2013 IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO)
Shibaura Institute of Technology, Tokyo, JAPAN
November 7-9, 2013

Humanoid Robots Communication with Participants Using Sign Language: An Interaction Based Sign Language Game

Neziha Akalin, Pinar Uluer, Hatice Kose, Gokhan Ince, *Member, IEEE*

Abstract - ***This work presents the preliminary results of an ongoing project which aims to use humanoid robots as sign language tutors. The study mainly focuses on children who have some problems when they are communicating with other individuals such as hearing-impaired or autistic children. In this paper, an interactive game, which is based on sign language, between a humanoid robot and a human participant is introduced. The game consists of an imitation based learning phase where the signs are taught in the first step and they are tested in the second step within the frame of an interaction game. The goal of the interactive game is to reinforce the semantic meaning of the signs in a motivating and engaging way, as well as to test the learning performance of the participants. We aim to design a comfortable learning environment by using the humanoid robot as an educational medium. The game also improves the participants' imitation and turn-taking skills and teaches the semantic meanings of the signs.***

Keywords: Human-robot interaction, sign language, humanoid robots, interaction game

I. INTRODUCTION

The human-robot social interaction is a popular research field among the academic communities in recent years. The field of human-robot interaction includes different disciplines like artificial intelligence, linguistics, cognitive science and psychology. There are many robotic platforms that serve the goal of developing human-robot social interaction [1-7]. Social interaction among humans is a good model for the researchers which aim to develop similar interaction with robots among each other and with humans. In the field of social robotics and human-robot interaction there are numerous researches indicating robots can be used as a therapy medium to assist children with special needs.

Usage of robots as therapeutic tools can be very helpful for children with different levels of disabilities. Various activities play an important role in child development. One of these activities is playing a game. The definition of play consists of the way to handle some objects and to interact with other people, being social and developing a role to play with the appropriate behavior [8]. Playing contributes the development of children by advancing their social skills, as well as their communication skills, and also sensory and motor skills [9]. Through the game play, children recognize their social environment and establish the necessary relationships [10]. According to the International Classification of Functioning and Disabilities- Version for Children and Youth (ICF-CY), the World Health Organization remarks that the game play is one of the most important standpoints for a child in his/her life [11].

*This work was supported by The Scientific and Technological Research Council of Turkey under the contract TUBITAK KARIYER 111E283.
Hatice Kose and Neziha Akalin are with the Faculty of Computer and Informatics, Istanbul Technical University, Istanbul, Turkey. Email: {akalinn,hatice.kose}@itu.edu.tr
Pinar Uluer is with the Galatasaray University, Istanbul, Turkey. Email: puluer@gsu.edu.tr

On the other hand, language acquisition is also an important standpoint in the development of a child with normal development or with a disability such as hearing-impairment. Therefore the acquisition of sign language is really important for individuals suffering from different level of impairment. The Sign Language (SL) is a visual language that uses manual and facial expressions with body language as a communication medium. Sign language is beneficial for hearing-impaired children and autistic children to communicate with other individuals.

In this study, we propose to use a nonverbal game for children with hearing disabilities because children with disabilities lack specially designed play activities regarding to their impairments. The game structure and the instructions in the proposed game are designed in such a way that children with hearing disabilities will be able to participate in the game without any additional help. This game can be also played with children with normal development. In this game we focus on teaching both the realization and the semantic meaning of signs by using the imitation and turn taking phases. The designed game offers a chance to children to learn and to use the new signs they have learnt during the game immediately.

The reminder of the paper is structured as follows: The related studies are presented in Section II. The humanoid robot Nao is introduced in Section III. Section IV addresses the aim of the study and experimental design of the game. Finally preliminary results and discussion are presented in Section V.

II. RELATED STUDIES

In the sign language teaching and learning, the sign recognition plays an important part. There are many studies focusing on the recognition, representation and interpretation of the hand gestures; [12] present in their study a set of algorithms designed to recover the 3D position, hand shape and motion in order to represent and interpret the sings in the American Sign Language whereas in the [13], authors present a combination of vision based features such as hand shape, place of articulation, hand orientation, and movement in order to enhance the recognition of underlying signs. In [14], a method to recognize hand gestures in a continuous video stream using a dynamic Bayesian network is proposed,

978-1-4799-2368-7/13/$31.00 ©2013 IEEE

and a gesture model for one and two handed gestures is developed.

