Robot-Assistant Behaviour Analysis for Robot-Child Interactions

Alina Zimina, Polina Zolotukhina, and Evgeny Shandarov(✉)

Tomsk State University of Control System and Radioelectronics
(TUSUR University), Tomsk, Russian Federation
evgenyshandarov@gmail.com

Abstract. The paper introduces research of interaction between a humanoid robot and a group of preschool children. As can be seen from the brief review the ultimate goal of any such researches is to create the most comfortable and native child-robot interaction with minimum involvement from the operator. But it is impossible to reach this goal without considering the peculiarities of robotics platforms as well as human psychology. A lot of number of features should be considered when conducting experiments and planning the scenario of interaction of a child with the robot.

Keywords: Humanoid robots · Child-robot interaction · Social robotics

1 Introduction

In cases where a child is in temporary isolation, for example, on clinical examination, it is difficult to provide a comfortable environment and plan time effectively, to include training sessions. Unfortunately, it is not always possible to attract people to this process, and it is not always effective. Most children do not feel comfortable in the presence of strangers. But all kids love toys. And the social robotics answers the questions of what should be the toy, and how it should interact with the child.

There are many definitions of a social robot:

- Socially evocative. Robots that rely on the human tendency to anthropomorphize and capitalize on feelings evoked, when humans nurture, care or involve with their "creation" [3, 4].
- Socially situated. Robots that are surrounded by a social environment which they perceive and react to. Socially situated robots are able to distinguish between other social agents and various objects in the environment [10].
- Sociable. Robots that proactively engage with humans in order to satisfy internal social aims (drives, emotions, etc.). These robots require deep models of social cognition [3, 4].
- Socially intelligent. Robots that show aspects of human-style social intelligence, based on possibly deep models of human cognition and social competence [5].
- Fong et al. [10] propose the term "socially interactive robot", which they define as a robot for which social interaction plays a key role in peer-to-peer HRI, different from other robots that involve "conventional" HRI, such as those used in teleoperation scenarios.

A. Ronzhin et al. (Eds.): ICR 2017, LNAI 10459, pp. 219–228, 2017.
DOI: 10.1007/978-3-319-66471-2_24

From the definitions it is clear that a social robot should have the following characteristics: be able to perceive and express emotion, recognize themselves like robots and people to maintain a dialogue verbally and non-verbally, to maintain long-term relationships, possess personal traits, personality, ability to study and learn new behaviors. These requirements are setting the following challenges to this social robotics:

- Clarification of human social behavior models, in particular, affective (emotional) and cognitive components of behavior, learning and adaptation in social behavior, the development of intelligence, etc.
- Social interaction between humans and robots (research, forecasts, the development of ethical standards, etc.).
- Social interaction between robots (collaboration, mutual aid).

2 Background

2.1 Survey of Child – Robot Interaction Projects

Human – robot interaction (HRI) is an interdisciplinary area: robotics, engineering, computer science, psychology, linguistics, ethology and other disciplines investigating social behaviour, communication and intelligence in natural and artificial systems. Different from traditional engineering and robotics, interaction with people is a defining core ingredient of HRI. Such interaction can comprise verbal and/or non-verbal interactions [11].

Dautenhan [6] proposed that approaches to social interactions with robots can be categorized into three groups: robot-centred HRI, human-centred HRI and robot cognition-centred HRI. Robot-centred HRI means that a robot is an independent entity with its own goals and desires, and human interaction is only a means to achieve them. Human-centred HRI is primarily concerned with how a robot can fulfill its task specification in a manner that is acceptable and comfortable to humans. Robot cognition-centred HRI emphasizes the robot as an intelligent system, i.e. a machine that makes decisions on its own and solves problems it faces as part of the tasks it needs to perform in a particular application domain.

