Designing, Implementation and Use of Robotic Devices in the Social Sectors in Foreign Studies

Natalya A. Aleksandrova
Yuri Gagarin State Technical University of Saratov
Saratov State University
Saratov, Russia
aleksandrovan@bk.ru

Alexander E. Hramov
Yuri Gagarin State Technical University of Saratov
Saratov, Russia
hramovae@gmail.com

Marina V. Khramova
Saratov State University
Saratov, Russia
mhramova@gmail.com

***Abstract*—The article presents the analysis of foreign scientific studies on the use of robotic devices in social spheres such as entertainment, education and health care, for therapeutic purposes for children with autism spectrum disorder, for patients with sensorimotor disorders during rehabilitation, and robots for pets. Also, social robots can promote cooperation in the workplace, as well as help to educate and deepen understanding of students in the field of natural science subjects. The experience of applying social robots in education is exemplified. The article focuses on the problems of using robotic systems in the educational process, such as: the discrepancy between the abilities of the robot and the users' expectations, insufficient degree of adaptation required to use the robot in educational process taking into account the physical and social context, the problem of user privacy, users' fears during interaction with the robot and many other social aspects of human-machine interaction.**

***Keywords*—robotic device; neuropedagogy; cognitive activity**

I. Introduction. The Study Of The Problem In The Scientific Literature

The methodological and theoretical basics of the research are interdisciplinary and are based on:

- "Psyche and reality: a Uniform Theory of Psychical Processes" L.M. Vekker;
- methodology of cognitive psychology – H.C. Longuet-Higgins, J.R. Searle, J.L. McClelland, etc.
- attention modeling theory: selection model (Broadbent, 1957; Treisman, 1966; Norman, 1976), mental effort model (Kahneman, 1973), skills model (Neisser, 1975), uniform limited resources model (Posner, 1980), multiple resource model (Wickens, 1987), model of multiprocessing information processing (Allport, 1989), a connectionist model that considers attention from the position of the organizational metaphor of the information processing system structure (Navon, 1989; LaBerge, 1990);
- attention cultural-historical theory (L.S. Vygotsky);
- attention concept as a component of any activity (B.G. Ananiev, F.N. Gonobolin, N.F. Dobrynin, S.L Rubinshtein, I.V. Strakhov);
- the gradual mental actions formation theory (P.Y. Galperin) and system of organizing the cognition process (F.G. Gonobolin, A.N. Leontiev, etc.);
- concept of voluntary attention development (B.G. Ananiev, N.F. Dobrynin, S.L. Rubinshtein);
- theory of age dynamics of attention development (I.L. Baskakova, N.P. Diyeva, S.N. Kalinnikova, N.N. Lila, V.Y. Chyapas, etc.) and its stability and concentration (N.P. Diyeva, S.N. Kalinnikova, N.N. Lila, T.V. Mazur, L.P. Nabatnikova, G.M. Ugarova, ect.) of younger schoolchildren (Y.L. Kolominsky, V.A. Krutetsky, N.D. Levitov, A.A. Lyublinskaya, E. A. Panko);
- concept of the influence of child's individual personal characteristics to the attention development level (M.N. Akimova, O.Y. Ermolaev, Y.L. Kolominsky, etc.);
- theoretical statements on low development attention level as one of the main problems of primary school age students. (L.I. Baskakova, S.V. Vakhrushev, A.L. Venger, F.N. Gonobolin, V.V. Davydov, I.V. Dubrovina, S.L. Kabylnitskaya, ect.);
- development of neuropedagogy (T.V. Akhutina, V.D. Eremeeva, K.A. Mornov, V.A. Moskvin, N.V. Moskvina, O.L. Podlinyaev, A.S. Potapov, A.L. Sirotyuk , T.P. Khrizman, etc.) and neuropsychology (AR Luria, YM Mikadze, LY Moskovichiute, ED Khomskaya, LS Tsvetkova, etc.);

