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Introduction

<u>Goal</u>

Parking spots on campus are numerous, and there's constantly a need for multiple people to constantly monitor parking spots to ensure rules aren't broken. It's very easy for an individual to make an honest mistake however, such as parking too close to the curb, forgetting the time limit they paid for, or parking in a spot they're not allowed to park in. We propose to solve this problem with an enhanced parking device that can be either mounted on a pole or a wall that will monitor cars coming in and out of the parking space, and notify the car-owner and the officials if there's a violation. Our device will also be able to assist the individual by giving signals in the form of color-coded lights on the device to assist them in parking (e.g. if they are too close to the curb or outside their spot, a visible light on the device will turn red. Stays green otherwise).

<u>Functions</u>

Recognition - Each parking space will have this device placed in a convenient location so that the license plate of the vehicle is visible. The device should recognize whether or not there is a vehicle parked in a spot, using image processing and recognition techniques.

Communication - The device will notify University Parking if a car is in violation of a parking rule. The device will also record a snapshot of the license plate number and an image of the car and send it back to a remote server.

Driver Assistance - The device will feature light signals to notify the driver if they are in violation of a parking rule. Using sensors and image recognition, the device will signal with a red light if the driver is outside their space or too close to another car or the device itself. If the space is a paid parking space, then the light will also turn red if the driver has exceeded their time limit and additional payment is required. In the case where the driver hasn't violated any rules, the light remains green. If a spot is unoccupied, the light will turn blue, signaling other drivers that there is an open parking space, which should help in finding parking at night during crowded events.

<u>Benefits</u>

This project will help the University Parking and drivers alike. With the automatic collection system, drivers will no longer have to worry about carrying around coins for parking meters; even if not all parking meters require coins, having a single unified system between which all drivers and University Parking itself can communicate will benefit both sides. Furthermore, the automatic collection will save the University Parking officials the need to inspect every meter manually; instead, they will be notified which parking meter has expired or if a car has committed a violation. Also, in order to reduce the number of violations committed by drivers themselves, the LED feature that detects if a violation has been committed will be a clear signal to the driver that they are at risk of being fined; since many fees are those drivers didn't mean to accrue.

Features

First, the number of features our device will possess will completely outshine the standard parking meter, so even if it's slightly more costly, the long-term benefit will eventually pay itself off since it will save a lot of manpower (gas + time of having to check every parking meter). Secondly, it benefits not only the University Parking to own these meters; it will help the drivers as well by telling them if they are at risk of being fined for a violation. This should hopefully reduce the number of violations committed, and save the hassle of having to deal with these fines. In addition to this, drivers will also have an automated way to make payments on their parking instead of having to carry around coins.

Optional/Extra Features

1. Camera cleaner if there are some dirt on the camera
2. Solar Powered
3. Mobile application for drivers

Design and Requirements

High-Level Requirements

• Ability to recognize if there is a car parked in the space (either via. computer vision or sensors), and identify its license plate and associate the license plate with a user account (if one exists)

• Ability to recognize if a car has committed a violation, and give a physical indication (LED color) to the driver

• Ability to communicate with the University Parking server in case there is a violation (e.g. empty balance, car is parked incorrectly)

