An Affectively Aware Assistive Robotic Platform for Rehabilitation of Deaf Children

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Abstract

This paper presents an overview of a project which aims at developing a social assistive robot platform for rehabilitation of deaf children to improve their performance and to increase their motivation during audiology tests and rehabilitation. Neurological, physiological, audio, and visual data will be collected from these children to detect their emotions, which will be used as a feedback to the robotic system. This paper also presents the results of a preliminary study of this project, which has been performed with 8 deaf children. The developed social assistive robotic platform will help deaf children in their rehabilitation process in the hospitals, and increase their attendance in the audiology tests based on games and language acquisition. The use of robot in the rehabilitation of deaf children is expected to increase their engagement in the process.

Author Keywords

Assistive robots; child-robot interaction; interaction games, multimodal emotion detection.

ACM Classification Keywords

HCI, robotics

Introduction

We are working on development of an assistive robotic platform, which uses the concept of social robots with smart sensors, and interaction games, to improve the conventional diagnosis and rehabilitation process of hearing-impaired children. Additionally, an emotion recognition module will be integrated to this platform to detect the emotions of these children. Note that children's motivation during the rehabilitation affects the success of the therapy significantly. Thusour objective is to improve the engagement of these children during the rehabilitation processes in the long term using this platform.

This interdisciplinary project involves several modules, including emotion recognition; game based audiological test production; and interaction with a social humanoid robot. The pedagogues and audiologists will develop the audiological test content and track the performance and involvement of children. The routines for the social robotics platform and the interaction between the robot and the children will also be developed. Furthermore, the video, audio, Electroencephalography (EEG) , and physiological signals will be collected, analyzed, and classified to understand the emotion (positive, neutral, and negative) of the children.

Emotion Recognition:

Various studies had worked on emotion recognition of children. Frightened, happy, and angry facial images were used in a healthy 7-year-old group [1].The averages of the EEG recordings were taken and the effects of the changes on the P300 amplitudes were examined for the emotional state [1]. It was also emphasized in [2] that the level of relevancy observed in the frontal region of the brain was affected by autism disorder by looking at with EEG analysis in healthy and autistic children between 8-16 years of age In this project Smart BCI Microbox 24 channel multi-purpose and wireless communication biosensor amplifier device will be used to record EEG data. EEG measurements will be collected using a 24-channel, MCSCap cap with an Ag / AgCl scalp electrode, in short open eyes, with a short duration of 3 min and a sampling frequency of 250 Hz. The hardware-compatible WinEEG software package will be used to auto-detect and filter out the noise (artifacts) caused by the environment, the measuring instrument, and the hand-arm-head movements or eye blinks. Analysis of the digitized EEG records will be performed in the MATLAB environment using a 2 second fixed-slipping windowing method. EEG affective rhythms, as one-channel EEG and two-channel relative, will be classified using Singular Spectrum Analysis [3] and spectral coherence estimation [4] methods on both the entire EEG signals and the EEG frequency bands. The classification process will be performed using the Support-Vector-Machine (SVM) method. Each classification step will be performed with a 10-fold cross validation algorithm.

Physiological data will also be recorded to determine the emotional state of the children. Physiological data measurements will be collected using the wristband E4. The skin conductance data will be received with the EDA Sensor (GSR Sensor) at 4 Hz. Blood volume pulse measurements will be taken from data collected at 64 Hz through the PPG sensor. The skin temperature data will be taken with infrared thermopile at 4 Hz. The E4 Wristband has a three-axis accelerometer. Mean value and standard deviation decisive features will be subtracted from physiological raw data. Feature selection will be performed using the Cohen's effect size and sequential floating forward selection (SFFS), sequential forward selection (SFS), set covering problem of correct classifications (SCP), minimal redundancy-maximal-relevance (MRMR) (RSFS), statistical dependency between features and labels (SD), and mutual information (MI) methods. Machine learning methods, such as linear discriminant analysis (LDA) and SVM will be used to classify positive, neutral, and negative motion of the children. Video footage (camera and Kinect) including face and posture, and voice recordings will also be recorded to understand the emotions of the children. Neurological and physiological measurements will be used as a reference data for face expression and voice measurements.

Game Audiology

Game audiometry, speech audiometry, and language acquisition analysis tests will be used as test material during the rehabilitation. Conditioned Play Audiometry (CPA) is a behavioral approach, which can be applied to children of 3 years or more, to detect the hearing threshold. CPA is specific to the ear and the frequency [5]. CPA is a "listen and throw" game. The child listens to the sound and gives a motor reply (throw a toy to the box, push a button, etc.) when the sound is heard. It is important to find motivating toys/stimuli to keep the children engaged for enough amount of time to complete the test, and to detect the thresholds. When the child gets bored or stressed he/she may not respond to the stimuli even if he/she can hear the sound, therefore it is important to change the stimuli when these negative emotions are detected.