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- synaptic plasticity theory and Hebb's postulate (Hebb, 1949);
- diagnostics methods of cognitive brain activity by signals of electric and magnetic activity (L.K. McEvoy, C.S. Herrmann, G.Buzsaki, A.I. Ivanitsky, A.A. Frolov, A.E. Hramov, A.E. Osadchiy);
- theoretical basis of the creation of brain-computer interfaces for mental external devices control (J.R. Wolpaw, A.Y. Kaplan);
- methods of mathematical modeling of the brain neural ensembles under various stimuli (M.Siegel, M.X. Cohen, G.V. Osipov, V.I. Nekorkin, A.N. Pisarchik).

The study and evaluation of the effectiveness of any educational process whether it be individual learning or group classes is reduced to the feedback analysis from learner, that is, determine the knowledge level. However, analysis of the information perception efficiency at the moment of learning is interesting because it will significantly reduce the time delay in feedback between learner and teacher, and to adjust the learning process in real time. Obviously, in this case we are talking about continuous evaluation of person's functional state during the learning process and instant decision-making to manage this process. Such an evaluation can be carried out with the modern means of recording and analyzing biometric indicators, for example, capillary blood flow, oculography, etc., representing multiply-connected processes that can be analyzed by nonlinear physics methods.

These methods give only indirect information about the effectiveness of the learning process, mainly, the student's concentration and willingness to perceive new information, but interest is evaluating the specific skills acquisition and their sustainable memorization by students. Of course, such subtle effects related to cognitive activity can be detected only by analysis of higher nervous activity. In recent years there has been a significant increase in the number of works devoted to the study of the processes occurring in the human brain during cognitive activity.

II. Foreign Experience Using Of Robotic Devices In Social Spheres

We present the analysis of foreign scientific research developments on the use of robotic devices in social spheres. Currently, robotic devices can help people in a wide range of areas [1, 2], and these areas are not limited to robots designed only to assist people during dangerous tasks [3]. On the contrary, there are many other areas where robots may find applications including entertainment, education and medical care. Robotic Pets such as Paro [4] or AIBO [5] are used for elderly patients [6, 7] and have a positive impact on mood and social communication among patients with dementia[8, 9].

In addition, social robots are used extensively for therapeutic purposes for children with autism to help build up their social skills, such as attention to the other person or emotions understanding [10, 11, 12, 13, 14, 15, 16, 17].

Researches on the use of robots for patients with sensorimotor disorders during rehabilitation are also presented [18, 19, 20].

Also, social robots can promote cooperation in the workplace [21], as well as help to educate [22], help to solve problems [23, 24, 25], and deepen understanding of students in the field of natural science subjects [26, 27].

Overall, these studies show that people are ready to accept social robots in some contexts, but may reluctant to do it in others. Consequently, research in social robotics should determine how to create robots that will suit people with different technical abilities, and what functions robots should have in order to be accepted as social companions and understand our needs, feelings, and intentions [28].

One of the problems of social robotics current research is a lack of systematics and insufficient study of specific features that would facilitate robotic companions development.

A team of scientists from Department of Psychology, George Mason University, Fairfax, VA, United States и Istituto Italiano di Tecnologia, Genoa, Italy [29] proposes to explore this problem, using behavioral and physiological neuroscience methods in researches to objectively measure how people respond to robotic agents how they perform tasks with robots and how they develop social interaction over time.

In particular, they argue if the robots are considered as social companions, they must evoke people's mechanisms of social cognition in the brain that are usually activated in interaction with other people, such as collective attention [30, 31], spatial perspective [32, 33, 34] and understanding of action [35, 36].

A survey of scientific research of creating social robots [37] indicates that some of the problems in the design of anthropomorphic robots require competences covering the full range of human cognitive skills, and in most cases psychological and neurophysiological based realizations of the skills are lacking.