Child-robot interaction is mainly based on Human-centred HRI and Robot cognition-centred HRI. An example of CRI is the number of projects designed to investigate the interaction of children with robots: Aurora project and ALIZ-E project. The first project studies the use of robots for therapy and education of children with autism. According Dautenhan [6], several experiments were supplied with different platforms and, consequently, different types of child-robot interaction. The researchers conclude that, in the case of children with autism robot-human relationships as effectively as human-human. The second project is studied for a long interaction with children who undergo clinical examination. The paper by Belpaeme et al. [2] describes the adaptive social models and their implementation with the robot Aldebaran Robotics Nao. For example, the robot remembers the children with whom it spoke, their faces, names, age and other information to further the impression that the robot is not just a toy, but something that has consciousness and memory. When communicating, the robot expresses emotions through poses and sounds, the robot's vocabulary is understandable to children. Most of the children engage is playing with Nao as well as playing with other children, and, in addition, all children like to chat with the robot, and many of them responded to the robot truly personal questions. The same conclusions are made by Baxter et al. [1].

Another CRI experiment is described in the article [14]: 3–6 years old children learn the English words with the robot and without it. Three forms of learning are used when working with the robot: direct teaching, gesturing, and verbal teaching. The direct teaching study means that the word (usually a verb), that should be studied, is exemplified by the showing a movement, that impersonates the word, to the robot. The gesturing means that child shows the robot motion which corresponds to the word, and the verbal teaching is process when the child give a voice command to the robot and then the robot does the movement. Aldebaran Robotics Nao was also selected for interaction. In beginning it is revealed the optimal number of children in the group (10–15 people). The experiment shows that learning with the robot more is 30% effective and the most interesting form of learning is direct teaching.

Ros Espinosa et al. [13] describes other robot-child interaction scenarios: copy-dancing, "Simon says" (a player has to follow Simon's instructions), question-answer when the robot asks a question and waits for a response from the child. All of them are the basis of the development of playful designs for a robot that can take on different roles (such as instructor, companion, and playmate). The experiments were implemented on Aldebaran Robotics Nao.

Based on these projects it can be concluded that humanoid medium-height (up to 60 cm) robots interact with children most efficiently. Children like the robot and usually see them as toys or equals. Non-verbal communication was important: the more dynamic were the robot's movements, the easier was understanding and memorizing. The experimenter or observer must be present (whether explicit or implicit, via telepresence) during the robot-child interaction. But several speech-related questions remain unanswered. What should the voice and speech rate be like? Could the robot deliver a lecture?

2.2 Aldebaran Robotics Nao

As a research platform Aldebaran Robotics Nao used by more than 550 high-profile universities and research labs around the world. It is a small humanoid robot, measuring 58 cm in height, weighing 4.3 kg and having 25 degrees of freedom. It has a lot of sensors and actuators: 2 loudspeakers, 4 microphones, 2 cameras, a gyroscope, an accelerometer, and range sensors (2 IR and 2 sonar). The robot has an Intel Atom CPU core and connects externally via IEEE 802.11g WiFi or Ethernet. The Nao has a generally friendly and non-threatening appearance, which is therefore particularly well suited for child-robot interaction [12]. Nao SDK includes a voice synthesizer and a voice recognition system. Visual IDE Choreographe is used for develop software applications.

3 Methods of Experiments and Interviews of Preschool Children

Preschool children have a number of psychological and behavioral characteristics that are necessary in order to obtain reliable results in the process of psycho-diagnostic testing. These features, in particular, include a relatively low level of consciousness and self-awareness. Most preschoolers' cognitive processes (such as attention, memory, perception, imagination and thinking) are at a relatively low level of development.

Preschoolers are not fully aware of their own personality and cannot properly evaluate their behavior. Staring at 4–6 years of age, children can evaluate themselves as a person, but still to a limited extent. So it is recommended to access the method of external peer review using experts as adults who know the child [8, 9].

Also preschoolers are not quite developed enough to complete personality questionnaires that contain direct self-assessment statements [9]. In general, the use of such questionnaires at pre-school age for psycho-diagnostic purposes should be kept to a minimum, and using them is unavoidable, every question should be explained in detail in a way that is understandable for a child.

Finally, attention should be paid to the characteristics of involuntary cognitive processes, for example, the volatility of involuntary attention, and the easy fatigability of children of this age. Therefore, tests should not be too long or requiring a lot of time. The best results can be obtained by observing children during the main activity at that age – during play [9].

