a form of assistive device that can help bridge the widening gap between the demand and supply of healthcare services [8]. The expected growth in the share of the older population has influenced researchers to design innovative solutions in the field of care for older people including robots [9].

The use of modern technologies in everyday life depends on social, psychological, technological as well as economic factors [10, 11]. Each technology should be implemented in a sustainable way which means acceptance of the technology by society. Among the social factors, demographic (age, education, sex) and cultural (preparedness to innovations, trust in technology) characteristics will determine the social acceptance of solutions and the success of implementing new technologies.

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Considering the current examples of the use of robots in the care of the older people (in Japan, the United States, France, Germany) and the growing interest in this technology, the research focused on identifying the willingness to accept such important and desired solutions. In particular, it applies to countries, including Poland, that have a growing number of older adults and a need for solutions that will make life easier for the older people of the future.

Results of a Eurobarometer survey showed that throughout the EU, the care for older adults tops the list of areas where the use of robots should be banned. In 24 Member States, absolute majorities hold this view. Portugal (35%), Bulgaria (40%) and Malta (49%) are the only exceptions. The public opinion is most emphatic in Cyprus (85%), followed by Luxembourg (78%). Bulgaria and Poland are the only Member States with less than three-quarters feeling uncomfortable about a robot minding their parents. However, more than nine out of ten respondents had the same feeling in Luxembourg (96%), France (95%), Germany and Sweden (93% each), and Cyprus and Slovenia (92% each) [12].

The purpose of this article was to identify the factors and their interlinks determining the attitude and the future use of humanoids by older people of the Polish society. The authors built a theoretical model that includes six variables, i.e. an impact on the quality of life, a technological impact, ethical and social problems, a user attitude towards a humanoid, and the future intention of use. The model was empirically verified using survey research.

The remainder of the article consists of the following sections: Part 2 reviews the literature on the issues relating to robots used to improve the quality of life. Also, it gives examples of humanoids used for the care of older adults. The literature review distinguished two types of research on humanoids: first related to the general social acceptance and factors determining the wider use of humanoids in everyday life, and second associated with specific experiments in a specific group of people (children, older adults) concerning specific functionalities of robots. Results of the literature review served as a basis for the formulation of hypotheses and the theoretical model included in Part 3. Part 4 describes the methodology. Results are described in Part 5. Finally, Part 6 summarises the findings and Conclusions briefly explain the limitations of the research and implications for a future research.

2. Examples of robots used to improve the quality of life

The conducted literature review allowed to distinguish between two types of research areas related to the acceptance of technology such as humanoids. One is associated with specific experiments in a specific group of people (children, older adults) concerning specific functionalities of robots, and second is related to the general social acceptance and factors determining the wider use of humanoids in everyday life by society in general and older people as a specific group in particular. It is widely known that widespread use of humanoids to care for the older people will largely depend on the social acceptance of the new solution [9].

The first research area related to the functionality of robots contains a subject of research. Robots have a great potential to aid independence and improve health outcomes for older people as well as relieve the burden for care-takers. The task of the robots is to help the older people so that they can live and function independently to the fullest possible extent. Robots can be used by the older people, among other things, to lift, capture, move items, be reminded about taking medication, recognise and assess health, monitor walking, motivate to walk, and to meet social needs through interaction. Broekens *et al.* distinguished between two types of robots that facilitate the functioning of older adults [13]: robots used as workers for rehabilitation and those used as social workers. Rehabilitation robots are mostly used for physical assistive technology features. They are not intended for communication with older adults, thus, they are not treated as social entities. Examples of such robots are smart wheelchairs [14], artificial limbs [15], lifting and walking robots, robotic beds [16] active orthoses [17] and exoskeletons [18]. In turn, social robots can be divided into service workers and associated workers. Service workers are used to handling the basic tasks of independent living, such as eating and bathing; mobility and navigation; nutrition advice or monitoring. Companion workers are aimed at improving the health and mental well-being of older adults. Often, however, social robots can be programmed to simultaneously perform activities providing support in the life of an older person

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(serve as service robots) and at the same time provide company to the older person (serve as auxiliary robots). According to Kate Darling, a social robot is a materially incarnate, autonomous actor who communicates and interacts with a human on an emotional level. In addition, social robots act by the principles of social behaviour, have diverse "states of mind" and adapt to what they have learned through interaction [19]. Social robots mostly resemble people (humanoid), dolls/toys (doll robot) or animals (animaloids, zoomorphic robot). Their character is of fundamental importance because the function of social robots is to interact with people on the emotional level, and this type of interaction is based on visual and tactile perception in no less than on verbal communication [20]. Table 2 presents the most important information about selected support robots.

