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Smart Human Following Baggage Transport Robot with Real Time Data System

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Abstract--- The current project is a human-following baggage-carrying robot, aimed at supporting the user in busy places of the population like airport, shopping mall, hospitals and campuses. The system combines enhanced sensing, geo-fencing with GPS, and data logging in the clouds to increase the movement, convenience, and safety of the user. The Arduino microcontroller is used to control the robot, which is powered by a 12V battery, with ultrasonic sensors to detect obstacles, a load cell to weigh baggage, and an accelerator to stabilize it. A push-button interface gives the user a simple way to begin and end the next operation, in addition to real-time information on weight, speed, distance, and location, which are constantly recorded and uploaded to the cloud.

Keywords- Human, following robot, baggage handling machine, Arduino technology, sensors and actuators, automatic security, tracking device, design of a mobile robot, proximity sensors, automation in airports, sensors and electronics, GPS based location, smart mobility in airports.

I.INTRODUCTION

We are introducing a human-following luggage-carrying robot that users/tourists can use in crowded public areas, including airports, shopping malls, hospitals and campuses. The solution combines state- of-the-art sensing, GPS geo-fencing, and cloud based data logging to increase user mobility, convenience and safety. The robot is manipulated by an Arduino microcontroller and driven through a 12V battery, obstacle detection takes place via ultrasonic sensors, baggage weight is measured with the help of load cell while stability is maintained by an accelerometer A touch-of-a-button interface ensures quick activation and shut-off of the subsequent operation, with intuitive data on weight, velocity, range and location gathered in real time and fed to the cloud.

There is also the unique dual geo-fencing capability of the system. The robot moves within a predetermined area marked by GPS coordinates of the place and inform both user and authorized people when goes across the range line before stop process. The baggage tracking system, controlled via a second ESP32 module, GPS and a radius of its own has been decided by the user to keep it within a safe area, and alerts are sent in case it crosses the perimeter.

Such system will provide a fast, effective and easy to use solution and ensure that they will not have to deal with manual handling and enhance security and accessibility to a greater extent. It is a significant breakthrough in the automated assistance and location technology.

A. Manual Baggage Handling and Its Limitations

Most of the airports and the transport centers have relied on the standard manual modes of handling baggage. Carts or trolleys are physically exerting to use and it becomes cumbersome particularly when the elderly are on board, when a family has several bags or when the person is handicapped. Users are likely to feel tired and inconvenienced during long transits or layovers, which declines comfort and mobility in general. Additionally, there is always the problem of human error in the process of baggage handling like misplacement or theft.

B. Limitations of Existing Automated and Semi-Autonomous Systems

Although the field of robotics and automation has improved, the current luggage-carrying systems at airports are mostly semi-automated or stationary. Conveyor belt systems are not mobile and provide no personal assistance only in a specific section such as the check-in or baggage claim. Existing robotic luggage prototypes rely on simple infrared/ultrasonic sensors to track a user, but such prototypes are not very reliable in a busy or complicated environment because they have limited range, poor obstacle detection, and no intelligent navigation.

C. Absence of GPS and Geo-Fencing Technology

The majority of the existing systems lack GPS module or geo-fencing capabilities that can be used to establish safe operational parameters. Consequently, this means that there is no alert system in case the baggage is not within a specific perimeter. This is a significant threat to security in most high density and busy places such as the airports where the use of loss prevention and positional tracking is essential.

D. Deficiencies in Control and Stability Mechanisms

The majority of currently operating systems lack a load cell or an accelerometer that will be utilized to measure the weight of baggage or provide a sense of balance during movement. This reduces the stability of the toppling over particularly where there is uneven distribution of weight or inclination of the surface.

E. Inadequate Safety and Emergency Features

Obstacle detection, emergency stop buttons or automatic shutdown mechanisms as safety measures are usually not installed or implemented poorly. This renders current robotic baggage systems unsafe to be used in dynamic and tight spaces such as in the airports or shopping malls.

