Project Proposal for Parking Lot Monitoring System

Abdulrahman Alrudayan, Khalifah Altamimi, Brady Beecham, Kyle Plant, Michael Sisk
Electrical and Computer Engineering
Tennessee Technological University
Cookeville, TN
aaalrudaya42@tntech.edu, kyaltamimi42@tntech.edu, bkbeecham42@tntech.edu, klplant42@tntech.edu, mtsisk42@tntech.edu

***Abstract*—Commuter students at Tennessee Technological University often face the difficulty of finding available parking in lots during the day. Due to the numerous products on the market being either expensive or not feasible for the campus of Tennessee Technological University, a parking lot monitoring system designed by students from the Electrical and Computer Engineering Department, in collaboration with the Department of Computer Science from Tennessee Technological University, can prove that there is a more cost-effective option that fits the needs of the university and its parking lots. This project along with the collaboration between the two departments 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**

I. Introduction

In a period of expanding enrollment and the need for convenient parking options, Tennessee Tech University in Cookeville, Tennessee, presents a particular parking dilemma. At this university, students can buy affordable purple parking passes that let them park in distant lots or more expensive red parking passes that allow parking closer to the academic buildings. The appeal of shorter commutes to the center of campus results in a strong demand for red parking passes. With the strong demand and limited supply, students can be hard pressed to find good parking, particularly during peak hours. There are 5,762 total parking places on campus [1], 2,388 are designated as red parking spots and 10,117 students enrolled as of Fall 2023 [2]. The amount of enrolled students is nearly double the amount of total parking places on campus.

Students' preference for parking as close to their academic buildings as possible, which causes congestion in parking lots, only worsens this parking situation. This project's goal is to create a proof of concept for a system that counts the number of vehicles in a specific parking lot. The system hopes to accomplish this by offering simple access to real-time information about parking spot availability via signage or a mobile application. However, to achieve this goal, the project must abide by several requirements and limitations. These include adhering to regulations like the IEEE 802.11 Wireless Local Area Networks for wireless communication and the National Fire Protection Association (NFPA) 70 and 70E Electrical Standards and Codes for electrical safety. Additionally, if pneumatic tubes are used for vehicle counting, ISO 4414 compliance is required. The Tennessee Hands-Free Law, which forbids using a mobile device while operating a vehicle, also raises moral questions about the use of mobile applications, necessitating possible safety features or educational projects. With the help of modern technology, this project aims to solve Tennessee Tech University's critical parking problem while also ensuring the convenience and safety of the student body.

II. Identified Problem

A. Background Information

The parking monitoring sensor will be implemented at Tennessee Tech University, located in Cookeville, Tennessee. At this university, commuter students have two options when it comes to 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 pricier, 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.

However, there is a significant challenge associated with the red passes, which is the high demand for these premium parking spots. This high demand often leads to difficulties in finding available parking spaces, especially during the early morning rush when many students are arriving on campus, causing congestion in the parking areas.

To put this issue into perspective, Tennessee Tech University's campus has a total of 5,762 parking spots [1], out of which 2,388 are designated as 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.

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 of 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:

- System shall not obstruct any parking spots on campus in a way that would not allow a person to park in a given spot.
- System shall not interfere with parking traffic on campus in a way that would cause traffic to worsen.
- System shall operate during parking enforcement hours of 8am - 4:30pm.
- System shall have outdoor signage to indicate parking availability to people searching for parking on campus.
- System shall show data relevant to parking availability.
- System shall have detailed documentation about the system's design and operation so future owners of the system can easily make adjustments to and maintain the system.
- System shall have a system of sensors to get count of vehicles present in parking lots.
- System shall have notification posted on mobile application about potential decreased system accuracy during inclement weather.
- System shall have notification posted on mobile application about dangers of driving while using a mobile device as well as its illegality in Tennessee on app startup.
- System shall not permanently store images. System shall not record videos.
- Shall have a ground monitoring system with a system of sensors capable of distinguishing cars from pedestrians and determining whether the car is entering or exiting the lot.
- System shall have a re-calibrate function in the event that sensors are returning inaccurate counts not due to external factors (e.g. weather, physical damage).
- System shall have protection against inclement weather (e.g. rain, snow).
- System shall have a mobile application for people wanting to check information about availability of parking on campus.
- System shall save data related to number of cars in parking lot at given times.
- System shall, at a minimum, perform its intended function in ideal conditions (i.e. clear weather)
- System shall have counts within at least 90% accuracy compared to the true counts.
- System shall have notification posted on mobile application if system is not fully operational due to system malfunctions (e.g. parts of the system are damaged).

