Enhanced Parking Space Monitoring System

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1. Introduction

1.1 Objective

There are many times when it can be difficult for people to find parking, especially in cities or parking garages. It can be extremely frustrating to circle a parking garage multiple times without finding a spot for several minutes. Extra time spent searching for a spot creates unnecessary traffic and wastes fuel. In addition, drivers searching for open parking spaces often are not paying full attention to the road ahead of them. This creates a hazardous environment for both drivers and nearby pedestrians. Due to this, a product that aids drivers in locating a parking spot would be beneficial.

Our proposed solution is to monitor the parking spaces with a camera, and provide an easy to use web interface that would show where available parking spots are located. This way, a person could easily go to the website, find where a parking spot is located, and immediately go there, cutting the search time down drastically. In addition, colored LEDs will indicate the status of a spot to nearby drivers to further reduce their need to search for open spots. Mounting the device on the ceiling of the parking garage as seen in *Figure 1* allows for a better angle of sight and provides a degree of protection from vandalism or theft.

1.2 Background

According to INRIX, a parking and driving data analytics company, Americans spend an average of 17 hours per year searching for parking. This extra time costs about $345 per driver in wasted time and fuel. INRIX also found that 40% of drivers report avoiding going to shops due to the hassle of finding parking [5]. Burdensome parking experiences not only annoy drivers but also hurt the economy and local businesses as a whole. As well as being economically disruptive, poorly operated parking lots can also be dangerous. The National Safety Council reports that there are more than 50,000 car accidents per year in parking lots and garages. These accidents result in an average of 60,000 injuries and 500 deaths every year. With our design drivers will be able to be less distracted while getting to a parking spot.

Currently implemented solutions to this problem do not provide the same level of accuracy or convenience as our design. Occasionally one can find signs outside of a parking garage that indicates the number of available parking spaces. These counters are prone to inaccuracy when a garage is busy and cars are tightly packed [7]. Newer parking garages will display colored LEDs above each spot to show availability, but lack the accuracy and online display of our design.

When compared to the previous group's project, our solution differs in several key areas. Instead of using an IR sensor, our design utilizes a camera and video processing software to detect the presence of a vehicle. The previous solution required the bumper of the vehicle to be unrealistically close to the sensor in order to be counted. Our design would allow for more accurate detection and more variation in vehicle sizes. The previous design could also send a false positive in the case of a pedestrian standing in front of the IR sensor. The video processing approach of our design would eliminate such errors. In addition, we would provide a web interface so that a person could view the availability of various spots. This would function as a website where one could view available spots on a map, and easily see where the nearest available spot is.

