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Humanoid Robots Communicating with Children Using Sign Language

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ABSTRACT

This paper presents preliminary results from a nonverbal interactive game between a humanoid robot and participants based on Sign Language. The study consists of an imitation based learning phase and the game phase where the signs taught in the first phase are tested within an interaction game. The aim of this interactive game is the reinforcement of the signs with an enjoyable way. The study also explores how to advance experimental setup before fully working prototypes are available. This can usefully guide the future design of experimental setup for better assistance to the hearing impaired and autistic children.

1. INTRODUCTION

Sign Language (SL) is a visual language that is composed by a combination of hand gestures, facial expressions, and head movements. Teaching sign language is an important and difficult task. Hearing impaired people need to learn sign language to communicate easier. Early education of sign language is essential for hearing impaired children. Teaching materials for children are not adequate, especially in different cultures i.e, Turkish Sign Language (TSL). Hearing impaired children have chance to learn sign language on the condition that their parents are hearing impaired as well. Schools that teach sign languages are not so common, but learning sign language is a vital need. Within usage of humanoid robot as a sign language tutor is fast, simple, motivating tool with easy update and it is facilitated to teach and practice sign language with children with different disabilities. Automation of the teaching sign language is attracted from many researchers with different methods. Sensor glove based sign language tutors (Mehdi S.A., 2002) and robotic hands as sign language tutors (Sugiuchi H.,2002) are some of the methods used. Despite of attention sign language tutoring, educational material is still not sufficient.

The work reported here aims to utilize humanoid robots for aiding sign language tutoring due to the difficulties with 2-D instructional tools developed for this goal and the lack of sufficient educational material. In the system we propose, a child-sized

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humanoid robot Nao H25 as a sign language tutor for children with different levels of disabilities especially for hearing impaired children. This will be achieved through the use of interaction games based on non-verbal communication, turn-taking and imitation, designed specifically for the robot and child to engage each other in play. Children with disabilities lack special design play activities regarding to their impairments. The designed game gives great chance to children to learn and apply new signs immediately.

The reminder of the paper is structured as follows: in section 2 the humanoid robot Nao is introduced. Section 3 addresses the aim of the study and experimental design of the game. Finally preliminary results and discussion are presented in section 4.

2. THE HUMANOID ROBOT NAO

The humanoid robot used for experiments is called Nao H-25. The Nao H-25 is a humanoid robot with 25 degrees of freedom, coreless motors and control software. The Nao robot has a height of 0.57 m. and a weight of 4.5 kg., is a system with 21-25 degrees of freedom, 500 MHz processor, two cameras, sonar sensors, and force sensitive resistors (Graf C., 2009). Nao makes available two loudspeakers and programmable LEDS around the eyes. In this study eyes LEDS are used for giving feedback to children. The Nao robots have hands and fingers to implement most sign language words and they are suitable to use in interaction games due to their expressive face, small size, compact shape and toy-like appearance.

The manufacturer of Nao humanoid robots is Aldebaran Robotics which offer several software tools for use with the Nao robot. Choregraphe is a simulation tool provided for Nao robot which can be used for face detection, face recognition, speech, speech recognition, walking, recognizing special marks and dances, and individual control of the robot's joints. The movements of robot can be managed from Choregraphe and has abilities to perform in sequence or in parallel.

NAOqi is another software provided for Nao that simulates the robot for Choreographe and tests it before trying on the actual robot. Monitor allows the user to access the robots memory, watch through the robots two cameras and observe the environment as the robot senses it. Also, it is possible to use some of program languages, Python or C++ to program the NAO.

In this study, a subset of the most appropriate words are selected due to the physical limitations of the Nao robot that the Nao robot has only 3 dependent fingers while most of the words from the TSL are performed by using 5 fingers and independent finger movements.

3. EXPERIMENTS

This study presents preliminary results of an ongoing research, which aims to employ humanoid robots for assisting sign language tutoring. The main goal of this study is to understand the usefulness of a humanoid robot in advancing teaching sign language and social interaction children with hearing impaired. One of the most important features of the study is the game is specially designed for the use of hearing impaired children therefore non-verbal and visual commands are employed. Children with no hearing impairment and adults can use the system without any further alterations. Another important feature of the study is the experiments aims to teach not only expressions of signs but also meanings of signs.