Although important aspects of human-robot interaction are currently being considered in isolated models, at this point doesn't exist more complex architecture that would combines cognitive and social functioning. The effectiveness of existing models in terms of human perceptions and attitudes, and their effectiveness in human-robot interaction haven't been sufficiently investigated.

In the future, neurobiologists and robotists will need to work together to identify at least a minimal set of physical and behavioral functions of the robot that will be able to activate the same region in the human brain that are activated when communicating with people. However, there is still no guarantee that the correct functioning of the human neural system can be emulated in artificial agents.

The design of social robots should be based on the methods of cognitive neuroscience to determine the functions of the robot (for example, behavioral characteristics, coordination of the head eye, frequency and duration of look on a person) that will subsequently activate social cognition mechanisms in the human brain. Neurophysiological results reveal what these mechanisms are like, how they are implemented in the human neural architecture, and when they are activated [38].

Experience of using social robots in education. Educational robots have been successfully used as a tool for teaching programming in schools in the developed world [39].

In the future, the researchers suggest that robots will be used as a tool not only to get students to understand certain notions, but also can help teachers in various areas of their activities [40].

It becomes topically to use robots that help teachers to perform repetitive tasks and to act in different social roles in an educational environment. Scientists conducted a series of researches focused on the study the opinions of teachers about the possible use robots in schools [41], and the survey to identify the types of activities that the robot must implement in the educational process[42]. The results of these studies were also directed to introduction of existing adaptive robots that were used in education.

Gonazalez et al. [43] presented the autonomous robot MAggie, programmed to play with children. MAggie is a voice system (ASR, TTS), Vision system (object identification), radio frequency identification (RFID), sensors, built-in tablet screens and interaction through a smartphone and gestures. The robot was able to adapt its interaction based on the game scripts presented to it. A series of experiments was conducted in which children took part and played various games such as Peekaboo, Guessing the Character, Tic-tac-toc, Hangman and Animal Quiz with the robot MAggie.

Janssen et al. [44] presented a study in which children played an adaptive game to learn arithmetic with a robot named NAO. The robot was able to adapt its behavior based on mistakes made by the user during the game. During the research project, NAO was able to change its behavior in two different situations. In the first case if the user made a mistake, the complexity of the game was kept at the same difficulty, and in the second case the complexity of the game was reduced. Children played the game three times with the robot, and their intrinsic motivation was measured. The results showed that in the second case, participants showed a higher level of motivation.

Szafir et al. [45] presented the design of an adaptive robot, which was able to monitor and improve the communication with the user during the interaction. The robot was supposed to tell the user story. The idea of a robot able to adapt on the basis of levels user interaction and information about the level of interaction was taken from the EEG device. A pilot study was conducted with the participation of 30 people where three groups of participants interacted with the robot capable to react on the basis of low spontaneity, random spontaneity, and adaptive behavior based on the level of interaction. The results showed that the use of adaptive agent has significantly improved attention and performance in narrative task. We also found a gender difference in terms of motivation during interaction with the adaptive version of the robot. Women's motivation was significantly higher than that of men.

Kuehnlenz et al. [46] developed an adaptation mechanism, based on which the robot EDDIE is adapted in accordance with the mood of the user, then displays the same emotional state. The adaptation mechanism includes the two different ways of expressing emotions: explicit and implicit. The explicit method implies that the robot asks questions to the user and responds with "me too", whereas an implicit method the robot generates verbal or facial emotions based on the user's mood measured through the questionnaire before the interaction. A five-step experimental evaluation was conducted with 84 participants, where the robot displayed an emotional adaptation in four different conditions (full emotions adaptation (FEA), implicit emotions adaptation (IEA), explicit emotions adaptation (EEA) or lack of adaptation).

L. Brown and his colleagues [47] conducted a research with the DARWIN robot that is able to adapt its behavior during a math test conducted on a tablet device. The robot was able to adapt its verbal and nonverbal behaviors during the interaction depending on the performance of the player. To test whether the use of an adaptive educational robot can to increase test efficiency 24 students took part in the study. The results showed that the subjects completed the test faster provided that the robot provided them moral support.

