Park Pal: Parking Guidance System

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Subject: ECE 198 Project Proposal

Customer Problem

For this project, the customers are Waterloo drivers who drive to work. According to the 2021 City of Waterloo Census data, the City of Waterloo has a population of 121,436, and 76.4% of residents commute to work by driving themselves [10]. This is a client size of about 92,777, placing the client within the scope of this project.

Like all drivers, those in the City of Waterloo must deal with bad parkers, and issues that come with it. Research shows that in Canada, 10% of all accidents occur in parking lots, and bad parking habits lead to inefficient usage of space [9]. In fact, on average, 100,000 hours are wasted annually by drivers searching for parking [8].

Through more efficient, organized usage of parking space, our product will lower wastage of parking space, time wasted searching for parking, and the rate of parking lot accidents.

Stakeholders

Government: Recently, cities across Canada have increasingly been forgiving millions of dollars on parking tickets [5, 6 ,7]. Additionally, according to Toronto Police Service statistics, fewer parking tickets have been issued post-pandemic [11]. Governments need a new solution to illegal parking habits, and tickets are insufficient. Additionally, excessive congestion, associated with bad parking, was estimated to cost Canadian cities $4.6 billion annually [4]. According to research, drivers are less likely to commit illegal parking behaviour if they believe there is a risk of being caught [3]. Governments need a solution to bad parking to serve their interests in economic upkeep and general safety.

The public/customers: Illegal parking is positively associated with congestion, increasing travel time and resulting in lost productivity [3]. Congestion lowers Canadians' quality of life: according to a CBC survey in the GTA, half of all respondents say they avoid shopping, entertainment or sports games because of congestion [2]. Therefore, a product aimed at reducing parking-related congestion would benefit the public's interest in productivity and quality of life.

Graduate TA (Shadi Vandvajdi): The graduate TA is concerned with the implementation of technical principles and the success of the project. Additionally, they will ensure the project meets project guidelines and academic standards. Finally, they are concerned with certifying that the project development aligns with the timeline tracker.

Special Interest Groups (Canadian Parking Association): The Canadian Parking Association seeks to adapt and develop new technologies to enhance the driver parking experience [1]. Therefore, they have a vested interest in a new parking-centric product, especially one that aims to reduce the problems associated with parking.

Suppliers: The client has no specific suppliers, as the client is a population of drivers.

Initial Requirements

Microcontroller

The product uses two STM32F401RE microcontrollers programmed in C++. One processes sensor input and transmits data to the other, which provides visual and auditory feedback for users to reposition their cars. This setup ensures instant feedback to the driver by facilitating communication between the user, sensors, and alert systems.

Functional

1. **Lights**: The product will use arrays of lights to alert the driver of parking errors. Lights have been proven to improve the visibility of signs, such as stop signs, and improve driver adherence [20]. The lights are necessary for device-user communication.
2. **Sound**: The product will use buzzers to alert the driver when they have made parking errors. This has been proven effective by research into railroad-grade crossing devices, such as sound, which have been proven to improve driver awareness and safety [19].
3. **Parking spot distance**: The product will use ultrasonic sensors to ensure cars do not park outside of the parking spot. This is because one of the most common parking lot accidents is incidents where cars pull out of tight parking spaces and scrape other cars [18]. These accidents can be minimized by ensuring each car remains within its bounds.
4. **Guidance system:** The product must be able to display arrows directing the driver in the correct direction to park. The usage of these arrows is integral to the communication component of this project. The province of Ontario has already implemented the usage of arrows in traffic lights, making it easy for drivers to understand [17].

Technical

1. **Light colour**: The LED arrays will display the symbols in green light. Green is the most visible colour to the human eye, making the symbols more visible to drivers. We specifically aim to have the light emit a wavelength between 550-555 nm [16].
2. **Frequency**: The product will use a Piezoelectric buzzer, which has a recommended usage frequency between 1-10 kHz [15]. However, research in music production indicates the most tiring frequency range for the human ear is 0.5-2 kHz [14]. The buzzer will emit a frequency of 1 kHz, which is the most efficient and effective.
3. **Distance**: For maximum accuracy, the ultrasonic sensors we are using have an accuracy of ± 3 mm, so drivers will have to park within 3 mm of the parking borders [13].
4. **Delayed guidance**: The product will give the driver a delayed grace period of 5 seconds to adjust their parking on their own before the alarm system activates. The product aims to reduce collisions in parking lots; however, sudden distractions are a leading cause of vehicular collisions, which is counterintuitive to the customer problem [12].

Safety Requirements

1. The product consumes less than 30 W of power and stores less than 500 mJ of energy.
2. No testing on human/animal subjects as drivers.
3. The sound emitted is within a safe range for the human ear.
4. The lighting system will emit a safe level of light for the human eye.

Principles

1. **Kinematics**: Ultrasonic Sensors

Ultrasonic sensors use sound waves to measure distances. They emit a sound pulse and calculate the time it takes for the pulse echo to return after bouncing off an object [21].

$$d = \frac{vt}{2}$$

Where:

- v is the speed of the sound wave in the air (343 m/s) [22]
- d is the distance from the sensor to the car
- t is the time taken for the pulse to return to the sensor

We will use the kinematics formulas to calculate the distance of the car using the time the ultrasonic sensor records, which is crucial in detecting if the car is parked correctly.

2. **Conditional Statements**: Software Conditions

In order for the LED light array to effectively communicate with the driver, it must display the appropriate symbol. Our product will require the use of conditional statements within the product software [23]. For example, on a basic level, some of our code may resemble the following sample:

```
if (sensorLeft > threshold) {
   displayArrow("right");
} else if (sensorRight > threshold) {
   displayArrow("left");
}
```

Where:

- the threshold is the parking boundaries
- sensorLeft and sensorRight are the appropriate sensor data from each ultrasonic sensor
- displayArrow is a function producing the appropriately directed arrow

3. **User Interface Design**: LED Light Display

We aim to achieve ultimate usability: anyone that is able to drive should be able to understand the symbols our product displays and act accordingly. Our product implements a section of the ISO standards, an international technological and manufacturing standard database [24]. According to standard *ISO 9241*, which governs user interface and usability:

> Usability is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”.

Without our client (Waterloo drivers who commute) being able to use this product, it will be rendered useless. Therefore, our design must be accessible and usable for the average driver.

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