3.1. Methodology

In the experiments we tested the system with adults and normal development children to improve experimental setup before testing with disabled children. We used live interactions and video based interactions to explore the video based studies effectiveness. A video of robot actions is used in the study. Four children and ten adults participate the experiments. Children participate to the video based experiments and adults participate the live experiments. All the participants have no previous knowledge of sign language. In order to verify the effectiveness of live studies we repeat the same experiment using video based study with adults after one week.

3.2. Research Questions

The research questions addressed in this study are:

- Do the live study and video based study influence the learning rate of sign language from the humanoid robot?
- How should be the best learning environment to participants feel comfortable?

Implementation of Signs

We select 15 signs from Turkish Sign Language Dictionary with respect to Nao H-25 limitations. The list of selected words are shown in Table 1.

Table 1 Selected TSL words

Turkish word	English meaning	Turkish word	English meaning	Turkish word	English meaning
Bebek	Baby	Siyah	Black	Büyük	Big
Atmak	To throw	Araba	Car	Okul	School
Elma	Apple	Ben	Me	Beklemek	To wait
Anne	Mother	Benim	My	Dağ	Mountain
Acıkmak	To get hungry	İlkbahar	Spring	Gelmek	To come

3.3. Scenario

In this study the main aim is teaching sign language to the hearing impaired children, with this purpose we design an interaction game. The game consists of three levels.

In the first level children introduce with robot and familiarize with signs. In this level participants watch the robot. The robot performs 15 gestures (from Turkish sign language). In this level participants both see the signs picture and watch the robot performing gestures. The purpose of this level is to teach children both expressions and the meanings of signs.

In the second level participants express the signs with the robot to gain reinforcement. In this level rather than teaching words in semantically teaching them kinematically is the basic goal.

Third level is an interactive game between robot and participant. At the end of the learning process the participant and the robot plays an interactive game using the signs the participant has already learnt. This interactive game aims to the reinforcement of the signs with an enjoyable way. In this level the robot asks a sentence with three signs to the participant. There are flash cards with three objects on them, the robot expresses a simple sentence using these three objects on the flash cards in sign language and waits for child to select correct flash card. In the video based studies the participant shows the card to the experimenter and

experimenter gives feedback to the participant. The game improves the performance of learning in a comfortable environment. Experimental setups are shown in Fig 1.

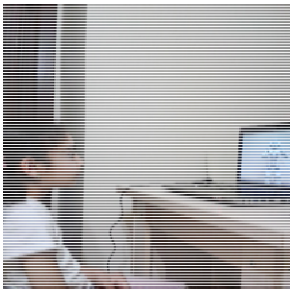
3.4. Results

In this study, 15 signs are performed by the humanoid robot Nao H-25 and a video is prepared to make comparison and to understand the live studies effect. It is noted that live studies are more attractive and ease the learning process. Another result obtained from experiments is that similar signs are difficult to learn at once. Nao H-25 robot has some limitations like short limbs and small figure and these limitations makes learning confusing in some gestures. The average number of learnt signs are 8 in live studies, it decreases to 6 in video based studies. The results are quite promising to drive ahead and we will improve the success, by optimizing the number of words and with live studies and we will decrease the similarity of the signs.

Fig. 1 Experimental design

a) Experiment setup

b) Live experiment with Nao



c) Video based experiment

4. CONCLUSION

This paper presents the part of preliminary results of an ongoing study which aims to help teaching sign language to hearing-impaired and autistic children by using interaction based games between a humanoid robot and children. More detailed results can be found (Akalin N. et.al., 2013).

The main aim of this study is to explore and compare the sign language teaching effect of live studies and video based studies.

The preliminary experiments are performed with ten graduate college students and four primary school children with normal development in order to improve the experimental setup before performing the tests with the disabled children.

Our studies with a different robotic platform with 5 fingered hands are in progress to prevent the physical limitations of Nao H-25 robot and to emphasis the importance of the finger gestures.

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