On the other hand, there are studies focusing on the facial expressions used in sign language communication in order to capture the non-manual cues [15] as well. Likewise, in [16], the skin color segmentation is used on 2D images to recognize the signs.

Various studies have been carried out for the teaching of sign language via the information technologies to facilitate the learning process. The study [17] presented an adaptive WWW-based system, Kids Sign Online (KSO), specifically designed to teach British Sign Language. The system uses adaptive learning strategies together with digital video, presented by deaf children, for deaf children, to facilitate learning.

The use of 3D application is also very common in the teaching of sign language; in [18] they implement a multimedia environment using mainly a Web-based tool which permits to interpret automatically written texts in visual-gestured-spatial language using avatar technology whereas in [19] they present an avatar based application implementing the upper body movements, hand shape and arm movement with fluent expressions. In another study, an interactive program is presented in order to teach mathematics to hearing-impaired children by the use of a 3D animation [20].

The interaction games are also popular in the human-robot interaction context and there are several successful studies on imitation based games played with robots and human participants. While the study in [21] they implement the rock, paper, scissor game; in [22] they describe a data collection experiment based on an interaction game inspired by "Simon says" where the turn-taking is engaged by gaze, speech, and motion. And they discuss how to implement their founding into a computational model of turn-taking. On the other hand, in [23], an affective modeling methodology is presented which is tested with a robot-based basketball game. The presented methodology allows the recognition of affective states of children with ASD from physiological signals in real time and provides the basis for future robot-assisted affect-sensitive interactive autism intervention.

III. EXPERIMENTS

A. *Research Questions*

The main focus of interest in this project is to try out and test the impact of humanoid robots and interaction games in teaching sign languages to the children with communication problems. We examine how a humanoid robot can encourage learning sign language as a tutor and improve the social interaction abilities of hearing-impaired or autistic children. In this study, we aim to evaluate the performance and the effectiveness of a humanoid robot in teaching sign language. The study attempts to answer the following research questions:

- Are the learners' competence, performance and interest of learning sign language improved when humanoid robots are used to teach Sign Language (SL)?
- How a humanoid robot can advance teaching sign language and can contribute on the social relation establishment capability?
- Is using humanoid robots and interaction games to teach SL motivate participants in learning SL?
- Do the learners enjoy while learning sign language via interaction game with the humanoid robot? Do the interaction games ease the learning process?

B. *Hypotheses*

The use of humanoid robots would enhance the learners' competence and performance of SL and encourage the learners to learn sign language easily and in an enjoyable way. It was also expected that there would be positive feedback about the content and usefulness of the interaction games and humanoid robot as a sign language tutor from the learners. Notice that the main aim is not to replace the human tutor but design an assistive robotic system which could be used with the human tutor or as an assistant to the human tutor. In order to achieve this goal, we try to improve the robot's performance, so that it will be close to the human tutor, despite the fact that it can never express the signs perfectly due to its physical limitations.

C. *Methodology*

The target group in our experiments is the hearing-impaired children but we tested the designed game with adults as a first step. Our aim was to figure out ways to improve the experimental setup before testing it with children. The preliminary results of experiment provide a guideline for more suitable experiment design in interaction between humanoid robot and children.

In the previous experiments, American Sign Language (ASL) and basic upper torso gestures were used [24, 25, and 27]. These experiments were performed with pre-school children and we had used flashcards for teaching the semantic meanings of signs. The results of these experiments were quite promising to go forward. It encouraged us to use cartoon like flashcards to engage the attention of children. While testing the current experimental setup with hearing-impaired children we plan to use flashcards to teach the meanings of the signs, but in the experiments with adults, we used only vocal cues to teach them the meaning of signs so that the children without any hearing-impairment problem and adults can use the system without any further alterations. The proposed game aims to teach not only the physical expressions of signs but also the semantic meanings of signs. The participant actively takes part in the experiments through interaction games based on non-verbal communication, turn-taking and imitation. These tests were required for improving the proposed experimental setup before testing it with children. In the current experiment, we implemented 15 Turkish Sign Language (TSL) words with Nao H-25 humanoid robot.