F. Lack of User-Friendly Interaction and Alerts

Most of the systems that are in use currently do not feature an interface that is easy or intuitive to the users. There is frequently no straightforward way to start or stop a robot on your own, and this can be quite frustrating to you as an operator as well as being inefficient. Systems which happened to be there were not capable of sending real-time notice in case something was wrong with robotic system: such as breaking through security boundaries, corrosion between user and machine, low battery etc. Without proper feedback systems it is clear that both convenience and safety will be affected.

In summary, any attempt to automate luggage transportation at all varying degrees has issued in systems which though they exhibit a certain measure of functions, accuracy and reliability are still minimal.

II. ARCHITECTURE FOR SMART HUMAN FOLLOWING BAGGAGE TRANSPORT ROBOT WITH REAL TIME DATA

The proposed System is a smart human-following baggage carrying robot to assist people in their movement at busy locations like airports, malls, hospitals and campuses. It follows users around and carries their luggage while it is completely automatic, hence making the experience way more convenient, secure, and burden-free. By using a combination of sensors, GPS tracking technology and communication with the cloud (IoT) to provide real-time monitoring and alerting features.

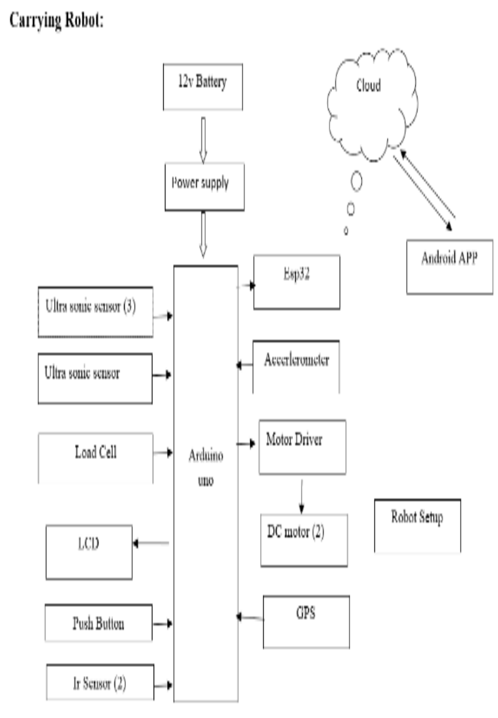


Fig.1. Carrying robot

This diagram explains how the main robot operates and interacts with sensors, actuators, communication modules, and the user’s mobile application.

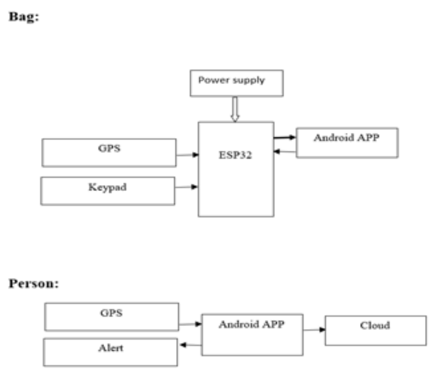


Fig.2. Bag, person

The 12V battery supplies power via a regulated supply to the Arduino which acts as the main controller for the robot.

Key Point: Arduino Uno -The tickler. It takes input from the sensors and sends output signals to the motors and communication modules. Ultrasonic Sensors (3 at front and 1 at rear These sensors are used for obstacle detection, as well as tracking the position of the user by detecting where they are. A back sensor allows the robot to follow precisely behind the user. Load Cell It measures the weight of the baggage, load cell process this data and sends it to app for monitoring. Accelerometer — tracks the tilt and orientation of the robot. Assists the robot stay balanced on rough terrain.

IR Sensors **(2)** One sensor measures the speed of the robot The other checks how much baggage is loaded on the platform Push Button Used to start and stop the robot's following operation Once pressed, the robot starts tracking the user; pressing again halts the operation. LCD Display Shows real-time data such as weight, speed, and distance Motor Driver → DC Motors **(2)** The motor driver controls the t wo motors, enabling movement based on sensor inputs.