2) Standards: The following are potential standards and regulations that continue to provide additional constraints [1]:

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 electrical safety of the system and of the working environment as the team is building and testing the system [6][7].

IEEE 802.11 Wireless Local Area Networks- This standard specifies the set of media access control and physical layer protocols for implementing wireless local area network computer communication. This standard will be following when designing any wireless communication between any sensors or servers [8].

ISO 4414 Pneumatic fluid power- This standard specifies general rules and safety requirements for pneumatic power systems and components. These standards should be followed if any pneumatic tubes are to be used to count vehicles [9].

Tennessee Code Annotated 55-8-199 - more commonly known as the Tennessee Hands Free Low, 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 important to take into account 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 implemented dynamic pricing based on demand or charged fees for gold, red, or green parking spaces. Also, This might include having resources to monitor and 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

TODO: maybe add organizations as stakeholder The implementation of a Parking Monitoring Sensor System is going to play a crucial role in our campus community. It will enhance the overall college experience for everyone involved. There will be many users of the parking sensor monitoring system as students, faculty members, and visitors. Nowadays, parking tracking is a mandatory requirement, especially with the rising student population and the sudden constructions within the campus. Using parking sensors has many advantages, especially for car users whether it's in campus parking, shopping centers, or airport parking.

The parking monitoring sensors will help drivers find parking more easily and more efficiently, especially during busy mornings. Saving time is one of the aspects of the parking monitoring system 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 monitoring on the campus.

Furthermore, it is crucial to meet and exceed our customer's expectations. Therefore, a beneficial approach for those wishing to benefit from the parking monitoring sensor is to develop an app that enables 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 engage in careful planning and consider ethical and privacy implications thoroughly 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 [3]. 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 set up 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. [4]
- 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. 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 [3]. 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 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, 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 the 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.

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 amount 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 nor the mobile application.

B. Unknowns and Obstacles

There are many unknowns and obstacles that may have am 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 possibly affect the sensors as well.
- Maintenance
  - With any system comes the necessary maintenance in order to keep the system working correctly. If the system has an issue, then the issue can affect traffic on campus. If people are unable to park, they will drive around campus until they find a lot that has available parking. With numerous cars moving around campus, congestion is likely to occur causing the small issue that is occurring from the system to lead to larger problems such as possible vehicle incidents. In order to avoid these possible issues, the system needs to be designed and built to allow easy access of all components to make the maintenance process as simple as possible for those working on the system.
- 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 tube 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 walking over or jumping on the tubes from cars driving over them.
  - 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.
- Accuracy
  - The system will have an accuracy of at least 90%.

C. Measures of Success

To ensure the success of the proposed parking monitoring system, several key measures of success (MOEs) will need to be established. These MOEs will serve as benchmarks and criteria for evaluating the system's effectiveness. Each MOE 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 MOEs are defined:

1) Accuracy of Parking Space Detection:
   - Experiment: Select and monitor a small parking lot for a week period. Compare the system's recorded data on parking lot availability with physical observation.
   - Success Criteria: The system should maintain an accuracy rate of at least 90% in detecting the availability of parking spaces.
2) Reliability in Adverse Weather Conditions:
   - Experiment: Subject the system to various weather conditions, including rain, snow, strong winds, and extreme cold, and assess its performance during adverse weather.
   - Success Criteria: The system should continue to function with at least 90% accuracy during adverse weather conditions.
3) Real-Time Data Updates:
   - Experiment: Continuously monitor and record the system's update frequency for parking space availability over a one-week period.
   - Success Criteria: The system should update parking availability data in real-time, with updates occurring at intervals no longer than 1 minute.
4) Detect Tampering and Sabotage for the system:
   - Experiment: Evaluate the system's ability to detect any tampering and sabotaging the system incidents.
   - Success Criteria: The system should have a tamper detection rate of at least 90% and be designed to resist common forms of vandalism.
5) The Capability of Installing the System:
   - Experiment: Evaluate the system's capability to be installed within the campus parking lots by physically evaluating each parking suitable for the project. The suitable parking lots must have at least one entrance and exit.
   - Success Criteria: The system should be suitable to cover the parking lots at Tennessee Tech University, accommodating at least 50% of the campus parking lots.
6) Safe Passage:
   - Experiment: Evaluate the system with pedestrians navigating the campus parking lots without encountering safety hazards or disruptions caused by the parking monitoring system. Also, confirm that the parking monitoring system complies with accessibility regulations.
   - Success Criteria: The system should have no impact on pedestrians and individuals with disabilities. The system should also not negatively affect driving on campus or hinder a driver's ability to safely move around campus.

