Conceptual Design and Planning for Parking Lot Monitoring System

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I. Introduction

The goals of this conceptual design document are to expand upon the fully formulated problem surrounding a parking lot monitoring system to be implemented on the campus of Tennessee Technological University, the fully decomposed conceptual solution, the constraints on the solution and sources of constraints, the analytic validation of the constraints, and an optimal detail design schedule. The conceptual design of the parking lot monitoring system breaks down the concept of a parking lot monitoring system into subsystems that perform tasks to meet the specifications from the customer and other stakeholders while also satisfying the constraints generated from customer specifications, engineering standards, ethical concerns, broader implications, etc.

A. Fully Formulated Problem

The parking lot monitoring system shall collect data and provide information regarding parking spot availability to students. The function requirements include:

(a) System shall not obstruct any parking spots on campus in a way that would not allow a person to park in a given spot.
- This constraint was explicitly defined by the customer NAVSEA as a major requirement and echoed by the Tennessee Tech Parking and Transportation Office, a stakeholder.

(b) System shall not interfere with parking traffic on campus in a way that would cause traffic to worsen.
- This constraint was explicitly defined by the customer and another major stakeholder, the Tennessee Tech Parking and Transportation Office.

(c) System shall not permanently store images.
(d) System shall not record videos.
(e) System shall operate during parking enforcement hours of 8:00 a.m. - 4:30 p.m.
(f) System shall have a system of sensors to get count of vehicles present in parking lots.
(g) System shall include a second system that can monitor ground truth to measure accuracy of vehicle counts compared to primary system.
(h) System shall have accurate vehicle counts within ±5% of the ground truth's counts.
(i) 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).
(j) System shall have protection against inclement weather (e.g. rain, snow).
(k) System shall have outdoor signage to indicate parking availability to people searching for parking on campus.
(l) System shall have a mobile application for people wanting to check information about availability of parking on campus.
(m) System shall have notification posted on mobile application about potential decreased system accuracy during inclement weather.
(n) 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.
(o) 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).
(p) System shall have mobile application display additional chart displaying average parking availability over operational times of day.
(q) System shall, at a minimum, perform its intended function in ideal conditions (i.e. clear weather)
(r) 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.
(s) System shall follow electrical safety measures as specified by the NFPA 70 and 70E Electrical Codes and Standards.

II. Broader Considerations

There are numerous considerations that were taken into account during the conceptual design and planning of this project, including ethical implications, engineering standards, and broader impacts, all of which had produced additional constraints on the system. These considerations and their produced constraints will be discussed in this section.

A. Ethical Implications

Safety - With the use of a mobile application to check for parking availability, there exists the risk of increased traffic accidents due to the apps usage while driving. Also,