GPS Module Provides location data for geo-fencing Helps in tracking the robot's position relative to predefined boundaries ESP32 Module → Cloud → Android App The ESP32 handles wireless communication. It transmits sensor data to the cloud, where it is accessed by the Android application. Users can monitor the robot's status remotely.

This diagram shows how the user interacts with the system through the mobile app Components and Connections GPS → Android App The user's phone provides GPS data to the app. Alert → Android App Alerts are generated if the robot or bag crosses a geo-fenced area. Android App → Cloud The app communicates with the cloud to receive and send location and alert data The cloud ensures synchronization between the person, robot, and bag.

III. DATA ACQUISITION AND DEPLOYMENT

Integrated hardware components are implemented to retrieve environmental data through sensor readings, which forms the initial step in the data acquisition method. Our system too possess ultrasonic sensors to detect and avoid any obstacles, a GPS module for navigation as well as geo-fencing, and a load cell to measure baggage weight. The collected distance, speed and position data is transmitted to an Arduino microcontroller for decision-making. This deploy allows the robot to autonomously follow users in the airport premises while ensuring safety and efficiency.

A. Data Capture Process

The robot's sensors work together, interfacing to collect information about the environment and operating parameters. Ultrasonic sensors detect distance of obstacles and humans, while accelerometers keep track of the stability of movement. GPS and Bluetooth modules capture position data and keep the connection with user's smartphone or wristband. A constant stream of sensor data allows the robot to adapt its speed and direction in real time. The data captured in the form of weight, speed and positional coordinates are stored and further uploaded on a cloud dashboard.

B. Ensuring Data Quality

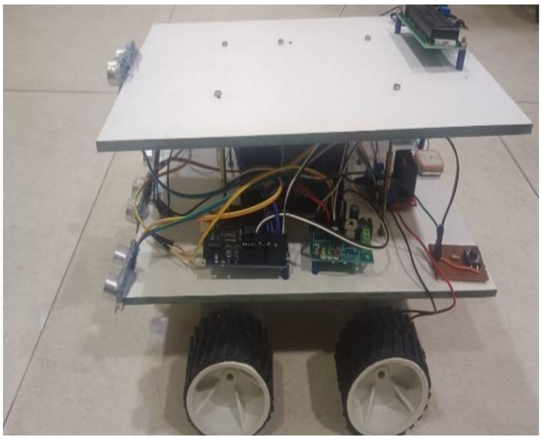
To ensure safe pathfinding and collision avoidance, quality data is obviously key. It uses redundant sensors to stay correct and real-time calibration routines. Kalman or moving average filters are used to filter out noisy readings from these sensors and provide a more reliable value. Interpolation methods are used to automatically correct and/or fill gaps in the presented data points. The robot is equipped to perform constant diagnostics on itself, which enables the sealing of data within certain confidence limits and helps to assure that the robot performs optimally as it traverses busy or eclectic environments such as airports.

C.Securing Data and Ensuring Privacy

Because the system relies on GPS and Bluetooth data linked to a user, it prioritizes security and privacy. This prevents third parties from using your data during transmission. [2] User location and tracking data are anonymized when sent to protect user confidentiality. HTTPS protocols are used to secure communication between the robot, mobile device and cloud platform. Moreover, the data logging framework includes industry-standard privacy compliance like GDPR to make sure user-related information is handled responsibly. The signals used to control the motion of the robot are created through real-time processing of data, ranging from light intensity to distance detected by different sensors in the environment. This includes filtering out sensor noise, calculating the distance between the user and robot as well as creating direction and speeds command. This processing is done at a high frequency by the microcontroller to allow for smooth and responsive movement. GPS module data enables the creation of a geo-fence that prevents the robot from moving outside specified areas such as the airport terminal. The processed results are then used to adjust the speed and steering of the motors using Pulse Width Modulation (PWM) signals.