1.3 Physical Design

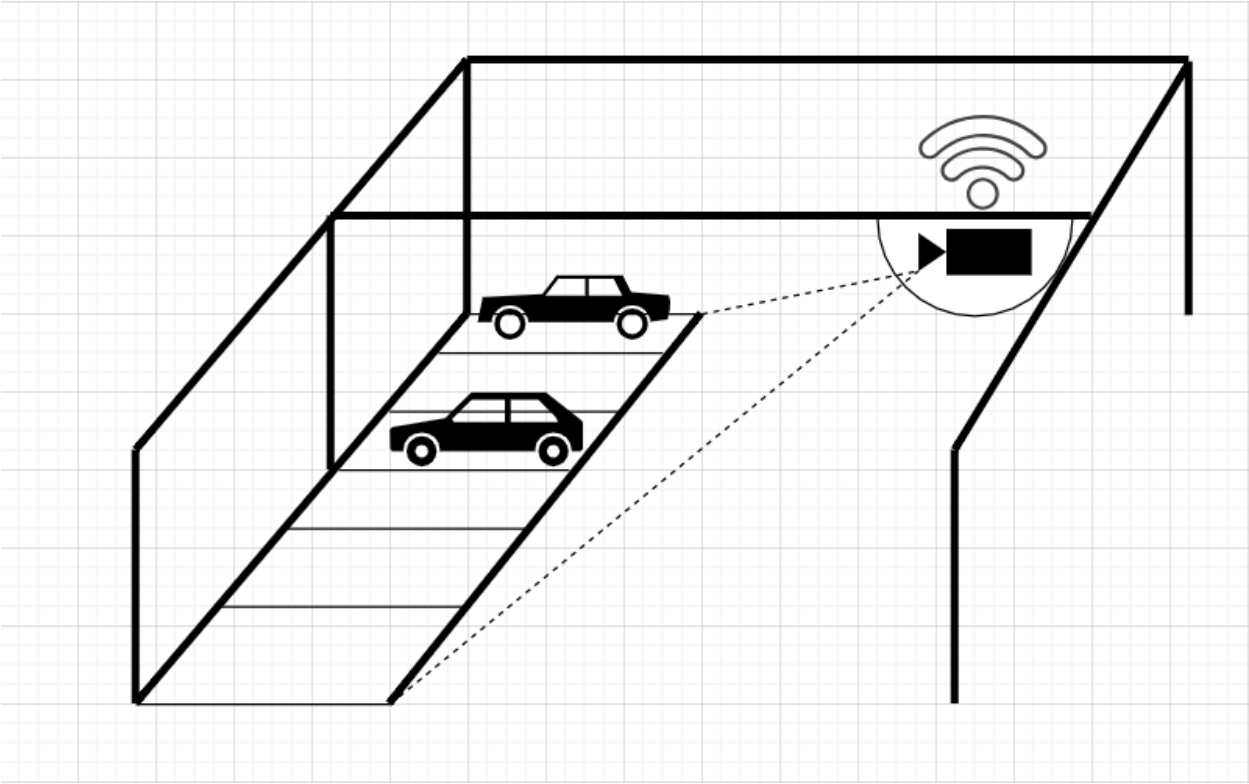

Figure 1. Enhanced Parking Space Monitoring System Physical Design

1.4 High-level Requirements:

The following are the most important qualities our project must exhibit in order to be successful:

- Be able to differentiate a vehicle from other objects.
- Detect the presence of a vehicle in a parking space with few false positives and false negatives.
- Conveniently notify users of available parking spots.

2. Design

2.1 Block Diagram

A modular representation of the core components of our design is presented in the block diagram below (*Figure 2*).

