THE DEVELOPMENT OF A ROBOT CONTROLLED BY SPEECH GENERATING DEVICES FOR CHILDREN WITH VERBAL IMPAIRMENTS

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ABSTRACT

Increasing the use of speech-generating devices (SGDs) would improve the quality of life of children with verbal impairments. In this study, SGDs are used as interfaces to robots to motivate children to increase use of their SGD. In this paper, the development process and user test sessions are described. Possible activities with this system are suggested for future studies.

INTRODUCTION

This paper describes the development of robots controlled by a speech-generating device (SGD) to engage children with verbal impairments in various activities. Robots have been used for children with physical and mental disabilities for purposes such as academic activities and social skills [1-3]. Augmentative and alternative communication (AAC) technology helps people with disabilities produce or comprehend natural speech and/or written language. AAC intervention can benefit people with verbal impairments by improving their communicative competence.

An SGD is often a PC-based AAC technology with a touchscreen that users to press buttons to speak words or sentences. Increasing the usage of the SGD is an important aspect of most users' speech therapy goals [4]. Cook and colleagues developed an SGD system that manipulates a robot through an infrared signal that allowed young children to participate in academic activities [5]. The primary goal of our research is to develop an SGD system that manipulates a robot through Bluetooth wireless communication. Advantages of the Bluetooth communication compared to the infrared communication are: no requirement of a line-of-sight, longer effective range (10m), and two-way communication. The secondary goal of this study is to understand how this robot-SGD system can improve speech rehabilitation of children with verbal impairments.

METHODS

Development environment

Microsoft Windows 7 Operating system and Microsoft Visual Studio 2010 were used for software development. Robots were constructed using the Lego Mindstorms NXT kit. A DynaVox Vmax SGD, manufactured by DynaVox Mayer-Johnson, was used as an interface for users to control the robot. A wireless Bluetooth USB adapter was used to establish a Bluetooth connection between the robot and the SGD. Microsoft .NET Framework 3.0 was installed in the SGD to run custom-made software.

Development process

The robot consisted of two servo motors and a toy wheelchair (Figure 1). The two motors could be controlled independently, so the robot could not only move forward and backward but also turn left or right. Because the DynaVox Vmax did not have enough memory to run a software development environment, or enough USB ports to connect a keyboard, a mouse, and a USB adapter, the software development was done on a desktop computer. The customized program that communicates with the robot was based on software developed by Kirillov [6], which was available under a GNU General Public License version 3 (GPLv3).

Figure 1: Lego mindstorm robot and participant's toy on a toy wheelchair

First, basic functions to establish wireless communication between the robot and the SGD were developed. Second, basic functions to move the motors were developed so that its speed, direction, and the amount of rotation could be controlled. Third, a page for robot control (Figure 2) was designed in the SGD, which consisted of four icons: go forward, go backward, turn right, and turn left. Fourth, a function, which sends a command to the next opened window, was programmed in an advanced programming page in the SGD. Fifth, a program that parses the input command and executes the desired operation was developed in the Microsoft Visual C# 2010. This program receives input from the robot control page and sends the appropriate command to the robot via Bluetooth.

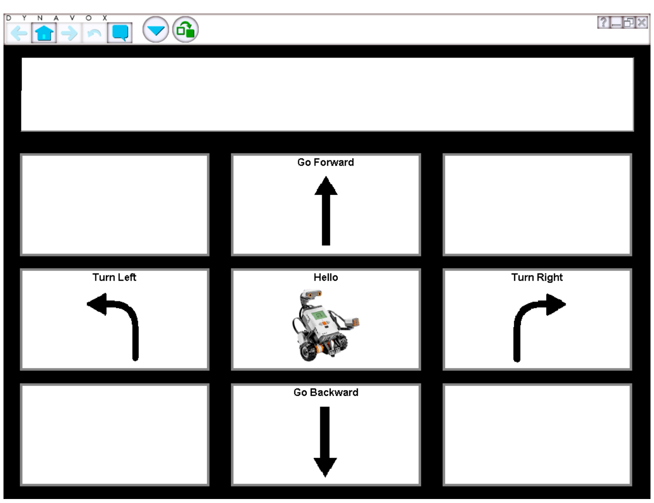

Figure 2: A page for robot control in SGD (Robot icon image courtesy of Lego Education)

The software was designed to be used without a keyboard because it was operated in a touch screen environment. The motor speed could be easily modified to meet potential users' requests. The balance of the robot was adjusted after test sessions because some users put their toy on the wheelchair. Additionally, a structure holding a pen was also attached to the robot so that the robot could draw color lines on paper, which was expected to engage children.

Test sessions

International review board approval of the study design was obtained from the University of Pittsburgh (IRB #10010440). Test sessions were conducted at the Children's Institute in Pittsburgh. Two young children (ages 6 and 7) who had cerebral palsy and had verbal impairments used the system with their speech therapist for their 30-minute sessions. During the sessions, the children were encouraged to move the robot by pressing buttons. When the children were familiar with the controls, the therapists gave them some challenges, such as making the robot come to the child or driving the robot to avoid an obstacle. For the child who did not engage in any previous activities, a pen was attached so that the child could draw lines on a paper while the robot was moving.

RESULTS

Two children at the Children's Institute in Pittsburgh used the robot-SGD system in their speech therapy session with their therapist. Both children were transitioning between speech therapists, so specific speech therapy goals were not firmly established. In the first session, the girl, age 7, tried to use an SGD to control a robot with encouragement by her speech therapist. The robot was placed on a bed so that she could see both the robot and the SGD while controlling the robot. She seemed to like pressing buttons randomly but she moved the robot without bumping into the wall or falling down to the floor. She enjoyed watching the anxious reaction of her therapist when one more forward movement would make the robot fall, but she quickly pressed the backward button just in time to keep it on the bed. Moreover, she had difficulty in pressing any button on the left part of the SGD because of the limitation on her arm's range of motion. However, she tried to extend her arm to press the left turn button to make the robot move left. It was also observed that she tried to use her SGD instead of vocalizations. For example, before the session, she used her arms and fingers to indicate someone who was pushing her wheelchair where she wanted to go; however, she pressed buttons on her SGD to express where she wanted to go after the session.

The boy, age 6, who had not been engaged in any other intervention to use his SGD, also used the robot-SGD system with his speech therapist. He used a head switch to select a button on the SGD to move the robot. It was difficult for him to press even a single button. However, he tried hard to press the button to play with the robot. A blue pen was attached to the robot so that any movement of the robot would draw a blue line on paper placed beneath the robot. He could move his head to control the robot and make abstract lines as he tried to draw. The therapist found that the children showed more concentration on using their SGD, so this robot intervention had the potential to increase their SGD usage.

DISCUSSION

Encouraging children to use their SGD is often a critical consideration for the development of AAC devices. If a device is not only easy to use but also enjoyable, users will be more likely to use it. The robot system controlled by SGDs showed the potential to increase the usage of SGDs by children with verbal impairments. To improve their quality of life, more robot-related activities could be explored in academic activities and social settings.

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