Project Proposal for Parking Lot Monitoring System

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***Abstract*—Commuter students at Tennessee Technological University often face the difficulty of finding available parking in lots during the day. Students from the Electrical and Computer Engineering Department, in collaboration with the Department of Computer Science, will design a cost-effective parking lot monitoring system that will fit the needs of the university's parking lots. This project will be under the direction of the Naval Sea Systems Command (NAVSEA) in Dahlgren, VA. This project is a continuation project from the 2022-23 academic year at Tennessee Technological University.**

I. Introduction

On college campuses, finding a parking spot is a common problem, and Tennessee Tech University in Cookeville, Tennessee, is no exception. Demand for convenient parking spaces is high due to a growing student population, particularly for the pricey "red passes" that offer nearness to buildings on campus. Because there is so much demand, it can be challenging to find a desirable parking space, which in turn causes congestion during peak traffic hours. For context, Tennessee Tech University has 5,762 parking spaces [1], of which 2,388 are red parking lot spaces. The university's Fall 2023 enrollment of 10,117 students makes it clear that there is a huge demand for parking spaces. Students' preference for parking as close to their classes as possible makes this problem even worse. As a solution to this urgent problem, our project intends to develop a proof-of-concept for a parking tracking system that would measure the number of vehicles in a parking lot to identify the number of available parking spaces. This number of available parking spaces will be displayed on a sign near the parking lot and also through a mobile application that indicates the parking availability information. In the previous installment of this project, vehicles were counted using image processing. However, this approach often proved inaccurate due to the highly variable nature of the images taken by the cameras. Our approach to the parking lot monitoring system will be ground-based, focusing on sensors that will detect vehicles without using cameras and image processing. Based on our estimates, we believe our approach will be more cost-effective, accurate, and scalable. We will describe the project's requirements, limitations, and objectives in this proposal and any potential difficulties and unforeseen elements that might affect how it is carried out. To ensure the system's effectiveness and address broader effects and ethical issues related to its use, we will also define critical success metrics. By thoroughly addressing these issues, we hope to offer a comprehensive solution that reduces parking congestion and improves campus safety and productivity at Tennessee Tech.

II. Identified Problem

A. Background Information

The parking monitoring sensor will be implemented at Tennessee Tech University in Cookeville, TN. Regarding parking, students who live outside the campus have two options for parking passes: they can opt for the more affordable purple passes, which grant them access to parking spaces on the outskirts of the campus, or they can choose the more expensive red passes. The red passes, while priced higher than the purple passes, provide the advantage of parking closer to the buildings where students attend their classes, reducing the walking distance to just about a 5-minute stroll to reach their classrooms. Residential Hall residents have a third option: green parking passes. Also, Tech Village residents have teal parking access [1].

However, a significant challenge associated with the red passes is the high demand for these premium parking spots. This increased demand often leads to difficulty finding available parking spaces, especially during the early morning rush when many students are arriving on campus, causing congestion in the parking areas. Tennessee Tech University's campus has 5,762 parking spots[1], of which 2,388 are designated red parking spots. Considering the university's student population as of Fall 2023, which stood at 10,117 students[2], it becomes evident that the demand for parking spots is considerably high.

Additionally, a contributing factor to this parking dilemma is that students generally prefer to secure parking spots as close as possible to the buildings they have classes in, exacerbating the parking congestion. Therefore, Tennessee Tech University aimed to address this issue by adding a bus shuttle ride that runs one route across campus for the parking lots further from the classes or buildings. The shuttle helped the student to save time to reach their classes. Shuttles run Monday through Friday, on days when classes are in session, during the fall and spring semesters[3]. Also, they have an app showing where the bus is and when it will arrive at your bus stop station.

Students, faculty members, and visitors would benefit from using a parking lot sensor application that indicates the parking lot's availability to plan where to park.