We implement sensor fusion techniques to combine readings from ultrasonic, accelerometer and GPS sensors for accurate positional awareness. The Kalman filter smoothens the sensor noise and provides stable measurements.

IV. HARDWARE INTEGRATION AND COMMUNICATI0N PROTOCOLS



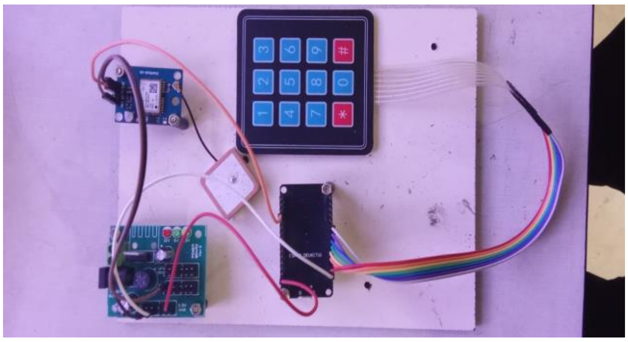


Fig.3.Hardware Design Module

The communication between the Arduino, GPS and the motor driver circuits is achieved using UART and I2C communications. All modules communicate with each other, by a well defined interface, making the entire set, up work at low latency. Power management and signal isolation circuits are added to prevent voltage drops and interference when the loads are high. The system has a feedback monitoring feature. The robot is continuously sending information to a mobile app or cloud interface to enable the robot to provide parameters such as location, , battery status etc. Visual encoders such as LED's and alarms are used to enable the users to monitor the robot during operations. Failures and monitoring: a number of fail, safes and monitoring elements are implemented to guarantee run, time safety of the system. These are meant to avoid accidents, guaranty the system stability and satisfy the public safety regulations.A. Emergency Stop and Boundary Control

An emergency stop button is provided to shut off the robot in the case of malfunction or emergency. Also implemented is a GPS based geo, fencing system that defines the operational region of the robot and warns the user if boundaries are violated. The accelerometer and load cell modules take care of keeping the robot steady during the transport of uneven loads or loads that shift. The system fixes the speed or stops in the event of instability. A comprehensive test will be conducted including a unit test of each individual module, an integration test, and a field test. Validation will include motion control, obstacle avoidance, geo, fencing and robustness

V.Output From Could Software

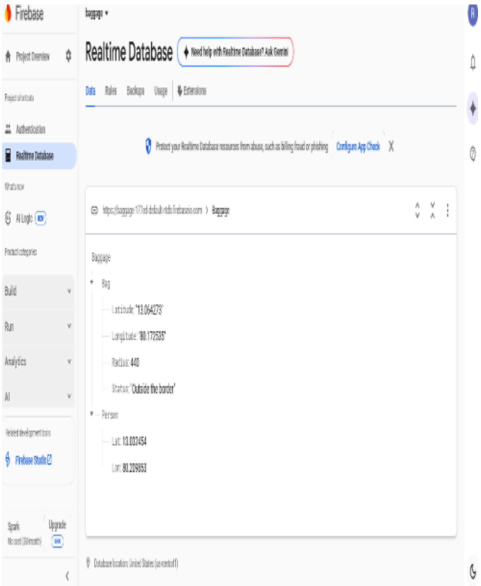


Fig.4.Fire base software

To realize the proposed concept, the Autonomous Baggage Carrying Robot has been successfully designed, developed and studied through incremental implementation stages, in order to measure its performance, accuracy and reliability in dual working environments of indoor and outdoor scenarios. The architectural design, with a combination of Arduino Uno as main controller and ESP32 as IoT communication interface, then further subdivided the computational task for selected & recommended motor, sensor and obstacle avoidance control operation while achieving a constant cloud update and monitor support on remote station. During assessment, responsiveness of motor operation in human, following mode with complementary use of ultrasonic sensors and accelerometer module was observed, where ultrasonic sensors work to precisely determining the distance between traveling user and robots () ensuring the 30~50 centi, meters feasible following distance and wherein ultrasonic sensors at front end for smooth reorientation thanks to confident obstacle detection up to 200 Centi, meters in advance().

