The Implementation of Safety Systems into Ride-On Cars to Enhance Play Therapy for Children with Physical Disabilities

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Abstract* - Children with mobility impairments experience less independence and freedom than other children. To solve this problem, the Lil' Rhody Riders project was founded between the physical therapy and biomedical engineering departments at University of Rhode Island (URI). Ride-on cars were adapted for children with mobility impairments to allow them to experience more independence, freedom, and interact with their peers. The most important aspect of modifying the ride-on cars is safety; cars were equipped with safety straps to aid in proper posture and positioning of limbs. The child's controls of the car were modified to simpler systems to fit each child's needs. To add additional safety, automatic collision avoidance systems using ultrasonic sensors, PIC microprocessors, C++ coding, and relays were implemented onto the ride-on car's electrical system. A parental override Android application was also developed using Android Studio and implemented using Bluetooth and the PIC microprocessor. A prototype was developed with these features and offered a model for a commercialized ride-on car for children with mobility impairments.

Keywords—mobility impairments; therapy; ultrasonic collision avoidance; Bluetooth; ride-on cars; Android

I. Introduction

Cerebral Palsy (CP) is the most common childhood disability. Around 500,000 children are currently living with CP. Studies have shown that about 3 out of every 1,000 babies born will be diagnosed with CP and roughly 8,000-10,000 babies or infants are diagnosed with CP each year. Similar to other mobility impairments, children with CP experience trouble with muscle coordination and control over motor movements [1]. Children with CP can benefit from various types of physical therapy; helping to overcome their limitations and improve muscle function is among the numerous benefits. One study involving 55 children with CP found that when examining functional skills in daily situations, children exposed to play therapy improved more than in traditional therapy [2]. Additionally, a study by Huang et al. [3] concluded "modified [ride-on] cars have a serious potential to be a fun and functional power mobility option for children with special needs". Commercially available ride-on cars have dual-task control systems that require the gas foot pedal and the steering wheel to be used simultaneously. The lack of muscle coordination in a child with a neurological disorder can make this task seem nearly impossible.

A multidisciplinary team of biomedical engineers and physical therapy students was formed at URI to solve this problem by integrating play and physical therapy. The team adapted ride-on cars for children in the community with CP and other mobility impairments. The prototype for this project included additional posture support with safety straps. The dual-task control system was rewired in to one task. An ultrasonic automatic collision avoidance system was also implemented to compensate for delayed reflexes (Fig. 1.). Emergency parental controls were created in an Android application to allow the parents to remotely stop the car using Bluetooth technology.

The modified ride-on car improved the child's sense of inclusion and independence through play and their mobility through physical therapy exercises. Each individual car was built depending on the child's dimensions, anticipated physical therapy exercises, and parental wishes. As this project progressed, the adaption of ride-on cars continued.

II. MATERIALS AND METHODS

A. *Electrical design*

One of the first steps taken to modify the ride-on car was to rewire the original wire control system to meet the specific requirements. A block diagram of the system can be seen below in Fig. 2. By rewiring the leads to the gas pedal, a single button could control the gas. Additional modifications to the car were made so that a joystick could be used instead of a wheel for simplified steering. This was achieved by tapping into the remote-control circuit so that the joystick is dictated by electrical signals rather than simple mechanics. The power to the car was rewired to our own integrated circuit board that utilized the ultrasonic sensors.

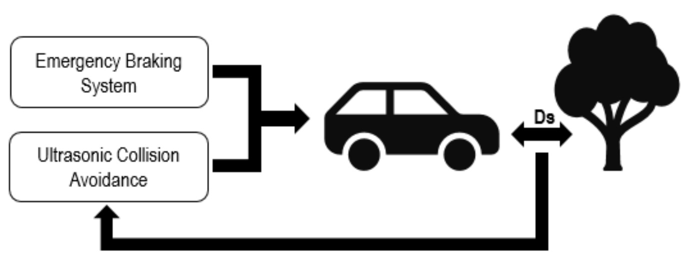

Fig. 1. Diagram of Incorporated Safety Features, "Ds" is Programmable Stopping Distance