B. Goal of This Project

The goal of this project is to design a proof of concept for a vehicle counting system that will be able to keep track of the number of vehicles in a given parking lot so that the number of empty parking spaces can be determined. The information on the number of empty parking spaces will be sent where it can be quickly viewed, such as a sign or mobile application.

C. Specifications and Constraints

1) Specifications: 1.1 System shall operate during parking enforcement hours from 7:30 a.m. to 4:30 p.m.

1.2 Shall have a ground monitoring system with sensors capable of distinguishing cars from pedestrians and determining whether the vehicle is entering or exiting the lot.

1.3 The system shall have outdoor signage to indicate parking availability to people searching for parking on campus.

1.4 The system shall not obstruct any parking spots on campus in a way that would not allow a person to park in a given spot.

1.5 The system shall be designed to not interfere with traffic flow around campus.

1.6 The system shall show data on the number of vehicles in a parking lot compared to the number of parking spaces in that specified parking lot.

1.7 System shall notify users of the mobile application about the current system status, such as in maintenance or fully operational.

1.8 The system shall notify users on the mobile application about the possibility of decreased system accuracy during adverse weather conditions such as rain, wind, snow, or ice.

1.9 The system shall notify users on the mobile application about the dangers of driving while using a mobile device as well as its illegality in Tennessee on app startup.

1.10 The system shall not permanently store images or record videos.

1.11 The system shall have a calibration function to update the vehicle count manually in the event that the displayed empty parking space count is inaccurate.

1.12 The system shall have a mobile application for people wanting to check information about the availability of parking on campus.

1.13 System shall have counts within at least 90% accuracy compared to the actual counts in ideal weather conditions (no rain, snow, ice, heavy winds, and in between temperatures of 50 degrees Fahrenheit and 80 degrees Fahrenheit).

2) Standards: The following are potential standards and regulations that continue to provide additional constraints.

National Fire Protection Association (NFPA) 70 and 70E Electrical Codes and Standards - This standard is intended to safeguard persons and property from hazards arising from the use of electricity. This standard will be followed to ensure the electrical safety of the system and of the working environment as the team is building and testing the system[7][8].

Internet Engineering Task Force (IETF)- This organization defines standard operating internet protocols that will be used when designing the wireless communication network between sensors[9].

Tennessee Code Annotated 55-8-199 - More commonly known as the Tennessee Hands Free Law, prohibits the act of holding a cellphone or mobile device using any part of one's body as illegal, in which only hands free devices are to be used while driving a motorized vehicle[10]. Taken into effect in July 2019, this state law raises ethical implications with regards to the possible usage of our mobile application while driving by students, which may cause a need to address some type of safety feature for the project to either educate or protect the user against misuse of the app related to the law.

3) Externalities: During the planning and design phases, it is essential to consider all potential positive and negative externalities that may arise from Tennessee Tech University's development and implementation of the Parking Lot Monitoring System.

Pedestrian Safety: There is an apparent concern for the safety of pedestrians navigating through the campus parking lots or sidewalks without encountering safety hazards or disruptions caused by the parking monitoring system. Also, the parking monitoring system complies with the accessibility guidance.

Economic Implications: The system could have economic externalities, potentially increasing parking costs for some users, if it implements dynamic pricing based on demand or charges fees for gold, red, or green parking spaces. Also, This might include having resources to monitor the maintenance team and fix any issues with the system during its operational time, which could include systems losing power, damage to the signage, sensor resets, etc.

D. Stakeholders

By implementing a Parking Monitoring Sensor System, it will play a crucial role in the Tennessee Tech community by enhancing the overall college experience for everyone involved. There will be many parking sensor monitoring system users, such as students, faculty members, and visitors. Nowadays, parking tracking is a mandatory requirement, especially with the rising student population and the sudden campus construction. Using parking sensors has many advantages, especially for car users on campus, shopping centers, or airport parking.

The parking monitoring sensors will help drivers find parking more quickly and efficiently, especially during busy mornings. One of the most crucial aspects of the parking monitoring system is to save time to be able to find parking, especially on crowded days.

