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A Novel, Robotic Assistant in the Education Using Embedded Systems

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Abstract—Babyhood ambulatory disabilities reduce not only the most effective physical development but also children's social attachment. Robotic aids can help improve the autonomy of children with disabilities; however, affordability issues, coverage challenges, and uncertainty regarding schooling requirements restrict the early use of these devices. In this work, we built on cheap research-grade learning aids for children and kept in mind the way to lay out and evaluate an assistive robotic that can aid the use of these gadgets. With kids' contingency gaining knowledge of skills in thoughts, we designed a robotic capable of offering age-appropriate help in learning, such as learning the alphabet and learning many valuable things in daily life. Typically, this paper reports on others interested in assistive robotic interventions for babyhood ambulatory disabilities. Moreover, the results prove that the designed and embedded system can give an acceptable control performance for the robotic considering the conditional environmental conditions of operation.

Keywords—Assistant Robotic, Android-based smart devices, Speech Recognition

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I. INTRODUCTION

Educational robotics is a contemporary innovation that improves learning environments and develops knowledge [1]. The development of a pleasant and practical environment by Educational Robotics increases students' interest in STEAM (Science, Technology, Engineering, Arts, Math) activities and programming [2, 3]. Educational robotics imparts knowledge of science, technology, engineering, and math [4]. It encompasses a wide range of educational initiatives, resources, and learning theories in addition to robotic technology [4, 5]. Knowledge of commonplace items, namely educational robotics, is a smart school paradigm component, such as speakers, buzzers, and sensors (temperature, proximity, motion, and light). This robotic is primarily made for this demographic because it was created to help those who have trouble learning [6].

The approach of instructional robotics is centered on creating a robotic from scratch and programming it. According to various studies [6, 7], educational robotics has several advantages, including teaching students how to code and program and enhancing their social, mathematical, and physical skills. Furthermore, educational robotics is a state-of-the-art teaching and learning tool that supports students [2] comprehension of abstract design by enabling them to comprehend concepts and create multiple representations.

Students' learning should be increased, especially in the STEAM fields, by fostering their high-level abilities, expanding their knowledge (by tackling problems from the real world), and improving their cooperation and communication skills [8-15].

Kurt Lewin and John Collier [12-17] developed action research in the 1940s with the intention of involving researchers with social groups in problem-solving. Action Research or AR techniques were included in educational research around the beginning of the 1970s to encourage teachers to become better researchers and further their professionalization [18]. Teachers can learn about educational practices, develop information, and, if necessary, evaluate their practice using the action research approach [19]. Because AR is primarily a short-range activity carried out by the participants and other individuals in the same community intending to practice, it is applied in many scientific fields nowadays, including information systems [18]. There are several AR ~~Action Research~~ models, and practically all of them follow a spiral or circular approach [21, 22]. The most popular action research paradigm presents a spiral of cycles where each research stage contains the following phases: preparation, action, observation, and reflection/evaluation, leading into additional cycles where these phases are repeated [23–25]. An application installed on the phone may be used to control the robotic's movement, among other things. In addition to the application, you can soon command the robotic with your voice. For several capabilities, such as voice control, the robotic can first use face recognition to confirm the identity of the person making the command.

II. SYSTEM ARCHITECTURE

The emphasis on extensibility, rapid development, and usability in the proposed instructional robotic design has to be considered. The robotic's construction should be straightforward to build and should not include any problematic ("exotic") electronic

components. In order for robotics to evolve with additional actuators and sensors, it should also be open-source. As the majority of devices (smartphones, tablets, and PCs) can operate without an internet connection or the need to download and install software, the robotic should be easy to program. Children grow their imaginations and creative skills as a result.

The block diagram of the robotic's architecture is shown in Figure 1. The major element of the block diagram, which determines how the robotic operates, is the microcontroller, which regulates several operations, such as,

- To perform the role of a middleman web server, managing requests from users' clients (devices like PCs, tablets, and smartphones).
- To link users' devices to the robotic's user interface (UI).
- To convert user-provided commands in programming languages into directives for robotics. As can be seen, a platform for image processing was developed.

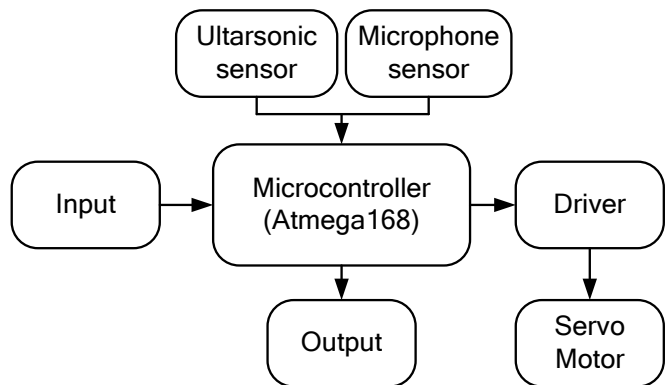


Fig. 1: System Architecture

1. Robotic Design

In robotics, a chassis denotes the fundamental framework or structural base upon which a diverse array of robot components is affixed. This foundational structure serves the pivotal roles of furnishing support, ensuring stability, and furnishing a secure anchorage for an assortment of integral parts, including sensors, actuators, and control systems.

