Garbage & Recycle Automated Disposal

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Project Narrative

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. This project aims to eliminate the physical demands, incorporate ease, and facilitate efficiency by providing an automated controllable system to schedule trash bin curbside placement.

The GRAD requires GPS and path planning. Implementing this element to the device ensures accurate collector placement and curbside positioning for collection. This would allow waste management to just pick and empty the trash can easily and would make it much faster as the trash can would be positioned. This smart trash system will allow the user to interact with the robot through an app from their phone. Two of the main features in the app include notifying the user if the trash can is full and allowing the user to drive the smart trash can to the curb. In addition, the user will be able to create a schedule depending on when their waste management picks up the trash, and the smart trash can will drive itself to the curb based on that schedule.

GRAD will be integrated into the garbage collectors. Due to modern environmental efforts, implementing solar panels into GRAD allows the decreased electricity usage from the home, and becomes self-operated. They will not require the user to have to plug the GRAD system in and out from an electrical outlet. This will allow the robot more independence and further fulfills the decreased user interaction with the robot. If the user forgets to plug in the robot or unplug GRAD, it would be unable to take the trash to the curb. Therefore, integrating a rechargeable battery alongside a solar system will allow for GRAD to charge during the day and implement curbside placement at any time. Monocrystalline Solar Panels and Thin Film Solar Cells seem to be the best choice for efficiency and for the project. Polycrystalline solar cells also seem to be reasonably priced. Further research will take place for the accurate determination of the solar-type. The battery will also have to be sufficient to support the GRAD system motors as well as the solar panel.

Smart garbage curbside robots are not actually on the market currently and are still in research and prototyping. These robots seem to offer limited functionality as the user has little capabilities and provides very little information that would be beneficial to the user. The robot will be able to report on the app the location and the actions it is taking. However, GRAD goes a step further by also detecting the weight amount every time the trash or recycle is disposed, keeping track of disposal and recycling amount. Implementing this will help users become more environmentally friendly, as they become aware of how much waste they produce compared to recycling. As previously stated, GRAD will be solar-powered, unlike its competitors saving money on the electric bill while staying environmentally friendly.

Implementing this system for public use would require the robots to be accurate, easy to maintain for the user (however maintenance from the company can be required). A mobile app will be implemented for user-friendly notifications, trash bin location, and waste management. Due to the fact of senior design, the project design, prototyping, testing, and final production will require an increased cost. As shown in Table 2, the cost for our model is set to be below $600 yet if ever moved to production, this cost would have to decrease to maximize profit. Trash cans usually weigh about 25lbs and the goal is to keep the total weight (before accepting waste) to below 70lbs after implementing the device into the trash can. The GRAD robot will be able to carry a minimum of 20lbs of waste within the bin. Whenever the GRAD system determines when it should send a notification to the user (such as Trash picked up and GRAD successfully returned to the station), the user should be notified within less than two minutes after the notification has left from the robot.

The GRAD system will have an ultrasonic level sensor that will detect if the trashcan is 90% full. Once the trash can level is full, the data will be sent to the microcontroller and then the microcontroller will process the data and through the help of the Bluetooth module it will send the data and notification to the app. The app will simply display the amount of trash in the trash can (measured by the percentage of the bin that is full) and it will also notify the user to empty the trash can if the weight or volume exceeds the specified amount. The user can also specify a weekly schedule for the GRAD system to specify when they want the garbage bin to be at the curb. For instance, if the trash day is every Tuesday and Thursday at 8:00 am, the user can set the arrival time for the garbage bin to match that time. The app will be flexible, so if trash day changes the user can update the schedule to reflect the new time at which the garbage bin needs to be at the curb. The user will also be able to cancel any scheduled times, in addition to being able to modify the dates and times the trash day. For the GRAD system to work properly, the user should also enter the location where they want the garbage bin to drive itself to. Once the user sets the schedule for the GRAD system and establishes the destination location, the trash can will follow the appropriate directions to drive itself to the curb. A GPS module and path planning algorithm will be required to navigate the trash bin from its starting position to the destination position. The microcontroller will transmit clock signals to the navigation software so that the GRAD system can operate in real-time.