In our specific case, NAVSEA is the sponsor for the project with their guidance and specifications. We were asked to implement the parking sensors that will monitor the campus.

Furthermore, it is crucial to meet and exceed our customers' expectations. Therefore, a beneficial approach for those wishing to benefit from the parking monitoring sensor is developing an app that allows them to check parking availability. This step will help bridge the gap between customers and the project. Given the substantial impact this project will have on the campus community, our objective is to attract as many users as possible while ensuring the highest level of accuracy.

The proposed parking monitoring system has the potential to make a positive impact on various stakeholders within the Tennessee Tech University community. It seeks to address a long-standing issue, enhance campus life, and bolster the university's reputation for innovation and problem-solving. However, it is imperative to carefully plan and consider ethical and privacy implications to ensure its successful implementation.

E. Current Solutions to Similar Problems

For many college campuses across America, parking is one of the biggest challenges that commuter students face daily. According to a survey by Mt. San Antonio College that included 1,033 responses, 68% of respondents state it takes 15 minutes or more to find a parking space with 32% stating it takes more than 30 minutes to find a space [4]. To solve this issue, the use of cameras or sensors to track the available parking would be a step in the right direction to help students know which areas of campus have available parking spaces. The following examples are just a few possible solutions to help college students find parking on campus.

- Parklio offers a product called Detect, which is an intelligent AI system that monitors, analyzes, and reports vehicle parking data through the use of cameras while also generating a blueprint of the parking area it covers, creating a more accurate number of available parking spots for that specific area. One single camera has the ability to detect up to 200 vehicles at once, depending on the location and setup of the camera. The data received from the cameras go into a software called Parklio Parking Management System that provides real-time analytics for each camera in the system. [5]
- PlacePod provides sensors that can be placed either in-ground or surface-mounted sensors that communicate with a gateway to provide accurate vehicle detection in parking through a Low Power Wide Area Network (LPWAN). These sensors provide stable results even in harsh weather conditions while also having a battery life of up to 10 years[11]. To communicate with the LPWAN, it includes a built-in long-range radio (LoRa radio) within the sensor. This product would be especially helpful in parking lots that are not close to buildings and may not have many light poles or power line poles near the parking lot to cover every spot.
- Currently, there are cameras that have the ability to detect the movement of vehicles. These cameras are primarily used for traffic flow measurement and automatic incident detection. With this type of system, the processing system for the camera is "taught" the image of a vehicle through the use of measurements from the ground and the distance between lanes of vehicles. It has the ability to track numerous amounts of vehicles on one camera [6]. These types of cameras can cost anywhere from $250 or more depending on the options and the functions that come with the camera.

F. Need for Proposed Solution

As stated in previous sections of this proposal, parking is an extremely common challenge on many college campuses across the country, and unfortunately, Tennessee Tech is not immune to this issue. Current solutions to similar problems do exist, however, they can be very expensive, require significant maintenance efforts, and use proprietary software. Tennessee Tech would benefit from a student-made solution in the way of achieving a more cost-effective and custom solution. An in-house solution would allow extensive customization to account for the unique problems campus parking may involve. An in-house solution would also provide students with helpful data and could help ease some of the stress and frustration that currently comes with searching for a parking spot on campus. A student-made solution would also serve as a showcase of Tennessee Tech's renowned engineering program. This project will involve the collaboration of engineering and computer science students and is a great opportunity to show that Tennessee Tech engineers are renowned for a good reason.