Table 2. Examples of robots and their functionality

The name of the robot	Basic features of the robot	Producer/ country
	ANIMALOIDS, ZOOMORPHIC ROBOT	
Aibo	looks like a dog; potentially enhances the quality of life of older people and people with disabilities by playing with them; eliminates stress in the older people [21]	Sony/Japan
Dog-Wan	looks like a dog; can carry and bring home shopping; according to the producer, the target owner is a pensioner [22]	Daisen/ Japan
iCat	looks like a cat; used primarily to improve the mood of older adults [23]	Philips Electronics
NeCoRo	looks like a cat, soft to touch; responds to movement and emotions of older people; responds to human movement and emotions; has feelings and desires, and a personality that adjusts to its owner; remembers its name and acknowledges its name when called; synthetic fur gives it a feline appearance, so it feels natural to treat it like a cat, stroking and hugging it; helps improve the communication among the older people and makes the environment calmer, easier, gentler and more comfortable [24]	Omron Corporatio n/Japan
Paro	looks like a seal; soft to touch; recognises a limited amount of speech; expresses a small set of vocal utterances; has been used at several facilities for the older people and improved their mood as well as activeness and communication with each other [25]	Intelligent System Co/Japan
Nabaztag	looks like a rabbit; can react to some predefined commands; however, there are no functions for learning or memory; communicates using audio, light messages or by moving the ears; gives messages about weather forecast [26]	Violet/Fran ce
	DOLL ROBOT	
Babyloid	A baby-type robot designed for being taken care of an older person requiring nursing care; it can cry and blush, and keep an older person less depressed with its unpredicted behaviour; designed to help ease depression among older adults by offering them companionship [24]	Chukyo U./Japan
	HUMANOID ROBOT	
PaPeRo	used for communication; recognises speech and speech synthesis, recognises faces; responds to touch; can understand several people talking to him at the same time, can also search the Internet to find answers to questions asked; is used to improve the well-being of older adults [27]	NEC/ United States
Ifbot	communication robot with the ability to respond to words and ask questions; reduces the feeling of loneliness in older adults through basic conversations [28]	Business Design Lab. Japan

Nodding Kabochan	reminds of a behaviour of a 3-year-old boy; provides relaxation to older people through communication; can speak, sing; can name the owner in eight different ways, including "Grandma" and "Grandfather"; can improve cognitive skills and promote positive mental and physical health of the older population [29]	PIP Co., Ltd/ Japan
Pearl	a robot that helps older people go about their daily routines; reminds older people about their daily activities such as eating, drinking, taking medicine or using the bathroom and helps older people navigate their environments [30]	CMU United States
Olivia	personal assistant and companion for older adults; it can imitate human movements and has speech capabilities to help it with intuitive learning and human interaction [31]	ASORO/ Singapore
Twendy-One	can carry out limited conversations and uses the built-in camera to locate the indicated objects; can say hello, bring breakfast on a tray, wish one a tasty meal; can help to get out of bed and give a dress or a cane [32]	Waseda U./Japan
Wakamaru	can also "take care" of sick people; can remind you about unrealised tasks (e.g. taking medicines); can check and inform about the current weather forecast; keeps eye contact with the interlocutor, greets and says goodbye to the owner; keeps in contact with a person from the parish [22]	Mitsubishi/ United States
ASIMO	will take over some of the home duties of older adults; recognises the moving people and their faces; it can also follow their movement; comes when called and can recognise dozens of phrases; can also recognise voices and respond to specific instructions; ensuring greater independence of an older adult [22]	Honda/ Japan
Pepper	can recognise older people and is able to have a conversation with them; can react to emotions, moves and lives autonomously; can react to moods, using intuitive interfaces like voice, touch and emotions; is used to provide company to older people but also to motivate them to walk; provides assistance while walking [9]	Aldebaran Robotics/ France
Kaspar Robots	using a humanoid robot to improve social skills of children with an autism spectrum disorder [33]	UK

Research on robots concerns both the anthropomorphic features of robots and the expression of realistic behaviour by robots as well. Lazzeri *et al.* concentrated on research of facial expressions performed by robot Eva, because facial expressions, in particular, convey emotional information that allows people to get involved in social interactions [34].

The second research area is connected with a level of social acceptance and awareness of robot functionality in daily life. All technology should be implemented sustainably. It is important to initially understand the motivations of older individuals to accept or reject a new technology [9]. Therefore, an increased understanding of factors predicting perceptions of technology attributes can potentially facilitate the widespread implementation of technology [35].

Authors Baganzi and Lau stated that factors affecting its sustainable adoption remain largely unknown. According to Baganzi and Lau, sustainable adoption of particular technology also means the need for research that explains trust and risk perceptions towards the adoption of new technology by society [36]. Sustainable adaptation of technology means that technology can improve social and economic development, as it provides access to applications that address social challenges faced by vulnerable people and enables innovations [37]. According to a report of GSMA, an adaptation of new technology should build societies that are environmentally sustainable [38]. One of the conditions for the sustainable implementation of technology is to identify factors that determine this process [39].

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The research conducted by Syrdal *et al.* aimed to identify cross-cultural attitudes towards humanoid robots in Japan and Western countries [40]. The authors tried to answer the question: How would people of Japan and Western countries react to the possible use of and daily encounter with humanoid robots. The researchers used the Frankenstein Syndrome Questionnaire containing variables reflecting negative and positive attitudes of potential users, principle objections, trust in humanoids and interpersonal fears.
Positive attitudes were connected to certain facts perceived by potential users, such as the ability of humanoids to make people's lives easier, perform dangerous tasks, be very useful in teaching or for caring of the older adults or people with disabilities. Negative attitudes were reflected by statements maintaining that widespread use of humanoid robots would take away jobs from people, they would be expensive to maintain, and could be frightening. Principle objections were connected with feelings that in the future, society will be dominated by humanoid robots and a perceived threat that the development of humanoid robots is blasphemy against nature. The construct trust reflects the facts, that people and organisations that develop humanoid robots can be trusted and seem sincere. Interpersonal fears reflect concerns that humanoid robots would encourage less interaction between humans; therefore, interaction with humanoid robots could sometimes lead to problems in relationships between people [40].

