Empowering Elderly Individuals through the Intelligent Shopping Trolley

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Abstract

In this research, we have developed a prototype that aims to improve the weekly shopping experience for senior citizens. Our system tracks the movements of elderly individuals, eliminating the need for them to exert physical force in pushing or pulling the shopping trolley. To achieve this, we utilize a combination of sensors, including a gyroscope and magnetometer, to estimate the user's walking distance and direction. Additionally, we employ WiFi fingerprinting to accurately determine the user's position. Our experiments have yielded satisfactory results in terms of tracking accuracy and the overall functionality of the system. By addressing the specific challenges faced by senior citizens during the routine and essential process of grocery shopping, our smart shopping trolley concept seeks to enhance their experience. Through the integration of tracking technology and sensor-based solutions, we aim to make shopping more convenient and comfortable for elderly individuals. The positive outcomes observed in our experiments validate the effectiveness and feasibility of this approach.

Keywords: smart shopping trolley, elderly citizen, smart phone, UML

1. Introduction

Senior citizens often encounter challenges when it comes to shopping, particularly in the case of grocery shopping. While there are options available such as helpers or online shopping, many elderly individuals prefer to do their own shopping but still require assistance in carrying their bags back home. The advancement of technology has sparked interest in integrating different systems, resulting in the rise of the Internet of Things (IoT) and its widespread use in wireless communication.

The term "smart" has become increasingly common in various electronic devices and technologies, such as smartphones, smart cars, smartwatches, and even smart homes. In line with this trend, the concepts of "smart shopping" and "smart trolleys" have emerged to provide valuable support to senior citizens. Smart trolleys often incorporate Radio Frequency Identification (RFID) technology, enabling products to be scanned as they are placed in the trolley. By utilizing ZIGBEE communication, the collected data can be transmitted to the counter, reducing the time spent waiting in queues. Moreover, the use of RFID technology in smart trolleys can enhance security by facilitating cashless transactions.

Additionally, the successful integration of purchased items, payment systems, and data collection relies on the implementation of IoT standards. This ensures smooth connectivity and compatibility among the various components involved in the shopping process. The Internet of Things (IoT) field is experiencing rapid growth in the world of wireless telecommunications [1]. Its purpose is to enable computers to interact with their surroundings and access information about devices and objects without the need for direct human involvement [2]. According to a report [3], IoT is characterized by moderate data transmission rates, affordability, and operates within the frequency range of 100MHz to 5.8GHz. This advancement in wireless technology offers users a flexible and cost-effective means of communication. A recent report [4], [5] suggests that by the year 2020, around 50 billion devices will be connected to the internet, opening up a plethora of functionalities. There is a rising demand for technology and a growing need for convenient shopping experiences, which has spurred increased research efforts in the development of smart shopping concepts. These trolleys are equipped with core functionalities such as following the user, navigating through the shopping paths, and avoiding collisions with obstacles. This technology aims to eliminate the physical strain and difficulties that elderly individuals often face while shopping, resulting in a more comfortable and enjoyable experience. Advancements in autonomous navigation have been a key focus in the development of smart shopping trolleys. Researchers have been exploring various approaches to enable autonomous navigation for smart shopping trolleys. For example, a new automated smart cart system for modern shopping centers was presented, along with Android application-controlled approaches [1]. These advancements in autonomous navigation provide the trolleys with the ability to move independently, allowing elderly individuals to navigate the store without physical exertion. The implementation of smart shopping trolleys for elderly care holds several key advancements and benefits. Other recent reports in [6], [7] describe a smart trolley system for mega malls that uses a microcontroller. It allows customers to automatically scan products with a barcode scanner and see running totals on an LCD display, without needing to queue for checkout.

In this paper, the novel smart shopping trolley has been introduced. The proposed smart trolley is designed to avoid the pushing the typical shopping trolley. It is also designed to follow the user to ease of the controlling process for the user.

2. Hardware Interfaces

The smart shopping trolley designed specifically for elderly care integrates various essential components to improve its functionality and user-friendliness. These components are crucial in creating a smooth and convenient shopping experience for elderly individuals. The following are the components utilized in this project:

2.1. *Micro Controller Unit (NodeMCU)*

The NodeMCU micro-controller is used in this project as the main controller which has the integrated WiFi module. NodeMCU is an open source Lua based firmware for the ESP8266 WiFi SOC from Espressif and uses an on-module flash-based SPIFFS file system. NodeMCU is implemented in C that ease the use of this component in IoT based projects.

2.2. *DC motor*

A utilized DC motor would have only two terminals. Since these terminals are connected together only through a coil, they do not have a polarity. Revering the connection will only reverse the direction of the motor.