III. Proposed Solution for Parking Lot Monitoring System

A. Solution Overview and Potential Approaches

1) Solution Set
   a) This project's scope is to be a proof of concept that can be scaled up to bigger parking lots and that can be applied to the majority of parking lots on campus. Our solution set includes parking lots that have designated entrances/exits and are only accessible through those entrances/exits, such as lots that are surrounded by curbs, sidewalks, or places that are not meant to be driven on. For example, the stadium lot is one of the most in-demand and large parking lots on campus. It has designated entrances and exits, and the rest of the lot is bounded by curbs or sidewalks, so it fits into our solution set.
2) Sensor Technology
   a) A pneumatic tube system with low power consumption that observes spikes in pressure when force is applied to it. These sensors could be used as a ground-based system to measure how many axles, and in turn, how many vehicles, will be entering or exiting a given parking lot.
   b) A weight sensor system observes a force applied to it and calculates the corresponding weight. Weight sensors could be used in a similar fashion to pneumatic tubes as a ground-based system to measure

if a vehicle is entering or exiting a given parking lot.

   c) Laser, lidar, and radar sensors all project a form of light or wave towards a target and, depending on the type, will receive the reflected light or wave. Any of these sensors could be used as an alternative to a ground-based system to detect vehicles entering or exiting a parking lot. These sensors can, however, introduce problems with false detection of vehicles and adverse results with different weather conditions such as rain or abundant sunlight.
   d) Camera or visual sensors would allow for the framing of visual images would could be processed to give information regarding the amount of empty parking spaces in a parking lot. The advantage of visual sensing is that the entire parking lot can be monitored compared to only entrances and exits.
   e) Magnetic sensors detect changes in the surrounding magnetic field. This could be used to detect if a vehicle is in the proximity of a parking lot or parking space. Magnetic sensors would have to differentiate between random metals, magnets, and vehicles for this system.

3) Data Collection, Transportation, and Processing
   a) Using any of the sensors mentioned above will require the transmission of the data they collect. For the ground-based approach, the data will be collected at each entrance/exit of a given parking lot. For a visual approach, the data will be collected at the individual camera or sensor being used. The data will be transported wirelessly to a central processing unit that will communicate to and control the mobile application and sign. Wireless communication will simplify any future expansion of the system.

4) User Interface
   a) A mobile application will display parking information. The students will be able to log in to the application using their student identification numbers and passwords. The app will display when the system is in operation, the number of empty parking spaces in a parking lot.
   b) A sign will be implemented that displays the total number of available parking spaces in a given parking lot.
   c) Both the mobile application and sign will send out data to users during the hours of 8:00 a.m. to 4:30 p.m., which is when parking is enforced on campus. Data will still be collected outside these hours, but they will not be displayed on the sign or the mobile application.

B. Unknowns and Obstacles

There are many unknowns and obstacles that may have an impact on our system, such as the following:

- Illegal actions
  - Vandalism of the system is an unknown. We can not guarantee our system will be safe from vandalism because it is essentially impossible to completely protect against all forms of vandalism. We do not know if this will be a problem, but it is a possibility.
  - Theft could occur if someone chooses to steal any part of the system. Attempts to make the system theft-proof will not be able to completely stop a thief in all circumstances. It is unknown whether this is likely to happen.
  - Illegal parking could affect the accuracy of our system. People may park in the grass or in a space that is not marked as a parking space. It is also possible that people could take up multiple spaces, resulting in less accurate data.
- Weather
  - Inclement weather could damage, disable, or in some way impede our system's ability to function properly.
  - It is possible that inclement weather, such as snow, heavy rain, or fog could affect the cameras' ability to see. Strong wind, extreme cold, and lightning could affect the sensors as well.
- Time Constraints
  - Time constraints will limit the scope of the project to a proof of concept system that can be scaled up for use with bigger lots on campus. Time constraints will be handled by scheduling milestones for the project.
- Device Specifications
  - Pneumatic road tubes would need to be properly calibrated and regularly maintained, the extent to which is unknown. There must also be some way of distinguishing people walking over or jumping on the tubes from cars driving over them.
  - Weight sensors would need to be properly calibrated and regularly maintained, the extent to which is unknown.
  - Laser sensors would need to be properly calibrated and regularly maintained, the extent to which is unknown. There must also be some way of distinguishing people and cars passing through the laser beam.
  - For a camera system, camera placement would be an obstacle as, in some places, there may not be enough conveniently placed light poles to mount a camera.
- Infrastructure
  - Installing sensors and signs will require the team to get approval from the Facilities and Parking departments.
- Scalability
  - We believe our system is very scalable and will cover the vast majority of parking spaces on campus based on our estimates, however, we can not predict the impact of external factors. This could mean that even

though our system would work on paper for a certain lot, maybe it can not be installed because there is no good place to mount our sensor, or maybe the facilities department does not want a sensor installed in what we may consider an ideal spot.