Broadbent *et at.* stated that properly assessing the needs of human users and then matching the robot's role, appearance and behaviour to these needs is a key condition which will help to increase acceptance of healthcare robots [8]. Authors distinguished between two groups of factors determining the successful development and implementation of healthcare robotics. The first group connected with individual features of users includes: age, needs, gender, cognitive ability, education level, experience, and culture. The second, referring to robot features, includes appearance (humanness, facial characteristics), size, gender, ergonomics, role and "personality" [8]. Research results in the field of social psychology allowed the classification of factors into three groups: organisational, technological and individual. The authors also pointed out that an important area of research should be the expectations of potential users with respect to robots. The fulfilment of user expectations will determine the future quality of interaction between humans and robots [8].

A literature review by Deligianis *et al.* indicated that the ability to generate and maintain trust is of paramount importance in human–robot interaction [41]. Three groups of factors influence the trust formation: a human, a robot, and an environment [42]. The literature review allowed distinguishing the following factors that affect human–robot interactions: (i) human-specific features which include national or cultural identity, age, expertise and attentional load (ii) environmental factors relate to the situation or task at hand and include task load (iii) robot-specific features, such as task type, proximity to a robot, and robotic "attributes", such as the robot's appearance. Robot reliability and predictability seem to be the main performance factors that influence trust formation in human–robot interactions [41].

Research conducted by Heerink *et al.* aimed at finding factors influencing the future intention of use of assistive social robots [43]. Apart from variables related to the functional evaluation, such as perceived usefulness and perceived ease of use, authors also considered variables that relate to social interaction. Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) authors explained the relationships between an attitude and an intention to use a robot, and they proved that the future intention is predicted by an attitude.

Torta *et al.* proved that people perceive robots more as companions and social actors rather than tools and this is likely to steer user acceptance in a positive direction [44].

Literature studies confirmed the existing interest in research aimed at attitudes and factors determining these attitudes in the context of the use of humanoids in the care of older adults. The future use of humanoids in the care of older adults will depend on the attitudes of users, which can be shaped much earlier.

Identified theoretical as well as practical problems, pose the following research questions: What attitudes characterise the Polish society in the context of using humanoids for the care of older

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adults?; Do attitudes determine the future intentions of users and what factors shape attitudes towards humanoids in the Polish society?

3. Research model and hypotheses

The current and future development of technology depends on two basic factors: the development of technology determined by the level of technological knowledge and the adaptation of the technology by society. Authors of the book *Technolife 2035. How Will Technology Change our Future* capture the process of adaptation of new technology through the prism of the Diffusion in Innovation Theory [45]. According to the theory, a person first becomes aware of a new technology (awareness), which is the basis of interest in this field (interest), and seeking additional information about the technologies necessary for its assessment. The following technology assessment process, based on available data obtained at the stage of interest, precedes the stage of attempts to apply a given technology and ultimately leads to its adaptation.

Many theoretical models have been developed to explain the processes related to the acceptance of the technology. The most popular is the Technology Acceptance Model (TAM), developed in 1985 by Davis as the result of his doctoral dissertation prepared at the MIT Sloan School of Management [46, 47]. The model developed by Davis used the assumptions of the Theory of Reasoned Action (TRA) developed by Ajzen and Fishbein [48]. According to TRA, the extent of the use of a given technological solution depends on intentions, which in turn depend on attitudes of users and subjective norms. Ultimately, Davis and Venkatesh in their technology acceptance model indicated that two variables of the ease of use and the usefulness of a given system/technology have a significant impact on the intentions of users, not always shaping their attitudes (understood as positive or negative attitude/feeling towards something) [49]. However, considering the different level of technology awareness, a user attitude towards technology, especially in relation to technology that raises social concerns, will have a significant impact on the future intentions of technology use. The conducted literature review pointed to a multitude of factors that determine the attitude and the future intention to use a humanoid for the care of older adults. Hudson *et al.* stated that there has only been a limited amount of work done on people's attitudes towards robots, particularly robots used in the care of older adults [50].

Considering the level of the use of robots in everyday life, as well as the relatively low level of robotics in Poland, the research on the identification of factors determining the social acceptance of solutions in the use of robots by humans seems to be important. While in Japan, the United States and Germany, already very advanced experiments on the use of specific robots and their functionalities from the user's perspective are carried out, Poland still needs to research the area of building social awareness of such advanced technologies.

