

Foodie Rover: The Food Delivery Robot

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ABSTRACT — **Foodie Rover is an innovative venture into the field of driverless ground vehicles designed with efficient food delivery in mind. Thanks to a well-thought-out arrangement of its sensory add-ons, this small car represents the ultimate in self-navigating without outside assistance. This project, which straddles the boundaries of computer and electrical engineering, is an example of creativity and cross-disciplinary cooperation. The project's main goal is to successfully complete a delivery mission while demonstrating Foodie Rover's autonomous driving abilities while navigating constantly changing campus circumstances. Subsidiary objectives include implementing computer vision techniques for obstacle detection, maintaining a consistent pace, and enabling user involvement through a mobile application interface.**

Index Terms — **Autonomous, efficient food delivery, Foodie Rover, innovative, self-navigating.**

I. INTRODUCTION

Foodie Rover is a product of engineering ingenuity and invention that appears as a way to simplify the food delivery process in busy campus settings. This project began when it was realized that instructors and students had limited time during meal breaks, which prompted our team of engineers to look for an autonomous delivery system.

Foodie Rover hopes to transform the dynamics of food delivery on campus by reducing stress and increasing productivity in the face of mealtime limits. This small, autonomous robot is ready to go beyond traditional approaches, combining advanced technology and sophisticated sensing abilities to move through campus traffic with ease.

The merger of computer and electrical engineering disciplines, which harmoniously balance software programming and hardware integration, is fundamental to the project's philosophy. The complex wiring and

painstaking programming highlight the teamwork required to achieve Foodie Rover's autonomous capabilities.

The project's many objectives are embodied by unique features like obstacle detection, dynamic routing, and user interaction. Foodie Rover is able to travel across difficult campus terrains by using ultrasonic sensors, cameras, and Google Maps' API endpoints. It does this by skillfully navigating around obstacles and guaranteeing fast and secure meal delivery. This is mainly because of the tank-like tracks that are on the chassis of the robot.

As the project progresses, its goal is to reach its destination by itself using all the tools it's equipped with, which will meet engineering requirements and match or exceed current autonomous delivery technology benchmarks. Foodie Rover is a prime example of innovation at the heart of technology and gastronomy, having developed an organized methodology that includes technical specifications, performance indicators, and engineering needs.

II. MOTIVATION

Picture yourself as a busy student-athlete or college student who is rushing to get lunch in between meetings or courses. Time is of the essence, but it is wasted standing in long lines at campus restaurants, especially the busy Chick-fil-A and the student union. Since we, ourselves, are full-time students, we are keenly aware of how frustrating it can be to watch the clock tick away as we eagerly wait for our orders, knowing that every minute we spend waiting will take away from our precious break.

We started the Foodie Rover project because we want to take back this valuable time and change lunch for all students, including ourselves. We aim to no longer continue with the current practice of forgoing downtime and rest in favor of a quick lunch on the run.

Inspired by our desire to improve university life, we came up with an idea for a solution that goes beyond conventional meal delivery systems. Foodie Rover is more than just a robot; it's a representation of empowerment that gives teachers and students alike the ability to take back control of their lunchtime schedules. Lunch breaks won't be ruined by the pressure to finish eating quickly or the trouble of having to leave the office to get food.

We were mainly motivated to create Foodie Rover because we are passionate about changing the way we think about lunch—turning it from a stressful time to one of rest, nourishing ourselves, and being productive. We hope that this project will positively impact our fellow students' lives in a concrete way, improving their overall campus experience and opening the door to a more effective and fun lunchtime routine.

III. ENGINEERING REQUIREMENTS

With the goal of creating an advanced and efficient food delivery system, Foodie Rover is a perfect example of how engineering creativity and careful design can work together. Its entire design and operation is meticulously crafted to meet conventional standards and go above and beyond accepted norms with an intentionally flexible design all in order to expand the possibilities for self-driving meal delivery.

A. Travel Distance and Speed

Foodie Rover is designed to travel over 200 meters with grace and ease, quietly cruising around the campus at a leisurely 1.5 to 2 miles per hour. This ideal ratio of endurance to speed guarantees prompt and effective delivery while upholding stability and safety.

B. Payload Capacity

The definition of gastronomic convenience is what Foodie Rover is, with a payload capacity that can hold delicious treats weighing up to three pounds. Its exquisitely designed interior and expertly constructed insulating materials guarantee that every meal stays delicious and fresh from the kitchen to the door.