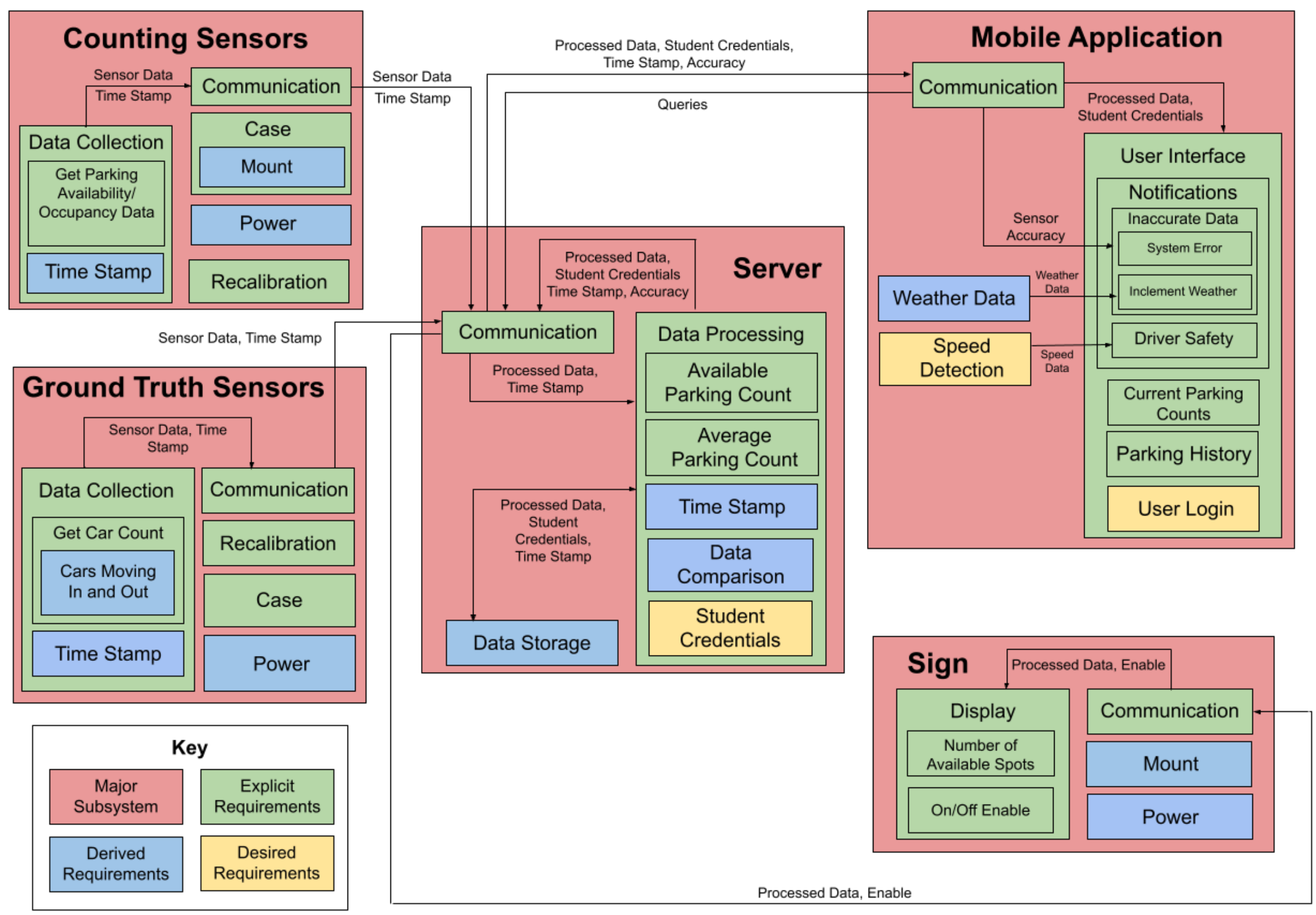

Figure 1. Block Diagram of Conceptual Solution

in Tennessee it is illegal to use a mobile device while driving unless the device is hands free (TN Hands Free Law).

B. Engineering Standards

Electrical Safety - In order to maintain the safe design, operation, and maintenance of the system, the project will follow the National Fire Protection Association (NFPA) 70 and 70E Electrical Codes and Standards.

Power - If solar energy is utilized to power any of the components in the system, the project will follow solar panel installation standards established by Clean Energy States Alliance (CESA).

Communication - Since multiple subsystems will be communicating with a server, the appropriate network communication protocols will be used to ensure proper transfer of data.

C. Broader Impacts

Due to the initial cost of deploying parking lot monitoring technology across the university, inflation in on-campus parking may be a possibility. Even though it would start out somewhat expensive, this cost would eventually go down, which would irk the student body. We aim to reduce hardware expenses to solve this issue by making sensible selections and only investing in features that are essential. Investing on an 8k camera system, for example, when it is not necessary.

The adoption of the parking lot monitoring system may result in an increase or decrease in accident rates. If the parking software was used appropriately, students looking for parking places would feel less anxious. However, if the app is used improperly (for example, by continually glancing down at the app while driving), it could lead to more collisions.

The addition of the parking lot system could be utilized to enforce proper parking. With upcoming system upgrades, it might be feasible to detect improper parking (i.e. obstruction of two spots). The system might also benefit from the ability to recognize colored parking passes. The appropriate parking pass for the parking zone is obtained in this way.

The addition of the gathered park data might be a fantastic resource for Tech's future growth. Knowing how each parking lot is used and at what time slots is useful information for potential expansion or refurbishment. With this information, Tech management may visually determine whether a lot is underutilized and whether it could be used for another structure or function, or perhaps a frequently utilized parking lot has to be expanded.

D. Constraints Produced from Considerations

Safety Constraint - The constraint generated from the ethical issue of driving safety is denoted by constraint (n) which clarifies a notification given to users of the mobile app to remind them of the dangers of using a mobile device while driving as well as its illegality in the state of Tennessee.

Electrical Constraint - Constraint (s) is generated in relation to the safety standards established by the NFPA which will influence design choices made for the system.

III. Conceptual Solution

Figure 1 shows the block diagram of the conceptual solution for a parking lot monitoring system that meets the requirements and constraints detailed in the fully formed problem. This section will briefly explain the functional expectations for each subsystem block and the associated constraints for each block.