Because humanoids are an emerging technology with relatively few application examples, it might be difficult for users to accurately estimate the ease or difficulty of "use" and the usefulness of the technology. With the rapid introduction of new technologies, it has become more difficult to predict the final user behaviours; that is, the perceived usefulness and the ease of use may not fully explain user motives or attitudes [51]. A more holistic and integrated approach has been recently suggested, based on existing theories and empirical evidence [52]. Most technology acceptance studies focused on a limited set of factors that can influence the public acceptance and were not based on a comprehensive framework including key factors influencing the technology acceptance. Based on the original model, many authors incorporated variables for the environment and market conditions into the model and studied the effects of environmental factors, market conditions, and network externalities on consumer technology adoption behaviour [53]. Considering the above, the authors took into account two basic variables from the TAM original model: the attitude and the future intention of technology use. The model proposed by authors focused on social and psychological factors that influenced attitudes (acceptability) and intention in favour of or against technologies. Based on the specific attributes of humanoid technology, the model hypothesises that an attitude to technology would be directly predicted by four perceived technology attributes: an impact on the quality of life, a technological impact, ethical and social problems, while a user attitude

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towards humanoid technology is predicted to have an indirect influence on the future intention of use (Figure 1).

In this paper, a technology acceptance framework to understand a citizen and consumer acceptance of new energy technologies, based on psychological theories and findings from technology acceptance studies was proposed. The authors limited their model to psychological factors [54]. Considering the above, the authors formulated the following hypotheses:

H1: The impact on the quality of life has a strong and positive influence on an attitude towards the humanoid use.

H2: The technological impact has a strong and positive influence on an attitude towards the humanoid use.

H3: Perceived ethical problems have a strong and positive influence on an attitude towards the humanoid use.

H4: The social impact has a strong and positive influence on an attitude towards the humanoid use.

H5: The attitude towards the humanoid use has a strong and positive impact on the future intention of the humanoid use.

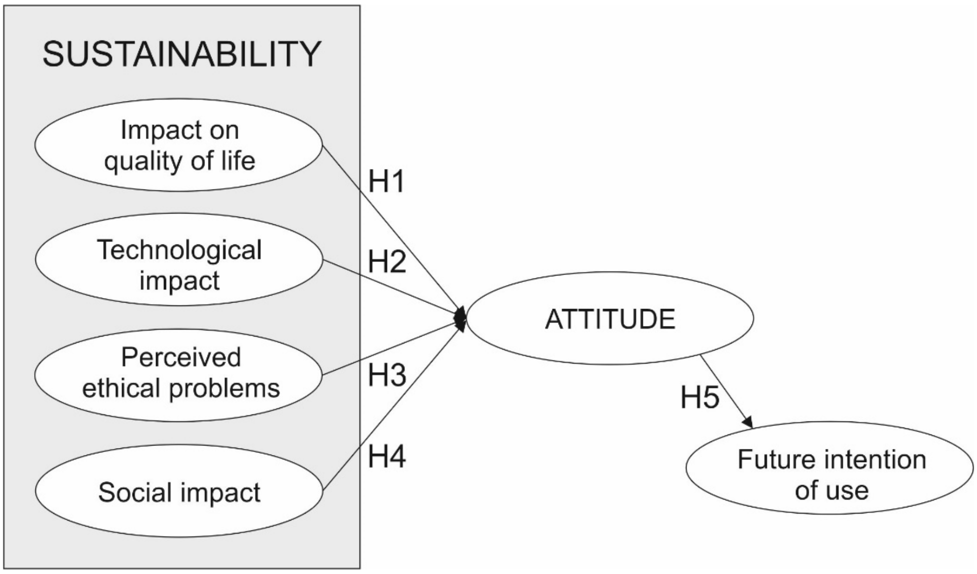

Fig. 1. Conceptual model

Also, the empirical verification concerned a hypothesis indicating the relationship between the attitude towards humanoids and the age and gender of respondents, which allowed to formulate the following additional hypotheses:

H6: The attitude towards humanoids is the same across all age groups.

H7: The attitude towards humanoids is the same across all gender groups.

In the proposed model, individual variables mean:

- the impact on the quality of life reflects the impact of the humanoid use on the quality of life, the comfort of life, the quality of the care system for the older adults;
- the technological impact reflects tasks performed by humanoids used by people;
- perceived ethical problems reflect a moral dilemma: to trust or distrust humanoids in the context of possible harm to people;
- attitudes are understood as a positive or negative feeling towards something;
- the future intention of use reflects the willingness to use technology by potential users.

3. Research methodology

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Data

The conducted research focused on humanoids used in the care of older people. A survey method was used to collect research data. An electronic questionnaire was used to conduct confidential interviews. It was distributed between April and May 2018. The electronic questionnaire survey targeted the Polish society. The number of returned questionnaires amounted to 643. Of 643 respondents, 373 (58.0%) were women and 270 (42.0%) were men. The proportion of the respondents aged 18–25 was 32,7% (210 persons), followed by 25.8% (166 persons) aged 41–60, and 24.9% (160 persons) aged 26–40 and 16.4% (107 persons) of persons over 60.

Measures

Since all constructs included in the theoretical model could not be directly observed, a series of measures were used in each case. All constructs were measured using a seven-point Likert scale to access the degree, to which a respondent agreed or disagreed with each of the items (1=totally disagree to 7=totally agree). The constructs' Cronbach's alpha coefficients were employed (ranging from 0.702 to 0.912). The author used the average score of measures of each construct for further analysis. Constructs and items are presented in Table 2.