C. Power Efficiency

Foodie Rover's design is centered on efficiency, as evidenced by its excellent power consumption profile. Its efficient operation is demonstrated by the fact that power consumption is limited to 400 Watts during delivery missions. Foodie Rover uses very little energy while it is at rest—just 50 Watts—which maximizes battery life and performance.

D. Battery Life

Ensuring uninterrupted service, Foodie Rover boasts a robust battery life exceeding 1 hour of operation on a single charge. This extended runtime empowers the robot to undertake multiple delivery missions without the need for frequent recharging, maximizing efficiency and productivity.

E. Sensory Precision

Foodie Rover's advanced sensor array provides it with an unmatched situational awareness, which allows for accurate navigation and obstacle recognition. Foodie-Rover's eight ultrasonic sensors, which are arranged in a strategic manner around its chassis, allow it to thoroughly monitor its environment and identify potential threats and obstacles with accurate precision. A high-resolution camera also improves its sensory capabilities by supplementing its

sensor data with visual feedback while adding to security. Foodie Rover can confidently navigate complicated settings because of its integration of sensing technology, ensuring safe and effective delivery operations.

F. API Capabilities

Foodie Rover's sophisticated networking features are essential to its seamless operation. Foodie Rover can easily make API requests thanks to a built-in Wi-Fi chip, allowing for real-time connectivity with external systems like Google Maps. Dynamic route planning and navigation are made possible by this integration, guaranteeing the best delivery routes and effective adaptation to shifting environmental conditions.

D. Innovative Design

Beyond its utility, the Foodie Rover captivates with its stylish and inventive design, which incorporates state-of-the-art security measures to protect its valuable cargo. A comprehensive magnetic lock and keypad system, carefully created to guarantee the security and integrity of the food during transit, is at the center of this design. Robust building materials and an effective locking mechanism give another layer of security by thwarting tampering and unwanted entry. With this cutting-edge security feature in place, Foodie Rover ensures that every delicious meal reaches its intended destination safely, bringing convenience and peace of mind together.

IV. HARDWARE AND SOFTWARE DIAGRAMS

A. Hardware Block Diagram

In the diagram, arrows directed toward a block signify inputs, while arrows extending from a block denote outputs. Detailed descriptions of each component, along with their current statuses as of the provided date, can be found in the accompanying legend table. Furthermore, for clear attribution of responsibility for each major component, distinct color-coding has been employed to designate the respective team members accountable for their development and maintenance.

Fig. 2.4 Hardware Block Diagram



Fig. 2.5 Diagram Legend for Hardware Block Diagram

B. Software Flowchart

Software flowcharts play a pivotal role in the development and understanding of software systems, serving as visual representations that illustrate the logical flow of a program's execution. These diagrams provide a

high-level, easy-to-grasp overview of the entire software structure, outlining the sequence of operations, decision points, and interactions between various components. The importance of software flowcharts lies in their ability to enhance communication and collaboration among developers, designers, and stakeholders involved in the software development process. By offering a visual roadmap, flowcharts facilitate clear comprehension of the program's logic, aiding in error identification, troubleshooting, and refining the software design. They serve as valuable documentation tools, assisting both in the initial development phase and subsequent maintenance or modifications, ensuring that the software remains comprehensible and maintainable over time. Ultimately, software flowcharts contribute to the creation of robust, efficient, and well-structured software systems, aligning the development team and stakeholders with a shared understanding of the software's functionality and design.

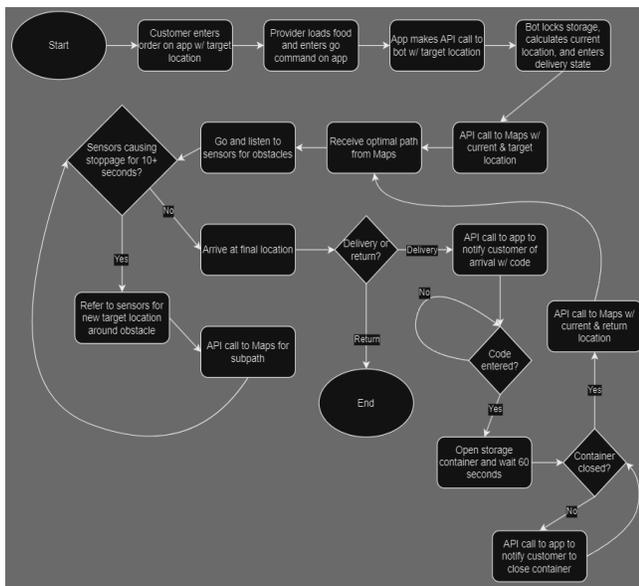


Fig. 2.6 The Flowchart of how we first anticipated everything working software-wise. It is a cumulation of our thought process stemming from our knowledge at the time of when we were first designing Foodie Rover

V. PART SELECTION

This section will provide a detailed account of our thought process on each part and the specific components that we got for the creation of the Foodie Rover design.