A. Subsystems

The parking lot monitoring system will consist of five major subsystems: counting sensors, ground truth sensors, a server, a mobile application, and a sign.

1) Counting Sensors: This subsystem will be responsible for helping fulfill shall statements “a”, “b”, “c”, “d”, “i”, and “j”.

(a) During the design of this subsystem, care will be taken to ensure that shall statement “a” is fulfilled and that no parking spaces are obstructed in the placing of this set of sensors.
(b) Care must be taken in the placement of this system of sensors in order to ensure that parking traffic will not worsen.
(c) This sensor system should not store any images, only send them.
(d) This system will be built with only still images in mind.
(f) Depending on lot size multiple field of visions might be needed to inspect the entire area.
(i) This system will need to have a form of re-calibration in the event of system failure.
(j) Protection from the elements is a key aspect of the longevity of the sensors system.

2) Ground Truth Sensors:

(a) During the design of this subsystem, care will be taken to ensure that shall statement “a” is fulfilled and that no parking spaces are obstructed in the placing of this set of sensors.
(b) Care must be taken in the placement of this system of sensors in order to ensure that parking traffic will not worsen.
(f) Multiple ground truth sensors would be needed for a parking lot with multiple entry/exit points.
(g) Secondary system is needed to act as a form of redundancy in our system similar to how a safety system has redundancy in it.
(i) This system will need to have a form of re-calibration in the event of system failure.
(j) Protection from the elements is a key aspect of the longevity of the sensors system.

3) Server:

(e) Sign usage will not be needed before 8am and after 4:30pm. Server is needed to process the time stamp and enable/disable the sign.
(h) Server will compare data from upper level/ lower level systems to verify accuracy.
(j) Protection from the elements is a key aspect of the longevity of the serve.
(n) API weather information will have to be processed before sending to app.
(o) Data from sensors should be consistent. If inconsistencies arise server will communicate data to mobile application and sign.

4) Mobile Application:

(l) Processed data will be sent from server to the mobile application.
(m) Weather API data will be processed by the server ans sent to the mobile application.
(n) Notification should be at the startup of the mobile application every time it is opened.
(o) Accuracy below the 95 percent will be considered as a system malfunction notification.
(p) Daily data will be stored and averaged to the whole integer point will be displayed.

5) Sign:

(k) Accuracy of data displayed will be accurate to processed data from the server.
(i) Needed to ensure accuracy can be re-obtained after an
(j) (no leaky parts)
(a)

IV. Optimized Detail Design Timeline

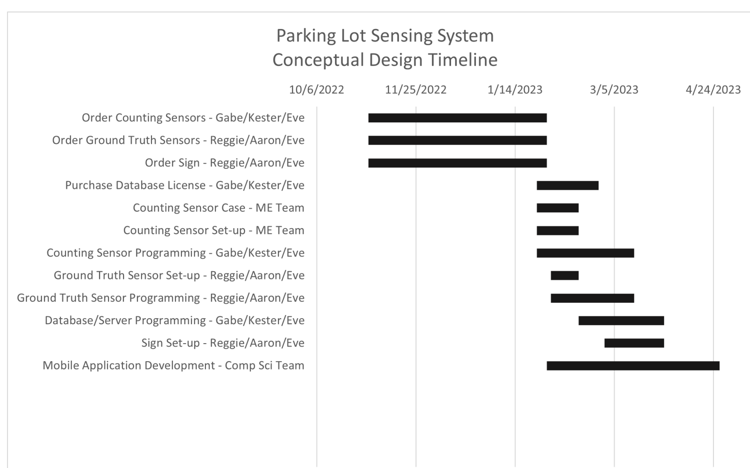

Figure 2. Conceptual Design Timeline

As examined in Figure 2, each task in the detail design is broken down into a time slot and the responsible parties. These tasks were assigned to parties based on related skills and concentrations. It can be seen that all tasks pertaining to counting sensors are assigned to Gabe, Kester, and Eve. Tasks pertaining to ground truth sensors are assigned to Reggie, Aaron, and Eve. Eve is included in both due to her being a double major (Electrical Engineering and Computer Engineering). This provides flexibility to have her on the side that may need more attention at a certain time. The mechanical engineering team will then be working on the housings for the sensors as well as setting them up. Lastly, the computer science team will be completely designing the app based on the data received from the sensing systems. This is why this is the optimal timeline.

V. Conclusion

The conceptual design of the parking lot monitoring system consists of five major subsystems: counting sensors, ground truth sensors, a server, a mobile application, and a sign.

References