Child-Robot Interaction Games

A child-sized robot will be employed as the assistive social robotic platform during the games. Social robotic platforms are used for interaction games with deaf children in our previous studies[6]. Several robotic behaviors involving speech, body, and facial gestures will be generated and kept in a behavior library. These behaviors will be used to manage the tests, and as a feedback mechanism. Child will use a tablet or his/her gestures to give answers to the robot, and get a feedback from the robot in return. The robot's actions will be triggered by child's responses. Wizard-of-Oz technique will also be used during the tests to initiate robot's responses. The tests will be repeated by using only tablet to analyze the robot's affect on the performance and motivation of the children. The game scenarios, audio and gestural feedbacks of the robot will be decided by the pedagogue, therapists, and child-robot interaction researchers together, and the results will be analyzed both objectively and subjectively.

Pilot Study

A preliminary study was conducted in November, 2017 at the Audiology department of Cerrahpasa Medical school with 8 volunteering family and deaf children of 3.5-6 years old. (This study is approved by the ethical committee). The children were asked to watch parts of cartoon movies of 5 minutes in total involving happy, neutral, and sad videos. All these videos were selected by the pedagogues and therapists. EEG, physiological data, and facial expressions by video camera were recorded during the experiments. Features were extracted from the recorded facial expressions. It was noticed that the lip corner angle was required to detect the positive emotions, while, the eyebrow angle was important in negative emotions [7].

Blood volume pulse, skin conductance, and temperature sensors from Thought Technology were also used to record the physiological data of the children. We noticed that although the sensors for receiving the physiological data were adaptive for the size of the hand and fingers, they were still big for the children. Therefore these sensors are not suitable for this age group. Additionally, the children were frequently moving their hands, which misplaced the sensors and we could not record the right data. That is the reason we decided to use a wristband to record the physiological signal in the project. The EEG data were recorded using the SmartBCI Microbox device.

At the beginning of the pilot study, children were asked to play HCI games "airhockey" and "fruitpicking" which were Kinect based games to motivate the children. When the children showed high performance and motivation in the games, in both games the difficulty level were are adaptively increased [8]. The children, who took part in the games, were more willing to take part in the data collection session, and communicated and collaborated with the researchers more. We plan to use these games as an alternative way to stimulate the emotions of children instead of the videos and pictures as used in adults.

Conclusion Future Work

This study is an interdisciplinary study bringing experts from social robotics, electrical-electronics, biomedical engineering, computer vision, pedagogy, and audiology; for the rehabilitation of deaf children, using an assistive social robotic platform to improve the therapy outcomes and to increase the motivation of the children. It is also possible to detect the emotions of the children (positive, neutral, and negative) using video, audio, EEG, and physiological data during the rehabilitation process, which can be used as a feedback mechanism for the robotic platform.

References

1. Kestenbaum, R., & Nelson, C. A. (1992). Neural and behavioral correlates of emotion recognition in children and adults. Journal of experimental child psychology, 54(1), 1-18.
2. Yeung, M. K., Han, Y. M., Sze, S. L., & Chan, A. S. (2014). Altered right frontal cortical connectivity during facial emotion recognition in children with autism spectrum disorders. Research in Autism Spectrum Disorders, 8(11), 1567-1577
3. Aydin, S., Demirtaş, S., Ateş, K., & Tunga, M. A. (2016). Emotion recognition with eigen features of frequency band activities embedded in induced brain oscillations mediated by affective pictures. International journal of neural systems, 26(03), 1650013.
4. Aydin, S., Demirtaş, S., Tunga, M. A., & Ateş, K. (2017). Comparison of hemispheric asymmetry measurements for emotional recordings from controls. Neural Computing and Applications, 1-11.
5. Northern, J.L., and Downs, M.A., Hearing in Children, Lippincott Williams & Wilkins, 2002.
6. Uluer, P., N. Akalın, and H. Kose, , A New Robotic Platform for Sign Language Tutoring, International Journal of Social Robotics, Springer Special Issue on: "Taking Care of Each Other: The Future of Social Companion Robots", Volume 7, Issue 5, pp 571-585, 11/2015
7. Bayhan, B., Aydinalev, T.C., Kose, H. Rule Based Assessment of Hearing-Impaired Children's Facial Expressions, 26th Communication Application Conference (SIU), 2018, Izmir, Turkey, accepted
8. Kandemir, H. and Kose H. Effects of Physical Activity Based HCI Games On The Attention, Emotion and Sensory-Motor Coordination, 27th International Conference on Robotics in Alpe-Adria Danube Region (RAAD), Patras, Greece, accepted