A. Frame/Chassis

	Metal Frame				
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Fig. 3.11 This table shows the differences in either Cost, Weight chassis can carry, the type of motors that come with the chassis, the general size of the chassis, the type of wheels/tracks that help it move, and the assembly parts that it would take to build the general frame of it. The highlighted chassis is the chassis we ultimately chose.

When it comes to robotics, choosing the right chassis is essential to a project's success. Examining a variety of choices, we examine multiple state-of-the-art robot chassis models, each with unique features designed for different use cases. Our choices of different chassis was chosen based on the fact of the fact that we wanted a chassis that can handle the wight of food and other frames on top of it and we wanted DC motors because it was the best option for what we were trying to accomplish and when we made a Pros and cons list the robots requirement for speed and load capacity, a DC motor was the best choice. Through an analysis of the price, weight-bearing capacity, motor characteristics, size, wheel arrangements, and frame elements, we enable a well-informed investigation of these innovative robotic workhorses, enabling us to select the best option for our project.

B. Magnetometer

price	\$7	\$16	\$10	\$9
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Fig. 3.13 This table shows the differences in each Magnetometer we were thinking about getting and the highlighted row is ultimately the magnetometer we decided to choose.

The effective functioning of our project depends on the selection of the appropriate magnetometer, which permits accurate navigation and orientation in dynamic situations. An overview of many magnetometer options designed specifically for compact food robots is provided in this table, which guarantees optimal performance and precision in detecting and reacting to magnetic fields. This table attempts to assist in the process of choosing which magnetometer technology to incorporate into our project in order to improve its effectiveness and adaptability in world obstacles.

C. Microcontroller/Microprocessor

We thoroughly assessed both microcontrollers and microprocessors for the project. It was decided to employ both as their advantages for embedded systems are complementary and beneficial in their application for Foodie Rover. This comprehensive evaluation was conducted due to the wide range of tasks it is expected to perform, some of which may necessitate a robust processing unit to handle high computational workloads. The selection of a microprocessor offers the advantage of

scalability, enabling us to enhance the intricacy of the software design while maintaining seamless hardware control.

Our decision was significantly influenced by key criteria, including the presence of Wi-Fi and Bluetooth capabilities, memory capacity, processing speed, and others. These factors played a pivotal role in our choice of the appropriate processing platform for the Foodie Rover.

To guarantee the best decision-making process, we thoroughly evaluated the peripherals of each microcontroller and microprocessor. These peripherals are crucial as they provide essential information about the available communication interfaces for connecting with other components, the allocation of pins for connections, and the inclusion of additional peripheral features.

Cost	35\$-75\$	~\$99
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Fig. 3.14 The table presents a comparison between the Raspberry Pi 4 B and the NVIDIA Jetson Nano microprocessors. The Raspberry Pi 4 B is highlighted as the chosen device for the project due to its flexible memory options, sufficient processing power, and a lower price point, making it an economical yet capable choice for various computing tasks.

Cost	~20\$	~15\$	~15\$
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Fig 3.15 This table shows the Microcontroller options we were looking at and ultimately the one we decided to choose, which is highlighted. Not a very powerful microcontroller was needed, only one capable of real time operation, therefore the choice of the familiar Arduino Uno board was made.

To accommodate the extensive connectivity requirements for sensors and peripherals on the Arduino Uno, we employ an MCP23017 GPIO expander, and to ensure safe and reliable communication between the 3.3V Raspberry Pi board and the 5V Arduino Uno, we employ the BOB-12009 level shifter design.

D. Navigation System

Cost	\$40	~\$15	\$9	\$40
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Figure 3.16

Fig. 3.16 This table shows the different navigation systems, and the highlighted row is ultimately the navigation system we chose.