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Block Diagram

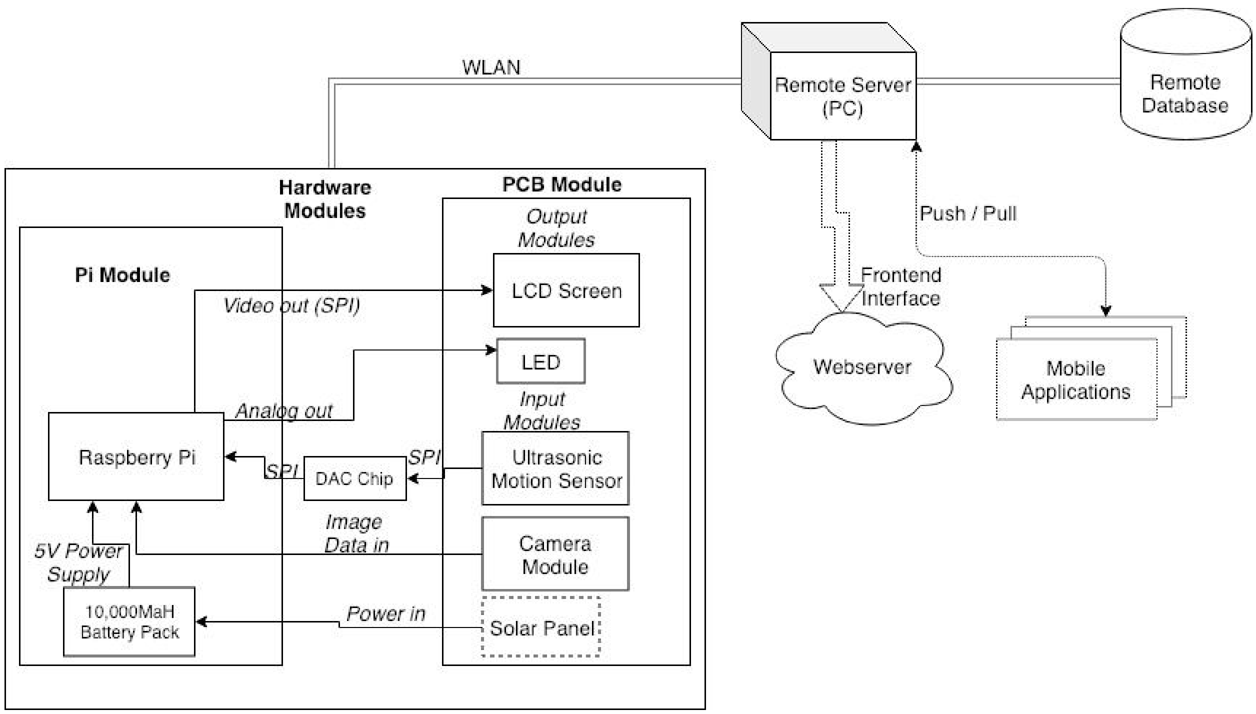

Figure 1: Hardware and Software components involved in the design of the smart meter.

Component Descriptions

Power Supply

Our device will utilize the 5.2V Raspberry Pi power supply, and will run from a ground line to provide power to the main device. In our initial proof-of-concept, this is just the power supply we plan to use; however, as an additional feature, we'd ideally replace this power supply with a Raspberry-Pi-compatible solar panel for outdoor positioning. In order to implement a solar-powered device, a compatible solar panel is clearly needed, but in addition to this, we will also need a volt/current meter because a battery by itself will supply power to the board until the battery is drained, and then the board will abruptly power off. In order to ensure a clean shut-down, it's necessary to monitor the volts left in the battery (a typical Li-Pro battery reads around 3.7V when it's nearly empty) to ensure that the proper shutdown operations can be executed before the battery is completely drained.

Requirement 1: Must supply a constant 5V and 2.5A power supply to the board while the board is powered on.

Requirement 2: Must allow for proper autonomous shutdown and power-on sequence without damaging any components of the board.
Requirement 3: (If using solar panel) Solar panel will be 6V, 2W connected with adapter and battery and boost to provide stable power to raspberry pi.

<u>Control Unit</u>

The main control unit is the Raspberry Pi. It will be responsible for recognizing license plates and transmitting the license plate number along with corresponding timestamps back to the main server. The Pi will also be in charge of ensuring that the car is parked correctly; which means it must be able to read inputs from the sensor module and camera module to detect if the car is parked incorrectly (too close to the meter, strange angle such that the plate is not visible, etc.), and it must be able to display the correct LED color upon these events. Furthermore, if the customer chooses to pay with cash, the Pi must also be able to compute the correct amount of payment, and display corresponding prompts (more payment needed/payment complete) to the LCD screen.
Requirement 1: Must be able to perform all computations corresponding to a single parked car on the spot. This includes plate recognition, which means it must be able to hold a model to read and identify license plates on streaming data.
Requirement 2: Must be able to signal the server in the case of an incorrectly parked car, and for bookkeeping purposes.
Requirement 3: Must be able to properly shut down and power on each peripheral upon being shut down and powered on itself.