The microcontroller that will be chosen for the GRAD system will most likely be an Arduino board. It should have enough I/O pins to satisfy the required connections that must be made to the motors, power source, sensors, and external clock. We will most likely utilize Python to implement the GRAD system's schedule planning algorithm, the final decision regarding which microcontroller and programming language to use will be made after conducting more research.

Besides programming the microcontroller, part of the research will focus on the software for the development of the phone application to be utilized by the user. The phone application will be integrated with the GRAD system to communicate over Bluetooth to send/receive signals. The application will be built using Android based technologies including MERN stack due to the abundance of resources available online.

Due to all the capabilities for implementation and with a focus on the technical aspect of electrical engineering and autonomous drive system, this specific prototype will not deal with the factors of weather. Further research and implementation of weather protective measures can be implemented in another project. Due to technological advancements in the waste collection industry the project will be implemented to include minimal device protection. The device components will be separated from waste, however with less human interaction and a more robotic type of trash collection, implementing this project into the future would allow less harsh movement of the trash bins.

Statement of Motivation

Before settling on the GRAD project, a few other project ideas were considered. Since our team consists of both computer engineers and electrical engineers, it was highly desirable to choose a project with equal amounts of hardware and software.

	Practicality	Difficulty	Cost	Interest
Garbage and Recycle Automated Disposal Bot	4	4	3	5
Indoor Trash Collecting Robot	3	4	3	2
Automated Transportation System for Garbage Bins	3	5	4	3
Smart Shower	2	5	4	3
Smart Pet Feeder	5	1	3	3

Table 1: Project Selection Matrix

As shown in Table 1, the practicality, difficulty, cost, and interest of five different project ideas were judged and carefully analyzed before making a final decision. As a team, we assigned a number 1 - 5 (with 1 being the lowest, and 5 being the highest) to our perceived values of each specification. We initially considered building a transport system for garbage bins rather than making the garbage bin itself smart- however, the difficulty of creating a mechanical body that is capable of lifting heavy weights made this idea undesirable, since our team does not have the same expertise as mechanical engineers regarding dynamics and rigid body motion. We also considered an alternative indoor robot that would navigate to the user upon command, however, this option did not interest all members since it would have leaned heavily towards software. GRAD was born out of these two ideas, it was the ideal middle-ground project that interested both the electrical and computer engineers on the team, and it combined elements that we liked (for example, implementing solar power into our design and path planning algorithms) while also eliminating difficult, unpractical elements (notably, the mechanical arm that is supposed to lift the heavyweight of a full garbage bin). Although a transport system would have been more scalable since it could be used to carry both recycle bins and garbage bins, it was deemed too impractical due to the mechanical aspects required.

The team also considered projects unrelated to garbage disposal: for instance, a smart shower system with features such as connecting to the user's internet to display water pattern usage, the ability to schedule showers ahead of time (which can optionally be accomplished by voice assistants such as Alexa), and precise control of temperature. Although everyone loved the smart shower idea, it seemed highly impractical since none of us had experience in controlling the flow of water through hardware, plus it would be difficult to test since that would require tapping into an already existing bathtub and shower. The last project under consideration was an RFID based smart pet feeder, which automatically disposes the correct food to each animal in a household. Although this project is highly scalable and seemed the most practical to build, the team was not too interested in it since none of us are pet owners. After considering the practicality, difficulty, cost, and interest of all five options, it was decided that the GRAD project would be the most ideal option since it scored the highest across all the categories.