In this paper, the robot is built on a chassis that was 3D printed, as shown in Figure 2. Every robot

component is 3D created and printed, making it simple for the educational community to alter. The 3D pieces and additional parts comprise its hardware, including two servo motors, a battery, and a battery holder, numerous electrical components, and other hardware for assembly.

The enclosure that houses the robotic's electronic components and gives it a more appealing look is known as the shell. One of the fundamental requirements for the robotic was that its design should be simple enough for the educational community to modify. Children can be able to build up the "ideal" for robotics by developing their creative instincts and imaginative faculties. Therefore, Solidworks, an online, cloud-based, accessible, collaborative, 3D program that can be 3D-printed by a 3D printer, was used to build its shell.

In Figure 3, the final form of the educational assistant robot is illustrated, presenting its final design and configuration.

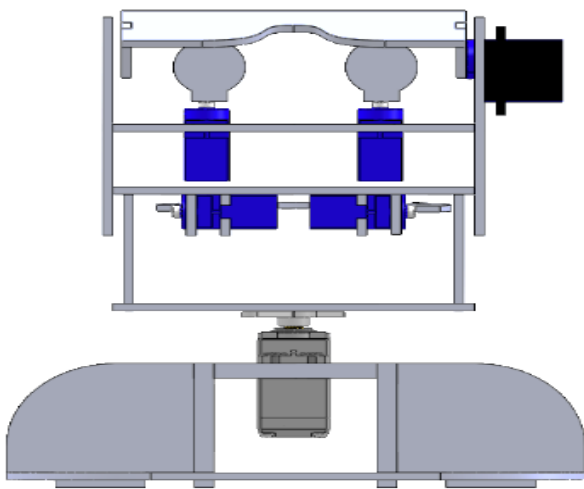


Fig. 2: Structure of educational robotic

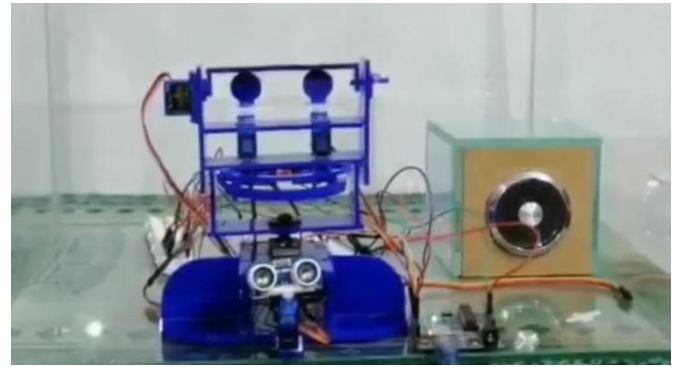


Fig. 3: The final design and configuration of educational robotic 2. *Local processing controller*

A CEREBOT NANO board with an Atmel ATmega168 microcontroller with 16KB Flash, 1KB SRAM, and 512B EEPROM serves as the local processing controller. It receives orders through a two-wire UART interface and converts them into motions by managing the two H-bridges. It takes information from two encoders positioned on each motor wheel's shaft. Then, it corrects the movement of the wheels based on that information to guarantee a straight and comfortable ride. This controller is compact and ideal for embedded robotic base control since it handles every component of movement, allowing the robotic base to be totally modular. With the aid of ATMEL AVR Studio and the Win AVR library, this microcontroller is programmed in C. Because of its wide range of supply voltage capabilities, it is ideal for battery-powered applications. Software-wise, the robotic base controls the motors by creating the proper PWM signal on two different channels, reading the encoders, and adjusting the speed in accordance with these values.

III. THE MAIN CONTROLLER

1. Ultrasonic sensor

The ultrasonic sensor measures the distance. It can produce high-frequency sound waves that are inaudible to the human ear, yet when these waves strike an object, they bounce back as an echo. The time takes to bounce back to the sensor and the distance traveled are also determined. The sensor transmits and receives ultrasonic waves when it collides with an item. The Arduino then does some calculations to convert the determined value from time to distance based on knowing the speed of sound in the air to measure the distance between the sensor and the object based on the time between transmitting and receiving the waves. The Arduino can then show the distance between them on the LCD screen. We must divide by 2 since we want to compute the distance, which depends on the time to go.