Table 2. Descriptive statistics and composite reliability

Constructs and items	Mean	S.D.	Cronbach's α
Impact on the quality of life			
QL1: The use of humanoids in the care of older adults will significantly improve the quality of the existing care system for older people.	4.70	1.86	
QL2: The use of humanoids in the care of older adults will be a source of additional benefits for their users (24-hour attendance, 24-hour care, a sense of security), which are unavailable using other solutions.	5.08	1.88	0.912
QL3: The widespread use of humanoids in the care of older adults will bring measurable benefits to human health and the quality of human life.	4.43	1.79	
QL4: The use of humanoids in the care of older adults can significantly improve the living comfort of older people.	4.98	1.89	
Technological impact			
T1: The use of humanoids should be easy and intuitive.	6.40	1.22	
T2: Humanoids will be able to perform difficult tasks in the care of an older person (e.g. lifting people, helping with movement).	5.57	1.62	
T3: An important feature of a humanoid will be the ability to remind an older person about the time to take medication.	6.02	1.43	
T4: An important feature of a humanoid will be the ability to interact or communicate.	5.39	1.77	0.867
T5: An important feature of a humanoid will be the ability to inform the family members about the health condition of the minded older adults.	5.88	1.53	
T6: An important feature of a humanoid will be the ability to call for help on behalf of an older person.	6.26	1.36	
T7: The use of a humanoid in the care of older adults is a very innovative solution that is in demand.	4.52	1.89	
Ethical problems			
E1: Widespread use of humanoids in the care of older adults can be the cause of moral dilemmas and doubts as to whether a humanoid could be entrusted with such care.	5.26	1.81	
E2: The use of humanoids in the care of older people may endanger health or life of a user.	3.67	1.86	0.702
E3: A humanoid may inadvertently harm an older person.	4.80	1.82	
E4: A humanoid can deliberately harm an older person.	2.77	1.96	

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Social impact			
S1: Widespread use of humanoids in the care of older adults will create new jobs.	3.24	1.80	
S2: Widespread use of humanoids in the care of older adults will bring measurable social benefits.	4.49	1.82	
S3: The use of humanoids in the care of older adults will improve the safety of older people.	4.67	1.83	0.837
S4: Humanoids may pose a threat to interpersonal relationships.	3.14	1.97	
S5: The use of humanoids in the care of older adults will contribute to a more pleasant time for older people.	3.94	1.90	
S6: The use of humanoids will be of particular importance in the care of lonely people.	5.08	1.91	
Attitude			
AT1: I believe that being in the presence of a humanoid can be pleasant.	3.84	2.01	
AT2: I believe that I could learn how to use a humanoid if I needed it.	6.21	1.43	
AT3: In the presence of a humanoid, I would feel safe.	4.21	1.76	0.824
AT4: Living in an old age in the company of a humanoid could be nice and pleasant.	3.87	1.92	
Future intention of use			
FI1: Would you be willing to use the help of a humanoid in the care of a member of your family?	3.33	1.31	0.870
FI2: Would you be willing to use the help of a humanoid in your own care?	3.79	1.26	

Within the construct reflecting an impact on the quality of life, highest ratings were given by respondents to the variable regarding the use of humanoids in the care of older people as a source of additional benefits for their users, such as 24-hour attendance, 24-hour care, and a sense of security (QL2).

Within the construct of technological impact reflecting the functionality of humanoids used in the care of older adults, the most important functions indicated by respondents were connected to easy and intuitive use of the humanoid support (T1), the ability to call for help on behalf of an older person (T6), and reminding an older person to take medications (T3). Respondents gave a relatively low score to the statement that the use of humanoid technology in the care of older adults is a very innovative solution that is in demand (T7).

From the ethical point of view, respondent expressed their concerns about moral dilemmas posed by the use of humanoids in the care of older adults and doubts as to whether people could trust a humanoid (E1). Respondent did not seem to be afraid of a humanoid deliberately harming an older person (E4).

In the context of social impact, respondents believed that the use of humanoids would be particularly important in the care of lonely people (S6). Relatively high scores were given to the safety function that humanoids could provide to older people (S3). However, some concerns were expressed in humanoids posing a threat to interpersonal relationships (S4).

A positive attitude towards humanoids was indicated by expressing the ability to learn to use humanoids (AT2) and the perceived feeling of safety when accompanied by a humanoid (AT3). Respondents were cautious in their assessment of the presence of a humanoid being pleasant (AT1).

The future intention of humanoid use was measured indirectly by asking questions about possibilities of using humanoids in the care of family members (FI1) and personally (FI2). In both cases, respondents were rather cautious and evaluated such possibilities at a low level.

Comparing four variables determining the attitudes of respondents towards the use of humanoids, the highest impact was technological (M = 7.721) reflecting the functionality of the analysed technology, and social was the lowest (M=4.092) (Figure 2).