Specifications

1. The robot shall have enough energy storage to be able to take itself from placement to curb and back at least once per day.
2. GRAD will use a 12V Solar Panel System.
3. Notification Latency: User shall be notified within two minutes if the robot trash can tip over.
4. The phone application shall allow the user to schedule the GRAD bot for day and time it will drive to the curb.
5. The phone application shall notify the user once the trash is picked up within two minutes.
6. The phone application shall notify the user once the GRAD system has placed itself back to the user's desired location within two minutes.
7. Trash Robot Placement on the curb and on return will be within five feet of the desired location.
8. Trash can robot hold at least twenty pounds of waste.
9. Trash can robot will work on a performance of 85% no obstacle collision.
10. GRAD system shall wait 10 seconds before continuing if stopped by an external object.
11. GRAD system shall stop a minimum of 6" from an obstacle.
12. GRAD trash storage bin shall be split into two bins (recycle & waste)
13. GRAD system shall have two motors.
14. GRAD shall traverse a maximum distance 500 feet from original placement location
15. GRAD System shall have two still location finders for robot destination planning

Constraints

1. The trash can only hold 20lbs trash
2. The trash can system shall only communicate in a certain range through Bluetooth
3. Solar charging is dependent upon daily irradiance loading (weather).
4. Solar charging will be based upon Orlando's (32817) average irradiance and solar efficiency.

Building Materials

1. Solar Panel, Rechargeable Battery and Diodes for Power Supply. The solar panel and battery should allow the robot to take itself from placement to curb and back at least once per day.
2. Four Wheels
    a. Use garbage can wheels with the addition of guide wheels in the front of the trash can.
3. Microcontroller and PCB to autonomously run the robot and control its electrical components
4. Phone app to schedule days/time for trash/recycle pickup
    a. Bluetooth or Wifi Module to connect with the phone using Bluetooth or across the home network
    b. Implement two options: Scheduling and User Command
5. GPS Model integrated with four Ultrasonic Sensors for path planning and Environment Interaction
    a. The goal is to be with five feet from accurate placement using a GPS module
6. 1 or 2 Weight Sensor for monitoring.
    a. Used to ensure the proper weight of trash for robot functionality
    b. Useful for waste management

Block Diagram

The block diagram in Figure 1 shows a high-level overview of the major components of the GRAD system. The GRAD system is divided into seven smaller subsystems blocks namely: Power System, Solar System, Drive System, Sensor system, Communication system, Software system, and lastly the Main Control system. Each of the system blocks are assigned to a System Lead as if in the real engineering world who are team members based on their knowledge and expertise.