<u>LCD Output Screen</u>

This device is responsible for displaying driver-assistance prompts such as time remaining, payment required, and messages for recognized parking violations such as a license plate not visible, car parked in a reserved/invalid spot (e.g. if parking is only allowed between certain times), car too close to the meter, or if the car is outside its designated parking spot.
Requirement 1. Must display the appropriate message based on feedback from the main control unit (Raspberry Pi).
Requirement 2. Must support a 16x2 LCD display, and accept 5V input directly from Raspberry Pi pin.

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Camera Module

The camera module must be able to recognize a single license plate when there is one present, regardless of the time of day, and at a distance of around 3 meters from the device. The camera module we've selected is an 8 megapixel, 1080p raspberry-pi compatible camera which can be purchased for 24 USD.

Requirement 1. Must be able to stream image data to the Raspberry Pi for real-time license plate recognition.

Requirement 2. Must be able to recognize license plates at different angles and distances.

Requirement 3. 2A power drawn directly from raspberry pi.

Motion Sensor

The proximity sensor will be used to assist in detecting invalid parking positions. The sensor will also notify the camera to take a picture when the sensor detects anything within a distance (1-2 meters). For more accurate measurements of the distance between the meter and the car, we may use several sensors to get a more accurate result.

Requirement 1. Sensor must correctly recognize when there is a car present within a distance of at most 2 meters from the meter and report the distance of the car from the meter.

Requirement 2. 5V 15mA powered from raspberry pi with a distance resolution of ±0.3cm.

Remote Server

The remote server will be the centralized communication point for all the smart meters. It will contain an interface for the all of the meters to communicate with. This communication layer will immediately route the data into the remote database via. a wireless connection. This must work regardless of whether the database if located on the same PC as the remote server, or a different one. The server will serve as the central hub of communication for push and pull requests. When a user wants to deposit funds into their account or view their current funds, the server will be responsible for the web service to mirror and modify the database.

Requirement 1. The server must be able to wirelessly receive data from all smart meters, and store this data in a remote database without any loss of data.

Requirement 2. The server must be able to quickly handle fetch requests from the web server when a user attempts to access or modify their information.

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Web Server

The web server is the software interface for users to interact with. This is the abstraction that users will use to deposit and view funds and violations on their accounts, update and add new license plates, and register for an account with the parking service. The web server will also be where University Parking will be able to interface with its users. An admin will be able to log in and view violations tied to a particular license plate, and will be informed immediately upon a violation being committed.

Requirement 1. The web server must be able to support all necessary user actions including: registering for an account, adding funds and license plates to an account, and fetching and modifying user information about violations, license plates, and existing funds.

Requirement 2. Admin accounts on the web server must be notified when a violation is committed. The notification must contain a location, timestamp, and license plate of the offending vehicle.

Remote Database

The database will be responsible for storing user records related to existing funds and license plates associated with those funds. Initially, for the proof-of-concept the database used will be a relational (SQL) database because data access will be infrequent (i.e. no analysis is being done on the data, and the data we wish to store is predefined and fixed).

Requirement 1. The database must be able to create and modify entries regarding user license plates and balances tied to those license plates.