Also, to obtain reliable results it is necessary to establish friendly contact and good understanding between the child and the experimenter. All testing methods developed for preschool children must be brought individually or in small groups of kindergarten children with teamwork experience. Typically, tests for preschoolers are presented orally or in the form of tests. Sometimes assignments may involve using a pencil and paper (for simple tasks) [16].

Let us consider the application of different methods children study, such as observation, quiz or interview, experiment and testing.

Observation is the one of the most important methods for children work. Many of the techniques commonly used in adult studies (test, experiment, survey) have limited use in children studies because of their complexity.

Observation has a lot of different options, which together provide a good variety of reliable information about children. Before monitoring what and how children do, one should identify the goal of observation and answer the questions: what is being done and for what, and what the results should ultimately be. Then the observation program needs to be developed and a plan needs to be designed to ensure that it leads researchers to the desired goal.

On the one hand, monitoring children is easier than adults, since children under the supervision usually act more natural and no not play special social roles inherent in adults. On the other hand, children, especially preschoolers, have an increased responsiveness and unstable attention and often switch between activities.

The method of **conversation** (or questions) can be used in working with children aged 4 years old or older when they already are sufficiently proficient with language, but in a very limited range. Pre-school children are not yet able to express their thoughts and feelings with words, so their answers are usually brief, formal and reproduce adult speech [15]. Difficulties may be caused by the fact that children do not always fully understand the questions addressed to them. Questions should be clear and interesting to the child, and in no case should give any clues. Conversation can only be used as an auxiliary, secondary method.

According to Drujinin [7], in children research, **experiment** is often one of the most reliable methods of obtaining reliable information about the psychology and behavior of the child, especially when monitoring is difficult and survey results may be questionable. Inclusion of children in the experimental situation of the game allows one to direct the child's response to acting on the basis of these reactions to judge whether a child hides from seeing or not being able to verbalize in the survey. The experiment in working with children can get the best results when it is organized and carried out in the form of games or familiar to the child classes – drawing, construction, guessing riddles, etc.

A **test** is a system of specially selected tasks that are given to children under strictly defined conditions. Each task is awarded with points. Assessment should be objective and not depend on the personal relationships of the experimenter. An important feature of practical application of tests that should be taken into account in conclusions, is getting used to the tests, and the relative variability, inconsistency of their results. Many children completing tests quickly get tired of repetitive and monotonous work, they unwittingly begin to change their answers or test procedure to get rid of satiety [16].

4 Interaction Scenarios and Experiments

The aim of the study was to determine the optimal parameters of child-robot interaction scenarios, the duration of stage cues between actions and so on. The result of the study was to be a modification of the script for the best possible interaction between a child and a robot [17, 18].

For the target audience, it was decided to select children aged 3 to 6. Children at this age tend to already know how to count using fingers, a part of the alphabet and know enough to act freely with adults. Because children feel more relaxed in the group we decided to interact with a group of children, rather than one child. The group included 5 children aged 4 to 5 years old. All children in the group were girls.

The chosen model focused on teaching mental arithmetic to children. The interaction scenario was developed as shown in Fig. 1.

A brief introductory lecture was delivered in order to establish closer contact with children and introduce them to the topic. The first part of the message was read out by one of the authors of this work, having experience with children as an animation actor. The second part of the presentation was doing the robot itself through its voice capabilities. In addition, the robot during a presentation actively gesticulated. It is assumed that this should help to establish closer contact between the robot and children.