Choosing the proper navigation system was of imperative importance if we expect our project to reach the desired level of autonomy. It needs to be quantifiably accurate, reliable, and fast for Foodie Rover to move in the right path. While the sensors will make sure nothing near the bot will lead to a crash, the navigation module will focus on the bigger scope and will lead the bot toward its final destination. In simple words, for the bot to know where to

go, it first needs to know where it is and that is the task of the navigation module. The specifications of interest when looking at parts consist of how accurately it can assess position, the speed at which it can update position, how it can handle weak signals from satellites, and its compatibility.

E. Motor Driver

When it came to choosing the motor driver, the specifications of greatest interest consist of its input and output voltages, the constant current it can maintain while in operation, and how many motors it can control. The motors we chose to use dictated how many amps of constant current we need to supply and the output voltage. The way we will power the motor driver influenced the choice of motor driver which is the reason why the input voltage is of interest. The parts chosen to be compared are diverse in both performances, with regards to the specifications of interest, and price. The selection of the part expectedly favored the specifications of interest but also took into account special features that can be of use or of significant positive impact.

Cost	\$7	\$3	\$3	\$16	\$23.50
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Fig. 3.17 This table shows the different motor drivers we thought about and ultimately the one we chose, which is highlighted.

F. Distance Sensor

When considering the utility of the distance sensor, our objective is to address any potential blind spots in the vicinity of Foodie Rover. It is imperative to acquire precise information pertaining to both the distance of objects and the respective angles at which these objects are situated. Achieving this objective necessitates deploying multiple sensors or a highly sophisticated sensor configuration, which could substantially increase the overall project costs. The choice of sensor considered both the necessities and the cost.

Figure 3.18				
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Fig. 3.18 This table shows the different sensors we thought about using and the one we ultimately chose, which is highlighted.

G. Locking Mechanism

Due to its compatibility with other components of our project as well as its lower price point, an electromagnetic lock was the optimal choice for a locking mechanism. A more advanced implementation of this concept in the future could consider this area as one to improve by investing in a more intricate and advanced locking technology that has the ability to integrate with the consumer application used for

the service. The choices of the different electromagnetic locks are below.

Price	\$21	\$40	\$36
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Fig. 3.20 This table shows the choices we thought about regarding the electromagnetic lock and ultimately the lock we decided to get, which is highlighted.

G. Power Source

The Batter which is a very important part of the Project was something that took us a little while to decide on because we had to run tests on all the other parts to see how much we needed for everything to run smoothly. We decided on the Ovonc 100C 11.1V 8000mAh 3S LiPo Battery because it had enough to handle everything we need and then more.

Total Weight	12.5 lb	6 lb	7 lb	1.1 lb
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Fig. 3.21 This table shows the choices we thought about regarding the Power Source/Battery we ultimately decided to get, which is highlighted.

VI. HARDWARE DESIGN

The hardware design of the Foodie Rover system is carefully crafted to ensure seamless integration of various components, each serving specific functions vital for the robot's operation. Figure 6 shows how everything relates to each other with the red connections meaning its power transfer and the black connections mean its for data transfer/control. Below is a breakdown of each subsystem:

A. Navigation Subsystem

This subsystem is essential to the robot's ability to navigate itself. It has a GPS module and magnetometer that are both separately coupled to a centralized microcontroller. The GPS module gives exact location information, while the magnetometer helps with orientation determination. Together, these elements give the robot a sturdy frame of reference for navigation.

B. Motor Subsystem

The Motor Subsystem is the foundation for effective movement and navigation. It consists of two L298N Dual H-Bridge Motor Drivers that finely regulate four DC motors. The strong microprocessor that these drivers communicate with gives the robot unmatched control and

maneuverability. In order to carry out the precise movements necessary for efficient food delivery operations, the Motor Subsystem is essential.

C. Sensor Subsystem

The Foodie Rover uses the Sensor Subsystem to sense and respond to its environment. By placing eight ultrasonic sensors strategically, the robot can identify obstacles along its path. Each of these sensors has a separate interface with a GPIO Expander, which connects to the main microprocessor via communication. This subsystem helps the robot avoid obstacles and also finds the best rerouting paths so that navigation continues unhindered.

D. Locking Subsystem

The security of the contained order materials is guaranteed by the Locking Subsystem, which is essential for food delivery operations. The container lid is locked in place by an electromagnetic lock that may be turned on or off using a keypad. Strong security is ensured by the subsystem's architecture, which includes intricate links between the microprocessor, electromagnetic lock, and keypad via a lock relay.