C. Measures of Success

To ensure the success of the proposed parking monitoring system, several key measures of success will need to be established. These measures will serve as benchmarks and criteria for evaluating the system's effectiveness. Each Measure of Success will be experimentally validated to ensure the system meets the specified constraints. It's crucial to conduct these experiments to demonstrate the system's reliability and functionality. The following measures of success are defined:

- To test if the system will operate during the Permits are required to park on campus between 7:30 a.m. and 4:30 p.m., Monday through Friday; permits are not required on the weekends (4:30 p.m. Friday afternoons until 7:30 a.m. Monday mornings) [3]. By inspecting the app operation during these times. Therefore, the success criteria would be the system counting the cars by increment and decrement the car counting when the permits are required to park.
- To test if the system identifies whether the detecting object is a car or a pedestrian, which would lead to an increment/decrement in the count of a specific parking lot by seeing the system act as a vehicle and pedestrian being at the sensor range. The sensor should not count if a pedestrian enters the parking lot and does the opposite if it is a car. Therefore, the success criteria will be if the system shows an increment if a car passes the sensors and not a pedestrian.
- To test if the parking sensor system would block a car from parking within a parking spot in the parking lot. To accommodate this test, the system should be tested after the installation of the parking sensor and test if the system would not allow a car to park in a specific parking spot in the parking lot. By bringing a vehicle and parking it at one of the spots.
- To test Real-Time Data Updates, continuously monitor and record the system's update frequency for parking space availability, potential decreased system accuracy during rain, wind, ice, and system malfunctions (e.g., parts of the system are damaged) during a rain, wind, ice, and system malfunctions. Success Criteria for this system is that it should update parking availability, any potential decreased system accuracy, and system malfunctions (e.g., parts of the system are damaged).
- To test if the outdoor signage indicates parking availability to the people searching for parking spots on the campus. To check if the signage functions count the available parking lot and keep updates on the parking spots. By physically watching the parking lot for part of the day to see if the signage shows the open parking spot. The success criteria will be if the signage shows the correct parking spot availability compared to the physical counting of parking spots.
- To test if the system would notify the users about the Hands-Free Law[10]. The test would be held by opening the app and see if the notification appeared or not. The success criteria will allow the system to show a notification to the app user.
- To test if the system stores data as pictures and videos. The system would be tested by looking for what is being saved in the data system. The success criteria will be the system. It does not store any data related to recording pictures and videos.
- To test if the system has a manual increment/decrement for the parking spots in a specific parking lot. The test would be to increment/decrement the parking spots in a particular parking lot and see if any updates are being made on the availability of parking spots. The success criteria will be the system increments/decrements the parking spot and updates the parking availability for a specific parking lot.
- To test if the system is connected to an online application that would display the availability of parking spots at a specific parking lot. The application should be able to be installed and show the available parking spot at a particular parking lot. The success criteria will be if the users can install the application on their phones and be able to see the availability of parking spots.
- To test if the system counts within at least 90% accuracy compared to the actual counts in ideal weather conditions (no rain, snow, ice, heavy winds, and in between temperatures of 50 degrees Fahrenheit and 80 degrees Fahrenheit). The test should be taken in ideal weather conditions (no rain, snow, ice, heavy winds, and in between temperatures of 50 degrees Fahrenheit and 80 degrees Fahrenheit). Then, the team will compare the system's recorded data on parking lot availability with physical observation. The success criteria will be if the system maintains an accuracy rate of at least 90% in detecting the availability of parking spaces.

