Garbage & Recycle Automated Disposal (GRAD)

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***Abstract* — This project aims to eliminate the physical demands, incorporate ease, and facilitate efficiency by providing an automated controllable system to drive the trash bin to the curb. The paper presents the methodology behind both the hardware and software design of the GRAD system. The main components of the GRAD system are as follows: Physical & Mechanical Implementation of Drive System, Solar Panel Integration, Schematic Design, Microcontroller Implementation, and Software Implementation. The GRAD utilizes path planning through line following. Implementing this element to the device ensures accurate collector placement and curbside positioning for collection. This smart trash system allows the user to interact with the robot through an app from their phone.**

***Index Terms* — Automatic Trash Disposal, IR path-planning, object-avoidance, solar-powered.**

I. Introduction

Taking the garbage and recycling cans to the curb can be easily forgotten during a busy schedule or when rushing to work in the mornings. For those with physical constraints, it can be demanding to accomplish such a task. Especially for vacation rental properties where guests forget to take out the trash/recycle bins to the curb on the correct schedule, and the pile-up of garbage creates extraneous work for the property manager. The Garbage and Recycle Automated Disposal (GRAD) bot eliminates the physical demands, incorporate ease, and facilitate efficiency by providing an automated controllable system to schedule trash bin curbside placement.

The GRAD bot focuses on three main components with some additional features. The first component of GRAD system success is accuracy, the ability for the robot to traverse to the desired destination. The GRAD bot is designed to be within 1 foot of the desired destination. The second aspect of the GRAD project is safety. The GRAD bot must detect an object within two feet and stop with no less than 1 foot from the object. This ensures safety of both the GRAD system and external objects. The third main objective of the GRAD bot is action latency. The GRAD bot should implement movement within two minutes of the user sending a command. This ensure the bot will move when desired by the user. Lastly, solar charging was implemented into the GRAD system, making the system closer to environment friendly. The solar charger should obtain a voltage of 13.8-14.1 V for proper charging voltage with a positive (≥0) current flow to ensure the battery is charged.

Deliverable	**Deliverable Description**
GRAD System Movement Accuracy	The GRAD system should end up 1 ft from intended goal.
Latency	GRAD shall implement movement to the desired goal within two minutes of user implementing a desired action within the provided app (ex. robot moves withing two m)
Object Detection Safety Measures	The GRAD system should be able to detect object within 1 feet and stop.
Solar Charging Voltage	Solar panel charges the battery between 13.8-14.1V for standard operation conditions.

Table 1: Deliverable Requirements

II. SYSTEM DESIGN OVERVIEW

The GRAD system is broken into five subsystems. The first subsystem contains the 30W 12V monocrystalline solar panel and the 12V battery, with a designed battery charger between. Followed by the main control system where through the use of ATMega 2560 microprocessor, voltage and signals are distributed through rest of the systems. It provides power to the Wi-Fi module in the communication system that allows connectivity with home network. The fourth subsystem is the software system that allows user to connect with the GRAD system through a smart phone application. Finally, the core component of this project is the drive system which uses a L298 motor controller allows proper voltage to the two motors and PWM connection for accurate control. The block diagram in Fig. 1 visually depicts the overview of the GRAD system as described above.

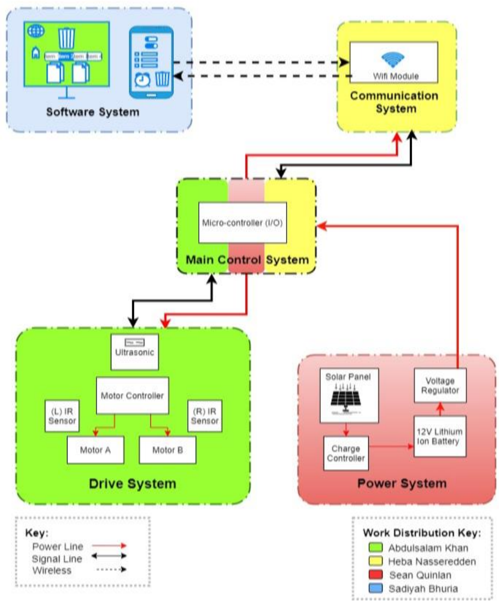

Figure 1: Block Diagram

III. PHYSICAL DESIGN & DRIVE SYSTEM

To implement our project design, a trash can is used to prototype and implement the drive, solar, and other components of the project. The trash can is modified to mechanically install two motors for the drive system and further modified to house other electronics and solar panels at the top.