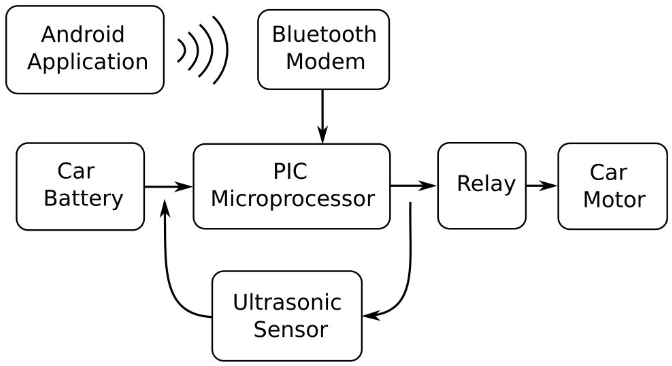

Fig. 2. Block Diagram of Adaptions in Ride-On Car

Using a PIC microprocessor, we can control the ultrasonic sensor and determine how the car reacts. From the output of the PIC, the signal from the electronics is not enough to power the entire vehicle so a relay was implemented allowing the low current electronics to control our high current car. Capacitors help retain the charge, which allows the car to remain powered without restarting.

B. *Software Design*

To implement the collision avoidance system, a program was developed in MPLABX (Microchip, Chandler, AZ), which programmed the PIC microprocessor to cut the power to the gas when the car was three feet or less away from an object in the distance. The program calculates the distance by computing the length of the echo received by ultrasonic system, and converts this to feet. The ultrasonic sends a signal out every 100 milliseconds, triggering fast enough to keep the child safe, but also slow enough to ensure there is enough time to complete the calculations. Another safety feature added to the car was the development of an Android application used as an emergency brake. An application was created through Android Studio with a single button for stop. Once the button is pressed, this information is relayed to the PIC microprocessor via Bluetooth, and the PIC is programmed to read this information and tell the car what to do.

III. Results

The ultrasonic automatic collision avoidance system was integrated into the car and successfully stopped the car (see Table I). The total cost of this system was approximately $15. Lastly, the Android application successfully communicated with the automatic collision avoidance integrated circuit and stopped the car (see Table I). The total cost of the Bluetooth Android communication system was approximately $25.

TABLE I. Time and Distance Delay *

	Time Delay (seconds)	Distance Delay (cm)
Ultrasonic Collision Avoidance System	0.51 ± 0.10	46 ± 6.1
Android Application Emergency Stop	0.33 ± 0.00	29 ± 2.8

*The time (seconds) and distance (cm) delay of the ride-on car stopping at 2 mph and Ds was set to 91 cm.

IV. Discussion

The main goal for the adapted ride-on cars is to ensure the safety of the children. The needs for the ride-on cars vary with each child. Future directions include the support design adjustments for each child, depending on their needs, dimensions, and personal goals. Throughout this project, we experimented with numerous hardware modifications, we learned how to rewire the gas to a simple pushbutton, and how to rewire the steering system to a joystick. These skills can be applied when changing the hardware in the other cars. By understanding the underlying system of the ride-on cars, rewiring the additional cars and making the adjustments will be rather simple. The software applications will be universal from car to car. However, before the collision avoidance system and emergency brake is implemented on future cars, more tests need to be run to ensure their prolonged safety. In the future, the implementation of a graded joystick with jitter control would be ideal for the car, especially for children with little to no control of muscle coordination [4].

A major technical contribution of this project is the development of the Android application for remote parental controls of the ride-on cars. The experimental data showed that the Android wireless platform provided a good response time to ensure safe operation of the ride-on cars. For this project, the Android application can only stop the car, future projects should enable the application to control direction of the vehicle and start the car as well. The prevalence of the Android smartphones and tablets is advantageous for the implementation of various safety features in a cost-effective way.

Acknowledgment

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