Auto-following Luggage Platform

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ECE 445 Senior Design: Project Proposal

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1)Introduction

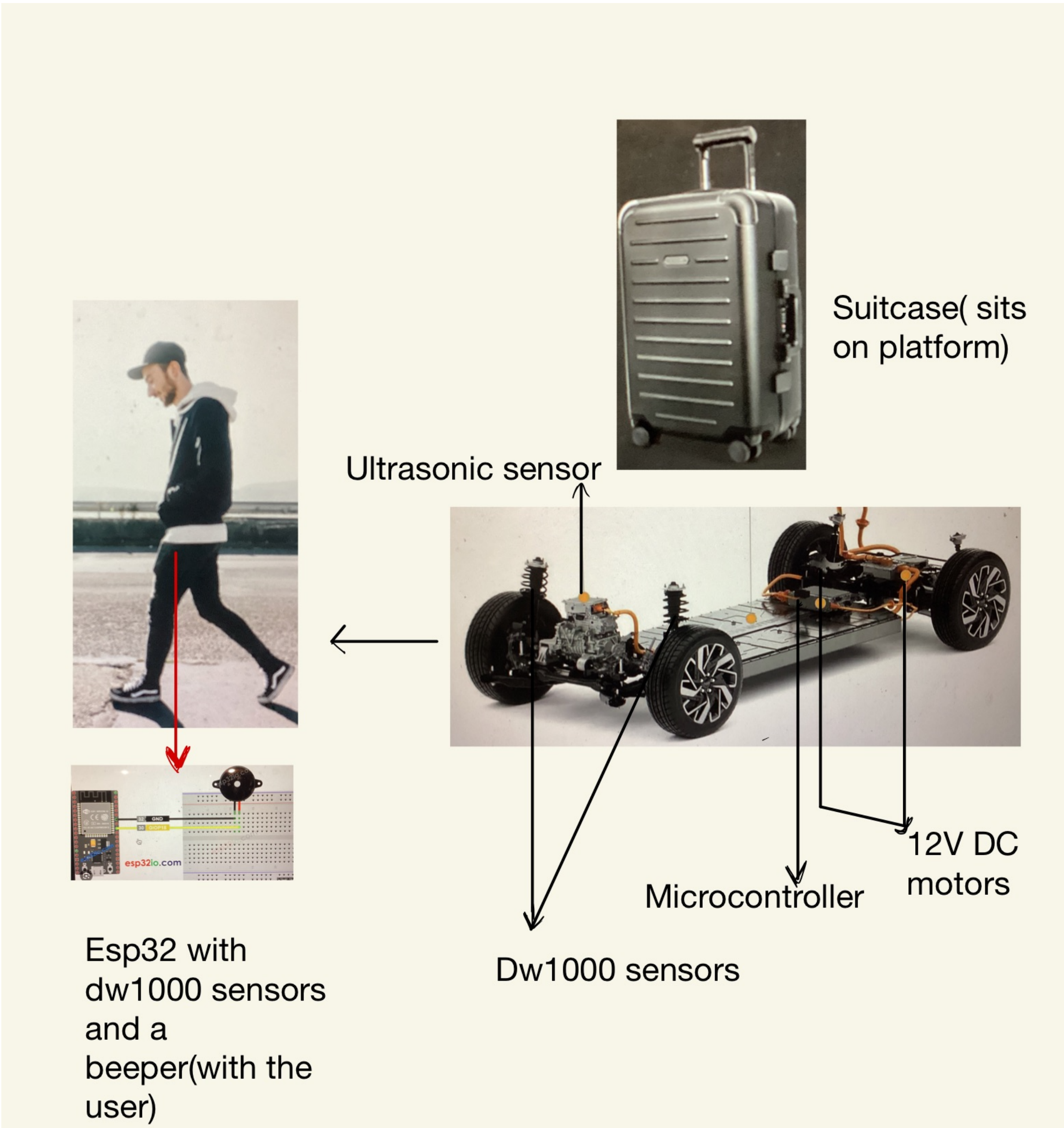
1.1)Problem

Imagine traveling with 2 - 50 lb check-in items of luggage and a carry-on bag along with a bag pack all ALONE. It can be a hassle, especially in an airport environment when the passenger is stressing about where to go for their next flight. Even if there is a cart available, it is inconvenient to carry it around everywhere due to its size.The need for smart luggage has surged in response to the evolving demands of modern travelers. With features like autonomous tracking, and GPS capabilities, these innovative travel companions offer peace of mind and accessibility to travelers, simplifying their experience. We are actively working on developing more cost-effective solutions to ensure that smart luggage becomes increasingly affordable and accessible, thereby revolutionizing the way we approach travel.