D. *Participants and Sample*

The preliminary tests were performed with fourteen volunteers (7 female, 7 male). All participants were graduate students in Computer Engineering Department of Istanbul Technical University (ITU), Turkey. The ages of the participants were distributed in the range of 24 – 28 with the mean $\mu = 26,29$ years and standard deviation $\sigma = 1,33$. None of the participants had any sign language knowledge prior to the experiments.

And it is important to mention that before the tests, four hearing-impaired people (one sign language tutor and a family with a pre-school child) observed the system and provided us with the necessary feedback about the realization of the signs and the interaction with the robot.

E. *The Humanoid Robot Nao*

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, 500 MHz processor, two cameras, sonar sensors, and force sensitive resistors [26].

Nao makes available two loudspeakers and programmable LEDS around the eyes. In this study eyes LEDS are used for giving nonverbal feedback to children. The Nao H-25 robots have also hands and movable fingers. It can implement sign language words and it is suitable to use in interaction games due to its compact shape and toy-like appearance, LEDs around the eyes which can express some emotions. It small size attracts the attention of children.

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

F. *Programming Environment and Software Tools*

The manufacturer of Nao humanoid robots is Aldebaran Robotics which offers several software tools to 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 also be managed from Choregraphe software. It also provides an opportunity to perform the behaviors 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. It allows the user to access the robots memory, to monitor the robots' environment through two cameras and also to observe this environment as the robot senses it. Also, it is possible to use some of the other programming languages such as Python or C++ to program the NAO.

G. *Experiment Setup*

The Nao robot was placed almost 1 m away from the participants on the floor (to avoid its falling down accidentally during its actions and hurting anybody). Kinect camera was placed next to robot to track and recognize the signs performed by the test participants. 2 experimenters were involved with Nao and the participants whereas the third experimenter was responsible from Kinect camera during the tests, as schematized in Fig. 1.

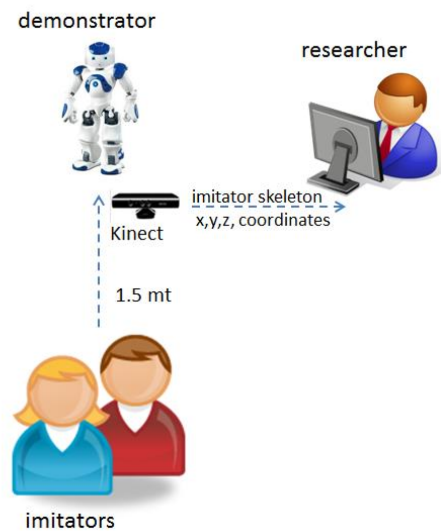
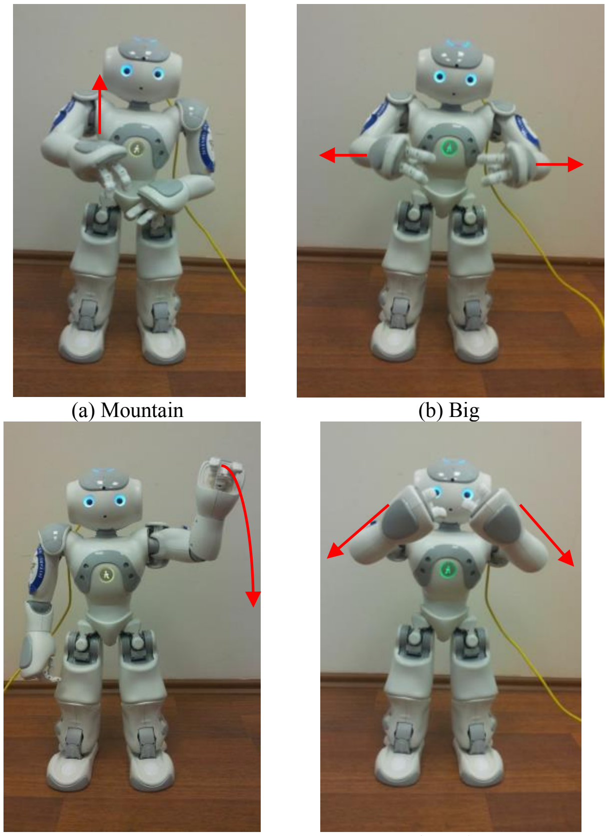