D. Broader Impacts/Ethics

Accident rates may go up or down as a result of the parking lot monitoring system. Users who choose to use the mobile application improperly (in a way that causes distracted driving and does not correspond to the Hands-Free Tennessee Law) may cause an increase in accidents across campus. To notify users of possible improper use, the mobile application will open with an informational message about proper usage that adheres to the Hands-Free Tennessee Law. If used properly, students will be more knowledgeable about parking availability on campus and have a reduced level of anxiety. With future systems, it might be possible to identify improper parking (parking in more than one parking space) or to even recognize the color of the parking pass of a vehicle and compare it with the designated clearance of the parking lot. With the implementation and upkeep of this system, the price of parking passes could increase. This could displease many students and faculty and cause more financial anxiety for those who are financially less fortunate.

IV. Resources and Requirements for Implementation

A. Resources

To implement and test this system, it will require the use of different hardware and software components, as listed below under Hardware and Software:

- Hardware
  - Sensors that can detect the presence of vehicles
  - Power supply to power the sensors used to detect vehicles
  - Computer to test the system application to verify it functions correctly and also to code the system
  - Sign that will display the number of available parking spots in the specified lot
  - A Wi-Fi module will be necessary to transmit the information from the sensors and the signs to the mobile application to show the number of available parking spots to those using the application.
- Software
  - Programming software to use to program the sensors
  - Server to store data from the sensors to a database
  - Programming software that can control the application and receive information from the database

B. Personnel and Skills

Due to the extent of this project, it will be necessary to have two teams to continue this project from the last group: an Electrical and Computer Engineering team that will lead the project and continue the work of the last Electrical and Computer Engineering team and a Computer Science team that will implement an AI system into the project.

1) *Electrical and Computer Engineering Team:* The Electrical and Computer Engineering (ECE) team will be responsible for leading the two teams mentioned and continuing the work of the last ECE team to work on this project. The group members of the ECE team bring a range of specialties from the fields of ECE. The team members of the ECE team are mentioned below, along with their respective skills and experiences they bring to this project.
   - Brady Beecham
     - Programming Languages: C/C#/C++, Python, VHDL
     - Software Skills: Object-Oriented Programming
     - Hard Skills: Soldering, Knowledge of electronic test equipment such as multi-meters, oscilloscopes, etc.
     - Engineering Experience: Co-op involving embedded software development
   - Kyle Plant
     - Programming Languages: Assembly, C/C++, VHDL, MATLAB, R, SQL, LISP, Bash, currently in the process of learning Python
     - Software Skills: Microsoft Word, Microsoft Excel, AutoCAD, LTSpice, Git, Unix, Docker, SaltStack
     - Hard Skills: Soldering, Arduino, Raspberry Pi, Electronics repair and troubleshooting, Reading controls schematics, Electrical circuit wiring.
     - Engineering Experience:
       * Internship at a chemical company involving database querying, statistical analysis of PLC data about gas purity and composition, GUI design.
       * Internship at a chemical company IT department involving network administration, troubleshooting, hardware installation and setup.
       * Internship at an automation and system integration company as a Controls intern that involved making AutoCAD controls schematics for motor panels, conveyor device layouts, and I/O modules.
   - Michael Sisk
     - Programming Languages: C/C++, Assembly, MATLAB, R, Currently learning PLC Ladder Logic for Allen Bradley PLCs
     - Software Skills: Microsoft Office, Google Drive, LTSpice, Microsoft Visual Studio, Currently learning Rockwell Automation Software Studio5000 and Rockwell Automation FactoryTalk Software for Allen Bradley PLCs
     - Hard Skills: Soldering, Electronics repair and troubleshooting, Reading electrical schematics, Electrical circuit wiring.
     - Engineering Experience: Internship at a beverage company involving updating safety procedures for the company's bottling facility. Obtained hands-on experience installing and repairing electrical equipment such as electrical switches, induction motors, etc. and troubleshooting electrical equipment in the bottling facility under the supervision of the facility's electricians.
   - Khalifah Altamimi
     - Programming Languages: C++, Assembly, MATLAB, R, Currently learning PLC Ladder Logic for Allen Bradley PLCs
     - Software Skills: LTSpice, Visual Studio, Microsoft Office, Currently learning Rockwell Automation Software Studio5000 and Rockwell Automation FactoryTalk Software for Allen Bradley PLCs
     - Hard Skills: Electronics repair and troubleshooting, Soldering, Reading controls schematics, Electrical circuit wiring
     - Engineering Experience: Tutor and Grader for the

