A Low-Cost Music-Interactive Accompanying Robot for Children with Autism

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Keywords: autism; social robotics; Arduino; accompanying robot

Abstract: This paper examines a music-interactive accompanying robot that is designed to improve the conditions of children with autism and help them regulate their moods. Compared to some of the current products that share the same goal as this robot, this musical robot has lower costs, more friendly appearance, and is better at providing and analyzing data for medical professionals. Through recognizing different NFC cards of various colors, this robot helps the children with autism identify their current moods and gives them a chance to create their own music in order to calm themselves down when they are feeling angry. Moreover, this robot will help the children connect their moods to different styles of music. The Arduino MEGA within the robot drives the entire system; the Bluetooth has the role of connecting Android devices with the robot itself (a bear toy). The control interface of the APP is made through APP Inventor.

1. Introduction

1.1 Motivation

Autism, also known as autism spectrum disorder (ASD), is a developmental disorder that features difficulties with social interactions and communication. It is caused by a combination of genetic and environmental factors. According to a governmental survey in 2018, the prevalence of autism is estimated at 1 in 59 births in the United States.

Autism is most common in children from 3 to 17 years old, and people with this disorder often have troubles with understanding social behaviors, expressing feelings properly, and developing language skills. Currently, the treatments for autism include medication and intervention. Medications like fluoxetine and naltrexone, though proven effective in some cases, are not necessarily the best way to treat autism. For children who are diagnosed of autism, their parents often use early intensive behavioral intervention, which involves the children's entire family, working closely with a team of professionals. Compared to medications, behavioral intervention can better help the children improve their conditions and learn linguistic and social skills, since it requires the children to be actively engaged with the environment they are in and teaches them how to interact with other people.

Though intervention can potentially improve the children's conditions, many children who have severe symptoms refuse to interact with real people around them. They often feel scared, or even angry, when other people, including their parents and teachers, try to talk to them. This disadvantage of behavioral intervention, as a result, inspired the creation of this music-interactive accompanying robot.

1.2 Commercial Products

Blossom: Blossom is a robot that helps children with autism with their social skills. It is a collaboration between Cornell University's Human-Robot Collaboration and Companionship Lab and Google Creative Technologies Singapore. One of the aims is to help children on the autism spectrum to develop social skills. It is all handmade and has a very appealing appearance, which is definitely one of its biggest advantages. However, the robot cannot speak to the children, which will potentially hinder the children from understanding what message the robot is trying to convey.

Milo: Milo is human-like robot that is able to mimic human facial expressions and help ASD children eliminate their uneasiness when interacting with human. Milo never gets tired or frustrated and is always friendly towards the children. However, the fact that Milo looks like real people can also become a great disadvantage. Many ASD children are afraid of real people and refuse to have face-to-face interactions with them. Therefore, they might feel uncomfortable when playing with Milo, just as they would when talking to real people.

1.3 Design Considerations

- Attractive appearance. The robot looks like a bear, which will better appeal to the children. Thus, the children will be more likely to play with the robot and engaged in the program designed in the robot.
- Inexpensive costing. The robot is made of inexpensive electronic components. This would allow the children and their teachers to change some of the aspects of the robot to cater to their own needs. In addition, the central chip and Arduino chip can be taken out from the bear toy and plugged into any toy favored by the children.
- Well-designed functions. The robot is able to recognize different color cards through NFC, interact with children using musical tones and rhythms, and etc. Therefore, the children with autism will be subconsciously connecting their different moods with different kinds of music. The goal is to have them manage their moods through creating music, and provide data for the medical professionals.
- Data collection. The APP will analyze data from the children's change in moods before and after the experiment. It can also provide medical professionals with related information, such as the children's preference over a certain type of music or color, to help them better understand the conditions of the children.

2. System Overview

2.1 System Diagram

The entire system is consisted of several connected modes. The first mode, for example, is a friendly self-introduction given by the system, or the bear toy, through a pre-recorded voice.

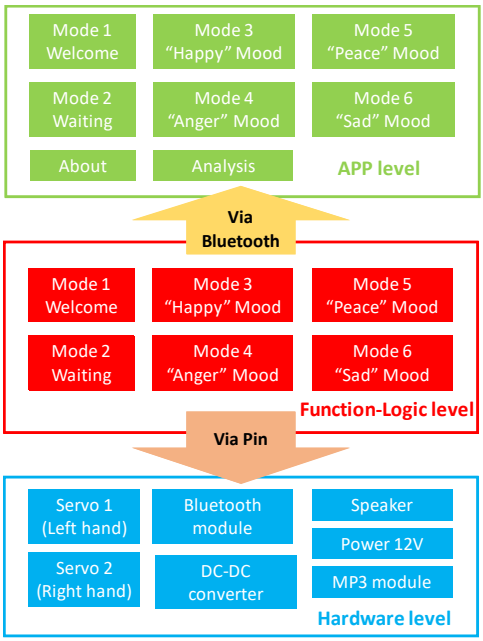

Fig. 1. System diagram.

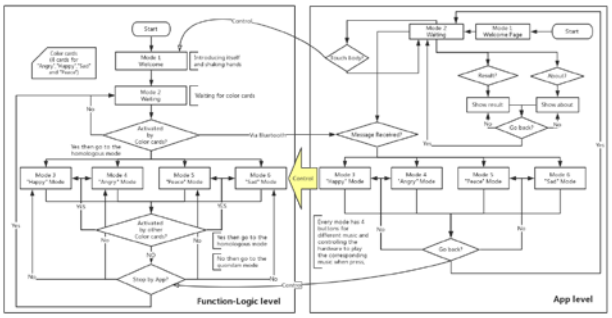

Fig. 2. Flow chart.

