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# Basket bot Navigator using RFID Technology

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**ABSTRACT:** This abstract is the opening paragraph on a Human-Following Robot which has been developed to tackle some of the problems with shopping, especially for people who have a difficulty with carrying things. Classic shopping carts bring along many challenges mainly catered to people living with the fear of getting their muscles weakened. However, our counterproposal entails a robotic system that is guided by different functions, for instance, a Robot that follows a person and serves as a shopping basket. This innovation significance is in making customers more autonomous and to provide them a way of shopping conveniently. It does this by opening opportunities for a better shopper experience in the retail space. The manufacture of this kind of robot is a big step for the implication of this technology into an inclusive, efficient and delightful customer service. Along with the RFID technology, the Human-Following Robot possesses increased tracking and navigation capability that would improve the user experience and help the operation to function more effectively.

**KEYWORDS:** Human following, shopping, IOT, RFID, robot.

## I. INTRODUCTION

The pace of robotization processes in our day-to-day life is growing, and it seems that there are more and more niche applications that can help improve convenience and accessibility for us in different spheres of our lives. When it comes to the retail sector, there is an emerging need for addressing the problems faced by the customers especially the shoppers facing some mobility constraints, which in turn lead to the development of some innovative solutions that finally end up to bring an exciting shopping environment for the customers. One such an answer is designing of the Human-Following Robot which deals with these issues and differs from the traditional shopping cart technique introducing an automated and hands-free way.

Through the narrow aisles, the shoppers of the previous times were to maneuver the large carts while the bulky carts could be at times very difficult to move for people with limited mobility or who require the assistance to carry items. This limitation could result in denying both autonomy and convenience when shopping, making the overall experience problematic. We are very cognizant of these challenges and that's why our project is about inventing a Robot which can follow humans and carrying a shopping basket, and thus lowering the dissatisfaction of the users and offering them more convenience and comfort at shopping.

The main idea of Human Following Robot is to increase the spirits of people who are finding difficulties in shopping independently, maybe with the help of some hardware support as an example. Through a hands-free device that automatically keep up with the user and do the pushing of the shopping cart, we are confident that we will be a better retail companion that enables the shopper enjoy a more comfortable and enjoyable visit in the environment. This innovation is not only cool but also by creating an inclusive environment which everyone can be treated well and relax comfortable when shopping.

Moreover, the Robot which is under human following and based on RFID technology is able to not only bring in better experience but also its navigation features are advanced which makes it most suitable for operation in retail spaces. Given it is on the basis of RFID technology the robot is capable of being located exactly and move through every aisle, avoiding obstacles within the route. Complementary usage of these techniques not only positively affects the end use but contribute to the management of the functional and more productive retail stores.

The implementation of RFID technology is just a starting point for the new channel of personalized shopping experience. Just for an example, The Human-Following Robot can be designed to find out specific items that is on users shopping list and guide them directly to those products and even tell them relevant information about prices and availability in real time. Another advantage of this approach is the whole new scope of individualization, which already simplifies and speeds up the purchase process, making it more relevant in terms of individual preferences and needs.

Furthermore, the Human-Following Robot can be used for guided navigation, automating the routine decisions such as selecting the optimal path, making the shop assistant focus on other areas of customer service. This automation which is fast-paced is not only a day-to-day running tool but also facilitate a more efficient allocation of resources, this eventually benefits both the shoppers and retailers.

That cutting-edge robotics system brought a meaningful development in the state of art support in the retail industry. Using radio-frequency identification (RFID) in ways which provide hands-free operability we have designed a robot that would provide a multilevel solution to shopping challenges that many people face, especially those who have limitations in mobility. This is inline with the growing need for the inclusion of more intelligent and convenient technology that is now part of everyday life for individuals across diverse groups.

In addition, the Human-Following-Robot in the retail section can lead to the development of new standards for the customer service and accessibility which may be used as a concept throughout the industry. With the success of businesses that offer solutions like this one that amplifies shopping into a more pleasurable activity, we foresee that there will be a large adoption and integration of similar technology into retailing sector. Such way of retail assistance becomes askew from only drawing some category of consumer to all customers who need it and the society which becomes sensitive as a concrete benefit.

In addition, i.e. the unveiling of our HR technology which has been carefully designed to overcome the difficulties that are faced by the shoppers with less mobility is indicative of a major breakthrough. Thanks to modern design, improved technology integration, and the enhancement of user autonomy and practicality as focus, the principal purpose of this project is to change old tradition of assistance in retail sector by providing more inclusive and accessible environment to all users.

## II. METHODOLOGY

### A. *Hardware Components and Connections:*

Human-following robot application consists of several and interconnected hardware devices to obtain real system functionality. From this list the ones featured are: a MFRC522 RFID module, a NewPing ultrasonic sensor, a servo motor used for indicating direction, and AFMotor motors that are DC. The RFID docks by SPI signal is directly to pin, but ultrasonic and micro motors are controlled by digital and analog pins of the MEGA chip.

