Autonomous Carrier Assistant

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***Abstract* — This conference paper shows the deign overview and the implementation of the autonomous carrier assistant. This brain of this ACA is the microcontroller that receives and process data according to its programming. The same microcontroller support collision detection through the ultrasonic sensor. It will also allow the communication between the Bluetooth and the mobile application The Bluetooth plays a vital role in the success of the project. It is thru the Bluetooth that the A.C.A be able to follow the consumer. Two DC The purpose of our project is to develop an autonomous luggage carrier (ACA) robot. The ACA is a motorized robot platform whose primary purpose is to assist humans in transporting goods, objects, or luggage.**

***Index Terms* — Autonomous, Communication, delay, Mobile application, GPS positioning.**

I. INTRODUCTION

The Autonomous Carrier Assistant (ACA) is at its very essence, an autonomous robot. The Autonomous robot is not a new concept. Autonomous robots that can follow someone are nothing new as well. This project will attempt to make an autonomous robot which follows someone, that will be versatile and efficient as well as being low cost to both produce and sell on the market. The hardware and software chosen to complete is project were all extensively researched to produce the most cost-efficient product to go to market.

The goals and the goals of ACA project are:

1-The first objective or goal of the ACA is that the robot is able to carry substantial amount of weight in a stable manner to the user's destination.

2- The second objective of the ACA is that it should be able to follow the user accurately while maintaining a proper distance as well as avoiding obstacles.

3- The third objective of the ACA is that it should be able to perform effective path planning in real time as well as navigation services to the user.

The ACA main goals are to be easy to be use and flowing the user, and that will be accomplished through the utilizations of sensors, microcontroller, Bluetooth, and another external receiver.

Our project ACA will include microcontroller board which has the ATmg328p. in our print circuit board PCB will contain also output Bluetooth HC-05 that is using +5 voltage and to input data base. So, form the Bluetooth data and information which transmitted to microcontroller which will analyze and processing the information and transmitted to the Motor control LM298. the LM298 will make the two motors turn left or right. We also using the Ultra sonic sensors, he will function like collision detector system. He will make the motors stop by transmitting data from sensors to the microcontroller, and from the microcontroller to the LM298 to stop the wheels and that if the sensors detect any object in 2 & ½ feet the ACA will stop , and beside the ACA will keep moving

II. DESIGN OVERVIEW

Every product and service have a defined scope or area of operation. The specification requirements were analyzed before starting the design by our team. First things first we needed to make a platform which can carry a decent size equipment or luggage. The platform was 16 inches wide in width and 22 inches wide in length. and so, we designed a rectangular shape wooden assembly. We picked DC motors for our design because the starting torque is high, and they are more efficient than AC motors. We Used a L298 motor Driver to connect the motors and the driver is attached to the controller. For safety aspect we installed and program ultrasonic sensor which can detect an object or obstacle as close as 2 cm and as far as 400 cm. A 12V Batter was added to the design to supply power for at least 2 hours. The design can handle up to 40lbs

- . Speed 1.5 mph
- Follow 3-5 Feet
- Battery Power up to 3 hrs.
- Collision detection 2 & ½ feet
- Carrying 40lbs
- Bluetooth connectivity
- Mobile Application
- Joystick controlled

The above standard was set to make this ACA design work. The ACA robot is designed to be a general-purpose multi-role robotic platform which can assist the people with their load in a number of scenarios. However, it is a known fact that every sector has its own set of problems, limitations, and constraints. The primary feature of the autonomous luggage carrier that it should be able to help the user in carrying his weight. The robot should be designed in such a way that it does not drop the luggage accidently or get unstable due to the loaded weight and does not hurt anybody by accident.

