Robotic Assistive Technology for Enhancing Autistic Children Social Life

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***Abstract*—Autism is a very serious and widely spread neurological disorder that affects millions of children around the world. Since 1990, the number of autistic children has increased in an alarming number, while many other children are still there who are not yet diagnosed. Autism cannot be detected at the birth or early stage of the child development. Unlike other diseases, the symptoms vary from one child to another. In this paper, we try to address this issue and propose a solution, a robotic toy, to improve the social interaction skills of autistic kids. These kids do not usually respond appropriately to human interaction. An effective solution that we are proposing to help solve this issue is to design a less intimidating companion, a toy robot, that can enhance their social interaction capabilities. Studies have shown that autistic kids respond and react to a robot, controlled by a therapist, more effectively than to a human being. It is easier for a therapist to gain the child's attention through the robot and can effectively help him/her learn the basic communication skills and prepare him/her to act as a normal person. The proposed solution can really help autistic children learn more quickly and have them lead a better social life.**

***Keywords*— Assistive Technology; Autism Therapy; Autistic Children; Robotics Intelligence; Autism Disorders.**

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I. Introduction

Autism is a developmental disability of the brain that presents itself in a child's early years of life. An individual suffering from such a disorder is incapacitated when it comes to social interactions, development of language and lack of communication with repetitive behavior. The degree of these problems fluctuates from one child to another, depending on the intellectual and social development of the individual. Problems vary from the inability to speak, difficulty in using language efficiently to troubles with word and sentence meaning, intonation and rhythm. Children suffering from this disorder have a very poor attention span and seldom make eye contact. They are unable to provide responses to the speech of others, but they unusually grow attached to objects [1]. Autistic children find it difficult to interact with humans as they find their emotions and behavior very confusing and difficult to understand. Some research shows that the success of standard therapy session between the therapist and the child is not guaranteed [2]. It has been reported in recent works that robots can provide a unique assistant to children with autism and improve the quality of their life [3, 4, 5, 6].

Robotics is extensively used in assistive technology. Assistive technology refers to a class of devices designed with the aim to interact with people incapacitated by functional impairment and disabilities. These devices seek to improve or facilitate one's function, and to speed up the recovery process. Assistive robotics has been developed for numerous domains like autism, elderly care, intelligent wheelchairs, assistive robotic arms, external limb prostheses, and stroke rehabilitation. In recent years, there has been an increase in research related to the use of robots in the attainment of therapeutic objectives for children diagnosed with autism. Initial results provide evidence that the behavior of autistic children is less severe when they interact with robots as opposed to their peers [2]. The advantage of robotic toys is that they are programmable and can be made to respond differently depending on various situations [7].

As autistic children have a limited repetitive weak social interaction, we believe that our project will help investigate the possibility of using robotic platform as part of therapy aid for children with autism. The robot could provide a comfortable atmosphere for autistic children to understand the general scene and not be distracted or stressed by every detail around. Moreover, they face difficulty interacting with humans due to the overwhelming nature of human interaction which consists of various facial expressions, tone of speech etc. Furthermore, the fact that their therapists are human makes it increasingly difficult for them. Therefore, a robotic platform whose interface is simpler compared to a human will help in providing a friendly environment for the child since the robot will present information to them in a familiar cartoonish manner. Another supporting study in the field of Human robot interaction is that of Robins, et al., who observes that robots can provoke social behavior that is not naturally occurring in children with autism [8]. Kasper is another robotic toy developed by researchers at the University of Hertfordshire's School of Computer Science in the United Kingdom as part of the Interactive Robotic Social Mediators as Companions (IROMEC) [9]. Bandit robot was developed by scientists at the University of Southern California as an attempt to create a human like robot that autistic children can communicate without reservation [10]. Pleo robot which resembles a baby Camarasaurus, a plant eating dinosaur from the prehistoric period. This robot is different with its uniqueness as it is built to constitute a very convincing motional and visual appearance [11,12]. Keepon robot, developed by Hideki Kozima Keepon, was designed to study social development by interacting with children [13].