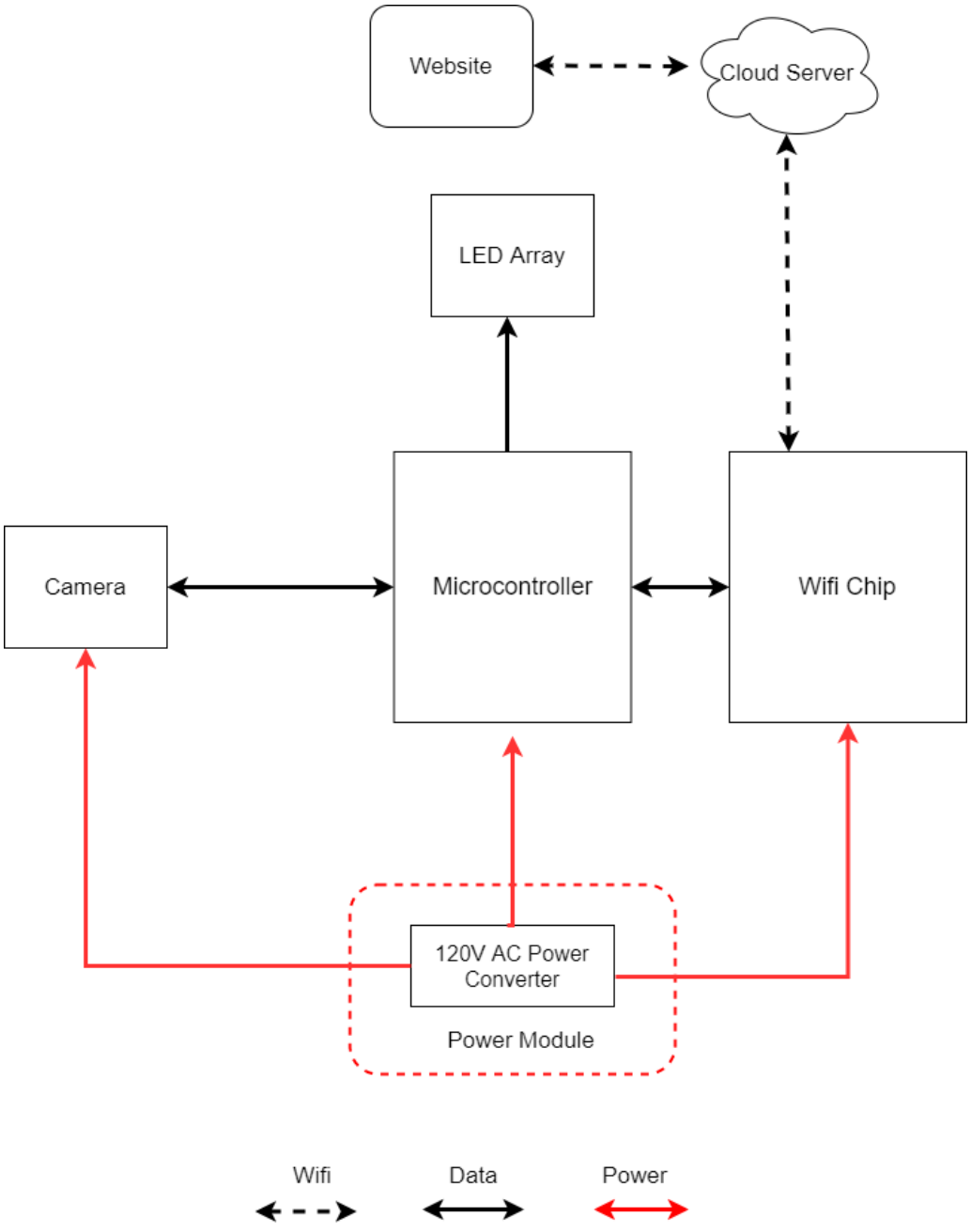

Figure 2. Enhanced Parking Space Monitoring System Block Diagram

2.2 Functional Overview

The following are brief descriptions of the function of each module in *Figure 2*:

- **Camera**
    - The Camera will be responsible for sensing a parking area and sending a constant stream of image data to the Microcontroller. It will take pictures of multiple parking spaces on a set time interval, such that the Microcontroller has enough time to finish one image before receiving the next. In order for the system to function properly, all parking spots will be visible by at least one camera.
- **Microcontroller**
    - The Microcontroller will receive a constant stream of data from the camera module. It will analyze the images it receives using a pre-trained neural network, identifying all vehicles in the image and deciding whether or not they fall within the bounds of a parking spot.
- **LED Array**
    - Every parking spot will have a red and green LED Array. Each array will connect back to its local Microcontroller to determine which array is active for that spot. The red array will inform the user the spot is taken, while the green array signals the spot as available.
- **Wifi Chip**
    - The WiFi Chip will keep a connection open with the Cloud Server, communicating data taken from the Microcontroller to the server. It will send data at a time interval set by the Microcontroller.
- **Power Module**
    - The Power Module is responsible for converting the 120V AC output from a standard wall socket to a format usable by the camera, Microcontroller, and Wifi Chip.
- **Cloud Server**
    - The Cloud Server will accumulate the processed image data from the hardware Microcontrollers. From there it will update the website with up-to-date information on where available parking spaces are located.
- **Website**
    - The Website will host a map showing the latest information on which parking spaces are available. It will receive this data from the Cloud Server.