The main part of the experiment actually began after a brief presentation. At this stage participation of adults was minimized. Since the NAO robot has only two

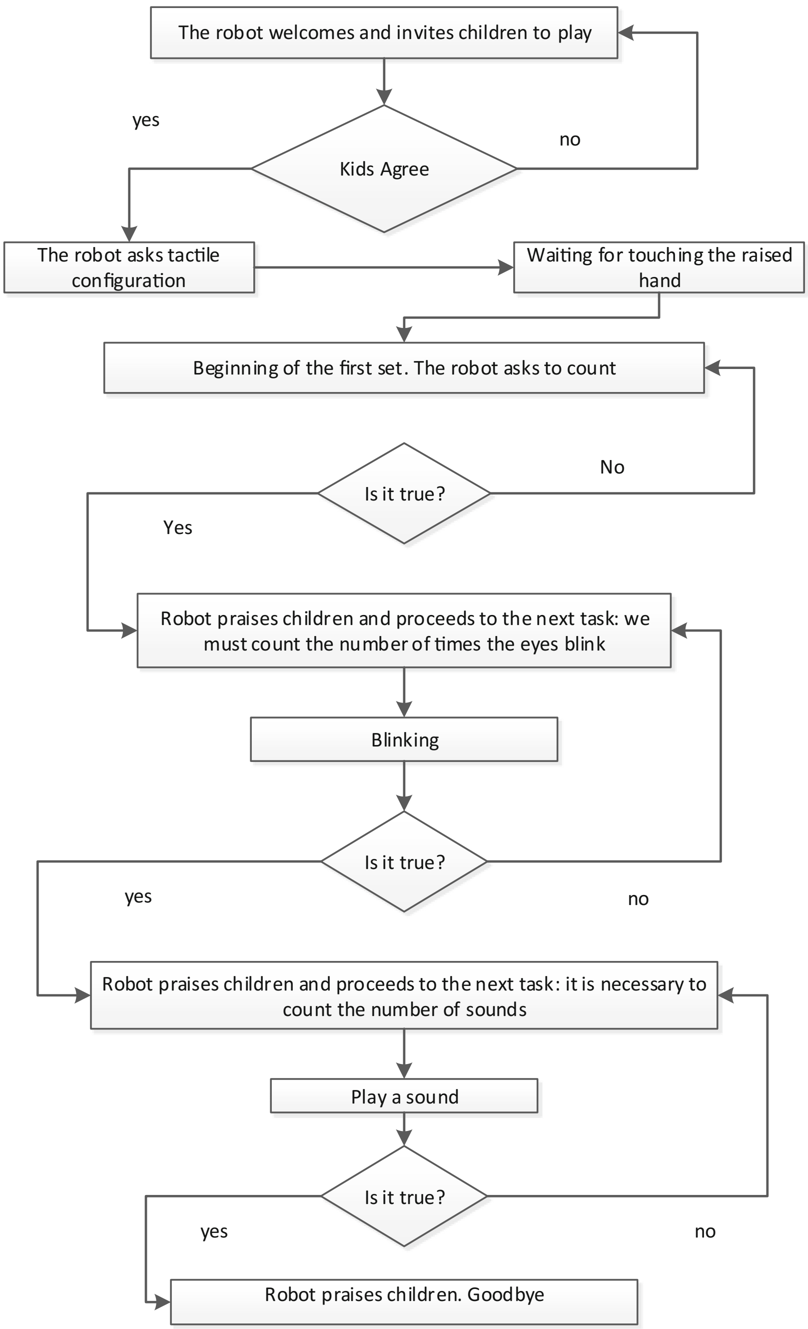

Fig. 1. Child – robot interaction scenario's scheme

channels of interaction allowing feedback: voice functions (synthesis and recognition), and tactile sensors (hands, feet, head), it was decided to include both types of interaction in the script. Thus, to establish robot – child contact the next episode was designed in the scenario. The child should shake robot's hand so that the tactile sensor is touched and NAO knows that someone is here.

As can be seen from the scenario of interaction, communication consisted of three parts. During the first part, the robot asked the children to count its fingers on both of its hands. The answer has to be spoken. The second part was based on the fact that the robot can blink, and the children have to count the number of these signals and answer the question "How many times have I blinked?" Finally, in the third part of the game children were asked to count the number of sounds. The role of the adult at this stage was limited only to help children in the performance of tasks, such as a hinting that it is easier to count using fingers.

It should be noted that the children successfully completed all the robot's tasks. The tasks were only difficult to complete when the answer exceeded the count of 7. Apparently, it is easier to count using only the fingers of one hand at that age.