Fig. 1. System setup with Nao robot

H. *Scenario*

In the play scenarios we designed different levels of complexity including a teaching phase, a reinforcement phase and a game phase. The game consisted of three levels. In the first level, participants were introduced with the robot and they familiarized with the signs. In this level, 2-3 participants interacted with the robot. The robot performed 15 gestures (from Turkish sign language) and said the meanings of the signs, one should note that the game was designed not only for hearing-impaired children but also for the children or adults who would like to learn the sign language. The purpose of this level was to teach the participants both the physical expressions (i.e. hand movement) and the meanings of signs; some of the gestures can be seen in Fig. 2.

In the second level, participants have reinforced and improved their performance with the signs by repeating them with the robot. 2-3 participants observed the robot and realized the signs at the same time. The robot was configured to wait for the participants to perform the signs correctly to continue with new signs. The participants' expressions were recognized by Kinect camera. When the correct expression was captured by the robot, it performed a new sign. Performing the gestures with the robot aims to progress the participants' kinematic imitation skills and improve the sensory motor coordination. The aim of this level was to teach the signs kinematically. Fig. 3 represents a capture taken from the second level of the interaction game.



(a) Mountain (b) Big

(c) To Come (d) Spring

Fig. 2. Four signs performed by Nao

Fig. 3. Participant performs the signs with the robot

At the end of the learning process, in the third level, the participant and the robot played an interactive game using the signs that the participant have already learnt in the previous levels. In this level, the humanoid robot and the participant interacted one-to-one. The aim of this interactive game was the reinforcement of the signs in an enjoyable way (while testing with children we planned to use flashcards with three objects on them for this level, to maintain the game). The robot will express a simple sentence using these three objects on the flashcards in sign language and it will wait for the child to select the correct flashcard. In the current test, no clue was given to the adult participants. The robot expressed the sentences with three words using sign language and it waited for a predefined time period and expressed a new sentence. The adult participants wrote down the sentences that they guessed and observed the following sentence. In this level, the semantic features of the signs join with kinematic and visual features. In this study, participants take an active role in the learning process and the game tries to help them improve their performance in a comfortable learning environment.

İ. *Measures*

During the experiment several sources were used to collect data. These sources included asking the participants to complete a test related to the signs they have already learnt, questionnaire related to the trials, recording the sessions by video cameras and Kinect camera (action recognition) , and getting verbal and nominal feedback from each participant for improving the experimental design.

IV. PRELIMINARY RESULTS AND DISCUSSIONS

It is important to emphasize that the preliminary experiments were performed with graduate college students in order to perfect the framework of proposed game before performing these tests with hearing-impaired children. The proposed game was tested with 14 graduate students with similar educational background and without any prior knowledge of sign language.

In this study, 15 signs were performed by the humanoid robot and a video of the robot was prepared in order to test the participants. The participants were asked to guess the meaningful sentence consisting from the 3 signs performed consecutively by the robot in the video.

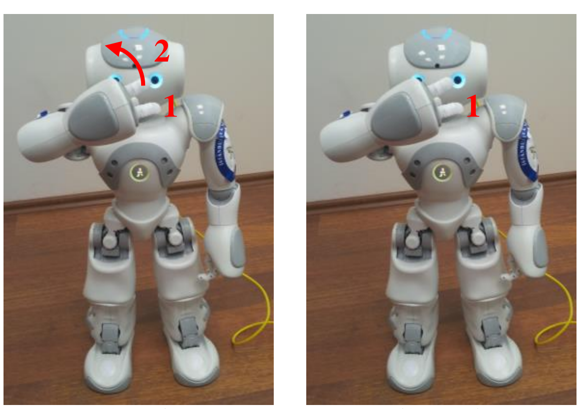
The recognition rate of signs in this test combined with the test results obtained from the previous studies that are performed with 5-9 years children [27] indicate that learning 6 to 8 signs in one session is ideal and to learn 15 signs in one session may be confusing for beginners. Despite the fact that the higher recognition rate of signs in the previous study with the children encouraged us to use a larger set of signs to teach in this study with the graduate students, the results show that the use of a set composed by 15 signs in one session isn't effective in the teaching of sign language. The TSL words, their English meanings and the recognition rate of signs are displayed in Table I.