6. *Drive Base Selection & Implementation*

As mentioned for our design and prototype, a 32-gallon Toter trash can is used similar to trash cans utilized in most residential homes. The goal of using a similar trash can is to do a proof of concept and implementation that could be later scaled to various sizes of trash cans. The trash can is equipped with two wheel which were reused in our selected three wheeled differential drive for our GRAD system.

The three-wheel drive takes its basic roots from a four-wheel standard drive with two motorized wheels in the back used for the same purpose of applying force and making turns. Instead of another set of two wheels in the front, we implemented one wheel for steering similar to a tricycle design. The velocity difference between the two motors drive the robot in any required path and direction. As shown in the Fig. 2 below, the differential drive can move forward, backward, make right and left turns by controlling the angular velocities.

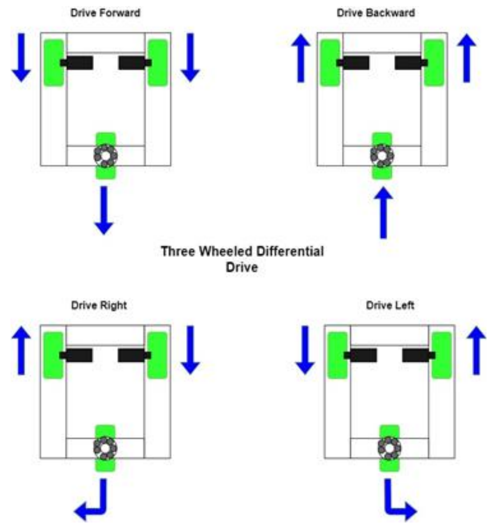

Figure 2: Three-Wheeled Drive controlled through angular velocities

The base of the trash can was modified to add two motors using metal frame to house and hold the motors which are attached to the two wheels. In the front of the drive base, a swivel wheel is added to create a complete three wheeled differential and allows steering.

B. Motor Mechanics & Calculations

To better understand and determine our requirements for motor selection, we considered some variables around the environment the motors will be used in. First, we calculated gradient resistance which is when our GRAD system moves up in the driveway incline with a certain degree, the weight will push in the opposite direction of its actual motion. In a case where there is not enough energy to propel the GRAD system up the incline, the whole body of the trash can will stall or torque of the motor is not able to hold its place, it will roll backward. To avoid this, we calculated the forces by considering the degree of angle, the weight exerting force along the road surface and perpendicular to the road as shown in Fig. 3:

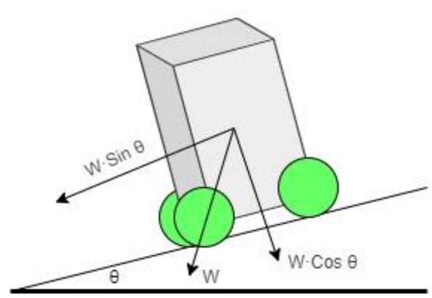

Figure 3: Illustration of forces to calculate Gradient Resistance

Below is the calculation for gradient resistance using about 79 pounds for weight, and the incline of the road of about 10% grade which is close to 5 degrees as theta value. This resulted in a gradient resistance force of about 30.6 newtons.

$$FG = w \cdot \sin\theta = mg \sin\theta$$
$$35.834kg * 9.8 * \sin 5 = 30.6067N$$

Next, rolling resistance is considered because it is expected that some friction will act against the motion of wheels in the drive way. The rolling resistance can be measured by multiplying the coefficient of the rolling resistance by the mass and the gravitational acceleration. This can be best expressed in the formula below:

$$FR = RR\ coefficient\ x\ mg$$

We used 0.01 as the rolling resistance coefficient and the max mass of GRAD system in kilo grams of 35.834 and 9.8 meters per second for the gravitational acceleration. The result of this calculation is as follows:

$$FR = 0.01 * 35.834kg * 9.8m/s$$
$$= 3.511N$$

Adding all of the forces together including a force to break the inertia and reach dynamic coefficient of friction which is four times the coefficient of the rolling resistance gives a value of 48.2 Newtons.