Ros et al. [48] implemented an adaptation mechanism for the NAO robot allowing it to adapt in accordance with the movements of the dancing children in the study long-term interaction. The NAO robot was able to update its verbal and nonverbal behavior based on current and previous user condition. User data included history of the user's dance movements, his profile (ID, name, age, gender), as well as the current configuration of the shell. The authors conducted a long-term research that had 18 sessions with 12 children, where the robot taught them different dance moves. The results showed a high level of interaction during the research and also stressed the need for the introduction of new ways of adaptation to influence long-term social interaction.

Uluer et al. [49] presented semiautonomous tutor Robovie-3 (R3) able to teach Turkish sign language. P3 was controlled by using WoZ, and the vision module worked independently to recognize different signs. The authors conducted a survey of three groups (18 students, 6 children with normal hearing and 18 children with impaired hearing) to evaluate the recognition abilities of the robot and its influence on the effectiveness learning of users. Recognition rates for each characteristic shown Robovie coincided (over 90%) for all three groups.

Paul Baxter et al. [50] conducted an experiment in elementary school. Two autonomous robots were built in two classes for two weeks as assistants for the education of children. The results indicate that children who learned in the interaction with the adaptive robot studied better than before. Additional evidence indicating a wider recognition of personalized robot compared to non-personalized version was obtained.

The study involved 59 children aged 7-8 years (UK, the time of the experiment — 3 years). All the children studied in the same elementary school, but were divided into two classes. Technical basis consisted of: touch screen (Sandtray), humanoid robot Nao, aluminum frame extrusion and the recording device.

The experimenters chose two topics for learning in interaction with the robot. The first was a new topic for children, but had to be studied in the next academic year. The second was known, because it was already studied. This form of the experiment was chosen in order to assess whether it is possible to use a robot companion as a method of influence on the learning process and also for presenting to children a new task in the context of the learning environment. The results of this study are the first evidence that personalization of the behavior of the robot companion has a positive effect on the learning process over a long period of time.

The survey results show that most of the studies conducted in education based on a one-time interaction, and a small number of users involved in these studies. We assume that in the case of a long-term experiment it is difficult to have a large number of participants, however, research is needed a large number of participants for the reliability and scalability of results.

III. Problems That May Arise When Using Robotic Systems In The Learning Process Of An Educational Organization

An important robotic systems problem in the learning process is the mismatch between the abilities of the robot and the users' expectations. The discrepancy is expressed in several ways: the obstacle to successful human interaction and social integration of robots in society [51, 52]; the need and insufficient of opportunity to reproduce human behavior [53]; most of the technologies, including robotics, have recently been using in school based on traditional teaching methods and it's doesn't forms critical thinking and creativity [54].

Zawieska K. et al [55] offers to consciously use anthropomorphism as a means of strengthening a person's ability to interact with educational robots over a long period of time.

However, with the advent of new technologies and socio-economic changes, there is also a need to develop new educational paradigms that will go beyond constructivism [56]. That is why it is proposed to use anthropomorphic robots as tools that not only encourage the person's ability to interpret, but also a challenge to this ability.

The use of robots in education, from robotic kits to humanoids, known for its positive impact that it has on the students interest and interaction, at least for a short period of time. It can be argued that the increased interest in the use of anthropomorphic robots is not due to the novelty of the work, and the illusion of human life. This illusion is based not only on the similarity of robot and human, but the differences (that's why it remains an illusion, not reality). For example, teachers can talk to robots, and consequently, take part in role-play games in class. Another element that can challenge the existing practices is the degree of adaptation required to use the robot in educational process taking into account the physical and social context. And last but not least, the importance attributed to anthropomorphic robot — such robots are tend to change over time. This may include both increase and decrease the degree of anthropomorphization. Although this trend is often seen as an obstacle [57].