Although the recognition rates for each sign displayed in Table I don't seem very promising, it is important to notice that apart from a set consisting from 7 signs (apple, me/my, school, to wait, mother, to get hungry), the recognition rate for the other signs are equal or higher than 50% with the highest score being 100% for 2 signs (big, car). On one hand, these results may be discussed in the context of the humanoid robot's ability to teach sign language even if it has some limitations. The higher recognition rates demonstrate that Nao was able to teach some of the signs with accuracy and the participants were able to recognize these signs each time they were asked to guess their semantic meaning.

TABLE I CHOSEN TSL WORDS AND RECOGNITION RATE OF PARTICIPANTS

Turkish word	English meaning	Recognition rate of participants
Bebek	Baby	79%
Atmak	to Throw	50%
Elma	Apple	36%
Büyük	Big	100%
Siyah	Black	57%
Araba	Car	100%
Ben	Me	43%
Benim	My	43%
Okul	School	7%
Beklemek	to Wait	36%
Anne	Mother	36%
Acıkmak	to Get hungry	43%
İlkbahar	Spring	71%
Dağ	Mountain	71%
Gelmek	to Come	57%

But on the other hand, the low recognition rates relating to the previously specified set of signs indicate that Nao is not capable enough to demonstrate the similar signs and the learning rates for the signs with similar gestures are low. The confusion mostly originates from physical limitations of Nao H25 robot. Several participants claimed that the robot's small figure and short limbs also had made it hard for them to see the gestures in precision, and distinguish similar gestures from each other. Also the fact that there are no "head" gestures or other visual cues (i.e. flashcards as in the previous experiments [27]) to distinguish signs with similar arm motions made it hard for the participant to successfully guess some of the words. For example the signs meaning "apple" and "to wait" in Turkish Sign Language slightly differ from each other with the orientation of the right hand on the face during the performance of the signs. The sign meaning "apple" is performed by the right hand first immobilized on the mouth level and then raised a little bit higher whereas the sign meaning "to wait" consists only the immobilization of the right hand on the mouth level as displayed in Fig. 4.



(a) Apple (b) to Wait

Fig. 4. Two similar signs, (a) Apple, (b) to Wait

And also this similarity among the signs allows us to explain the low recognition rates displayed in Table I. It is important to remark that all the signs with a low recognition rate had another sign performed with a slight difference of the arm or the hand movement. The similar signs with different meanings are shown in Table II.

TABLE II SIMILAR WORDS LIST

Word	Similar word
Apple	Wait
Me/My	Get Hungry
School	Mother

V. CONCLUSIONS AND FUTURE WORK

This study has been carried out as part of an ongoing research, with the aim of helping to teach sign language to hearing impaired children by generating interaction based games between a humanoid robot and children.

In this study, an interaction game is proposed with a set of 15 signs from Turkish Sign Language with similar gestures to test the success rate of the test participants without any previous knowledge of sign language.

The tests carried out with graduate students show that it is difficult to learn 15 signs and the similar signs are confusing for the beginners. Despite the existence of bias related to the familiarity of some words and high number of signs, the success rate of the test participants is quite high in guessing the sentences performed consecutively by the humanoid robot. And the test participants have verbally reported that to interact and "play" with a humanoid robot was really fun and they were eager to play with it another time.

The results are quite promising and we plan to improve the success rate by optimizing the number of words that are tested, and their similarity due to the physical limitations of Nao robot with its short limbs and the fact that it has only 3 fingers moving dependently which increase the similarity of the signs. We plan to move the project to a different robotic platform with 5 fingered hands to prevent the similarity of the signs and emphasize the importance of the finger gestures.