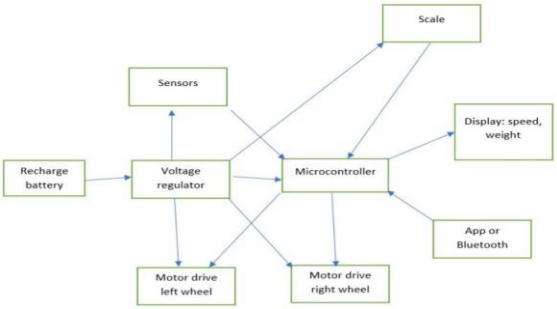
III. Case Scenario

The autonomous luggage carrier robot platform finds its applications and uses in many industries and social segments. In fact, such an autonomous robot can be used in all scenarios where user needs assistance with carrying objects around and finding their way to the desired location.

- Medical industry: The ACA can be used as an assistant for the nurses and paramedical staff. Specially during this pandemic and social distancing. It can help the humans in carrying around objects within a hospital premises or medical facility.

- Airports: The ACA can prove to extremely useful on airports. Passengers face a lot of difficulty in transporting their luggage from one part of the airport to another. This is especially a significant challenge for the elderly
- Manufacturing: The ACA can also be of great use in industrial manufacturing environments. On large shop floors, a lot of parts need to be transported from one area to another during the assembling and manufacturing process. Taking help from the autonomous robots on the shop floors to transport the parts will boost the process efficiency and save time.
- Warehouses: Today the large retail chains and online stores manage huge warehouses across the globe. The people working at these warehouses need to pick and place a lot of packages. This is a tedious task for the human operators. The employment of ACA robots in such warehouses will assist the human operators greatly and it will reduce the burden on their shoulders. It will also increase efficiency and order processing times.

IV. System Components



The autonomous luggage assistant is established from a number of important system components. The system is best described in terms of system components; that is, the individual physical modules that were purchased or designed for our project. This portion covers a semi-technical introduction to each of these components

A. Micro-controller

The Microcontroller is the brain of the system. The Microcontroller uses the I/O pins so it can communicate with the word around it in easy way, so it can receive information as input and give order as output. So, in our project the Microcontroller is programmed to control few tasks such as: Motor controller to control the two motors we are using, ultrasonic sensors which is for collision detection, also Bluetooth and GPS. during our Senior design one we did research about different Microcontrollers that can be compatible for our project. It was very important to understand the benefits of each one and the functionality to perform the task that is given. Our standard to choose the microcontroller were easy to program, implement electronically and can be using less power to handle our tasks.

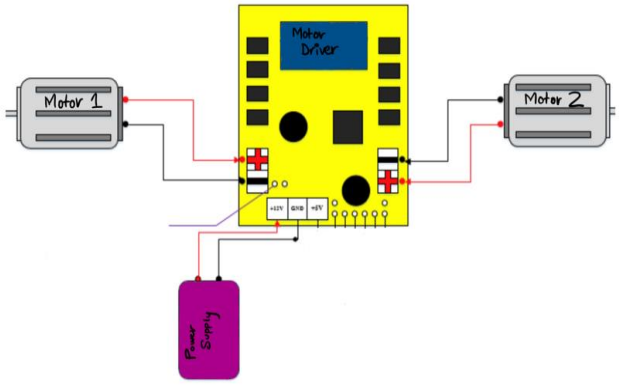
The MCU that is used for this project is the Atmega328p. The Arduino Uno development board has this chip mounted on it which is Atmega328p. One of the main reasons for the choice of this MCU is because the ATM is so popular and that can support many applications Its popularity gives it a lot of advantages over the other boards that were considered. Due to that popularity there is a lot of information available. It has a vast library which is easily accessible

. The device operates between 1.8-5.5 volts. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. The cost of the Arduino comes in at 22.00. Arduino Uno is a microcontroller board based on the ATmega328p. The ATmega328P is an Advanced Virtual RISC (AVR) microcontroller that can support data up to 8-bits, has 28-pins and has 32KB flash memory. It has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM), as well as 2KB Static Random-Access Memory (SRAM). The CPU speed 20 MIPS. It also has 3 built-in Timers, two of them are 8 Bit timers while the third one is 16-Bit Timer. It operates in a range from 1.8V to 5.5V. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, real timer counter with separate oscillator.