### B. *RFID Tag Detection and UID Comparison:*

The signal of MFRC522 lets the proximity of the robot to the RFID tags be detected. When the detector has the Tag, it could read its unique UID (Unique Identifier) and compared it with the given set of values (tagUID). The logic to identify the given tag determines what the robot will do next. This can either be the robot activating its follow mode of still being at standby; or the robot doing another action.

### C. *Activation and Behavior Modes:*

The HFR can alter behavior like traffic stop, emergency evacuation, or just normal patrol depending on the fasted detected RFID tag. An example is when the tag signaling "E3 A5 07 9A" is detected, the robot is woken up

through this tag, and follows the user and carries the shopping bag. Instead, it might perform another action specific to another label, or it could even stop the robot from working.

**D. Ultrasonic Sensor for Obstacle Avoidance:**

The NewPing library bridges our testing code with the ultrasonic sensor that measures the accurate distances. The sensor being employed is essentially controlling the safety of the robot during its movement if it would encounter an obstacle or not. A robot uses its distance sensors to take measurements and then calculates the best way to reach its destination without obstacles and thus without any collisions.

**E. Servo Motor Control for Directional Adjustment:**

As a servomotor acts as a moving part, it can be used for the control of the direction of the robot movement. The motion of servo motor is dynamically moved continuously based on the desired frequency. For example, when the user follows, the motor servo adapts according to the orientation of the robot, thus assuring it remains close to the user.

**F. DC Motor Speed and Direction Control:**

The AFMotor library was used as a means of controlling DC motor's speed and change of direction that provided movement to the robot. The power settings and direction of the motor are changed (on the basis of ultrasonic sensor input, which is for obstacles distance, and for RFID tag detection for variations in the behavior mode).

**G. Real-time Feedback and Serial Communication:**

On-line data streaming or remote control is often called for to ensure fast feedback for troubleshooting. The system provides telemetry information including RFID tag detection, ultrasonic sensor measured distance, motor control actions, and overall system status over the serial interface. By doing this, the late learning can be used for getting the knowledge about the robot's operation and detect any technical problems happened during operation.

**H. Initialization and Setup Procedures:**

The setup function has two complementary features: it is one responsible for the startup of the system, and the other is for the setup of the components needed during the system startup. The establishment of the SPI channel for RFID module configuration, setup and connection of the servo and ultrasonic sensors, and initiation of serial communication for debugging, being part of the process. Furthermore, procedures related to calibration and initial provided in order to guarantee stable operation.

**I. Main Loop Execution and Decision-making:**

The main loop of the program continuously checks for the presence of RFID tags and reads their UIDs. Based on the detected tag and corresponding UID comparison, the program makes decisions regarding the robot's behavior. This includes controlling motor movements, adjusting servo motor position, evaluating obstacle proximity, and sending relevant data over serial communication for monitoring and analysis.

**J. Integration and System Optimization:**

The methodology encompasses the integration of hardware components, software libraries, and decision-making algorithms to create a cohesive Human-Following Robot system. Continuous optimization and testing are conducted to improve the robot's performance, responsiveness, and overall user experience in retail environments.

### III. IMPLEMENTATION

The Human-Following Robot developed for shopping basket moving encapsulate the most recent technologies and algorithms with an aim of improving the shopping experience for customers, especially those with the mobility issues. Here's a detailed breakdown of how this innovative robot operates. Here's a detailed breakdown of how this innovative robot operates:

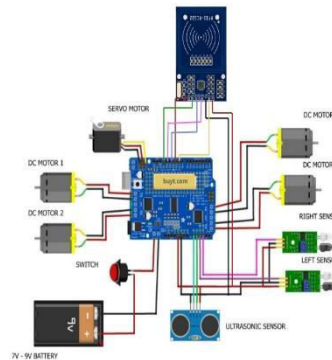


Fig. 1. It represents the circuit diagram of Basket bot Navigator using RFID Technology.

```

Arduino_Follow_MQ_Robot (Arduino IDE)
File Edit Search Tools Help
Arduino_Follow_MQ_Robot
#include <SPI.h>
#include <MFRC522.h>
#include <NewPing.h>
#include <Servo.h>
#include <Arduino.h>

#define ROT_PIN 9 // Configurable, see typical pin layout above
#define SP_PIN 10
MFRC522 MFRC522(SPI, ROT_PIN);
String tagUID = "43 A3 47 5A"; // Your RFID tag's UID
bool followActive = false; // Create MFRC522 instance

#define RIGHT_A0
#define LEFT_A0
#define TRIGGER_PIN A1
#define ECHO_PIN A0
#define MAX_DISTANCE 200
#define ROT_SPEED 100

unsigned int distance = 0;
unsigned int Right_Value = 0;
unsigned int Left_Value = 0;

NewPing ping (TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

AP_DCMotor Motor1 ( MOTOR1_UART);
AP_DCMotor Motor2 ( MOTOR2_UART);
AP_DCMotor Motor3 ( MOTOR3_UART);
AP_DCMotor Motor4 ( MOTOR4_UART);
    
```

The above represents the sample code used in this project.