$$Total\ Resistance\ Force = 30.606 + 3.511 + 14.14$$
$$= 48.2N$$

Next, using the values from above, we calculated the least torque required to select the correct motors.

$$Torque = Force\ x\ Distance$$
$$= 48.2N\ x\ 0.1015$$
$$= 4.886\ Nm$$

Finally, the value for revolution per minute (RPM) is calculated by using a round trip distance of 50 feet and circumference of the tire at 2.073 feet based on an 8-inch tire. The value calculated is round per trip and then converted to RPM of 18.95.

$$Round\ Per\ Trip\ (RPT) = Distance/Cw$$
$$= 50ft/2.073ft$$
$$= 24.11\ RPT \rightarrow 18.95\ RPM$$

As a result of calculations, it is determined that DC gear motors would suffice our project need the best due to heavy load requiring high torque. ServoCity-Econ Spur Gear Motor was selected with 19RPM and torque of 18.82 Nm.

IV. POWER SYSTEM & PCB

The main control subsystem used the voltage from the motor control to power the system PCB. This system contains the ATMega 2560 microprocessor as well as pinouts for our sensors and communication modules. Pinout for the modules were chosen for flexibility in sensor placement and programming delicacy of the Wi-Fi module. The first schematic contained only pinouts for the desired components, as well as the microcontroller. After having difficulty removing the microcontroller from the development board, a second PCB that is programmable was created as suggested by Dr. Wei. Below is the schematic of the third subsystem (114.55 x 68.07 mm).

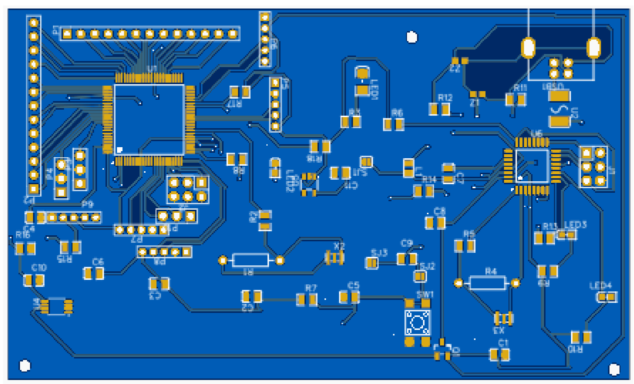

Figure 4**:** GRAD PCB

After completing the above PCB, the system did not perform as desired. This could be due to human error with limited resources for soldering surface mount pieces or microcontroller issues with such a large PCB. Therefore, the development board was implemented alongside soldered through-hole PCB boards to connect desired components, as instructed, to achieve proper GRAD functionality.

V. SOLAR POWER INTEGRATION

To integrate power into the GRAD system a solar panel and a battery storage system was implemented. This ensures increased mobility of the system. Solar charger calculations and a charger device was implemented.

A. Solar Power Calculations

The National Resource Energy Laboratory (NREL) is a national lab dedicated to research, development and implementation of renewable resource materials. NREL has a database comprised of solar radiation per zip code (kWh/m2/day). The zip code for the University of Central Florida is 32817, which has an average solar irradiance of 5.09 kWh/m2/day. This is based on a yearly average, depending on the month and day this will fluctuate from 3.2 to 6.7. This number aims to include weather as it is based upon average and data collection from the NREL [3]. However, numbers could fluctuate due to certain weather conditions. According to NREL the Normal Operating Cell Temperate (NOCT) derate factor is .731 [4]. The next step is to take solar panel data. For these calculations the Renogy 30-Watt 12 Volt Monocrystalline Panel will be chosen for analysis, as it is the best candidate for the GRAD system. With, the specifications sheet for this device states that the PDC, STC is 30W which is calculated with the assumption of STC Irradiance of 1kW/m2 and operation temperature at 25℃. To calculate the amount of energy that the system will be supplied the equation below will be implemented:

$$Energy(Wh/d) = PDC,\ STC * Derate\ Factor * \ (h/d\ Peak\ Sun)$$

For calculation purposes the h/d Peak Sun is calculated assuming there is 1-sun insolation (1kW/m2), just as stated in the solar specifications sheet. Therefore, dividing 5.09 kWh/m2/day will get 5.09 h/d of peak sun. Implementing these numbers into the equation results in:

$$Energy(Wh/d) = \ 30W * .731 \ * \ 5.09\ h/d \ = 111.6\ Wh/day$$

This number will vary due to the weather and sunlight conditions, as well as the seasonal conditions. The tilt and position, as well as the efficiency of the solar battery charger can also affect this number. Therefore, the estimated energy charge per day will vary.

6. *Battery Charger Device*

A designed battery charger circuit was implemented to create a small device that was lightweight and could be implemented to ensure proper battery charging voltage. The charger implements the voltage regulator LM317 which output a voltage range. Implementing resistors calculated to boost the voltage to the proper range. The formula:

$$V = 1.25V\left(1 + \frac{R2}{R1}\right)$$

A potentiometer is implemented to ensure that the designer can increase the system accuracy. Diodes are implemented to ensure the proper voltage across the system ensuring forward flow to charge the battery.

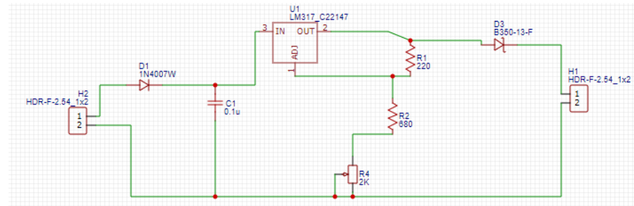

Figure 5: Solar Charger

The battery is essential to the operation of the system to ensure that the motors and the rest of the system have enough load at the time of operation. If the system is to operate later in the day, the solar panel will be tasked with charging the battery to which the battery is the main source of power if the load is greater than what the solar panel produces at a given time.

For proper functionality of the battery, the use of voltage regulators and diodes are implemented into the system (as seen above) to ensure the battery does not experience either over or under voltage as well as overcharging. The charging of the battery must be between 13.8V and 14.1V.

This ensures proper functionality and reliability of the system to increase the safety of the device. Implementing ANSI standards into the battery subsystem allows proper functionality and safety of the overall system due to the Lead Acid battery being placed within the GRAD system [6].

6. *Battery Implementation and Standards*

To increase the capacity available to our system, the GRAD system will have a 12V 20AH or 240Wh battery as its supply. This will ensure enough storage for the GRAD system for weekly trips to the curbside. Implementing a 12V lead acid battery with a 19.5V output solar panel. The voltages of the system do not exceed that of 20V. The GRAD system is classified as a Class I product, non-hazardous.

IEC 61140 is an international standard for protection against electrical shock. The International Electrotechnical Commission (IEC) is an international standards organization that implements standards for electrical and electronic technologies. The IEC 61140 standard is implemented to protect humans and animals from the electrical shock of systems and applications. Installation, equipment, coordination is covered in this standard as well as ensuring proper functionality and protection of the system [5].

The classification of power sources is outlined in the power supply section. However, to comply with standards and to ensure the safety of the users and any obstacle that may encounter the GRAD system. Class I power supply was implemented. Upon this classification, the GRAD system is run on voltage not exceeding 20V. This allows the system to not be labeled as a hazardous voltage.

While the GRAD system implements a non-hazardous voltage, many measures were implemented to keep the user safe. All bare wiring for the grad system has been covered to protect any user from exposure. Components, including the battery have been placed in a separate compartment to keep the electrical equipment separate from trash and any external user.