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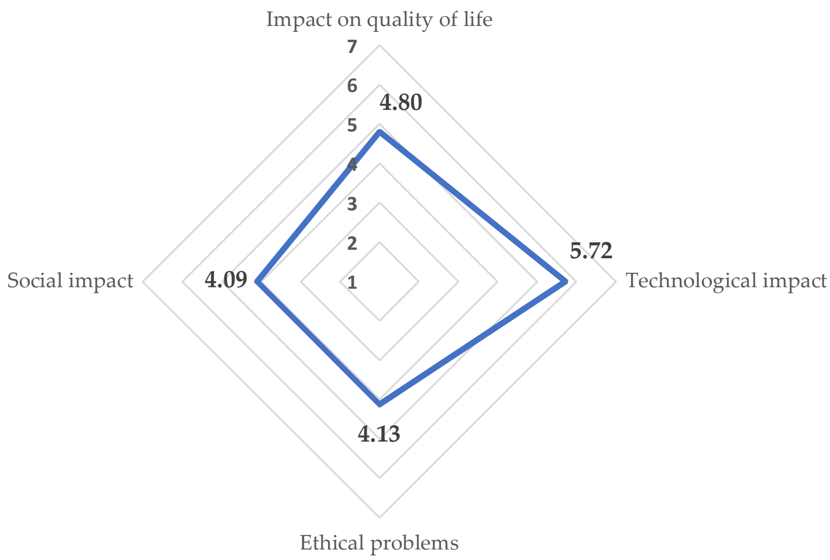

Fig. 2. Assessment of a construct determining an attitude towards the use of humanoids (Mean)

4. Results

To answer the research questions and verify the hypotheses, the authors used a two-step approach. First, the correlation analysis was applied, and then, the authors followed it up with the regression analysis.

Table 3 shows a correlation matrix for variables. Significant correlations were found between all constructs, and the strength of dependence was rather strong. In the case of relationships between constructs of ethical problems and other variables, a negative correlation appeared with low to moderate dependence.

Table 3. Correlation matrix (Spearman's coefficient)

	Impact on the quality of life	Technological impact	Ethical problems	Social impact	Attitude	Future intention of use
Impact on the quality of life	1	0.721**	-0.404**	0.829**	0.763**	0.702**
Technological impact	0.721**	1	-0.281**	0.675**	0.669**	0.572**
Ethical problems	-0.404**	-0.281**	1	-0.470**	-0.430**	-0.419**
Social impact	0.829**	0.675**	-0.470**	1	0.824**	0.683**
Attitude	0.763**	0.669**	-0.430**	0.824**	1	0.657**
Future intention of use	0.702**	0.572**	-0.419**	0.683**	0.657**	1

**. Correlation is significant at the level of 0.01 (2-tailed).

Source: elaborated by the authors.

Table 7 reports the results of the follow-up regression analysis, in particular, the beta coefficients for the parameters. To verify all five hypotheses, two regression models were built. According to the achieved results, all hypotheses were supported. In Model 1, the regression analysis showed that relations between four variables (QL, T, E, S) determining the attitude towards humanoids (AT) are statistically significant ($p<0.05$). Model 2 proved that the relation between the attitude (AT) and future intention of humanoid use (FI) is also statistically significant ($p<0.05$). The results of the multiple regression analysis are presented in Tables 3 and 4.

Table 3. Results of the multiple regression analysis — Model 1

Specification	Unstandardised coefficient		Standardised coefficient	t-value	p-value
	B	Standard error	Beta		
Fixed	0.635	0.215		2.956	0.003
Impact on the quality of life (QL)	0.159	0.038	0.180	4.225	0.000
Technological impact (T)	0.216	0.037	0.173	5.757	0.000
Ethical problems (E)	-0.078	0.026	0.072	-2.942	0.003
Social impact (S)	0.544	0.045	0.520	12.157	0.000
F	401.042				
p	0.000				

Dependent variable: attitude towards humanoids (AT)

Predictor: Impact on the Quality of Life (QL), Technological Impact (T), Ethical Problems (E), Social Impact (S)

Table 4. Results of the regression analysis — Model 2

Specification	Unstandardised coefficient		Standardised coefficient	t-value	p-value
	B	Standard error	Beta		
Fixed	1.012	0.115		8.769	0.000
Attitude towards humanoids (AT)	0.561	0.024	0.675	23.147	0.000
F	535.793				
p	0.000				

Dependent variable: future intention of humanoid use (FI)

Predictor: attitude toward humanoids (AT)

To verify the hypothesis H6, non-parametric ANOVA Kruskal-Walls test was used, and to verify the hypothesis H7, the Mann-Whitney test was used. The statistical verification allowed to reject both hypotheses. The research proved that the attitude towards humanoids is differentiated across age groups (the significance level of 0.05) as well as gender groups (the significance level of 0.005). For the purposes of graphical presentation of the attitude towards humanoids among four age groups and gender groups, box plots were used (Figures 3 and 4).