- **RFID Tag Detection and UID Comparison:**

The robot is fitted with an MFRF522 RFID reader, which has an area of coverage defined by its capacity to scan RFID tags. These particular tags are for shopping baskets and user identification. Once the device detects an RFID tag, it extracts its UID and then matches it with the values which are preprogrammed in the robot’s memory. If the required item, it can activate its navigation and following features if by chance it discovers no, a designated shopping basket and user.

- **Activation and Behavior Modes:**

The robot initiates the mode of navigation and following when the RFID tag currently in the basket or with the user is detected and the specific tagUID matches the tag which is present. This kind of robot will be pre-programmed to accompany designated users carrying a shopping basket. The robot thus offers a hand-free way of shopping allowing a user to focus on shopping at his or her own pace.

- **Ultrasonic Sensor for Obstacle Avoidance:**

The bot has equipped an ultrasonic sensor that employs the NewPing package, to monitor its environment continuously. The bot scans around it for any obstacles or blockages. The recognition of obstacles happening by the use of measured distances through the factor of ultrasonic sensor is the main reasons for making the robot navigate within the stores without any pressure.

- ***Servo Motor Control for Directional Adjustment:***

Servo motor is cannot be overlooked as it is responsible for maintaining the stance and direction of the robot which sticks to the particular person. The microcontroller makes it possible by adjusting the servo motor's position according to the movement of the user and the navigation requirements of the robot, guaranteeing that the process is effective and the robot's behavior is spot-on.

- ***DC Motor Speed and Direction Control:***

An AFMotor library is used in a setting where the motor in the AFMotor library drives the robot's movement and relocation across the retail space. The microcontroller is able to manage the speed and direction of DC motors depending on the sensor (obstacle detection) readouts and the track navigation model.

- ***Real-time Feedback and Serial Communication:***

The machine makes connection with a serial, control unit which can be computer or mobile application based, for the purpose of real-time feedback and homeostasis monitoring. Data like tag receipt, distance to obstacle, motor actuation and system control are transmitted in serial communication interfaces for debugging and performance analysis purposes.

- ***Initialization and Setup Procedures:***

Among the startup routines, the robot sets up its RFID module, ultrasonic sensor, servo motor and DC motors while using the proper protocols of serial communications. Part of calibration procedure may consist in performing diagnostic tests for sensor accuracy, motor system's responsiveness, and system overall state for operating in clean and safe conditions.

- ***Main Loop Execution and Decision-making:***

The main part of loop algorithm of the robot program looks for the tags of RFID which correspond with carts (shopping baskets) or the users. The robot, in reaction to tag detection and the tag identity verification via the UID comparison, makes decisions regarding its behavior, navigation path, obstacle avoidance, and speed adjustment.

- ***Integration and System Optimization:***

All hardware components, software libraries, and final decision-making algorithm are used in an interconnected manner allows a Robotic System for Human Following to be created. Our process of optimization aims to develop the robot's responsiveness to the user, in order to follow the user precisely and navigate the retail environment, reduce or avoid obstacles, and offer the best experience to the user.

## IV. RESULT

The Human-Accompanying Shopping-Basket Navigation System uses RFID (Radio Frequency Identification) technology, Ultrasonic (US) sensors, servo motors, and DC (direct current) motors to do human-following autonomously in store almost fashionably. Via RFID tags detection RFID identification robot using a navigation code and dynamically changing its movement and direction based on the relative distance to obstacles and the behavior of users. In this regard, the ability of the drone to have continuous feedback through its serial interconnections enables the system to be more effective, therefore improving shoppers' time in the journey, and they get the needed assistance and convenience.