B. Motors / Motor Driver

The autonomous luggage carrier robot is a mobile robotic system and therefore it cannot operate on AC power. Since, the system must operate on DC power through batteries therefore the use of DC motors is intuitive. By using small-size high-torque DC motors, the weight of the robot is reduced, and its mobility is improved. Additionally, the speed and direction control of DC motor using a DC drive controlled by microcontroller is quite straightforward. Also, DC motors is low voltage operation and portability system.

A DC motor is an electric motor that runs on direct current power. In an electric motor, the operation is dependent upon simple electromagnetism. A current-carrying conductor generates a magnetic field, when this is then placed in an external magnetic field, it will encounter a force proportional to the current in the conductor and to the strength of the external magnetic field. It is a device which converts electrical energy to mechanical energy. It works on the fact that a current-carrying conductor placed in a magnetic field experiences a force which causes it to rotate with respect to its original position

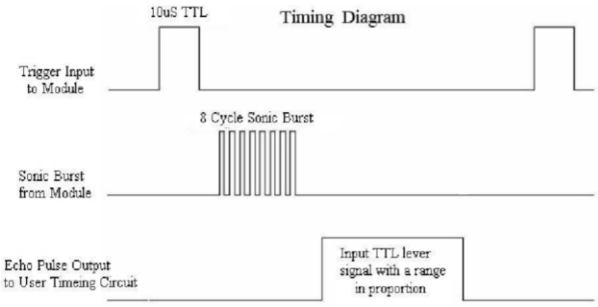


One of the most well-known DC motor drivers is the L298N dual H-bridge motor driver. This driver allows the circuit designer to control the speed as well as the direction of the DC motor. The L298N driver also consists of heat sinks for high current loads. It also incorporates motor direction LED indicator. Most of the DC motors lie within the operating voltage range of 5 to 35VDC. Therefore, this driver is ideal for all such motors.

Specification of L298N
Drive Voltage 5-35Volts
Max Stall Current 3 Ampere
Max Power 25 Watts

C. Sensor

We kept safety in mind while designing this autonomous carrier assistant and sensor will play a big role when it comes to safety. This module is built to detect any obstacle or object and respond. The HC-SR04 sensor has two ultrasonic transducers. First one works as a transmitter which changes electrical signal into frequency ultrasonic sound pulses. The receiver waits for the transmitted pulses. If it gets them it provides an output pulse whose width can be utilized to calculate the space the pulse travelled. According to the above comparison table, ultrasonic HC-SR04 is the best option for the autonomous luggage carrier which will prevent any collision and avoid any obstacle in its way.



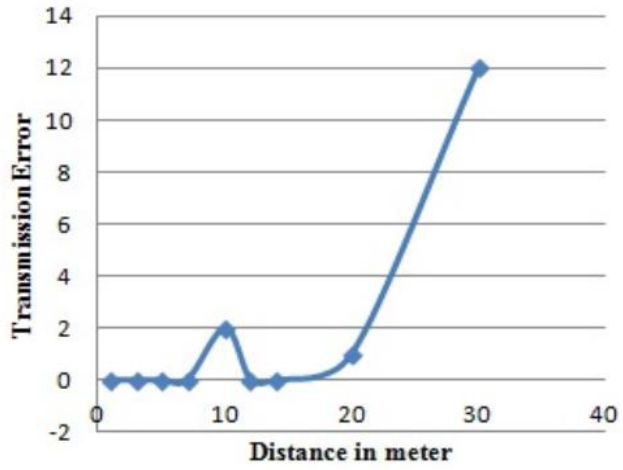
Distance Equations for sensors $D = (\Delta t/2)\ x\ c$

D. Bluetooth

There is a plethora of different products that contain Bluetooth such as tablets, speakers, mobile devices, laptops, gaming products, and high-end headsets. Bluetooth is one of the most useful tools to use when transferring information between two or more devices that are near each other in low bandwidth situations. Bluetooth implementation for the Autonomous Carrier Assistant would be very easy to implement because we would just have to purchase a device that already has the capability to use Bluetooth and have it interact with a mobile device to control/track the ACA. We chose HC-05 Bluetooth and the pin configuration of the module can be seen below.