The load cell sensor gave reliable readings of the weight of the luggage with an accuracy of less than ±50 g. This was sufficient for size of regular baggage to be measured. Over loading was checked by weighing tests where the motor would be automatically stopped and an over load warning would be shown on the LCD screen once the load exceeded the maximum specified. The MPU6050 accelerometer successfully kept the trolley balanced and prevented it tip, ing over when traveling over uneven surfaces.

A.APP AND WORKING DETAILS

Fig.5.App Working Process

The android app is the universe user interface of human following baggage robot system, it gives user around the clock information of the state of robot and smart baggage unit via cloud. When a user login to the application, it will sync up itself to Firebase, the cloud database, , then keep on getting live stream data from ESP32 modules, such as robot and user geo, position, smart baggage unit's weight, speed, balance, overall system status. And this information will show in a simple dashboard, meanwhile a google maps embed system is used to present both user, robot and baggage location at the same time.

Furthermore, a geofence system will constantly evaluate whether the robot limitation and the user, defined baggage radius are breached or not; if any of this condition occurs, the application will respond immediately by pushing out alarming message and flashing warning sign to notify user. Instead of recording past session, this monitoring and alerting system mainly care about instant reaction and emergency warning, which make the application run smoothly, lighten neither server storage nor the machine's running cost, at the same time, supervises the system well.

VI. CONCLUSION

The project entitled "Smart human, following transport baggage with real time data System" proves a great breakthrough in the area of concept of autonomous mobility and intelligent transportation in an airport. The collaboration of ultrasonic sensors, GPS system, BTA (Brush Tire Controller) and the intelligent path, following Algorithms makes the system capable of successful human detection and following. Human following with obstacle avoidance is achieved, by the robot, so as to provide ease, safety and efficiency for airport baggage handling. It is a significant contribution for the transformation of traditional airport logistics into a modern automated passenger service.

The integration of hardware and software design achieves real, time object detection, motor command and human following capability, all of these are implemented using microcontroller module in order to process the sensor data in a relatively short period of time to enable quick response and decision making in terms of walking and obstacle avoidance. The incorporation of power management system, load sensors and communication devices can significantly improve the system performance and robustness by supporting long continuous operation time in a crowded airport areas. The system can also be used as a reliable and modular transport system for other significant places such as shopping malls, hospital etc.

In terms of engineering, the project comprises of the implementation of automation, control systems, and embedded technology. The architecture of the system was designed to be integrated with relatively seamless working of the sensors, controllers and actuators with low power consumption. System calibration and synchronizing between input and output data sets have been performed to ensure the accuracy of the navigation & obstacle avoidance modules, even in high campus clutter streets with numerous motion vehicles, bus and pedestrians. These implementation aspects of the project have reflect the overall feasibility of the prototype.

VII. FUTURE ENHANCEMENT

While the current implementation of the Smart Human, Following Transport Baggage With Real Time Data System has performed successfully so far, there are several areas of future work that could make it more efficient, intelligent, or adaptable. A next step for future work would be to explore the use of computer vision and artificial intelligence, instead of ultrasonic and infra, red sensors, for the purposes of human recognition and following. By using model, based deep learning and vision tracking such as YOLO or OpenCV vision tracking, the system could be more effective in following a human in a crowded environment. Further, the addition of a LiDAR sensor and an advanced SLAM system could enable the robot to map a real, time airport environment more accurately and navigate it efficiently.

One other major aspect of the future development is connectivity, automation and sustainability. The system could be improved to include IoT based cloud connectivity for anticipatory maintenance, real time location tracking through android and iOS apps and data analysis for adequate work. Introducing solar charging units and low power consumption motors will increase the operational time and the robot won't have to be plugged in frequently. Interaction with the user can be made available through a voice command recognition system, or a gesture controlled interface or an app based virtual assistant.

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