VI. MICROCONTROLLER

The microcontroller that we have chosen, the Arduino Mega 2560, will be interfaced with the Wi-Fi module, motor drivers, and power supply. The Arduino Mega 2560 will need to process information transmitted by IR and ultrasonic sensors to implement the line-following algorithm required for path planning. In addition, the microcontroller will continuously read information over serial communication to determine if it should start driving to its destination: when the user deploys GRAD from the mobile application, the microcontroller will receive a signal from the Wi-Fi module to turn on the motors and drive to the user's curb. The Arduino Mega 2560 is an 8-bit board that operates at 5 Volts, and it has 54 digital I/O pins (15 of which have PWM output), 16 analog input pins, 4 UARTs, a 16 MHz clock speed, and 4 serial ports [12]. The figure below summarizes the technical specifications of the Arduino Mega 2560.

Arduino Mega 2560 Specifications	
CPU	8-bit ATmega2560 processor at 16 MHz
Programming Languages	C, C++, Python
SRAM	8 KB
GPIO Pins	54
Power Source	6 to 20V
Bluetooth/Wi-Fi Module included	X
Starting Price	$38.50

Table 2: Arduino Mega Specifications

The ample amount of GPIO pins made this microcontroller a desirable choice for our project since it could accommodate the required number of connections for the IR sensors, ultrasonic sensors, motor driver, battery, and Wi-Fi module. Moreover, Arduino has many software libraries available to install and use- they include built-in functions that make it easier to control sensors and outputs, and to perform other useful tasks. Arduino uses its own programming language that we have used in conjunction with the C programming language. In addition, having more than one serial communication port on our microcontroller allowed for easier debugging of our project- one serial communication port was used to observe output of print statements to a serial monitor, and another serial communication port was used for interfacing the ESP8266-01Wi-Fi module.

Another advantage of the Atmega2560 chip is the friendly user interface provided by Arduino IDE and existence of supporting documentation. Due to the online popularity of Arduino products, we were able to find a multitude of information regarding how to integrate peripheral modules into our project. Having a solid support network was helpful for debugging code and resolving problems similar to those that other people have previously experienced.

Although we are not using the original Arduino Mega 2560 board for the final implementation of our project, it was still useful for initial testing phases. Once the final version of the microcontroller software was achieved, we removed the Atmega2560 chip from its board and soldered it onto our custom designed PCB.

VII. WIRELESS COMMUNICATION

GRAD requires a communication system to transmit and receive information between the user and the garbage bin. For instance, the user needs a way to signal GRAD to travel across their driveway and to the curb. For this to occur, GRAD needs to have access to a database and constantly probe it to determine when to take out the trash. The user is able to deploy GRAD through a mobile application which communicates with the Wi-Fi module and microcontroller.

GRAD's communication system has been implemented with Wi-Fi, which is synonymous with the IEEE 802.11 family of standards. Wi-Fi uses radio waves to transmit and receive digital signals/data. Radio waves that are used for Wi-Fi can be categorized within several frequency bands: 900 MHz, 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, 5.9 GHz and 60 GHz [13]. Each frequency range is divided into channels, each channel is identified with a number that refers to its center frequency. The main bands used for carrying Wi-Fi are 2.4 GHz and 5 GHz, with the 5 GHz Wi-Fi providing more bandwidth, less interference, and a shorter range than the 2.4 GHz Wi-Fi.

We have chosen the ESP8266-01, shown below, to be our Wi-Fi module.

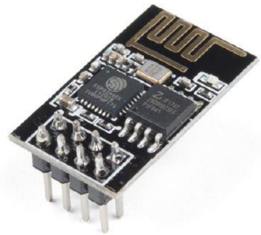

Figure 6: ESP8266-01 Wi-fi module size comparison. Licensed under CC by 2.0

It is a system on a chip (also known as SOC), which means it is an integrated circuit that contains all the components of a computer. The ESP8266-01 Wi-Fi Module features 802.11 b/g/n, Wi-Fi Direct (P2P), soft-AP, an integrated TCP/IP protocol stack, a low power 32-bit CPU that can be used as an application processor, 1MB of flash memory, as well as SPI, I2C, and UART capabilities [14]. The ESP8266 is compatible with any microcontroller and can provide a microcontroller with access to a Wi-Fi network. It can connect to networks of varying security, including open, WEP, WPA and WPA2 networks [15]. The maximum data transfer rate is 72.2Mbps using a 2.4 GHz band. This module can be used to host an application, or it can be used to offload Wi-Fi networking functions from another application processor. The table below summarizes the technology specification of the ESP8266-01 Wi-Fi module:

Esp8266-01 Specifications	
Manufacturer	**Espressif Systems**
Price	$2.71 each
Power Supply	3.3 V
Current Consumption	Up to 215 mA
Maximum Data Transfer Rate	72.2Mbps using a 2.4 GHz band

Table 3: Wi-Fi Module Specifications

The ESP8266 can be integrated with sensors and other application-specific devices through its GPIOs, and it also supports Bluetooth co-existence interfaces. Regarding the required power supply, it runs on VCC-3.0-3.6 Volts, and draws an average current of 80 mA. However, the ESP8266 is not capable of 5-3V logic shifting, and therefore needs an external Logic Level Converter. The ESP8266 can work under all operating conditions and does not require external RF parts, since it contains a self-calibrated RF. Priced at $2.71, the ESP8266 is a very cost-effective module. Equally important, the ESP8266 has a large community of users, so there was a wealth of resources and support available online to help us in using the module.

VIII. Path Planning

Path planning- or the process of driving a robot from a specified start point to a specified end point- is an integral part of GRAD. In order for GRAD to be autonomous, it must be able to distinguish free space from space with obstacles to avoid collisions with nearby objects and safely transport itself to the user's curb [11].

There are different types of path planning, and they are distinguished by the information available about the environment, for example: fully known/structured environment, partially known environment, and fully unknown/unstructured environment. The figure below illustrates how path planning will be used in our project- to drive GRAD from a start point to an end point while avoiding obstacles in its environment.

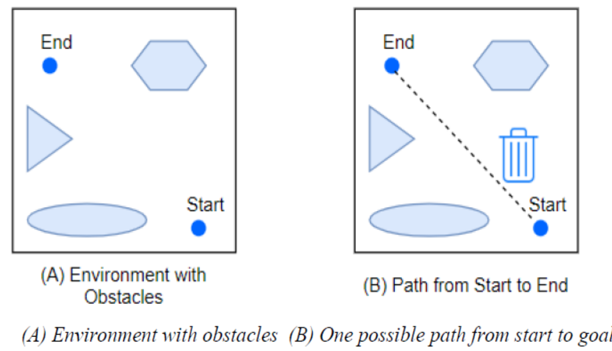

Figure 7: Path Planning with Obstacles

Implementing a line following algorithm was determined to be the cheapest, simplest, and most accurate method to achieve GRAD's purpose of transporting trash to and from the user's curb. GRAD follows a black line in a white background, it can also be programmed to follow a white line in a black background. Line following robots can distinguish the line from their background and run over it, hence the reason for choosing contrasting colors for the line and background. To incorporate line following into GRAD, the user would need to outline the desired path from their garage to the curb by placing tape on the ground that define the trashcan's path. In this case, the path planning environment is fully known since it is defined before the robot starts moving.

Two individual IR sensors are used to implement line following by calculating the reflectance of the surface beneath them, as shown below in the figure [9]. A white line would almost completely reflect any light that falls on it, while a black line would absorb most of the light that falls onto it. The value of reflectance detected by IR sensors is used as a parameter to detect the position of the line. The IR sensors emit a light that strikes the surface of the line and is reflected back to the IR photodiode. The photodiode then responds by producing either a high or low value for output voltage (high for light surfaces, low for dark surfaces) proportional to the level of reflectance of a surface [10].

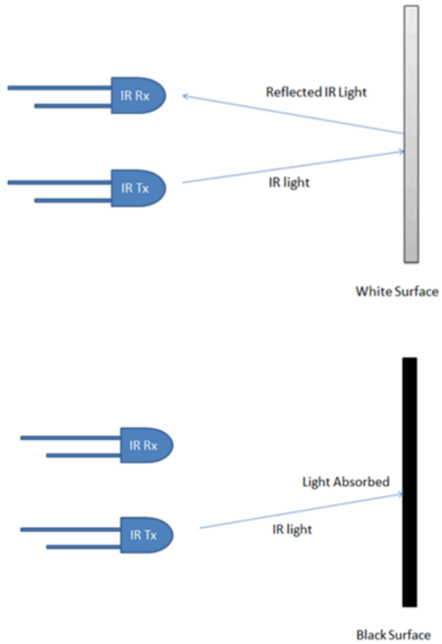

Figure 8: IR light reflection on white surface and IR light absorbed on black surface. Reprinted with permission from circuitdigest.com