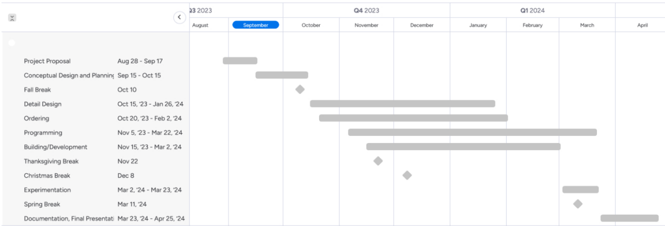

Fig. 1. Expected Timeline

Electrical and Computer Engineering Department at Tennessee Technological University

- Abdulrahman Alrudayan
  - Programming Languages: C++, MATLAB, R, Currently learning PLC Ladder Logic for Allen Bradley PLCs
  - Software Skills: LTSpice, Visual Studio, Microsoft Office.
  - Hard Skills: Electronics repair and troubleshooting, Soldering, Reading controls schematics, Electrical circuit wiring

2) *Partnerships*: Our team will also being working together with a team from the Department of Computer Science. This team will focus in implementing artificial intelligence (AI) to the application software for future use and development of the system. Due to the background and knowledge of the ECE team members, the collaboration between the Department of Computer Science is instrumental in the continuous development of the system to help students find available parking in an efficient and timely manner.

C. Budget

The cost of each parking lot will vary depending on the number of entrances and exits in the specific lot. The project is a proof of concept for a single lot that can be expanded to many lots. The single lot can have as many entrances/exits as we choose, with a likely choice of 2 or 3. We estimate the budget for an operational proof of concept ranges from \$300-\$500 for a lot with 2 or 3 entrances/exits.

D. Timeline

The group expects this project will be complete in nine months. Figure 1 shows the projected plan of progress for the project. At the beginning, specific ideas will be considered. As the project progresses, the group will create detailed designs of the system at the halfway point of the time frame and end the project with experimentation and a product capable of helping people to find available parking in an efficient and timely manner. These deadlines are the class deadlines, so this timeline may cause possible issues with the ordering of parts if specific parts that are required for the system to function properly are on the backlog with the manufacturer.

V. Conclusion

A parking lot monitoring system that is designed and implemented on the campus of Tennessee Technological University would be beneficial in many ways to students who commute to campus daily and save students a few extra minutes to get to their classes on time. By designing the system on campus, the system would be designed with the students in mind and the issues they currently face on the campus parking lots while also being cost-effective for the university. With the system being designed on campus, this will allow for a collaborative effort between the senior students of the Department of Electrical and Computer Engineering and the senior students of the Department of Computer Science to test both the knowledge and skills they have acquired over the course of their undergraduate education. Since this project will take numerous years and numerous groups to complete, this project will be well documented in every aspect, from the Project Proposal to the Detail Design to the Results. With the project being well documented, this will allow future groups to continue with the work to have an understanding of what did work and how it worked and also what did not work and the reasoning for why it did not work. By being concise in the documentation of all aspects of the project, future groups will be able to pick the project up with the information necessary to continue the project with the end goal of developing a parking lot monitoring system that fits the needs of the Tennessee Tech community to find available parking in an efficient and timely manner. To summarize, the design and implementation of a parking lot monitoring system on campus by students who face the same issues today will have numerous positive impacts for the Tennessee Tech community for many years to come.

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