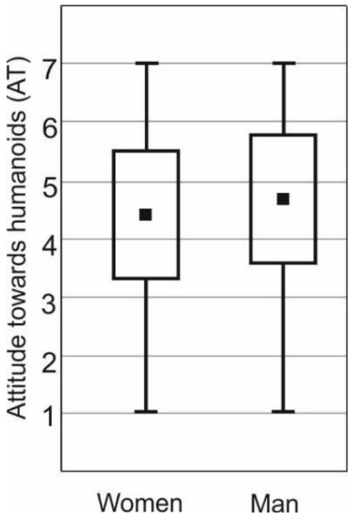

Fig. 3. Attitude towards humanoids in gender groups

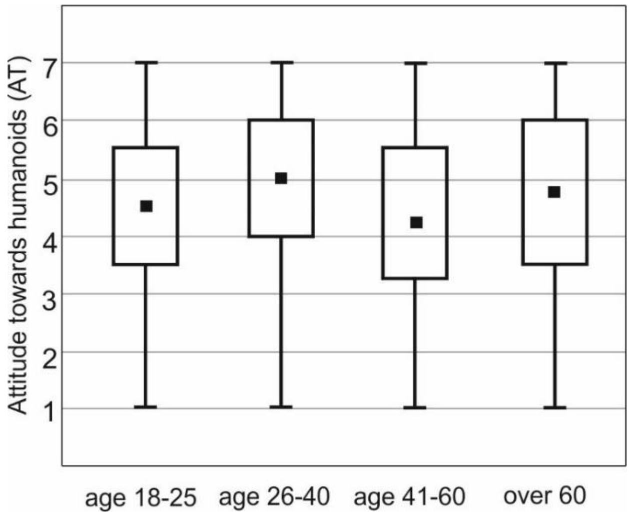

Fig. 4. Attitude towards humanoids in four age groups

To verify statistically significant differences between individual age groups, the Mann-Whitney test was conducted using paired data. The test results showed statistically significant differentiation of attitudes between age groups 18–25 and 26–40 as well as between age groups 26–40 and 41–60 (the significance level of 0.05). The comparison with pairs of other age groups did not show statistically significant differences in attitudes towards humanoids.

5. Discussion

The conducted research confirmed that an attitude towards humanoids is determined by four factors: an impact on the quality of life, a technological impact, ethical problems as well as a social impact. The regression analysis showed that the most important factor influencing human attitudes is a social impact reflecting the fact that humanoids could be useful in the care of lonely people and could improve the safety of older adults, as well as the technological impact of using humanoids reflecting the functions of humanoids desired by respondents.

Respondents stressed the importance of measurable social benefits brought by humanoids in the care of older adults. At the same time, respondents indicated their concerns regarding possible threats to interpersonal relationships and new jobs creation. A low level of assessment given to the possibility of new job creation (M=3.24) suggested that respondents were rather inclined to agree that robots could pose a threat to the labour market. The achieved results were consistent with the results received from a Eurobarometer survey, which confirmed that robots would steal people's jobs. Only five Member States had absolute majorities agreeing that the widespread use of robots can boost job opportunities in the EU: Denmark (65%), Finland (57%), Lithuania (52%), Sweden (51%), and Austria (50%). Only five Member States had absolute majorities agreeing that the widespread use of robots could boost job opportunities in the EU: Denmark (65%), Finland (57%), Lithuania (52%), Sweden (51%) and Austria (50%) [10]. From the sociological point of view, respondents were concerned for interpersonal relationships. They thought humanoids might pose a threat to interpersonal relationships (M=3.14). Also, results of a research conducted by Syrdal *et al.* confirmed that the use of humanoids might threaten interpersonal relationships [40].

The second important factor determining attitudes towards humanoids was the technological impact (T) reflecting the functionality of the analysed technology. Four variables reflecting the technological impact received the highest marks given by respondents in 7-point Likert scale: the use of a humanoid should be easy and intuitive (T1, M=6.40), an important feature of a humanoid would be the ability to call for help on behalf of an older person (T6, M=6.26), another important feature of a humanoid would be the ability to remind an older person to take medication (T3, M=6.02), and yet

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another important feature of a humanoid would be the ability to inform family members about the health condition of their older people (5, M=5.88). The research conducted by Deligianis *et al.* also confirmed that one of the important factors determining humanoid acceptance were tasks and functions performed by humanoids [41]. Regarding tasks performed by humanoids, respondents would expect improvement in the communication between older people and their environment (e.g. family members). The research conducted by Nomura *et al.* confirmed that actually, people expect robots to function in communication tasks such as service in public settings and provide care at home or in welfare facilities [54].

Ethical problems perceived by respondents were mostly connected with safety issues. Respondents signalled their fears and doubts regarding a possibility to trust humanoids (M=5.26). Deligianis *et al.* discovered that people were willing to trust robots when it meant accomplishing a more difficult task with their help [41]. On the other side, Polish citizens were not afraid about humanoids endangering health or life of a user (M=3.67) or deliberately harming an older person (M=2.77). A low level of assessment given to indicated variables reflects a relatively high level of trust in humanoids among respondents. A negative correlation coefficient between variables connected to ethical problems and attitudes towards humanoids shows that when people perceive new technology in terms of threats and untrusted solutions, then positive attitudes cannot be expected. Social programmes aimed at building awareness in society as well as education programmes should be concentrated on showing positive examples of humanoids helping people to avoid any threats rather than being a source of threats.