1.2)Solution

Our proposed solution is a luggage system that autonomously follows the user while avoiding obstacles and adjusting its direction as needed. The four DW1000 sensors will provide triangulation data for accurate positioning via the ultra wide band transceiver technology. These four sensors would be on the luggage system and are called "anchors' '. We will have a tag that the user will carry. This tag would be another ESP32 along with a DW1000 sensor. Now, the anchors along with the tag can accurately create a local positioning system. Ultrasonic sensors will detect obstacles, including people, while the ESP32 microcontroller processes sensor data and calculates the optimal path. The motorized system comprises two motors (differential drive) and two 360-degree wheels as support.

1.3)Visual Aid

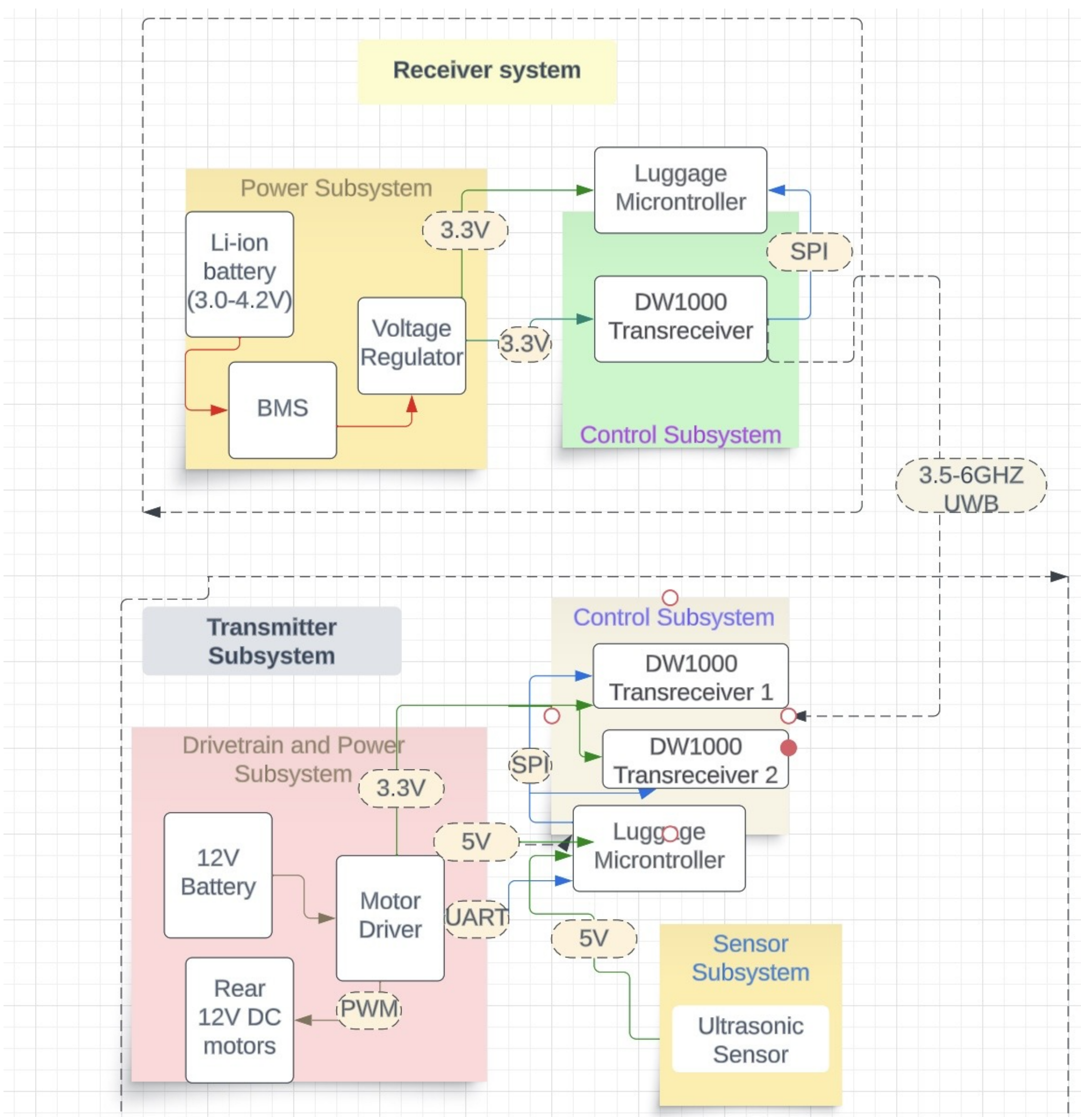


1.4)High-level requirements list

1. **Accuracy of Tracking:** The system must achieve a tracking accuracy of at least ±100 centimeters, ensuring that the luggage consistently follows the person without deviation.
2. **Real-Time Responsiveness:** The system should provide real-time tracking updates with a latency of no more than 100 milliseconds, allowing for swift adjustments in the luggage's movement to keep pace with the person.
3. **Battery Life:** The system must ensure a minimum battery life of 8 hours for the person-wearable component, allowing for extended use without frequent recharging.
4. **Collision Avoidance:** Avoid Collisions and inform user incase of out-of-bounds

2)Design

2.1)Block Diagram



2.2)Subsystem Overview

2.2.1)**Control Subsystem** The Control Subsystem plays a pivotal role in seamlessly integrating the DW1000 transceiver module with the ESP32 microcontroller. Its primary function is to ensure accurate distance measurements between the receiver in the two control subsystems and the ESP32, facilitating precise control and communication.