- CVCC This pin supplies Voltage of 3.3V to 5V
- GND This pin is simply the ground pin.
- TXD&RXD which acts as the UART interface for communication

The HC-05 module was used in our design to connect the platform through the mobile application.



This graph represents the signal strength of the HC-05 Bluetooth module. According to the datasheet the effective range is up to 20 meters and past that the signal strength is significantly weaker and will lost connection. As you can see in the graph past 20 meters the number of transmission errors dramatically increases because the effective range is only up to 20 meters. There is a small bump at 10 meters but that is most likely from interference in the connection and the connection should is still intact at that bump. Once you get closer to that 20-meter mark the transmission errors will start to increase.

E. GPS

GPS stands for Global Positioning System and is a satellite-based radio navigation system The GPS operates independently of the Internet reception, but the use of the Internet or telephonic reception can increase the effectiveness of the GPS positioning information. Communication with GPS comes in the form of navigational signals transmitted by GPS satellites encoding a variety of information which includes satellite positions, state of internal clocks and the health of the network. For security reasons there are two different encodings that are used to transmit these signals: one is a public encoding that enables lower resolution navigations and the other is an encrypted encoding which is used by the United States military. The Autonomous Carrier Assistant only required to use the lower resolution navigation frequency because there is no need for it to use the encrypted United States military frequency. The way the GPS satellites work is that they continuously broadcast a "navigation message" on L1 and L2 frequencies at about a rate of 50 bits/s. Each message has a 1500-bit-long frame made up of five subframe with each subframe being 300 bits long. The following table describes what each subframe does and what it has to do with the satellites

Subframes	Description
1	Satellite clock, GPS time relationship
2-3	Ephemeris (precise satellite orbit)
4-5	Almanac component (satellite network synopsis, error correction)

Each frame inside of the first subframe is encoded with the week number and the time within the week. Then inside of the second and third subframe they contain the ephemeris which is the precise orbit of the satellite. Inside of the fourth and fifth subframe is the almanac which contains the coarse orbit and status information for up to 32 satellites in the constellation. We have used a sim33eau GPS module as it is connection Via Bluetooth device to connect to the mobile application.

F. Mobile Application

We used blynk app for mobile application which is available in android and iOS both operating systems. Blynk is an IOT platform which lets us interact with our design. This app has a bunch of different features from which we used Bluetooth and GPS. We also set up a button in blynk app to turn on and off the ACA. It provides us a simple user interface to implement and access the ACA through a mobile phone.

G. Power Supply

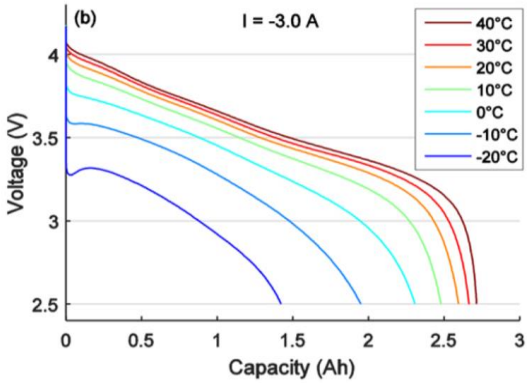
During our research that we did last semester in senior design 1 about which battery will fit our project (ACA) Autonomous Carrier Assistance. We pick Nickel cadm batteries and that because:

- 1-Ni-cd batteries offer high energy density which is a significant advantage is portable and compact electronic devices. High energy density means

that the battery has a high energy storage capacity for lesser weight

- 2-Absence of memory effect is another advantage of Ni-cd batteries. In normal batteries, when the battery is repeatedly partially discharged before recharging then over the time the energy delivery of the battery would downgrade. This memory effect is not present in Ni-cd batteries

- 3- Another huge advantage of Ni-cd batteries is their low self-discharge rate. When the batteries are stored or not used then they tend to discharge over the course of time.