2.2 Hand Waving System

In order to maintain the flexibility of the robot, a mechanical structure that allows the movements of its arms was designed. The movement, or "waving," is accomplished through two servos. The two servos mimic the movements of human arms. To avoid malfunctions of the robot due to too much movement, the angles of movements are between 30-150°. Even though the NFC system is only installed within one arm of the robot, the waving system is designed to involve both arms due to the following reasons: 1) maintain symmetry of the robot; 2) create more variety in the robot's movements; 3) keep the robot balanced while it is moving. The waving system is shown in Fig. 3.

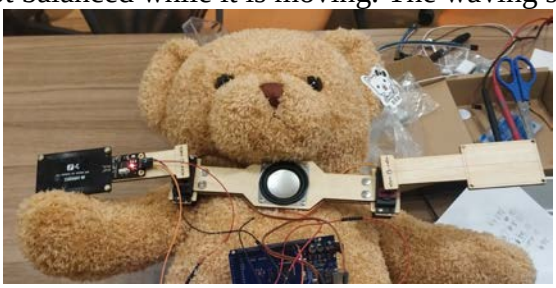

Fig. 3. Illustration of the hand waving system.

2.3 NFC Module

The NFC module is within the right arm of the robot, secured by screws. Since the NFC module is able to work within a certain distance, it will still be able to read and process the information even it is installed inside the bear toy. This design ensures the consistency and effectiveness of the robot. The NFC system is shown in Fig. 4.

Fig. 4. NFC system.

2.4 Speaker System

The speaker system is consisted of a 3W speaker and a SD chip. The SD chip provides input signals for the speaker, and Arduino Mage is in charge of controlling and providing power. Shown as Fig. 5.

Fig. 5. The speaker system.

2.5 Music System

The music system is supported by the Fruit Studio (Fig. 6). The user is able to change different music genres and styles using different color cards that represent their moods. Every music style has four sound tracks, which are drum beats, rhythms, and two other instruments. The synthesized sound tracks are stored within the robot under the MP3 format in various combinations.

2.6 User Interface and Operation Flow

The user interface is developed on APP inventor and is adaptable to the Android system. It connects automatically with the robot through Bluetooth and exchanges data with the Arduino on the robot. Therefore, it is able to analyze these data within the APP.

This robot has 6 modes (Fig. 7) in total, two of which are pending modes, and four are music-playing modes. When the robot first starts, it will be in its welcoming mode. This welcoming mode allows the robot to introduce itself and its functions, in order to eliminate the distance between the children and the robot. While it is in pending mode, the robot will be waiting for the children to swipe the color card, which will activate its music-playing modes.

Fig. 6. Sound editing system.

Fig. 7. Android APP user interface with different modes.

The APP has 8 functions. When the APP opens, it will automatically connect with the robot, after which the children can activate the robot's welcoming mode to listen to its self-introduction. While

the robot is in pending mode, however, the APP waits for the robot to send out signals that indicate the children's mood. As soon as the APP receives the signal, it will transition into the respective interface that invites the children to mix and match different musical rhythms and beats to create a melody of their own. When the creating process is finished, a feedback form will appear on the screen, and it asks for the current mood of the children. This function is designed to see whether creating music will actually help the children to adjust their moods.

2.7 Bluetooth Communication

The type of Bluetooth module is HC05 (Fig. 8). It is in charge of the signal communications for the entire system. The module activates as the robot starts to work and connects to the APP automatically. This function solves the potential problems caused by manually connecting Bluetooth with the system.

Fig. 8. Bluetooth module.

3. Project Output and Testing

The results brought by this musical robot is successful and as expected (Fig. 9). After several improvements of the system and the appearance of the robot, the children express the willingness to play with it and show their patience in "communicating" with this bear toy. They also show the gradual improvement in creating music on their own as they get used to using this robot.

During the experiment, the children were cooperating with the bear toy, which acts like a friend of theirs, and trying to create their favored musical melodies on the APP installed on their phones.

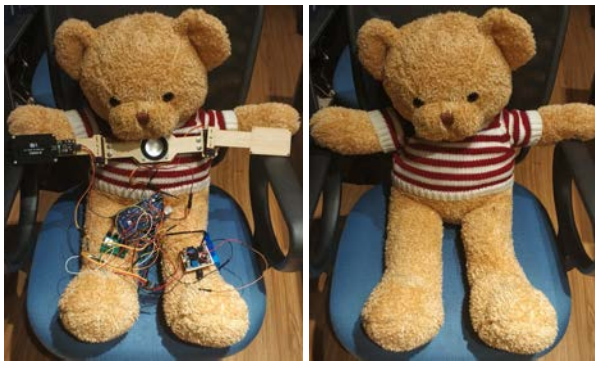

Fig. 9. The robot before and after the installation of the system.

One of the improvements about the robot made during the experiment is the overall aesthetics of the APP, because more organized and simple-looking APP pages can attract the children's attention.

4. Conclusion

This musical robot is designed to help the children with autism who have difficulties expressing their thoughts or regulating their moods. The goal is to help these children build a personal relationship with these bear-looking friendly robots.

The children can tell the robot their mood by swiping the color card that is respective to that mood. This would allow the robot to activate different beats and rhythms stored in the system. Then, the

children can start making their own unique music on the APP portal. At the end, the APP will ask the children to select their current mood after playing with the robot and later send these data to medical professionals who can potentially use the information to adapt the treatments for these children.

The overall system is very effective and affordable. In addition, the system can be installed into any other toys that has arms, if the children prefer.

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