2.2.2) **Sensor Subsystem** The Sensor Subsystem is responsible for providing accurate distance measurements between the luggage and objects in its path to prevent collisions. This subsystem consistently delivers reliable distance values.

2.2.3)**DriveTrain and Power Subsystem** The DriveTrain and Power Subsystem is essential for supplying the required voltage to power both the motors and the ESP32 module, enabling the proper operation and movement of the system.

2.2.4)**Power Subsystem** The Power Subsystem, residing in the tracker that is kept by the user, is responsible for supplying power to the ESP32 and DW1000 sensors, ensuring continuous operation of the system.

2.3)Subsystem Requirements

2.2.1) **Control Subsystem** The control subsystem's key requirement is the seamless integration of the DW1000 transceiver module with the ESP32 microcontroller, all while maintaining a stable 3.3V voltage level. This integration is vital for establishing reliable communication, enabling real-time tracking, and ensuring precise luggage control. Compliance with this requirement is paramount for achieving accurate triangulation and maintaining system efficiency.

2.2.2) **Sensor Subsystem** When integrating sensors like the 5V-operating ultrasonic sensor into an ESP32-based subsystem, voltage compatibility is critical. To bridge the voltage disparity between the 5V sensor and the 3.3V ESP32, a voltage level shifter or regulator must be incorporated. Additionally, it's important to consider current requirements, optimize data rates, and implement power-saving measures. Safety precautions, such as voltage regulators, should be included, and environmental factors, physical integration, and regulatory compliance must be addressed.

2.2.3)**DriveTrain and Power Subsystem** Torque provided by the motor system must be sufficient to drive the entire machine forward under full load of 20kg with speed above 2 mph but not exceeding the 4 mph. The torque at the left and right motors should also be sufficient to turn the machine around under full load.

2.2.4)**Power Subsystem** When configuring a power subsystem with a Li-ion battery to power a DW1000 sensor and an ESP32, including a Battery Management System (BMS) and voltage regulator, voltage compatibility is crucial. The Li-ion battery's 3.7V output must be regulated to match the ESP32's 3.3V requirement while meeting the power needs of the DW1000 sensor. The BMS ensures safe battery operation, guarding against overvoltage and overcurrent situations, and the voltage regulator maintains a stable 3.3V output. Optimize power consumption, consider environmental factors, and adhere to regulatory requirements for battery usage to create a reliable and efficient subsystem.

2.4)Tolerance Analysis

Our design is based on the requirement that the accuracy of the luggage tracking system must be 1 meter + - 10%. A distance less than this will be too close to the passenger and difficult to control. On the other hand, a distance greater than this will be too far to the passenger and there is a possibility of the luggage being left behind.

The motor control algorithm needs to be carefully designed to vary the speed based on the distance from the passenger. Since we will be using differential drive motors, the individual motor speeds should also vary based on the turning of the passenger.

3)Ethics and Safety

During the development of our project, we will follow the Code of Ethics described in IEEE and ACM. We aim to ensure an equal distribution of workload and a healthy and supportive working environment free of discrimination and racism, according to IEEE Code of Ethics II [1]. We will strive to work with mutual respect and equal rights. We will recognize the support of the TAs, professors and all other course staff. We will not accept plagiarism and guarantee that all our work will be fair and original. We'll also carefully cite and give credit to all the external works done by others that have helped us along the way.

As for the safety of our project, we will be working with batteries. Therefore, we will consider all the catastrophic events that can result from a lithium battery and keep necessary safety protocols in mind [2], including but not limited to keeping the temperature of the battery within the safety range of 32 to 130 Fahrenheit, avoiding sudden and drastic movement of the battery carrier, etc. We will also include motors in our project to account for the movement of the luggage. Again, we will use necessary equipment to avoid any collisions with humans and other objects.

References

[1] "IEEE Code of Ethics," IEEE. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed 8 Feb. 2023].

[2] Batteryuniversity.com, 'Safety Concerns with Li-ion Batteries – Battery University', 2023. [Online]. Available at: http://batteryuniversity.com/learn/article/safety_concerns_with_li_ion. [Accessed 8 Feb. 2023].