Garbage & Recycle Disposal(GRAD) Bot

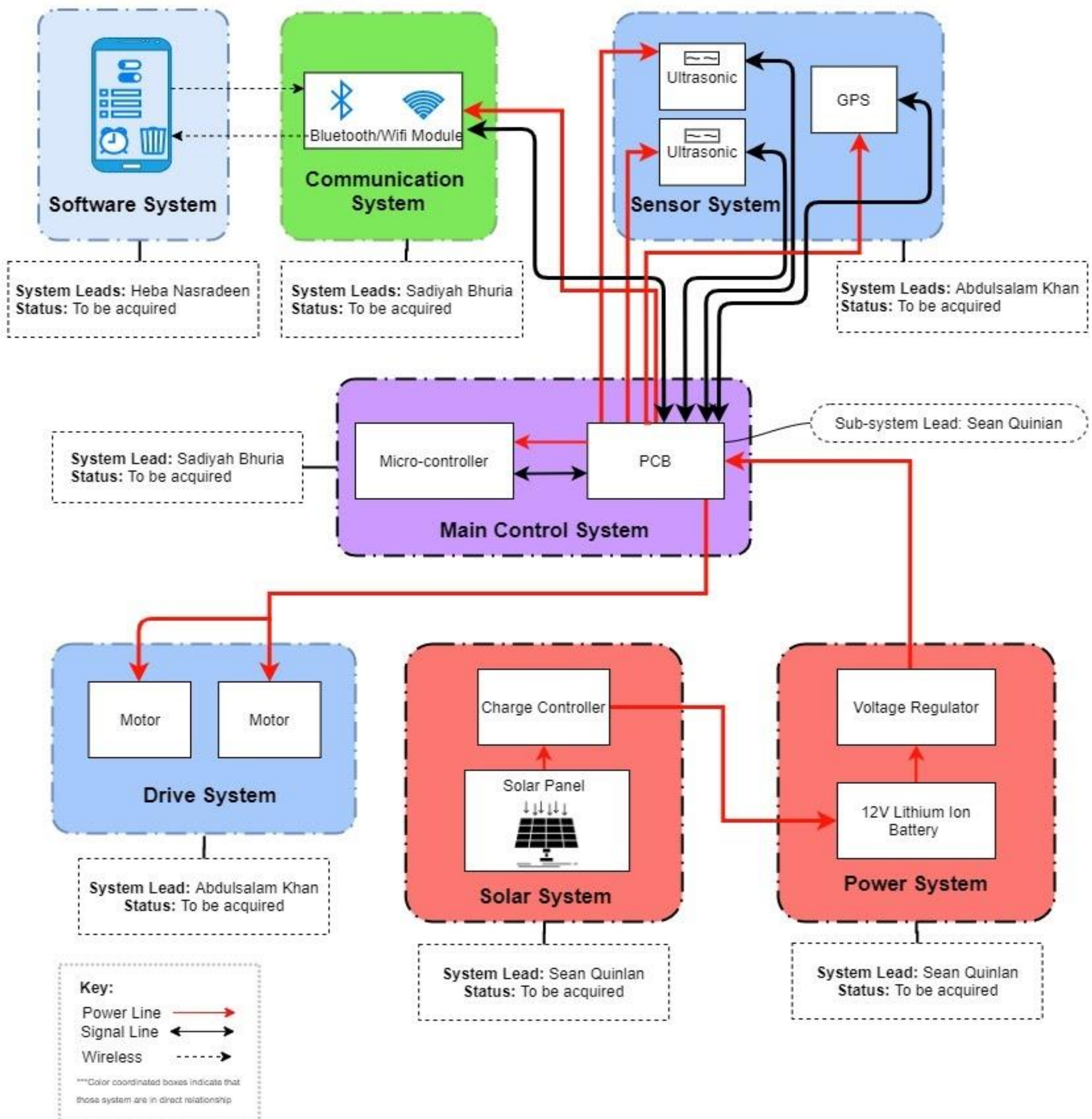


Figure 1: GRAD Bot Block Diagram

Table 2: Estimated Project Budget

Budget						
Part Number	Description	Vendor	Price Per Unit	Units	Estimated Price	CumulativeTotal Price
1	64 galloon outdoor trash can	Home Depot	$79.97	1	$79.97	$79.97
2	12-Volt 140 CCA Lithium Rechargeable Po	Home Depot	$84.99	1	$84.99	$164.96
3	ARDUINO UNO R3 [A000066]	Amazon	$18.00	1	$18.00	$182.96
4	Versatile u-blox 6 GPS modules	uBlox	$16.67	1	$16.67	$199.63
5	HC-06 Bluetooth module	Amazon	$8.99	1	$8.99	$208.62
6	PCB	JLCPCB	$0.40	5	$2.00	$210.62
7	owa 10 Watts 12 Volts Polycrystalline Solar	Amazon	$20.99	1	$20.99	$231.61
8	Wires	Amazon	$8.47	1	$8.47	$240.08
9	HC-SR04 Ultrasonic Sensors	Amazon	$4.95	1	$4.95	$245.03
10	DC 12V 100RPM Gear Motor	Amazon	$14.99	2	$29.98	$275.01
11	Extra wheels for 64-gallon trash can	Home Depot	$31.99	1	$31.99	$307.00

Total estimated price: **$307.00 + $200 (unplanned fees) = $507.00**

Table 3: House of Quality

The house of quality is useful for defining and analyzing how the project can become more efficient in the desired attributes and reduce those that are not as significant. Below is the Trade-off Matrix for the Garbage Automated System. The left side of the table labeled "Target", shows the requirements that customers would consider for buying product. The blue section in the table depicts the engineering requirements/ trade-offs for which the team will have to achieve and execute upon the final product that will be built. The description of the arrows is shown in the Legend section.