REFERENCES

[1] Gouaillier, D.; Hugel, V.; Blazevic, P.; Kilner, C.; Monceaux, Jerome; Lafourcade, P.; Marnier, Brice; Serre, Julien; Maisonnier, Bruno, "Mechatronic design of NAO humanoid," *Robotics and Automation, 2009. ICRA '09. IEEE International Conference on* , vol., no., pp.769,774, 12-17 May 2009

[2] Salichs, M.A.; Barber, R.; Khamis, A.M.; Malfaz, M.; Gorostiza, J.F.; Pacheco, R.; Rivas, R.; Corrales, A.; Delgado, E.; Garcia, D., "Maggie: A Robotic Platform for Human-Robot Social Interaction," *Robotics, Automation and Mechatronics, 2006 IEEE Conference on* , vol., no., pp.1,7, 1-3 June 2006

[3] Tsagarakis, N.G.; Sinclair, M.; Becchi, F.; Metta, G.; Sandini, G.; Caldwell, D.G., "Lower Body Design of the `iCub' a Human-baby like

Crawling Robot," *Humanoid Robots, 2006 6th IEEE-RAS International Conference on* , vol., no., pp.450,455, 4-6 Dec. 2006

[4] Nishiwaki, K.; Sugihara, T.; Kagami, S.; Kanehiro, F.; Inaba, M.; Inoue, H., "Design and development of research platform for perception-action integration in humanoid robot: H6," *Intelligent Robots and Systems, 2000. (IROS 2000). Proceedings. 2000 IEEE/RSJ International Conference on* , vol.3, no., pp.1559,1564 vol.3, 2000

[5] Kaneko, K.; Kanehiro, F.; Kajita, S.; Yokoyama, K.; Akachi, K.; Kawasaki, T.; Ota, S.; Isozumi, T., "Design of prototype humanoid robotics platform for HRP," *Intelligent Robots and Systems, 2002. IEEE/RSJ International Conference on* , vol.3, no., pp.2431,2436 vol.3, 2002

[6] Hackle, M.; Schwope, S.; Fritsch, J.; Wrede, B.; Sagerer, G., "Humanoid robot platform suitable for studying embodied interaction," *Intelligent Robots and Systems, 2005. (IROS 2005).*

[7] Sakagami, Y.; Watanabe, R.; Aoyama, C.; Matsunaga, S.; Higaki, N.; Fujimura, K., "The intelligent ASIMO: system overview and integration," *Intelligent Robots and Systems, 2002. IEEE/RSJ International Conference on* , vol.3, no., pp.2478,2483 vol.3, 2002.

[8] S. L. Spitzer, Play in children with autism: Structure and experience. In L. D. Parham and L. S. Fazio (Eds.), Play in Occupational Therapy for Children (2nd ed.) St. Louis, MO: Mosby Elsevier, 351-374, 2008.

[9] Iacono, I.; Lehmann, H.; Marti, P.; Robins, B.; Dautenhahn, K., "Robots as social mediators for children with Autism - A preliminary analysis comparing two different robotic platforms," *Development and Learning (ICDL), 2011 IEEE International Conference on* , vol.2, no., pp.1,6, 24-27 Aug. 2011.

[10] S. Besio, Analysis of Critical Factors Involved in Using, Analysis of Critical Factors Involved in Using in Interactive Robots for Education and Therapy of Children with Disabilities. UNIService, Trento, 2008.

[11] WHO,I nternational Classification of Functioning. Disability and Health. Geneva: World Health Organization, 2001.

[12] Ding, L. and Martinez, A. M., “Modelling and Recognition of the Linguistic Components in American Sign Language”, Image and Vision Computing, Volume 27, Issue 12, Pages 1826-1844, November 2009.

[13] Zaki, M. M., and Shaheen, S. I., “Sign Language Recognition Using a Combination of New Vision Based Features”, Pattern Recognition Letters, Volume 32, Issue 4, Pages 572-577, 1 March 2011.