2.3. *Inertial gyro sensor*

In our proposed design, we have included a special sensor called a gyroscope to help us keep track of how something is rotating. This sensor is pretty clever because it also has a built-in accelerometer, which measures how fast something is moving in a straight line. So, while the accelerometer tells us about the linear movement of the user, the gyroscope tells us about the angular rotation. By combining these two sets of information, we can accurately detect and understand how the user is moving. Another great thing about this sensor is that it's small and doesn't cost too much, which makes it a perfect fit for our project. We wanted to make sure we chose components that are both effective and affordable.

2.4. *H-Bridge dual motor controller L298N*

In order to control the rotation direction of the motor, the current flow through the motor must be inverted. The most common method of doing that is by using an H-Bridge circuit. An H-Bridge circuit contains four switching elements, transistors or MOSFETs, with the motor at the center forming an H-like configuration. By activating two switches at the same time, the direction of the current flow and as a result the rotation direction of the motor will be changed. In this project, the L298N is used as a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time.

3. Design and fabrication

In the world of shopping trolleys, we've seen various types introduced over the years. However, our project takes things a step further with the development of a smart shopping trolley that brings convenience to a whole new level. Imagine being able to control your shopping trolley using your smartphone, thanks to Wi-Fi technology. Through a real-time Wi-Fi connection between the trolley's micro-controller and your smartphone, you can effortlessly guide the trolley to your desired destination. All it takes is a few taps on a dedicated app installed on your smartphone to send commands to the micro-controller via the Wi-Fi signal. It's like having a personal assistant for your shopping needs.

But convenience isn't the only thing we focused on. We also wanted to ensure the safety of both the user and the trolley. That's why we integrated an ultrasonic sensor right at the front of the trolley. This little hero plays a crucial role in preventing accidents and damage caused by sudden stops or collisions. It works by emitting sound waves and then listening for the echoes that bounce back. By analyzing the time it takes for the sound waves to travel and return, the ultrasonic sensor can accurately measure the distance between the trolley and any obstacles in its path. This allows the trolley to adjust its movement and avoid potential collisions by utilizing the signals it sends and receives. So, in a nutshell, our smart shopping trolley combines the convenience of smartphone-controlled Wi-Fi technology with the added peace of mind provided by the ultrasonic sensor. With this integration, we aim to enhance your shopping experience by giving you seamless control and ensuring a safe journey through the store, effortlessly avoiding obstacles along the way. It's like having a reliable shopping companion right by your side. The operation of ultrasonic sensor has been shown in Fig. 1.

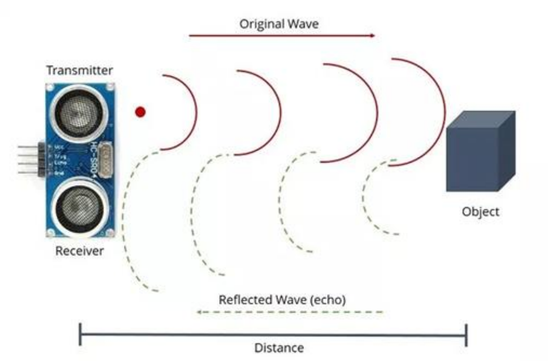

Fig.1 Obstacle detection via ultrasonic sensor

To establish the necessary connections for the ultrasonic sensor in the trolley, we connect the VCC (power supply) and GND (ground) pins to a 5V power source. Additionally, the trigger input (Trig) pin is linked to a digital output, while the echo (Echo) pin is connected to a digital input on the trolley's microcontroller.

To accurately measure the distance between the trolley and an obstacle, we employ a technique that involves pulsing the trigger pin to a high level for approximately 10 microseconds. After that, we wait for a high-level signal on the echo pin. The duration of this high-level signal corresponds to the time it takes for the ultrasonic sound to travel to the obstacle and back. By analyzing the response time and duration, we can determine the proximity of the trolley to the obstacle. This allows for precise distance measurement and enables the trolley to effectively detect and avoid obstacles. The distance can be calculated as follows:

$$\text{Distance} = \text{Time} \times \text{Speed} = \text{time} \times 0.034\text{cm}/\mu\text{s} \quad (1)$$

As sound travels at approximately 340 meters per second. This corresponds to about 29.41 µs.

The circuit design has been shown in Fig. 2. As shown in this figure, the MCU, ultrasonic sensor, two motors and motor controller are connected together as the main components of our proposed design.