E. Power Subsystem

Acting as the backbone, the Power Subsystem supplies all components with vital power while preserving operational stability. To achieve the required battery life of 1-2 hours, careful integration is required to guarantee that every component receives the right voltage without going over its limits. Ineffective power distribution management could result in component failure or jeopardize system security.

VII. SOFTWARE DESIGN



Fig. 7. This figure shows the software flowchart.

This software flowchart delineates the operational sequence within Foodie Rover's computer during a delivery attempt, providing a comprehensive overview of firmware interactivity and the requisite server-side interactions for seamless execution. Upon placement of an order through the Foodie Rover application, the associated dropoff location is communicated to Foodie Rover. Subsequently, the rover calculates its current position, a crucial step for obtaining comprehensive routing information from Google's Directions API. It is imperative to communicate both the starting and ending coordinates for this purpose.

The information retrieved from the API call encompasses an array of steps, fragmenting the entire route into discrete segments characterized by changes in direction. Foodie Rover then processes each step, examining details such as maneuver descriptions and the step's target coordinates. Based on this information, it determines the requisite operations for the DC motors and initiates obstacle detection protocols. In the event of an encountered obstacle, Foodie Rover executes basic evasive maneuvers. Upon completion of processing all steps, it may be inferred that Foodie Rover has arrived at the designated drop-off location. At this juncture, the customer is notified with a code, enabling them to unlock the food storage and retrieve their meal.

The mobile application for Foodie Rover is crafted utilizing React Native, this allows users to place orders for their preferred food items. This application holds pivotal significance in Foodie Rover's service, as the data transmitted from the application to Foodie Rover includes crucial information regarding the delivery destination.

VIII. PCB

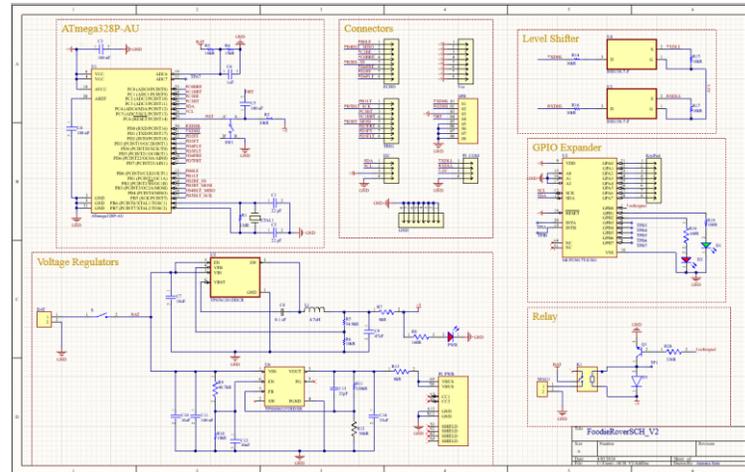
The PCB serves as the central hub for powering major components and transmitting critical data throughout the system. It also provides protection to the overall circuit and organizes the wiring connecting various components to the Raspberry Pi.

A careful selection procedure is carried out, carefully examining parameters including tolerance, voltage limitations, and power dissipation to make sure they meet design standards. Cost and availability are two further factors taken into account.

Using Altium Designer software, schematics are created and used to generate a PCB project. Components are strategically placed to allow for efficient routing, with vias utilized for connections running over and under the board. Design rule checks are employed to validate results.

Components are initially placed on the top layer, with the mounting component strategically positioned on the bottom layer to prevent obscuration of connectors once mounted. A dedicated layer is generated to outline the PCB's shape. Careful consideration is given to board size to balance handling convenience and prevention of component overheating. Drill holes are added to corners for additional Fig. 8.1 This shows the schematic design of the PCB.

securing mechanisms. Overall, this approach ensures a well-organized and functional PCB design that meets technical requirements while considering practical constraints and cost-effectiveness.



IX. CONCLUSION

Although reading these instructions may have been an unpleasant experience, following them will improve the quality of your paper and the RFIC Digest. Table I summarizes much of the detail provided and illustrates one of the rare instances where the double column format can be violated. If you have comments, suggestions, or are willing to volunteer your time to improve these instructions, please contact one of the RFIC TPC Chairs.

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