II. Proposed Solution

The proposed robot design is intended to help autistic children. The proposed solution explores the use of a remotely controlled mobile robotic toy to improve autistic children social skills. The interaction will be solely between the child and the robot. A therapist will be able to remotely control light display to grab the child's attention and make it flashing whenever they think it is appropriate. Ultrasonic sensors are used to maintain the distance between the child and the robot. A video camera is used to act as the eye of the therapist through which he/she can see and observe the child and also record the session for future study purpose and further analysis. The robot is also capable of producing sounds via a wireless speaker, so as to initiate conversation, compliment the child and/or give instructions to the child to do various things.

A. *Functional requirements*

The robot is required to do the following:

Display Flashing Lights: The therapist, when feels the need, can switch it on and off. This particular feature was added for interactive purposes. It is intended to grab the attention of the child. Autistic children, being non- verbal, do not respond to speech. Therefore, flashing colored lights are used to grab their attention.

Produce Sounds: Sounds resembling that of their parents will be produced by the robot in the form of compliments, conversation and initiations (for play, exercise). This is in order to create a sense of familiarity between the child and the robot.

Detect the position of the child: The robot is expected to detect the position of the child and move away when too close and move closer when too far. It also avoids obstacles in its way. Since, autistic children have issues with impulse control and have the tendency to get too close to people and invade their personal space. For this purpose, sensors are used to ensure that a safe distance is maintained between the child and the robot.

Video stream to remote locations: A video camera is fitted on the robot to fulfill this requirement. A video of the robot-child interaction session is recorded using the camera for exploration study and further analysis by the therapist on the behavior of the child. The camera can serve as the eye for the therapist through the robot during the interaction by providing live video feedback.

Motion: The robot can move in all directions using various motors to enable movement. The robot mimics the actions of a human, although not entirely; it is capable of moving around. A remote control is used to control the motion forward, backward, right, left, and spinning in place motion.

B. *High level architecture of the proposed system*

Figure 1 shows the block diagram of the high level architecture design:

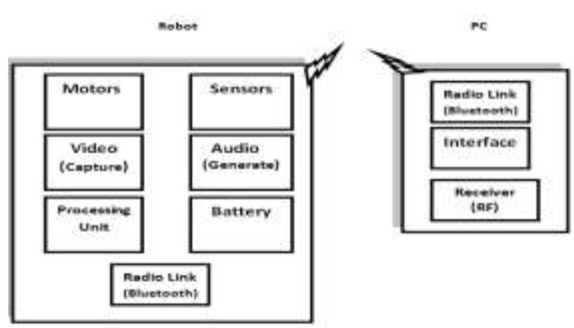

Figure 1. High level architecture design.

Figure 2 shows the block diagram of the basic circuit of the robot system:

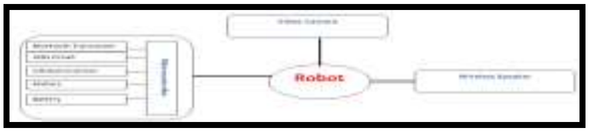

Figure 2. Basic block diagram of the robot system.

LabVIEW software is used to integrate the hardware with the user interface. LABVIEW is short for Laboratory Virtual Instrumentation Engineering Workbench. It provides a visual graphical programming environment for the development of highly sophisticated measurement, test, and control systems with the use of graphical icons and wires resembling a flowchart. The most significant feature of this software is the ability to integrate numerous hardware devices and its built-in libraries for advanced analysis and data visualization namely data acquisition, signal generation, mathematics, statistics, signal conditioning and analysis. It operates on multiple operating systems [14].

C. *Hardware design*

We used one of the high quality educational robotics kits, Johnny-5 [15], a robotics kit provided by Lynxmotion. Johnny-5 consists of a Servo Erecter Set aluminum brackets, custom injection molded components, and ultra-tough laser-cut Lexan structural components. The robot is made from Servo Erector Set of aluminum brackets and ultra-tough laser-cut Lexan structural components. The torso is fully articulated utilizing 8 x HS-645MG, 3 x HS-475HB / HS-485HB, and 3 x HS-422 servos. The tracks utilizes heavy duty polypropylene and rubber with durable ABS molded sprockets. Arduino Mega ADK 2560 microcontroller, see Figure 3, provides 14 ports making it an ideal microcontroller for the use in this project.

Figure 3. Arduino Mega ADK 2560 Microcontroller.

As shown in Figure 4, each motor will have three ports and each port is connected according to its color: Black to the ground , red to the voltage supply, and white to a specific pin in the microcontroller.