D. Broader Impacts/Ethics

With people using this system, their focus will be split in half as they focus on both the road in front of them and focus on the system as they find a lot with available parking. With their focus potentially being split in half, especially when traffic on campus is at an increased level, the risk of having a vehicle accident may increase. This impact may cause larger issues if the ease of access for the driver to use the system is not taken into consideration.

The main benefit of having a parking lot monitoring system that is easy to use by students, faculty, and visitors is that the amount of traffic on campus is able to decrease, even during peak hours. By reducing the traffic on campus, people will not have to search an entire lot to find available parking, but instead plan their route ahead of time to find parking in an efficient and timely manner without causing stress and anxiety, which could lead to major problems.

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 to also code the system
- 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 continue the work of the last ECE team to work on this project. The group members of the ECE team brings a range of specialities 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 multimeters, 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
     - 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 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 to use 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.

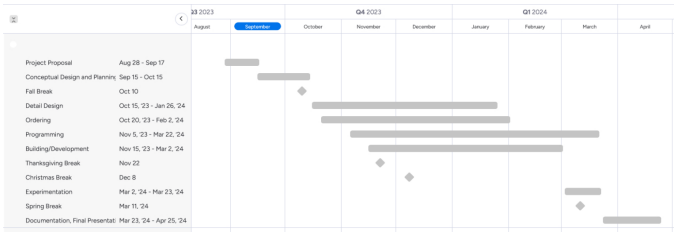

Fig. 1. Expected Timeline

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 range 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.

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 more 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 their knowledge and skills they have acquired over the course of their undergraduate education. 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.

References

[1] Kesternucum, "KESTERNUCUM/ECE-capstone-team3: Parking lot monitoring system," GitHub, https://github.com/kesternucum/ECE-Capstone-Team3/tree/main (accessed Sep. 13, 2023).

[2] "Tennessee tech grows total enrollment to more than 10,100 students, fueled by fourth largest freshman class in university history," Tennessee Tech University, https://www.tntech.edu/news/releases/22-23/tech-grows-total-enrollment-to-more-than-10100-students.php (accessed Sep. 13, 2023).

[3] Student survey on parking and desired parking structure location, https://www.mtsac.edu/president/cabinet-notes/2016-17/PTK_College_2016_Parking_Student_Survey.pdf (accessed Sep. 2, 2023).

[4] "ParklioTM detect - AI parking monitoring system," Parklio Detect, https://parklio.com/en/parking-solutions/detect (accessed Sep. 2, 2023).

[5] Tbowman, "Video vehicle detection," Cerritos College, https://www.cerritos.edu/auto/basic-its/vvd.htm (accessed Sep. 12, 2023).

[6] "NFPA 70 - National Electric Code," National Fire Protection Agency. https://www.nfpa.org/codesand-standards/all-codes-and-standards/list-of-codes-andstandards/detail?code=70. (accessed Sep. 12, 2023).

[7] "NFPA 70E - Standard for Electrical Safety in the Workplace," National Fire Protection Agency. https://www.nfpa.org/codes-and-standards/all-codes-andstandards/list-of-codes-and-standards/detail?code=70E (accessed Sep. 12, 2023).

[8] [1]"Browse Standards — Get Program — IEEE Xplore," ieeexplore.ieee.org. https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=68 (accessed Sep. 12, 2023).

[9] [1]14:00-17:00, "ISO 4414:2010," ISO. https://www.iso.org/standard/44790.html (accessed Sep. 12, 2023).

[10] "Hands Free Tennessee," Tennessee Highway Safety Office, 2021. https://www.handsfreetn.com. (accessed Sep. 12, 2023).