Introduction:

1. Objective

Parking spots on campus are numerous, and there is constantly a need for multiple people to constantly monitor parking spots to ensure rules are not broken. It is 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 are 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 is 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).

2. Background

In our state, when people forgot to pay the parking meter due to carelessness or some emergencies, people could be charged for $50. Also, sometimes because of the bad schedule plannings, people ran late to the parking lot to pick up their car. In case of these scenarios, people usually pay extra money to safely cover the time they will use, which in turns cause people losing money because they left early. Our meter attempts to solve all these problems.

Our meter will check the person’s balance on the server and calculate the time the person parks the car. Remote server will automatically charge from the account for the time the car parked. When balance in this person’s account runs out, we will notify the person first. Through our website, they can pay the account. As a result, the person will only receive parking ticket when he or she refuses to pay. This could greatly reduce the waste of money and accommodate some emergencies.

3. High-level requirements list

• Able to recognize if there is a car parked in the space (via. ultrasonic sensors), which is defined as a car sitting at a distance of 0.75 meters +/- 0.25 meters, and identify its license plate within the next 1 minute and associate the license plate with a user account (if one exists), and begin charging the driver’s account after 5 minutes of being parked.
• Able to recognize if a car has committed a violation, and give a physical indication (LED color) to the driver within 10 seconds of the violation being committed. A violation is defined as the following:
  - The car is parked 0 or more centimeters within another parking spot.
  - No license plate is detected after 5 minutes of an object being detected (car might not have a license plate, or the spot is obstructed; in either case, University Parking will be alerted).

• Upon the driver leaving the parking spot, the database should accurately reflect the parking time and updated balance within 5 minutes of the driver leaving. This change should be reflected on the web server (viewable by the driver) within 1 additional minute.
Design:

3. Block Design

Microcontroller, Ultrasonic Motion Sensor, and LCD Display

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>For an 8Mhz oscillator crystal to be used with the PIC16F877A, capacitor 1 and 2 must be supply within the range of 15pF to 33pF.</td>
<td>An digital multimeter will be used to measure each capacitor before it is connected to the circuit, and we will ideally observe a value of around 22pF.</td>
</tr>
</tbody>
</table>
Power Module

VCC should provide stable 5V and 500mA power for raspberry pi to safely work.

We will use oscilloscope to measure the voltage and the current when MCU allows VCC supplies raspberry pi.
Central Server

a. The central server will handle the main logic shown in the server-side software flowchart (figure X). Thus, it is responsible for managing the flow of data between the database and the main server computer, authentication and security (including user/admin sign-up), and transfer of information to and from the smart meters.

![Flowchart: Central Server and API Gateway](image)

*Figure X: Top-level data flow of the entire system.*

b. The flow of data on the server-side is shown in the flowchart below. The server will be responsible for handling requests that come through the API gateway and making the correct query to the database to check if the license plate exists. If the plate isn’t already registered, a new entry will be created with a balance of 0, and when the driver with that license plate signs up, any remaining balance will be saved to their account, and their user information will be synced with their existing plate.

![Flowchart: Flow of data on the server side](image)

*Figure X: Flow of data on the server side.*
c. Upon a driver arriving, a request is made to query the database for an existing plate. If an existing balance is found, the balance is sent to the smart meter and converted into a number of minutes the user is allowed to park for. If the balance reaches zero, or a violation is committed at any point during the flow, an interrupt is generated and if the issue is not cleared within 15 minutes, University Parking is alerted of the incident, and the driver’s account is updated with the corresponding incident message.

![Software logic flow on the meter/client side.](image)

**Figure X: Software logic flow on the meter/client side.**

d. Security
The account information involving each user will be encoded on the server side and decoded on the raspberry pi board when requesting from users database.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should be fast and efficient. The information should be correctly encrypted and should be correctly decrypted</td>
<td>We will make several testing requests and display both the encrypted messages and decrypted messages to verify. We will also time the process to evaluate the</td>
</tr>
</tbody>
</table>
4. Tolerance Analysis

1. Distance estimation

Accurate estimation of the distance between the car and the meter is important for first, assisting the driver to park car, and second, help to maintain car at a similar distance from the camera so that the plate number can be recognized with higher accuracy. We have not tested with real cars yet. From datasheet of ultrasonic sensor (HC-SR04), the measuring angle is 15 degree, and the measuring accuracy is 3mm. Because of the different reflection surface and different height of cars, more than one sensor might be needed to be placed on different positions.

2. Plate recognition algorithm accuracy and response time

Our model needs to accurately recognize the plate number in a limited time frame. Due to our implementation, we will start the raspberry pi board first if MCU detects a car parking into our spot. The starting time of raspberry pi takes less than 2 minutes. The recognition algorithms takes less than 1 minute. In total of 3 minutes, we should have output before the driver is ready to leave. The accuracy of openALPR (4), as it is reported, has reached 99.2%. We believed that in our case, the actual accuracy will be higher because we limit the possible positions the plate number will show up in the camera.

Cost and Schedule
1. Cost Analysis

- Labor:
  Rate: $13/hr
  Bo Wang: 13 * 2.5 * (10 * 3) = $975
  Christopher Santoso: 50 * 2.5 * (10 * 3) = $975
  Ximin Lin: 50 * 2.5 * (10 * 3) = $975

- Parts:
  1. Raspberry pi board model 3 b+ from amazon:

<table>
<thead>
<tr>
<th>Name</th>
<th>Quantity</th>
<th>Unit price($)</th>
<th>Subtotal($)</th>
</tr>
</thead>
</table>


| **Raspberry pi board**
Raspberry Pi model 3 b+ from amazon | 1 | 35 | 35 |
|-------------------------------|---|----|----|
| **Camera Module v2**
Raspberry Pi from amazon | 1 | 23.9 | 23.9 |
| **SanDisk Ultra 16GB Ultra Micro SDHC UHS-I/Class 10 Card**
from amazon | 2 | 7.2 | 14.4 |
| **CanaKit 5V 2.5A**
Raspberry Pi 3 B+
| **LCD screen** | | | |

2. Schedule

<table>
<thead>
<tr>
<th><strong>Date (by end of week)</strong></th>
<th><strong>Group Scheduled Progress</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2/18</td>
<td>Simulate ultrasonic sensor and part of power module, cable modification for raspberry pi. Develop plate number recognition model.</td>
</tr>
<tr>
<td>2/25</td>
<td>Programming MCU for ultrasonic sensor and LCD, simulate on breadboard</td>
</tr>
<tr>
<td>3/4</td>
<td>Design PCB on Eagle for the first wave PCB order.</td>
</tr>
<tr>
<td>Date</td>
<td>Task Description</td>
</tr>
<tr>
<td>-------</td>
<td>------------------</td>
</tr>
<tr>
<td>3/11</td>
<td>Finish plate recognition model and testing. Build the structure of software in Python. (PCB modification)</td>
</tr>
<tr>
<td>3/18</td>
<td>Spring break (no scheduled work for now)</td>
</tr>
<tr>
<td>3/25</td>
<td>Coding for data transfer between smart meters and server. Build the database and user interface of our service.</td>
</tr>
<tr>
<td>4/1</td>
<td>Continued and design a custom cover for system. (may order a powerful battery to supply the project for outdoor testing)</td>
</tr>
<tr>
<td>4/8</td>
<td>Testing</td>
</tr>
<tr>
<td>4/15</td>
<td>Testing</td>
</tr>
<tr>
<td>4/22</td>
<td>Testing</td>
</tr>
<tr>
<td>4/29</td>
<td>Testing</td>
</tr>
</tbody>
</table>

### Discussion of 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.

Citations