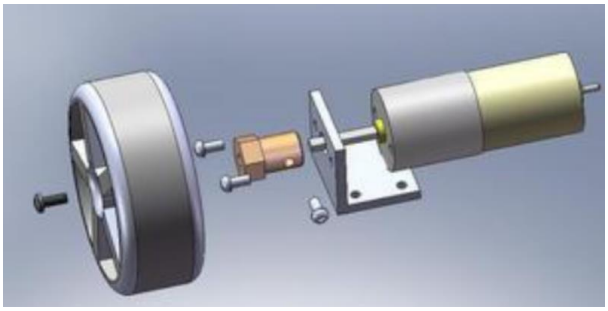


Most of the component that we are using the ATmega328P, sensors, Bluetooth, and GPS all need +5 volts VCC input to energy the elements. So, in this condition we build a linear voltage regulator in the Print Circuit Board (PCB) to regulator from 12 volts to +5 volts DC. These power supplies are not as robust as other types of batteries. These batteries require very tight voltage and current control. Protection circuitry must be present which saves the battery from being overcharged and over-heated. It also problematic and that because they have a high resistance comparing to other power supply. Cycle life is normal with other batteries

H. Wheel

*W*heels came about in an era of a primitive, caveman-level technology. Still, they are so ingenious that it took until the Bronze Age circa 3500 B.C. for someone to invent them. We designed the platform with 3 wheels, 2 motors. The three-wheel design allow for quick movements. They are easily controlled and have the ability to spin on the spot. These features are an advantage in crowded place and is also good when trying to avoid obstacles and collisions. These features make the 3 wheeled system a good contender for this project.

In order to attach the wheels with our platform we had to used a hub which is much wider on one end and the other end is 6mm because the motor shaft was 6mm. the wheel setup is given below how we used a hub for connecting the tire to the motor shaft

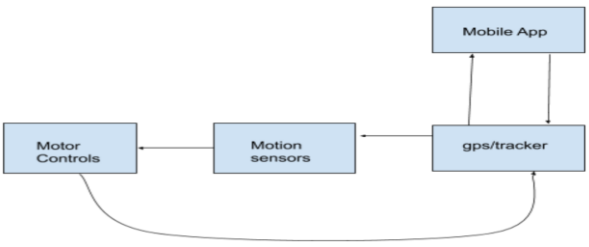


In order to control the turning operation since we picked 3-wheel design from which two front wheel are static, and each connected with a DC motor. one wheel on the back is rotational wheel. The platform was programmed to get signal from the device connected to the ACA platform which will inform the platform the direction of its user. When user turn right then the platform right wheel will be barely moving, and the left wheel will be at its full speed which will result in turning right through a rotational wheel. Similar operation will occur when the user turn left the right wheel will be in motion and the left wheel will barely move which will result in turning the platform

I. Assembly

The platform implementation of our model design was vital part of our project. We had to keep certain things in our mind while designing the assembly such as it can hold a specific wait and the load will stay stable while in motion. The platform was made of wood. The two different layers of wood, first layer holds the controller, battery, and other components and the second layer can carry the cargo.

V. SOFTWARE



Mobile App Block Status:

Input: The User give commands to the ACA such as Follow.

Output: Connects to the GPS block using Bluetooth and gives data on what to do.

GPS/tracker Block:

Input: Data that is coming from the Mobile App block which tells where the GPS where the phone is located. Also, information coming from the Motor Control block updating which direction the ACA is moving.

Output: Current location to the Mobile App and Motion sensors block.

Motion sensors Block:

Input: Receives the obstacle in front of the ACA from the transmitter and pass the information to the receiver on potential threats around the ACA that is being picked up by the sensors.

Output: Will give out warnings to the Motor controls block about threats around the ACA and will give suggestions on alternate routes to take or stop.

Motor Controls Block:

Input: Receives information from the Motion sensors block that warns the motor controls to turn or stop because of an object in the way.

Output: Controls the speed of the wheels and what direction the ACA will go in. Also updates the GPS block of what direction and how fast the ACA is moving.