After the main part of the experiment, children were given questionnaires to fill out, containing three questions:

- Did you like the robot?
- Who was a more interesting speaker?
- Did the robot tell the story clearly?

Of course, filling out questionnaires is not a very easy task at that age. Therefore, questionnaires also involved colorful pictures. View profiles shown in Fig. 2.

When children fill out the questionnaires adults actively help them by explaining the questions. At the end of the action, the robot thanked the children for participating in the experiment and performed a short dance. The children applauded to the robot's performance.

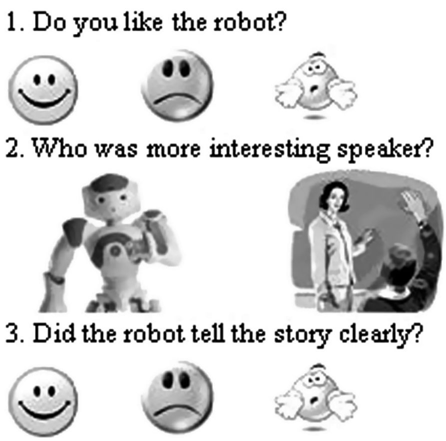

Fig. 2. Questionnaire for children

Adults who were present at the event completed the questionnaire containing the following questions:

- Do you think the robot is a good addition to the educational process of pre-school children?
- How attentively do you think the children listened to the robot?
- Is the robot interesting for children?
- What do you think are the requirements to the robot that should be considered in robot-human interaction?

The entire experiment was video recorded and photographed.

5 Experiment Analysis

The material results derived from the experiment were video and photo materials and the completed questionnaires of children and adults.

The questionnaires of the 3 observing adults were analyzed. According to their questionnaires, the robot was interesting to children. It holds the child's attention longer (and the same can be noted in the video: the children focused their attention on the robot for longer periods than on the assistant.) A child perceives the robot as an equal in age, in contract to the teacher who has a bigger age difference with the child.

The observers pointed out that, first, the voice of the robot has to be softer and more human-like, so the children will better understand the robot. Second, in dealing with a child the robot has to talk using age-appropriate language, avoiding formal phrases and limiting the vocabulary to domestic and familiar words. Finally, tactile interaction is very important with a robot, it is necessary to introduce elements of interactivity and more robot movements during the dialogue (facial expressions, gestures).

In addition, the following problems were noted:

- Speech Recognition. Children do not pronounce the words clearly, and the robot did not always properly understand them.
- Short training scenario. As it turned out three math problems were insufficient for a full lesson.
- Position of the robot. During the experiment, the robot was standing on the table, so that the children perceived it on a par and it was difficult to reach when the robot said, "Give me five".

It may be added that adults relate to the robot with some caution and perceive it only as a supplement to the teacher in the educational process.

As adults actively helped the children in completing questionnaires, it has been suggested that the results of this survey will not be valid. On the one hand, adult help was absolutely necessary, because children can not read; on the other hand, adults can influence the answers given by children. In addition, as we have seen, the three-choice tests were not the best approach for a child. As it is easier to give one-word answers, all answers were identical:

- All children liked the robot.
- The robot talking about itself was more interesting than a man talking about the robot.
- The robot talked clearly to all children

Despite the non-relevant results of the survey, this part of the experiment was important: we were playing with children while making known the image and the functions of the robot.

Thus, the following conclusions were drawn from the analysis. In general, the interaction scenario was well chosen, because all children were actively involved in the process, gave the correct answers and showed no anxiety about having to communicate with robot. Initial is necessary, but it should be shorter, and its text should be made more "childish". It is possible and desirable to have the robot interact with the audience, for example by means of tactile sensors. The number of tasks that the robot gives to children seems optimal: the children do not look tired, and take a keen interest. The feedback channel for interaction should be made free of the drawbacks of voice control (low noise resistance, inaccurate recognition, long response times), perhaps it would be advisable to use the technical vision of the robot. Instead of filling out questionnaires after presentation, it is advisable to hand out informational materials to children, such as posters with the robot in it and its mnemonic function mappings.