[14] Suk, H., Sin, B., Lee, S., “Hand Gesture Recognition Based on Dynamic Bayesian Network Framework”, Pattern Recognition, Volume 43, Issue 9, Pages 3059-3072, September 2010.

[15] Nguyen, T. D., and Ranganath, S., “Facial Expressions in American Sign Language: Tracking and Recognition”, Pattern Recognition, Volume 45, Issue 5, Pages 1877-1891, May 2012.

[16] Paulraj, M.P.; Yaacob, S.; Azalan, M.S.Z.; Palaniappan, R., "A phoneme based sign language recognition system using 2D moment invariant interleaving feature and Neural Network," Research and Development (SCOReD), 2011 IEEE Student Conference on , vol., no., pp.111,116, 19-20 Dec. 2011

[17] Ohene-Djan, J.; Naqvi, S., "An adaptive WWW-based system to teach British sign language,", ICALT 5. Fifth IEEE International Conference on Advanced Learning Technologies, vol., no., pp.127,129, 5-8 July 2005.

[18] Jemni, M.; Elghoul, O., "Using ICT to Teach Sign Language", ICALT '08. Eighth IEEE International Conference on Advanced Learning Technologies, vol., no., pp.995,996, 1-5 July 2008.

[19] Xinxin Xu; Xuan Wang; Lin Yao; Deyuan Zhang; Hainan Zhao, "Avatars based Chinese Sign Language Synthesis System," IEEE International Conference on Systems, Man and Cybernetics, vol., no., pp.444,449, 12-15 Oct. 2008.

[20] Adamo-Villani, N.; Doublestein, J.; Martin, Z., "The MathSigner: an interactive learning tool for American sign language," Information Visualisation, 2004. IV 2004. Proceedings. Eighth International Conference on , vol., no., pp.713,716, 14-16 July 2004.

[21] Ho-Sub Yoon; Su-Young Chi, "Visual Processing of Rock, Scissors, Paper Game for Human Robot Interaction," SICE-ICASE, International Joint Conference , vol., no., pp.326,329, 18-21 Oct. 2006.

[22] Chao, C.; Jinhan Lee; Begum, M.; Thomaz, A.L., "Simon plays Simon says: The timing of turn-taking in an imitation game," RO-MAN, IEEE , vol., no., pp.235,240, July 31 2011-Aug. 3 2011.

[23] Changchun Liu; Conn, K.; Sarkar, N.; Stone, W., "Online Affect Detection and Robot Behavior Adaptation for Intervention of Children With Autism," IEEE Transactions on Robotics , vol.24, no.4, pp.883,896, Aug. 2008.

[24] Ertugrul, B.S., C. Gurpinar, H. Kivrak, A. Kulaglic, H. KOSE, “Gesture Recognition for Humanoid Assisted Interactive Sign Language Tutoring”, The Sixth International Conference on Advances in Computer-Human Interactions (ACHI 2013), February 24 - March 1, 2013 - Nice, France.

[25] Ertugrul, B.S., H. Kivrak, E. Daglarli, A. Kulaglic, A. Tekelioglu, S. Kavak, A. Ozkul, R. Yorgancı, H. Kose, “iSign: Interaction Games for Humanoid Assisted Sign Language Tutoring”, International Workshop on Human-Agent Interaction (iHAI 2012), 11 October, 2012, Vilamoura, Algarve, Portugal, *accepted*

[26] Graf, C., Härtl, A., Röfer, T., and T. Laue, A robust closed-loop gait for the standard platform league humanoid, In Zhou, C., Pagello, E., Menegatti, E., Behnke, S., Röfer, T., eds.: Proceedings of the Fourth Workshop on Humanoid Soccer Robots in conjunction with the 2009 IEEE-RAS International Conference on Humanoid Robots, Paris, France, 2009, pp.30 – 37.

[27] Akalin N., Uluer P., Kose H., “iSpy-uSign: Humanoid Assisted Interactive Sign Language Tutoring Games”, 22nd International Syposium on Robot and Human Interactive Communication Conferance, RO-MAN 2013, Gyeongju, Kore, 26-29 August 2013.