VI. Standards

The autonomous luggage carrier platform falls under the category of mechatronic systems. Mechatronics is an interdisciplinary branch of engineering which deals with the development of systems which consist of electrical, electronic, mechanical, and software components. Due to this complex nature of the mechatronic systems, there are a number of standards which need to be followed to ensure the quality and safety of the ACA robot platform.

Some of the major standardization organizations include ISO (International Standards Organization), IEEE (Institute of Electrical and Electronic Engineers), ANSI (American National Standards Institute) and OSHA (Occupational Safety and Health Administration).

There are certain critical components in the ACA project which can pose a potential risk to the users or people in the immediate environment. These components include

Batteries
Motors
Electrical wiring
Mechanical platform

The ACA is a mobile platform and therefore requires batteries for its operation. Since, the commercial version of the product is expected to be substantially large in size therefore, bigger batteries are needed. Almost all the major battery types pose one type of hazard or another. Li-ion batteries that we are using in this design, can be explosive when poorly handled. Hence, proper guidelines and standards were followed for the installation and operation of batteries in the ACA project.

One of the most crucial components of any robotic system are the motors. All the movements of the robot are dependent on the use of motors. There are also several hazards attached to the motors. Motors consist of moving parts and therefore exposed motor shafts can pose health related challenges for the operators. Additionally, the motor driver circuits make use of high frequency DC-DC converters which create electrical noise and EMI. The interference signal can interfere with sensitive electronic equipment in the environment and cause malfunction of that equipment. This becomes even more critical in the environments such as hospitals, airports, and industries. The malfunction of sensitive equipment can lead to many different hazards and risks. Therefore, the mechanical motion as well as the EMI emission of the motors and their circuit was checked for any malfunction. The design of the motor control system was carried out according to the relevant standards.

Another challenge associated with electrical system of the ACA robot is that of electrical wiring. Faulty electrical wiring can lead to device malfunctions and fire hazards. Therefore, the electrical wiring of the robot was carried out properly in line with the appropriate standards and guidelines. In addition to that, the mechanical motions of the robot were also carefully designed so that it does not pose any harm to the people in its vicinity. A robot colliding with a human can cause severe injuries and this possibility was eliminated at all costs.

VI. ProjectN Constraints

A. Design Constraint

Every product and service have a defined scope or area of operation. In other words, every product or service has a set of its limitations out of which is it is not suitable to operate. Understanding of these limitations is crucial for the safe and reliable function of that particular device.

The autonomous luggage carrier robot system also has its limitations and design constraints. The primary function of the ACA robot is to assist people in handling their

luggage. Hence, one of the key factors in the design of this robot is the weight limit that this robot can handle. At present the ACA robot can carry a maximum weight of 30 pounds. Thus, if weight of more than 30 pounds is handed over to the robot then the operational reliability and safety of the robot becomes uncertain. Therefore, it is important that the robot is operated within its designed parameters.

B. Safety Constraint

Safety is one of the most important considerations in all types of machines. It becomes even more important in case of automatic machines. The devices which do not fulfill the safety requirements can prove to be dangerous for the operators and other humans in the vicinity of the machine.

The biggest safety concern in the ACA robot is the collision with humans and objects. Due to the substantial weight of the robot, the collision must result into injuries and financial loss. Hence, it is extremely important that the distance sensors and robot algorithms work as intended. All the sensors and the code logic were extensively tested in order to ensure safe operation of the robot. The mechanical movement of the robot was also constrained while interacting with humans. Safe operation of autonomous robots was the key for this project

Another safety factor in the design of the ACA robot is the speed. If the robot speed is too high, then the chances of injury are too high upon collision. Therefore, just like the weight, a reasonable limit for the speed was determined for the ACA which was 3 to 4 miles per hour r. If the speed is too low, then the robot might lag behind and loose contact. If it is too high, then the risk factor is enhanced.