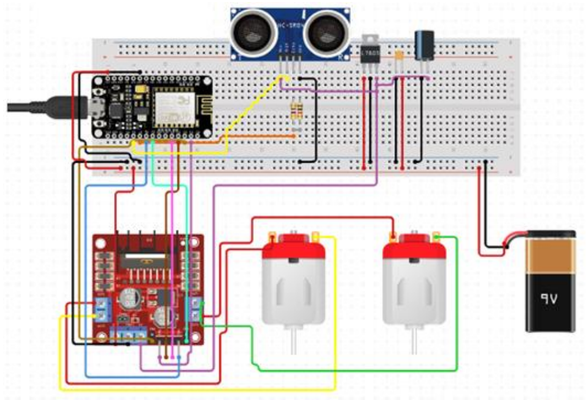

Fig.2 Circuit design for the proposed trolley

The Node MCU, known for its energy efficiency and 16-bit RSIC, is utilized as a controller because of its integrated ESP-12 and convenient WiFi module, which streamline the control process. The ESP-12 incorporates a CPU clock speed of 80MHz, with the ability to reach a maximum value of 160MHz. The L298N motor controller is employed to connect the DC motors to the microcontroller. Both the microcontroller and L298N motor controller are powered by a 9V battery in parallel. The controller has been programmed to define the movements of the trolley, as outlined in Table 1.

Table 1. The motor movement instruction

Movement	**Left motor forward**	**Left motor backward**	**Right motor forward**	**Right motor backward**
Forward	High	Low	High	Off
Backward	Low	High	Low	High
Left	-	-	High	Low
Right	High	Low	-	-

The controlling instructions are sent to the microcontroller through the app created by MIT app inventor. The block function of the created app is shown in Fig. 3.

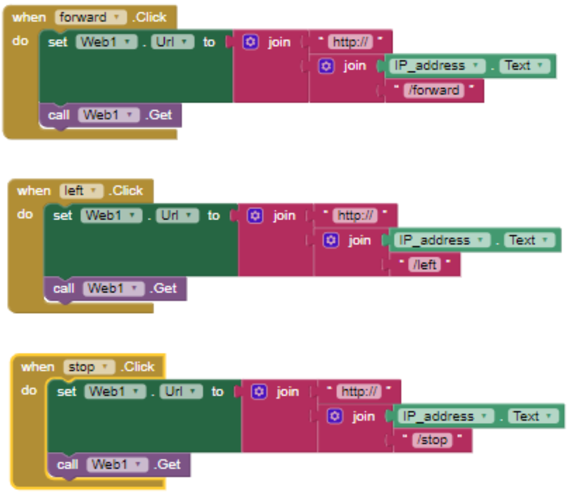

Fig.3 The controlling function block of the app

The fabrication of our proposed prototype is shown in Fig. 4.

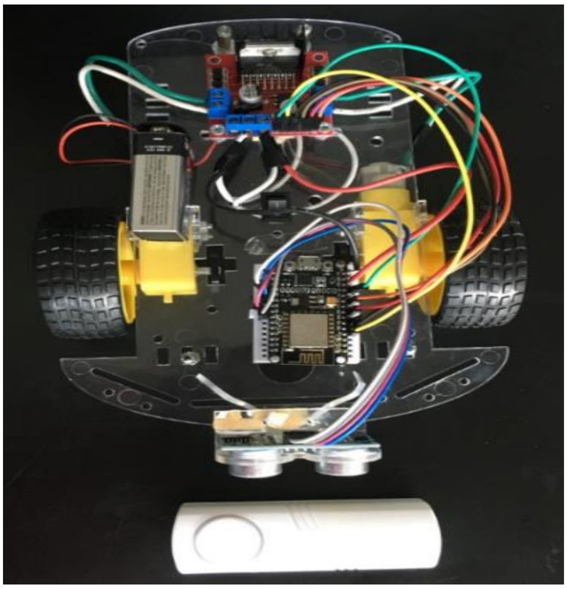

Fig.4 The fabricated prototype

4. Conclusion and Future Work

In conclusion, we have successfully designed, fabricated, and tested a smart shopping trolley specifically tailored for elderly care. The results have been highly satisfactory, indicating the effectiveness of our proposed solution. By implementing advanced technology, our smart trolley is designed to recognize the movement patterns of elderly users and autonomously follow them. This eliminates the need for users to exert physical effort in pushing or pulling the trolley, providing a more convenient and comfortable shopping experience. Looking ahead, there is potential for further improvement and expansion of our smart shopping trolley. One possible avenue for future work is the integration of GPS technology. By incorporating GPS, the trolley can accurately determine its indoor and outdoor location, allowing users to easily navigate and even return the trolley to its designated location rather than being limited to indoor use only. This enhancement would offer even greater convenience and flexibility to the users, making their shopping trips more efficient and enjoyable. In summary, our smart shopping trolley for elderly care has shown promising results, offering a user-friendly and assistance-driven approach to shopping. The inclusion of GPS technology in future iterations has the potential to further enhance the functionality and versatility of the trolley, providing an improved and seamless shopping experience for elderly individuals.

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