6 Conclusions

This paper provides a survey of HRI research in the context of CRI. The results of experimental research of CRI was provided.

An experiment was carried out consisting of two parts. The first was passive listening and the second was an active game. The experiment analysis were defined new challenges to be investigated in the future. First we need to find new ways of child-robot interaction instead of voice input. Next we should develop of additional tests and experiments that help to compose adequate statistical picture of the developed scenarios.

References

1. Baxter, P., Belpaeme, T., Canamero, L., Cosi, P., Demiris, Y., Enescu, V.: Long-term human-robot interaction with young users. In: ACM/IEEE Human-Robot Interaction 2011 Conference (Robots with Children Workshop) (2011)
2. Belpaeme, T., Baxter, P., et al.: Multimodal child-robot interaction: building social bonds. J. Hum.-Robot Interact. **1**(2), 33–53 (2012)
3. Breazeal, C.: Designing Sociable Robots. MIT Press, Cambridge (2002)
4. Breazeal, C.: Towards sociable robots. Robot. Auton. **42**, 167–175 (2003)
5. Dautenhahn, K.: The art of designing socially intelligent agents-science, fiction, and the human in the loop. Appl. Artif. Intell. **12**, 573–617 (1998)
6. Dautenhan, K.: Socially intelligent robots: dimensions of human–robot interaction. Phil. Trans. R. Soc. b **362**(1480), 679–704 (2007)

7. Drujinin, V.: Experimental Psychology. SPB, Saint-Petersburg (2002). (in Russian)
8. Elkonin, D.: Child Psychology. Practical Psycology Institute, Voronej (2011). (in Russian)
9. Elkonin, D.: Mental Development in Childhood. Prosveshenie, Moscow (1995). (in Russian)
10. Fong, T., Nourbakhsh, I., Dautenhahn, K.: A survey of socially interactive robots. Robot. Auton. Syst. **42**, 143–166 (2003)
11. Klingspor, V., Demiris, Y., Kaiser, M.: Human-robot-communication and machine learning. Appl. Artif. Intell. **11**, 719–746 (1997)
12. Nalin, M., Bergamini, L., Giusti, A., Baroni, I., Sanna, A.: Children's perception of a robotic companion in a mildly constrained setting: how children within age 8–11 perceive a robotic companion. In: Proceedings of the Children and Robots Workshop at the IEEE/ACM International Conference on Human-Robot Interaction (HRI 2011). IEEE, Lausanne, Switserland (2011)
13. Ros Espinosa, R., Nalin, M., Wood, R., Baxter, P., Looije, R., Demiris, Y., Belpaeme, T.: Child-robot interaction in the wild: advice to the aspiring experimenter. In: Proceedings of the ACM International Conference on Multi-modal Interaction, pp. 335–342. ACM, Valencia, Spain (2011)
14. Tanaka, F., Matsuzoe, S.: Children teach a care-receiving robot to promote their learning: field experiments in a classroom for vocabulary learning. J. Hum.-Robot Interact. **1**, 78–95 (2012)
15. Vallon, A.: Mental Development of the Child. Prosveshenie, Moscow (1967). (in Russian)
16. Vigotsky, L.: Pedagogical Psychology. Prosveshenie, Moscow (1991). (in Russian)
17. Zimina, A., Rimer, D., Sokolova, E., Shandarova, O., Shandarov, E.: The humanoid robot assistant for a preschool children. In: Ronzhin, A., Rigoll, G., Meshcheryakov, R. (eds.) ICR 2016. LNCS, vol. 9812, pp. 219–224. Springer, Cham (2016). doi:10.1007/978-3-319-43955-6_26
18. Gomilko, S., Zimina, A., Shandarov, E.: Attention training game with aldebaran robotics NAO and brain-computer interface. In: Ronzhin, A., Rigoll, G., Meshcheryakov, R. (eds.) ICR 2016. LNCS, vol. 9812, pp. 27–31. Springer, Cham (2016). doi:10.1007/978-3-319-43955-6_4