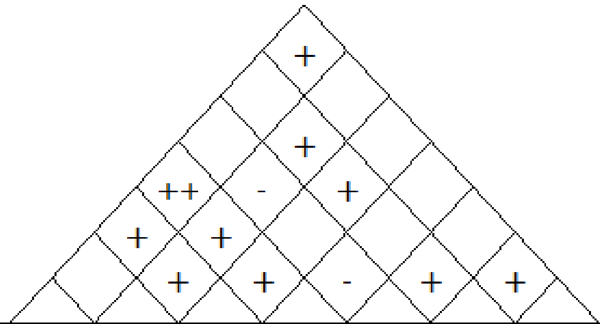
Legend

↑ = Positive correlation ↑↑ = Strong positive correlation

↓ = Negative correlation ↓↓ = Strong negative correlation

\+ = Positive Polarity Increasing the Requirement

\- = Negative Polarity Decreasing the Requirement



	Column #	1	2	3	4	5	6	7
	Direction of Improvement	+	+	+	+	-	-	-
Maximum Relationship	Engineering Requirements / Target	Effifiency	Power Usage	Control	Accuracy	Cost	Weight	Dimension
+	Efficiency		↑↑	↑↑		↓↓	↑	↑
+	Durability	↓↓				↓↓	↑	↓↓
-	Dimension	↓				↓		
+	User-Friendly			↑↑		↓↓	↑	
+	Accuarcy		↑	↑↑		↓↓		
-	Maintence	↓		↓	↓↓	↓↓		↓
		Solar Only	<200 W	85% Incident Free	5 Feet From Destination	<$600	70lbs	6" Extended Build From Bin

Table 4: Initial Project Milestones

Number	Task	Start	End	Status	Responsibility
Senior Design 1					
1	Ideas	1/8/20	1/17/20	Completed	Group B
2	Project Selection & Role Assignment	1/8/20	1/17/20	Completed	Group B
	Project Report				
3	Divide & Conquer	1/17/20	1/29/20	In-Progress	Group B
4	Table of Contents	1/29/20	4/15/20	In-Progress	Group B
5	First Draft	1/29/20	3/16/20	In-Progress	Group B
6	Final Draft	1/29/20	4/15/20	In-Progress	Group B
	Research, Documentation & Design				
7	Schematic	2/1/20	2/15/20	Researching	Sean Quinlan
8	GRAD Structure/Packaging	2/1/20	2/15/20	Researching	Abdulsalam Khan
9	Object Avoidance	2/15/20	2/28/20	Researching	Sadiyah Bhuria
10	GRAD Drive system	2/15/20	2/28/20	Researching	Abdulsalam Khan
11	GRAD Detection	2/1/20	2/15/20	Researching	Sadiyah Bhuria
12	Microcontroller	2/15/20	2/28/20	Researching	Heba
13	PCB Design/Layout	2/28/20	3/22/20	Researching	Sean Quinlan
14	Path Planning	2/1/20	2/15/20	Researching	Abdulsalam Khan
15	Power Supply (Solar Panel & Battery)	2/15/20	2/28/20	Researching	Sean Quinlan
16	App Development	2/28/20	3/22/20	Researching	Heba
17	Wifi/Bluetooth for connectivity	2/28/20	3/22/20	Researching	Heba
18	Standards/Other Report Aspects	3/28/20	4/15/20	Waiting	Group B
19	Order Parts	4/30/20		Waiting	Group B
Senior Design 2					
20	Prototype	8/1/20			Group B
21	Test/Redesign	TBD	TBD		Group B
22	Final Product	TBD	TBD		Group B
23	Peer Presentation	TBD	TBD		Group B
24	Final Report	TBD	TBD		Group B
25	Final Presentation	TBD	TBD		Group B