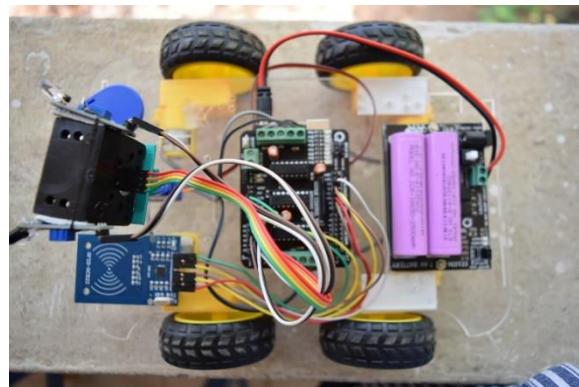


Fig. 2. Front view of Basket Bot Navigator

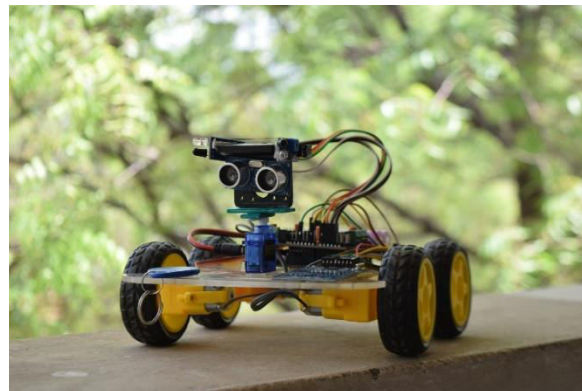


Fig. 3. Overview of Basket Bot Navigator

## V. CONCLUSION

The combination of the Human-Following Robot product and the Arduino and RFID technologies used in the shopping system can be considered the future vessel for improving the retail experience for those who are akin to mobility limitations. Besides tracking vaccinated people, in the future we can expect to see more intelligent automated health advisors with RFID tags to advise and ensure the safety of the customer when shopping. This innovative approach not only facilitates convenience but also champions inclusivity by accommodating in the different needs of diverse users where retail businesses are found.

Firstly, the incorporation of ultrasonic sensors provides the robot with a capability to identify and bypass obstacles, thus boosting its safety features as well as operation effectiveness. This ability to avoid obstacles is a vital responsible building for the impressing impression of smooth and uninterrupted movement within crowded retail spaces, which is going to increase further the user confidence and comfort while using it.

The online monitoring system integrated in the process of serial communication performs one of the most vital functions – that of tracking the robot's performance with immediate feedback on its issues and adjustments or troubleshooting features. This will identify the problem early and give adequate time to fix the problem which is of great contribution to the overall efficiency of Human-Following Robot employed in a shopping context.

Furthermore, the Human-Following Robot's attributes like flexibility and scalability give it a competitive edge in the retail industry for other than just retail basket navigation. Considering this, it might apply to the functionality of performing inventory management or customer navigation or providing personal experience where a shopper's profiles and preferences stored in the tags of RFID are applied.

Moreover, the Human Following Robots go beyond personal use to have an impact on the overall workings of retail stores and customer service operations. This automation helps employees to conduct such customer-oriented tasks as product restocking, overall store management, as well as interacting with the customers more directly. Through these resource optimization techniques, retailers are able to achieve higher operational efficiency and a more smooth-running retail environment which in turn is for the benefit of both retailers and/or shoppers.

Moving along, continuous study and development in robotics, RFID technology, and artificial intelligence promise to establish a wide platform and various features to the functionality of Human-Following Robots. Subsequent versions could have adaptive navigation with machine learning algorithms, better object recognition for improved obstructing obstacles, and smart retail integration with spontaneous check-out processes as well. This represents not only an exciting move toward creating intelligent and intuitive robotic assistants but also a paradigm shifts of retail towards inclusiveness and efficiency which makes everyone's shopping trip spectacular.

The in-built feedbacking of serial communication in monitoring the robot's workflow, identifying the possible flaws and facilitating fast changes and troubleshooting is critically important. This predictive view of how the robot is going to unfold is a proof that the Human-Following Robot is robust, reliable and efficient operation in a shopping environment.

Furthermore, this Human-Following Robot expresses great adaptability and scalability which make it excellently multifunctional for various retail instructs other than a shopping cart leader. Example, it can be expanded upon to handle the areas of stock gathering, customer help and tailored shopping experiences based on preferences of individual customers which are stored in RFID tags.

Secondly, the Human-Following Robot's effects on individual customers go beyond personal interactions to have repercussions in store operations and top-notch customer service delivery. Responsibilities, such as basket hauling and directing customers, are assumed by the robot. This soon will allow the store associate to have more time for counter sales and other store operations. The resource optimization translates into the efficient use of operations and a more accurate retail environment that supports the performance of both the retailers and shoppers.

Human-Following Robot reaching the market highlights the prospect of robotics and IoT technologies to redefine the future of retail services, as they promise to elevate the industry by making it more approachable, accurate, and customer-centric. With the advent of more advanced hardware technologies and innovative sensor development, machine intelligence algorithms are also getting better, so the future models of such robots will be able to stand out not only by their superior functionality, but also their increased level of autonomy, integration and their world-wide deployment.

Anyway, human-following robot which relies on Arduino and RFID technology presents a transformatory solution which besides solving mobility problem in shopping also stands as proof of intelligent and adaptive robots that are applicable in commercial and other industrial settings. This project presents a perfect melding of the power of technology and human-focused design which leads as a long-term result to the improvement of people's place of living and their independence in the modern retail situation.

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