The sensor transmits ultrasonic waves, which bounce back when they encounter an obstruction. This allows the Arduino to calculate the time it takes for the waves to go and return.



Fig. 4: Ultrasonic sensor

2. Central processing controller

A PIC32MX795F512 microcontroller is found in a CHIPKIT Max32 board, which serves as the central processing controller. It runs at a relatively high frequency of 80 MHz and has 83 open I/O ports, 512K Flash, and 128K RAM. One of its most significant aspects is that this board is compatible with Arduino, both in terms of software and hardware. Due to this interoperability, the design may be quickly expanded by utilizing the well-known Arduino shields while ensuring great code portability.

This Arduino clone serves as the primary controller and is linked to every part of the robotic:

1. The range sensors
2. The Servo motor
3. The Bluetooth module
4. The robotic base

The powerful microcontroller allows for rapid system enhancement with multiple sensors, advanced neural networks, and actuators.

IV. THE TABLET PC

1. Specifications

The TABLET PC may be an excellent tool for developers, mostly because it has a variety of onboard sensors and because its operating system, which is often Android, allows for quick development. This development platform offers the following benefits:

The target devices are compact, portable, battery-powered, and multimedia-enabled; the development tools are open

source or free; and the majority of the devices support WIFI, Bluetooth, GPS, and GSM.

The TABLET PC selected for implementation has a 1,2 GHz Core 2 Duo processor and a 1GB RAM. A WIFI adaptor external to the device. This adapter fills in for the one that is missing, and there is no difference from a software standpoint. Android 2.3 is the operating system that this TABLET PC uses. The TABLET PC receives Internet, voice, or manual commands, which then process and send the outcome to the robotic base.

2. Software client

A software client was written in order to connect a PC to the TABLET PC. The software client is written in Java using the Slick 2D game library. The connection is done via the internet, offering users a telepresence service. The keyboard Mapping is as follows:

- Up key = the robotic moves forward
- Down key = the robotic moves backward
- Left key = the robotic turns left
- Right key = the robotic turns right
- Space key = sudden burst of speed
- Q key = head up
- A key = head down

V. RESULTS

This work features a constructed robot in Figure 3 that can be remotely controlled over the web. The following tests have been conducted to evaluate the performance of the presented design:

A. First Test

The remote user may drive the robot forward, backward, and left or right when the client software is linked. The user is able to browse remotely thanks to a video feed. The robot has the ability to protect itself from harm as well as the environment in which it operates. The robot stops at a safe distance from an item thanks to the two IR range sensors, and it prevents movement in that direction until the barrier is eliminated. The item can still be avoided by turning to the left and right or by going backward. This is a safety measure to prevent injury to people or environmental harm. Voice instructions can also be used to operate the robot. To do this, the user must speak "manual control" to enter a specific mode. By uttering the keywords "left," "right," "forward," and "backward," after entering this mode, the user may move the robot forward, backward, or turn in either direction. The robot moves for a certain distance when given the orders to go forward or backward, while the commands to rotate to the left or right cause the robot to spin for a predetermined number of degrees. The user cannot change those specified distances.

B. Second Test

The user just uses the word "exit" to leave the manual command mode. Even if a user was connected to the robot when the manual control mode was activated, the robot could not be controlled remotely while in manual control mode. A follow-me feature may be used to control the robot. When using this option, the user must say, "Follow me." The robot then switches to a mode that keeps a safe distance from the person and follows them. The user must speak "stop" before the robot can halt. A rudimentary dialogue between a person and the robot is possible thanks to the robot, in which the person asks questions, and the robot responds. When a user says hello, the robot can introduce the man. The robot can also provide the current time and date if one asks.

C. Third Test

A primary health problem diagnostics chat is also offered so that the robot may advise the patient on what to do if they have a condition that can be treated quickly and locally, such as by taking some medication. If the user permits it, the robot can call for assistance from another human or emergency service.

Conclusions

In this study, an instructional robotics system produced using an embedded system after being inspired by survey data was given a favorable evaluation by the model, which is especially promising for further robotics development. The adoption of technology by the user suggests a favorable psychological state towards the usage aim, thereby guaranteeing the success of the robotic. In addition, technological acceptance must always reflect consumers' needs for technology, and this study has certain limitations. First, because of COVID-19 constraints, the researchers could not evaluate students in the classes. Second, this model was employed for evaluation. It would be more trustworthy if this research could be utilized in conjunction with other theories, such as the Unified Theory of Acceptance and Use of Technology. Third, the participant-related characteristics and other external variables were not considered. Previous research has shown that elements such as age and gender might have an impact on users' opinions. Future work has been planned to improve the control performance of the robot by integrating advanced control algorithms and incorporating AI and image processing techniques.

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