The Effect of Embodiment in Sign Language Tutoring with Assistive Humanoid Robots

Type of Project

Finished research project

Summary

This study presents interactive games for sign language tutoring assisted by humanoid robots. The games are specially designed for children with communication impairments. In this study, different robot platforms such as a Nao H25 and a Robovie R3 humanoid robots are used to express a set of chosen signs in Turkish Sign Language (TSL) using hand and arm movements. Two games involving physically and virtually embodied robots are designed. In the game involving physically embodied robot, the robot is able to communicate with the participant by recognizing colored flashcards through a camera based system and generating a selected subset of signs including motivational facial gestures, in return. A mobile version of the game is also implemented to be used as part of children's education and therapy for the purpose of teaching signs. The humanoid robot acts as a social peer and assistant in the games to motivate the child, teach a selected set of signs, evaluate the child's effort, and give appropriate feedback to improve the learning and recognition rate of children. Current study presents results from the preliminary study with different test groups, where children played with the physical robot platform, R3, and a mobile game incorporating the videos of the robot performing the signs, thus the effect of assistive robot's embodiment is analyzed within these games. The results indicate that the physical embodiment plays a significant role on improving the children's performance, engagement and motivation.

Low-tech, high-tech products, services and contexts for play

The humanoid robot used in the study is a specially modified version of the Robovie R3 robot. The standard R3 platform is 1.08 m tall and weighs 35 kg and has 17 DOF (2*arms*4, neck*3, 2*eyes*2, wheels*2) but the modified version of R3 robot has additional DOF in wrists, and fingers, 29 DOFs in total; and also a LED mouth to imitate and/or express some basic emotions (such as a happy, sad or neutral facial expressions). The robot has five-fingered hands with independent fingers and longer limbs providing the opportunity to implement signs more accurately. The robot has also a small platform on the chest with an ASUS RGB-D camera which is used for gesture recognition. This platform provides also some flexibility on the interaction level and with respect to game scenario e.g. the depth camera attached to it can be easily replaced by a touch pad tablet according to game requirements in future studies. The other humanoid robot is Nao H25 robot. It has a height of 0.57 m, a weight of 4.5 kg, and is a system with 25 DOF, two cameras, sonar sensors, and force sensitive resistors. Furthermore, Nao robot provides two loudspeakers and programmable LEDs around the eyes. In this study, eye LEDs are used for giving nonverbal feedback to children. The Nao H25 robots have hands with three dependent and movable fingers to implement most sign language words. They are suitable to be used in interaction games due to their expressive face, small size, compact shape and toy-like appearance. For virtual games, two different sign game applications have been developed for Android platform. First application consists of a beginner version of an interaction game. This application includes little number of signs and a training session with the aim of teaching signs from TSL. It also gathers the subjective evaluations of the user for different robot platforms used to generate the signs within the project. This game is designed to be played by the users with no prior sign language experience or just beginners level sign language knowledge, especially children of early age group. The second application was for the users with advanced sign language knowledge. This application was used to verify the recognition rate of the signs generated by different robot platforms. This game had no training session and consisted of more questions. The flashcards/visual icons used in the physical game were replaced with the multiple choices for the tablet/web based test, where the participant watched the video of the physical robot’s signing.

The context of use

The presented platforms (robots and Android applications) can provide assistance to deaf or hard of hearing children with different levels of TSL knowledge in learning new signs or reinforcing their prior knowledge by playing different games. Therefore, the robots and the apps may be used in different environments such as homes or classrooms.

Type of play in this play system

Cognitive

Practice
Rule play (including videogames)

Social

Solitary
Cooperative

Objectives related to play according to ICF-CY

Play for the sake of play: Major life areas - d880 enagement in play

d8803 shared cooperative play
d8809 engagement in play, unspecified

Play-like activities: Therapeutic and educational objectives

d1 Learning and applying knowledge (learning through symbolic play, learning through pretend play)
d3 Communication
d7 Interpersonal interactions and relationships

Chronological Age

3-6 years
6-12 years
12-18 years

Development Age

3-6 years
6-12 years
12-18 years

LUDI Categories of disabilities

Hearing impairments:
Partially hearing impaired
Deaf

Explanation on the use of low-tech, high-tech devices, services or contexts

Explanation

Verbal instruction, language and communication fitting to chronological age
Verbal instruction, language and communication is adapted
Visual instruction with written language
Visual instruction with pictures or drawings
Hand over hand: therapist/researcher leads the actions of the participant
Guided discovery: therapist/researcher coaches the participant so s/he discovers how to use the assistive technology

Involvement

Adult: therapist/educator/researcher

Role

Providing instruction
After the instruction, providing supervision during play

Information about availability of outcome measure: publisher, website, contact person

Participants' teachers and TSL instructors were interviewed before and after the studies. The children participants have been handed questionnaires with pictures to evaluate the designed system. Their recognition abilities per sign, per robot platform, and subjective evaluations of the robot's signing performances are gathered and analyzed.

Summary of achieved effects

The virtual games were tested with 16 adults and 5 children having no sign information and no hearing problems, as well as two groups of 31 hearing-impaired children with different levels of sign knowledge (beginner and advanced). Although the children preferred to play with Nao robot more, their success rate using the R3 robot was higher. The results verified our hypotheses and research questions:
(1) the age of the participants, who did not have sign language acquaintance, did not influence their preference about the human or robot signer;
(2) physical differences of the robot platforms did not matter when their videos appear in virtual signing game;
(3) physically embodied robots improve the recognition rate of the signs drastically compared to virtually embodied robots;
(4) the level of sign language knowledge changes the fact that the recognition performance gets better with the physically embodied robots in comparison to the virtually embedded robots.

References to the intervention or research project

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Keywords

Humanoid robots, Interaction games, Embodiment, Non-verbal communication, Sign language tutoring