One more safety risk in the project is the batteries. Batteries are charge storage devices and their charging needs to be carefully controlled using power electronic converters for safe operation. Improper charging of Lithium ion batteries can result into explosion and fire hazards. Excessive load currents and improper ventilation can cause battery overheating. This is also a hazardous situation which can initiate fires. Therefore, batteries in the ACA project were deemed safety critical components and must be handled accordingly. Proper cooling and ventilation of batteries was ensured.

C. Environmental Constraint

The ACA project does not use any type of fossil fuels and completely runs on clean electric power. This is a positive feature which is environmentally friendly. The batteries used in the project, however, pose some degree of environmental challenge as they contain toxic materials. However, with proper recycling strategy, the impact of this problem can be minimized. Other ACA components such as motors mostly consist of steel and copper which are very easy and profitable to recycle. Therefore, the recycling of motors is not an issue at the end of life cycle.

A significant portion of the ACA project consists of electronic circuits. These circuits consist of ICs and electronic components which make use of rare earth metals and other solid-state materials. These circuits can potentially become e-waste at the end of product life cycle. Hence, it is important that these circuits and components are reused and recycled in accordance with the appropriate standards and guidelines.

VII. DESIGN OPERATION

The Autonomous Carrier Assistant (ACA) project focuses to provide a user with a hassle free carrying assistant that can assist them in carrying their cargo across various distances from point A to point B. User experience is a priority, and achieving straightforward incorporation between its user and device is both exciting and rewarding. To begin, a user should approach the ACA platform with their handheld Bluetooth capable device. The user must first download the application from their desired platform application store and need to be paired with the device. The user should Immediately be able to Log in to their account on the mobile interface and start the pairing process. The ACA platform will be always ready for new devices to pair with when it is not in use, and associate links based on information relayed by the Bluetooth connection through the app. Once the pairing process is complete, the user is now on their way to burden-free travel. After the device and the user's mobile phone are paired, the ACA will search for Bluetooth around the area to locate and initialize its following capabilities. The user will designate the follow mode and will then proceed to be closely shadowed. Travelling through crowds and obstacles, the Autonomous Carrier Assistant (ACA) should keep up with Speed and avoid any possible collisions along the way providing the user with an efficient and safe experience. Once the user has reached their destination, they will be able to disengage the device with a simple touch of a button on their handheld device and continue on with their travel. The ACA will then reset and allow for continued use by anyone else who may wish to test. There is an additional

joystick option that can be used during low GPS signals through blynk app.

VIII. Conclusion

The goal and objectives were pretty clear from the beginning of this project to design a platform which can assist conveniently in situation in which equipment, object or luggage needs to be taken from one place to another. The Autonomous Carrier Assistant is at its very essence, an autonomous robot. Autonomous assistant that can follow someone. This project was an attempt to make an autonomous robot which follows someone, that will be versatile and efficient as well as being low cost to both produce and sell on the market. The hardware and software chosen to complete is project were all extensively researched to produce the most cost-efficient product to go to market.

There are many challenges that we faced in completing this project. Our choice of hardware and software would have had a great effect on how well the ACA performs in different environment. Performing in crowded areas is essential for the ACA. The challenge to avoid collisions was solved by using accurate sensor and the right number of sensors. Applying the proper coding also enhanced this feature of the ACA. Following at the correct distance was another hurdle that was overcome. Maneuvering through different terrains can be achieved with a good quality motor and wheels. Having enough power to carry loads and perform efficiently will determine by our power supply along with motor quality. Choosing the right microcontroller with versatility so that we can implement all of our feature. The right answer for all the challenges was an intense research about every single aspect of this design.

It is one of the tools that solve human being problem and make our living easier, practical, and faster. In the end, it is safe to conclude that the ACA project meets all the set requirements in a satisfactory way. It meets all the requirements while ensuring functional and occupational safety. Moreover, the project has a positive social significance and contributes positively towards enhancing the quality of life of its users.

BIOGRAPHY

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Hunter Busa is currently a senior at the University of Central Florida and will be graduating with a Bachelor of Science in Computer Engineering in August. After graduation he will be pursuing a career in Software Engineering.

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