Thus, the IR sensors allow the robot to "see" the line and notify the robot if any adjustments need to be made if it strays from the path. Line following robots estimate if the line beneath them is shifting too much to the right or left, and based on these estimations, it signals the motors to turn left or right in order to keep the line at the center of the robot.

IX. ULTRASONIC SENSOR

The team will be using HC SR04 ultrasonic sensors in order to detect an obstacle as the sensor is cheap and the working principle behind it is easy to understand. An ultrasonic sensor is one of the sensors that measure the distance of an object by sending the soundwave of a specific frequency. Ultrasonic sensors have some advantages. Ultrasonic sensors can detect objects easily because of high frequency. They are also easily compatible with microcontrollers. Everybody considers safety as a priority, these ultrasonic sensors are feasible to use also they are not dangerous and do not harm any person, object or material nearby it [8].

The ultrasonic sensor waits for the sound waves to be reflected back when it detects an object and also calculates the distance based on the time required. Ultrasonic sensors are accurate in measuring short distances. The ultrasonic sensor comprises a transmitter that transmits the ultrasonic waves and a receiver that receives the ultrasonic waves, and both are operated at a specific and same frequency.

IX. SOFTWARE DETAILS

A major component of the GRAD system is the accompanying mobile application that allows user to press a button on the mobile application and the trash can will drive itself to the curb. The mobile application was developed using Android studio platform. In this section the software behind the mobile application involved in the GRAD system will be discussed.

A. Database and Mobile Application Connection

The mobile application has the ability to connect and retrieve information from the microcontroller that is attached to the Automated trash disposal. The team utilized Firebase for our database to store the user's information and the signals associated with driving the Automated trash disposal to curb and returning it to home. In order for the flags/signals to be operated using the button, it was crucial for the Android mobile application to establish a secure connection with the user's specific account on Firebase.

B. Android Studio for GRAD app

The mobile application for GRAD system was developed using Android Studio IDE. This IDE offers a variety of developer tools and a strong coding editor. Moreover, it has a built-in debugger. The Android Studio has an intelligent code editor that allows the user to write better code and it also offers advanced code completion. The Android Studio gives suggestions as the user is typing the code.

Android Studio IDE supports a variety of programming languages such as C++, Java, Go (with extension) and Kotlin. For the GRAD mobile application, we utilized Java as the primary programming language because the team was familiar with Java programming language and it made it easier to code in Android Studio. While developing the app, it was easy to test on the emulator even when we did not have the actual Android device in the beginning stages of testing. Android Studio is designed for teams so that they can collaborate easily. It integrates with GitHub and Subversion so that the teams can sync with the project and build changes as they code [7]. This is a very great feature in Android studio as it allows to share code and makes sure that no code is overwritten by other changes.

One interesting and most useful tools of Android Studio is that it allows you to set up Firebase. There are several options each having detailed description on how to use and connect the Firebase and Android Studio application. The Firebase tool in Android Studio made it easier for us to understand and utilize it in the app.

C. *GRAD mobile application Functionality*

The mobile application is the crucial endpoint in in the GRAD system that connects the GRAD to the user. It comprises of two features: Drive to Curb and Return Home buttons. When the user opens the GRAD mobile application, the user will see the Login page initially. The outline of the mobile application that was ran on emulator for the login page & Welcome page for GRAD system is shown in Fig.9. Once the user enters their login information, the mobile application will direct the user to the welcome page where the user will have the ability to operate the "Drive to Curb" and "Return to Home" buttons.