2.3 Block Requirements

- **Camera**
    - Description
        - The Camera contributes primarily to the second high level requirement, since it is responsible for generating the images that allow software detection of vehicles to occur.
    - Requirements
        - Generate an image of the environment such that a human can easily identify vehicles and parking spaces in the image
        - Send an image to the Microcontroller
- **Microcontroller**
    - Description
        - The Microcontroller contributes to the first and second high level requirements. Not only is it responsible for deciding what is and is not a vehicle in an image, it must detect whether or not that vehicle is in a parking spot and report the status of every spot it is responsible for to the Wifi Chip.
    - Requirements
        - Correctly identify the parking spots assigned to this processor
        - Correctly decide whether or not a car is in each of its parking spots 90% of the time
        - Process the images quickly enough to keep up with the set time interval
        - Transfer the status of the parking spots to the Wifi chip at each time interval
- **LED Array**
    - Description
        - The LED Array contributes to the third high level requirement, as it makes identifying open spots when at the parking area much easier.
    - Requirements
        - For a red LED Array, only turn on when the associated parking spot is unavailable
        - For a green LED Array, only turn on when the associated parking spot is available
- **Wifi Chip**
    - Description
        - The Wifi Chip contributes to the third high level requirement. It is responsible for taking the data from the Microcontroller and transmitting it to the Cloud Server.
    - Requirements
        - Receive data from the Microcontroller.
        - Transmit data to the Cloud Server.

- **Power Module**
    - Description
        - The Power Module contributes to all three high level components because it is responsible for powering the hardware components by converting 120V AC to a form usable by the Camera, Microcontroller, and Wifi Chip.
    - Requirements
        - Accept 120V AC from a wall socket.
        - Output power in a form usable by the Camera, Microcontroller, and Wifi Chip.
- **Cloud Server**
    - Description
        - The Cloud Server contributes to the third high level requirement. It collects and sorts data gathered by the hardware devices.
    - Requirements
        - The server will be able to receive data from at least one hardware component.
        - The server will be able to take data that is collected from at least one hardware component and update the website with the latest parking information.
- **Website**
    - Description
        - The Website contributes to the third high level requirement. It takes parking space data from the Cloud Server and displays it in a readable format to consumers.
    - Requirements
        - The website will be able to receive data from the server component.
        - The website will be able to take data received from the server and display it in a readable map format for consumers.

2.4 Risk Analysis

The blocks that pose the greatest risk to the successful completion of our project are the Microcontroller and the Camera. As a group, we have some experience programming FPGA boards, but have only run very basic programs on microcontrollers as a whole. Due to this, we will need to learn how to program microcontrollers while working on this project. In addition, a camera is a complex input, not just a high or low signal, so we will have to learn how to properly connect it to the microcontroller. We believe that this goal will be completed; however, it will take more work than the other modules from a learning perspective.

3. Ethics and Safety

As the developers of this project, we believe it is important that we produce a safe, reliable, and efficient product to our user. We commit ourselves to holding a high degree of professional conduct in accordance with both the IEEE and ACM Code of Ethics. We will avoid ethical breaches by following all device specifications, working in our respective areas of competence, and clearly stating proper operating procedure (ACM 2.6). At the same time, we acknowledge that our device could be misused; therefore, we will take all necessary precautions to prevent any harmful modes of operation.

In accordance with the ACM Code of Ethics, this project will pose no risk to the user or community under standard operations. We will ensure that all wireless protocols are followed, and communications will be secure. The data gathered by our sensor will be the sole property of the intended user of the device (ACM 2.9). All software will follow accepted community standards.

Our module will have a camera attachment. Since a parking lot or parking garage is a public place where one does not have a reasonable expectation of privacy, cameras are allowed to record without any posted signage by law [3]. It may be nice, however; for consumers of the parking lot or garage to have a notice that cameras are active posted via sign.

It is both illegal and unsafe to use one's phone while driving [4]. As such, on the sign that gives the URL to the parking map website, we will post notices to either pull off to the side and stop while accessing the website or have a passenger navigate the website.

In addition, we will ensure there is no exposed wiring or electrical components in our design to minimize the risk of electrical shock. Similarly we will ensure all components are operating within their respective operating regions to reduce the risk of a short or fire hazard. We will also be mounting the hardware components with screws, mitigating any risk of the hardware falling and causing damage to vehicles or people in the area.

References

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