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Risk Analysis

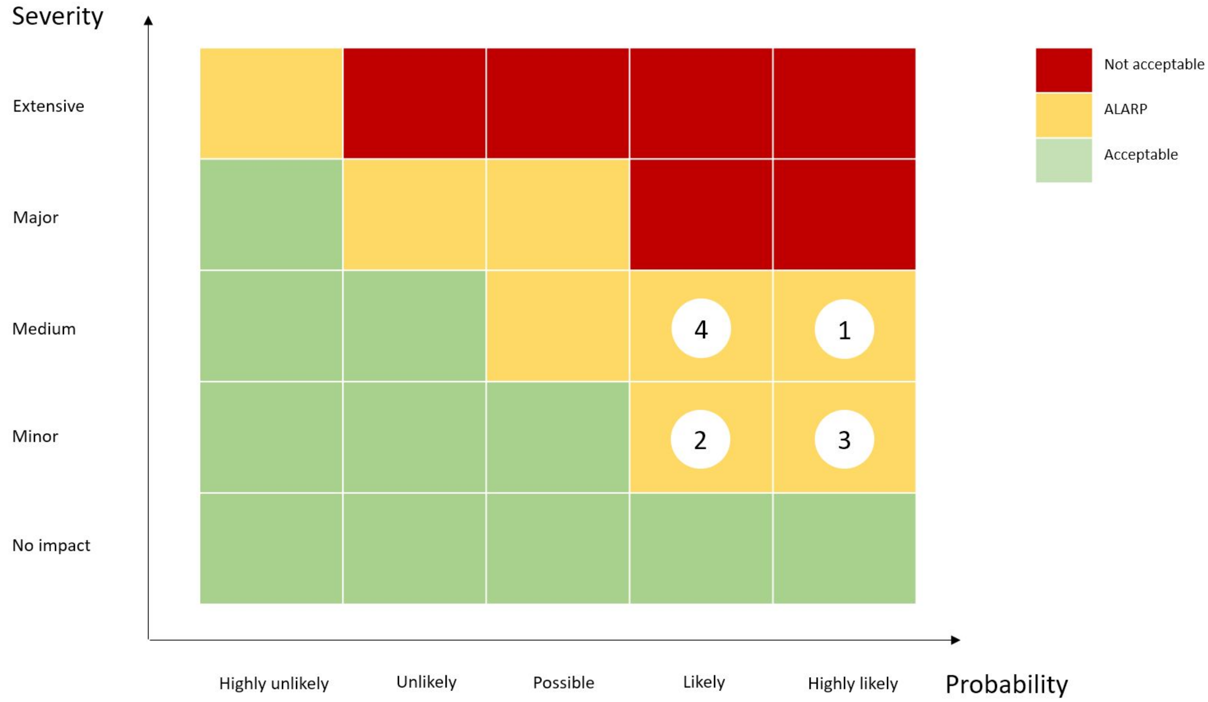

Figure 2. Risk Assessment of significant project components

The numbered bubbles represent:

1. User information protection
2. Power supply
3. Data transmitting
4. Mechanical stability

The communications layer between all the devices as well as the server is likely going to be the most challenging part. This is because we'll need an easy way to integrate new smart meters into the design as they're added, and there must be reliable data transfer between each meter and the server to ensure customers aren't overcharged or undercharged. Furthermore, when a violation is committed, the University Parking must be notified in real time so action can be taken. Overall, there will be a complex network of communications going on at the same time, and the infrastructure must be able to support all of it at once. On top of this, we will have to come up with a way to test its scalability without building tons of the parking meters themselves, in order to show that the design truly works. This will require us to research methods of scalability testing with what resources we have. Furthermore, we will have to build multiple mock interfaces to ensure that these operations can be performed all at once. Ultimately, testing our network is going to be very challenging because it will involve hardware and software debugging on a large level. This is where we plan to spend a lot of our time researching how to minimize and reduce errors on both fronts.

Ethics and Safety

One of the primary concerns to be aware of is the fact that user data and their credit card account information is being stored and charged while utilizing our service. For this reason, it's imperative that user information is properly encrypted and transmitted in a safe and secure manner. This will require us to research our options for when it comes to storing and transferring data.

An issue brought up during our discussions revealed that a similar automated parking collection meter was installed in Palisades Park (1). As a result, user complaints were numerous, and stores lost customers because they simply didn't want to deal with the complications of these new meters. Furthermore, the city was able to raise a lot of money from drivers going over time, since tickets would be automatically billed to their address. This practice seems to clearly violate IEEE ethics code #5: "to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems." Because the use of their meters was confusing and unclear, many users suffered fines, which only seems to exacerbate the concern of automated processes. We seek to improve user parking experience with a more fully-featured automated driver parking assist. Our meter will provide clear signals to the driver when a violation has occurred, and one of our biggest goals is to make the user interface as simple as possible. To reap benefits from users' confusion is unethical, so it's very important that our design choices make sense to the driver and that our signals and instructions are easy to follow.

IEEE ethics rule #6 ("to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations") brings up another concern about storing and transmitting user data. Only one of us has experience with storing and retrieving encrypted user data for public services, so in doing so, we acknowledge that our knowledge in the field is limited, so in order to prevent unsafe practices, we plan to consult online resources and utilize existing tools for secure transfer and storage of user data.

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