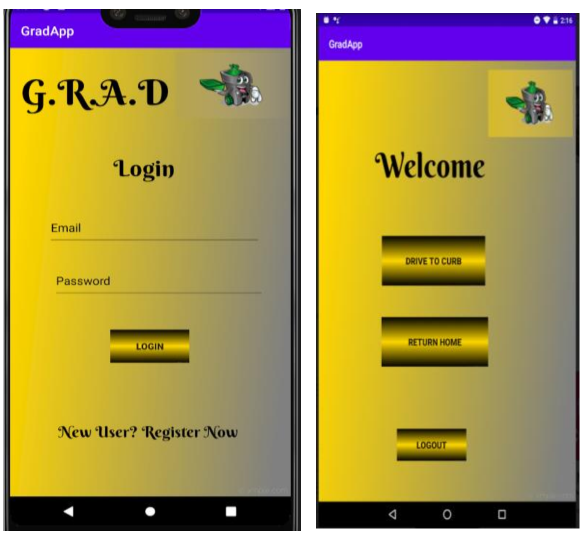

Figure 9: The *home and login pages* for the GRAD mobile application.

D. *Software Testing*

The project includes software not only for the mobile application but also for the functionalities of the microcontroller and its connection with the database by transferring the data or command from the app to the microcontroller. A set of testing of the software was done throughout the entire software development in order to verify or confirm that every single part of the software involved in this project is functioning properly individually as well as after integrating. The software test was conducted in parts through unit testing. Unit testing is a crucial step for all software development.

The mobile application was opened on Emulator that is built in feature in Android Studio. The Firebase was also opened and viewed side by side. Firstly, the authentication of user registering and logging in mobile application was tested. Secondly, the mobile application was connected and opened on actual physical android device. The next test was done by pressing the "Drive to curb" button on the application to test if the signal on the Realtime database was changed. The Firebase Realtime database was opened and the value changing from "0" to "1" was observed when the user hit the button on the mobile application.

The aim of unit testing was to sort out each part of the program and test that each individual part is working correctly. This composes of checking if the buttons are functioning properly when pressed and that specific button will redirect to the appropriate page and store information. The integration testing was done by connecting the microcontroller and the mobile application to the database. The motors were observed to ensure that they work on the signal ("1") stored in the database by the user from the mobile application. Also, the connection between the WIFI module, mobile application, and microcontroller were tested to ensure that they were connected.

XI. CONCLUSION

The integration of the described hardware subsystems with the software resulted in the Garbage and Recycle Automated Disposal (GRAD) bot. Implementing these subsystems to create a user-friendly product during the COVID-19 pandemic was challenging, however the main objectives as discussed: Destination Accuracy, Notification Action Optimization, Object Detection Safety Measures, and Battery Charging Voltage Protection were satisfied. This project acts as a model for further development in society and can be further advanced in later studies to implement user specific desired tasks such as voice-control, yardwork implementation, or other various uses.

XII. THE ENGINEERS

Sadiyah Bhuria is a computer engineering student graduating in Fall 2020 from the University of Central Florida. She is currently working as an Undergraduate Learning Assistant as well as

Undergraduate Research Assistant under Dr. Ronald F. Demara. Sadiyah plans on beginning her Masters in Computer Science in Spring 2020 at University of Central Florida.

Heba Nassereddeen is a computer engineering student graduating in Fall 2020 from the University of Central Florida. She is an active member of the Burnett Honors College, and she is currently working as an Undergraduate Research Assistant at UCF's Computational Biology Lab. After graduating, Heba will be joining L3Harris Technologies as a software engineer in the Space & Airborne Systems segment. She plans on continuing her education in computer science after gaining industry experience.

Sean Quinlan is an electrical engineering student graduating in Fall 2020 from the University of Central Florida with a minor in Intelligent Robotic Systems and Mathematics. He is currently an intern in the Distribution Planning and System Reliability group at Orlando Utilities Commission. In 2021, he will be starting his career full-time as a Distribution Engineer at Enercon Services Inc.

Abdulsalam Khan is a computer engineering student graduating in Fall 2020 from the University of Central Florida. He is an active member of the engineering college's selective Tau Beta Pie Engineering Honor Society and has served many leading roles. Currently, he is a Network Engineering intern and upon graduation, he will be starting his career full-time as a Cyber Systems Engineer at Northrop Grumman's Defense Systems.

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