Social robotics and adaptive interaction of the robot with a human, robotic systems participation in education it's a relatively new area, and we understand that in the near future it will be necessary to answer some research questions. Let us denote the common problems related to the design, implementation and evaluation of adaptive social robots.

1. It is important to understand which individual adaptive behavior leads to a positive impact on users, or which of them lead to entanglement in a variety of contexts. We believe that depending on the characteristics of the user and the social environment, it is necessary to individually select a set of the robot adapters. This adaptation set may depend on the environment in which a particular robot will function. We believe, for example, that adaptation to user personality may not be necessary in the public area of space. If you compare the effect of different adaptations based on the user emotions, memory and game events to maintain social activity during long-term interaction with students, the results showed that the adaptation based on emotions proved to be the most effective, followed by adaptation based on memory. If you compare the effect of different adaptations based on the user emotions, memory and game events to maintain social activity during long-term interaction with schoolchildren, the results showed that the adaptation based on emotions proved to be the most effective, followed by the adaptation based on memory. Game adaptation didn't lead to long-term social engagement. Therefore, we believe that more research is needed to understand the impact of adaptation on user interaction or perform administrative tasks for a specific script.

2. Indicators necessary for the evaluation of adaptive systems should be thoroughly investigated. There is a need for the development a research protocol as it will help researchers to systematically compare results with previous. The adaptive system changes its behavior based on the behavior of users, so it should be evaluated in long-term interactions, to confirm its potential. Most of the results presented in our review based on the video analysis carried out during the interactions. Unfortunately, there is no research protocol to analyze these videos to fix changes in different robotic systems. So, it is requires a set of principles that will determine the assessment methodology, as is also data analysis obtained at sessions of the assessment.

3. Adaptive robot needs to store information about patterns of user interaction. Therefore, data privacy is one of the problems that need to be considered. We need to define guidelines that will be able to support ethical considerations and indicate data the robot must to store and potentially can use, especially in cases where the user group is a subsidiary.

4. Another problem lies in the understanding of acceptable adaptations, as a certain group of users may be scared or have feelings of discomfort from the unpredictability of the robot. So we also need to explore the question of the users' fears during interaction with the robot [58].

Undoubtedly, it is necessary the design and development of anthropomorphic robot that will be able to adapt to the learner depending on its learning process. The learning process monitoring can be accomplished through the fixation of signals from the brain and their analysis, i.e. definition of features of human information perception in real time. Thus, to build an optimal learning process with the help of anthropomorphic robotic systems, it is necessary to analyze multivariable nonlinear processes that occur in the neural network of the brain during learning, and on the basis of this analysis to adjust the educational process in real-time.

To solve these problems there is urgent need for the creation of knowledge-intensive methodologies for the initial stages of finding solutions to difficult (non-standard) practical tasks with a difficult to formalize conditions and high quality requirements management (assessment, forecasting). Its main purpose is information support of activity of the identification subject in the transformation from difficult to formalize conditions in a well formalized based on targeted data collection, processing and generation of new knowledge. A key role in the development of such methodologies will undoubtedly play: a systematic approach to the study of problems of identification, as well as fundamental research on mathematical and computational issues management, conceptual and cognitive aspects of identification and modeling, and computer problems in the development of the global computing environment.

Undoubtedly, the education needs in these developments that are currently in their vast majority are borrowed from other science and technology and adapt to the goals of the educational process. This practice cannot be considered a positive development, since such development for educational purposes should be created in accordance with the pedagogical requirements for information systems ensuring automation of the methodical providing of educational process.

There is no doubt that the developed information system must successfully and effectively involved in the learning process, conforming to the normative documents in the sphere of education, creating the preconditions for affordable and quality education. Such developments are particularly relevant in the inclusive education where the robot will be able to partially take over the functions of the teacher's assistant.

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