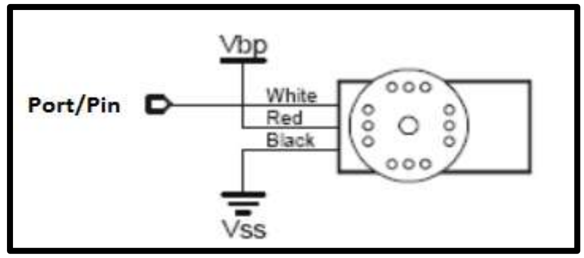

Figure 4. Servo motor PWM ports.

As opposed to the PIC series microcontrollers, Arduino Mega ADK 2560 microcontroller is much smaller and can fit into the compact structure of the robot. BASCOM-AVR software is used to program the microcontroller. BASCOM-AVR is a very powerful and easy-to-use compiler for the AVR series of microcontrollers developed by Atmel. The program comes with a very user-friendly interface and a set of simple commands, and provides more flexibility than other programs in this category. It has a low flash memory requirement. The pins and ports are assigned as shown in Table 1.

An LED circuit is designed to help fulfilling the flashing light patterns feature and it is used to attract the autistic child to interact with the robot.

TABLE 1. ASSIGNED PINS AND PORTS OF THE MICROCONTROLLER

The Port name	Pin number	Port number
Left Wheel	22	A0
Right wheel	24	A2
Left hand 1st motor	26	A4
left hand 2nd Motor	28	A6
Left hand 3rd Motor	30	A7
Right hand 1st motor	32	C5
Right hand 2nd motor	34	C3

The 555 monolithic timing chip is wired to act as an oscillator as shown in Figure 5. The output of the 555 is directly connected to the input of a 4017 decade counter. The input of the 4017 counter is called the CLOCK line. The 10 outputs Q0 to Q9 become active, one at a time, on the rising edge of the waveform from the 555 chip. Each output can deliver about 20mA, but with a current-limiting resistor used (270R.)

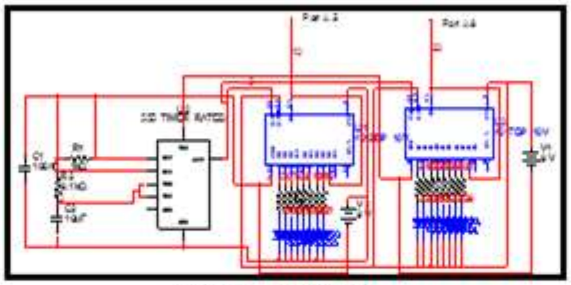

Figure 5. LED circuit

The user interface basically consists of the sounds that can be played by the user, i.e. the therapist or the parents, through the robot. It has a list of phrases in English and in Arabic as shown in Figure 6. The user needs to press the buttons on the VI to be able to play the sounds and the sounds are grouped into Arabic and English to provide versatility. The user interface allows the therapist or the parents to control the robot via a joystick controller. This controller is initialized by LabVIEW interface and the outputs of the joystick are processed to generate the required output control signals. These signals are sent via Bluetooth (the mode of communication between the robot and the LabVIEW interface) to the microcontroller which performs the required tasks.

Figure 6. LabVIEW Interface.

The different components of the robot are integrated and then tested to meet the desired functionalities. The robot has produced a certain flashing pattern of red light in response to certain behavior in order to catch the child attention. The robot played audio signals resembling that of their parents in the form of compliments. The robot used sensors to detect its position from the child and move away when too close and move closer when too far. It also avoids obstacles in its way. A video of the robot-child interaction is also recorded by the robot camera for investigation study and future analysis by the therapist on the behavior of the child.

III. Conclusion

This work presents a research work on designing a toy robot that helps improving the social interaction skills of children diagnosed with autism. The objective of the project is achieved. The robot functionalities are implemented and tested to meets the requirements. This work targets autistic children to enable them to overcome their fear of communication with their peers. Information from a therapists, specialized in autism therapy, is used to complete the tasks of the robot. The features and functionalities of the robot are proposed by a therapist. The project is effective in completing the intended functionalities. It is capable of various movements, actions, playing sounds, and displays flashing lights. The movements are controlled by a joystick controller. Also it is capable of determining and keeping a safe distance away from the child. It interacts with the child using audio records played through a Bluetooth interfaced speakers. The improvements of the child interaction is recorded using a wireless video camera for investigation analysis and further diagnosis purpose.

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