Also, research efforts by other authors demonstrate that trust in human–robot relations is crucial for technology acceptance. Gaudiello *et al.* analysed two types of human acceptance of robots: functional and social. Functional acceptance means the trust of users in the functional savvy of robots and social acceptance is the trust of users in the social savvy of robots. Researchers proved that robots seemed to be more easily accepted for functional rather than social tasks. The authors also suggested that trust in robots could not be equated to mechanisms that have trust similar to that of computers (functional savvy) or trust in humans (social savvy) [55].

The conducted research confirmed that attitudes towards humanoids determine the future intention of technology use. The received results have been confirmed by other researchers dealing with the issues of technology adaptation. In many cases, research on new technology adaptation pointed out that attitudes towards particular technology influenced the future intention of users to use this technology [58]. Some respondents believed that being in the presence of a humanoid could be pleasant and safe. A positive attitude reflects readiness to learn to use a humanoid if needed (AT2, M=6.21). More often, respondents declared that they would feel safe in the company of a humanoid (AT3, M=4.21), and time would be pleasantly spent (AT1, M=3.84). It was strange that respondents were more willing to use the help of a humanoid for their personal care (FI2, M=3.79) than the care of their family member (FI1, M=3.33).

Considering the demographic features of a respondent, the achieved results confirmed that human attitudes towards humanoids depended on age and gender.

The research confirmed statistically significant differences between attitudes towards humanoids among different age groups of respondents. In contrast to the results of other researchers, for example, Hudson *et al.* [50], it is not obvious and unambiguous that older people would be more hostile to robotic care. The research by Hudson *et al.* confirmed that young people were relatively positive about robots, but older people were rather negative. In the context of the Polish society, the research found that comparing the two age groups of respondents, namely, 18–25 and 26–40, the attitude towards humanoids was less positive in the younger group. The results of this analysis confirmed the results received by Nomura *et al.* showing that age seemed important in Western cultures as well, with the youngest group of participants being the most sceptical of humanoid robots both in terms of General Attitudes as well as Interpersonal Fears when compared to older age groups [54]. Similar results were received by Turja *et al.* who concentrated on researching the attitudes of healthcare professionals towards robots and robot acceptance at work. Among healthcare professionals, younger age, on the contrary, predicted a lower level of robot acceptance at work [0].

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The study of attitudes towards humanoids in the care of older adults held by particular age groups is important because the process of technology development seems to be relatively long and its implementation on a mass scale might be seen by the current generation of the youngest citizens. Often, the more positive attitude of older people to humanoids might stem from either living in loneliness or the lack of faith that technology would become widely used. The knowledge about attitudes toward humanoids and factors determining them may help in the future to adjust the education system of particular social groups and build positive attitudes.

The obtained results differentiating attitudes towards humanoids by gender confirmed that men had a more positive attitude towards humanoids than women. The diversity of attitudes towards humanoids depending on gender was confirmed by other authors although the results were not unambiguous. Tung researched a group of children and confirmed that girls were more accepting and reflected more positive attitudes towards humanoids compared to boys [57]. Turja *et al.* concentrated on the research of attitudes held by healthcare professionals towards robots and robot acceptance at work. The general view of robots was consistently the most positive among men representing Finish healthcare professionals [0].

6. Conclusions

The conducted literature review confirmed that the ageing population motivates the growing body of research on the subjects of technologies such as humanoids. The research concentrated on functional and technological aspects as well as social aspect such us relationships between humanoids and people.

According to a Eurobarometer survey, the Polish society belongs to the group of countries, in which (compared to other EU countries) a relatively low share of the society would feel uncomfortable having a robot to mind their older parents. Gathering the knowledge about determinants that affect attitudes towards humanoids in the Polish society still remains valuable and necessarily from the perspective of momentum gained by the process of population ageing.

The aim of the research, on the one hand, was to identify key determinants of attitudes towards humanoids in the care of older people and, on the other hand, the conducted research was an effort made towards the awareness shaping in the Polish society regarding the possibilities of using modern technologies in the future.

The Polish society believes that from the social point of view, using humanoids in the care of older adults could be particularly important in the case of lonely people. The analysed technology could be useful for reminding the older people about taking medications, informing the family members about the health condition of their older people, and calling for help on behalf of an older person. Respondents did not believe that a humanoid could deliberately harm an older person. Results confirmed that respondents were aware of the fact that humanoids could occupy jobs and impact labour markets negatively, and they did not believe that humanoids used in the care of older people could create new jobs.

The main limitation of the conducted research was too general a view of factors determining attitudes towards humanoids and the future intention. Because the research was the first of the kind in Poland and considering a low level of social awareness and practical application of such technology, the authors decided to use more general questions and not go deeply into all factors influencing human attitudes towards humanoids.

Therefore, the achieved results could be useful for the future research and can serve as a starting point for further research. Perspective future research includes an investigation of factors influencing different types of attitudes (cognitive, affective) and an investigation of different types of motivation for using humanoids in the care of older adults (an obligatory or voluntary use of technology). Also, from the perspective of the influence of humanoids on the labour market, more in-depth research efforts are required. Together with the growing use of robots in everyday life, one of the additional variables that could influence the use of future humanoids would be user experiences of robots in other spheres of life.

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