Parking Space Monitoring System

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1 Introduction

1.1 Objective

Finding an open parking space in a crowded parking lot is often a long and frustrating endeavor. This irritation frequently stems from being unable to know where the open spots are, forcing drivers to wander aimlessly aisle by aisle, floor by floor, until finding a vacant spot. An IBM survey conducted in 2011 found that over “30 percent of city traffic is caused by drivers searching for a parking spot” [1]. Furthermore, the survey found that 29 percent of drivers in New York City spent 20 minutes on average searching for a parking spot, while 10 percent spent over 40 minutes. INRIX, a leader in transportation analytics, issued a report stating that “motorists spend an average of 17 hours a year searching for [parking] spots...estimated $345 per driver in wasted time, fuel, and emissions” [2]. The extra time spent searching for a parking spot also contributes to the discharge of more vehicle carbon emissions [3], which exacerbates a growing pollution problem. Clearly, the problem of finding an open parking space extends far beyond just the time wasted by the driver. Our goal is to find a solution for this dilemma. This will not only lead to happier customers since they can identify a spot faster, but may also lead to reduced accidents in the parking lot. A driver will spend less time circling the lot and will not need to be as visually distracted.

The objective of our project is to design a system which reduces the time spent by the driver searching for an open parking space. By monitoring the status (occupied or vacant) of each and every spot in the lot, we can collect the necessary data to alert the driver to vacant parking spaces faster. Parking spots will be monitored for vacancy/occupancy using a proximity
sensor, which transmits data to a central hub via an RF signal, where the data will be aggregated and presented to incoming drivers through an LCD display. Additionally, LED light bulbs at parking spots will visually indicate its occupancy status by color, providing another alert system for the driver.

1.2 Background

As stated earlier, a driver in the US spends on average 17 hours a year looking for a parking spot [2]. And in the country’s largest cities, such as New York City (one of the best known cities for traffic and parking difficulty), that number can rise to over 100 hours annually. Typical parking lots do not present incoming drivers with any data or visual markers regarding the vacancy/occupancy of spots. In large and crowded parking lots, it is often very difficult to easily identify where the open spots are because other vehicles block them. This system would provide drivers with useful data to make finding a spot much easier.

While attempts have been made to put parking lot systems in place to perform the function of identifying vacant spots [4][5][6], most notably outside the U.S.A, similar systems have yet to fully integrate themselves into American life. The marketability of such a system has yet to develop fully, so it is important that our solution be somewhat cost-effective in order to incentivize the installation of such systems in parking lots. The time wasted and potential pollution concerns associated with driving around searching for spots must be addressed and our goal for this project is to design and implement a system which helps reduce the magnitude of the problem.

1.3 High-Level Requirements

- IR proximity sensor must be able detect the presence of a vehicle and toggle connected LED light bulbs between RED (occupied) and GREEN (vacant)
- Proximity sensors must be able to send their data via RF transmission to a central data hub to be processed
- The processed data aggregated from all the proximity sensors must be displayed in visual format to the user (driver) via LCD display.
2 Design

Figure 1: Block Diagram
2.1 Power Supply

This module is responsible for supplying power to all the components required in the design. There are 3 different voltage levels in this design. The standard wall output of 120VAC would be used to power the LED light bulbs. The IR sensors will be powered by the necessary voltage output required by the specific model of sensor we use. For the rest of this proposal, we will assume a 24VDC value for the IR sensor power, but this is subject to change dependent on the exact model of the proximity sensor. A voltage output of 5VDC will be used to power the microcontrollers. We will use 120VAC to 24VDC/5VDC converters to get the required voltage and all the power circuitry would be mounted inside an industry standard control panel.

Requirement: Must provide between 4.5-5.5 V to the microcontrollers

Requirement: Must provide required operating voltage for the IR sensors within a tolerance of +/-10%

Requirement: Must provide line voltage of 120V to the LED module(s)

2.2 Proximity Sensor Module (s)

This module will have IR sensors and SPDT relays. This module is responsible for the transmission of data into the LED Module and RF Transceiver module (Slave).

2.2.1 IR Sensors

We will use one IR-based proximity sensor for each parking space. The output of these IR sensors will be 0 or 5V depending on whether the sensor detects presence of vehicle. This sensor will be mounted at bumper height of the vehicle so when a vehicle approaches the sensor, the sensor will output 5V and that would indicate that this is an occupied spot. Otherwise, for a vacant spot, the sensor will output 0V. This information is then passed onto relays (for toggling connected LEDs) and also to the associated RF slave transceiver module.

Requirement: Must output no less than 5 V to the relays upon detection of a vehicle.
2.2.2 SPDT Relays

We will use SPDT (single pole double throw) relays in which coils are energized when 5V output from IR sensor is applied across its input terminals. This will serve as our mechanism to turn on the red or green LEDs depending on whether the coil is energized or not. The input of 5V is drawn from the IR sensor output so whenever the sensor detects a vehicle, it generates 5V across its terminals and this 5V is supplied to the SPDT relay, which will turn on a green LED, otherwise it will turn on a red LED.

Requirement: Must switch to ON position when provided at least 5 V input and must switch to OFF position when provided any voltage value below 5 V.

2.3 LED Module(s)

This module has 4 pairs of green and red LEDs. A single pair of LEDs will be mounted above its associated parking spot (and proximity sensor). The LEDs will be powered by 120VAC line input. The sole purpose of this module is to visually display the status of each parking spot.

Requirement: Must be visible to drivers entering the parking lot.
Requirement: Only one LED of a given pair must be powered on at a given time (RED for occupied, GREEN for vacant).

2.4 Slave RF Transceiver Module(s)

This module is responsible for the data transmission using RF waves and it is termed as a slave unit because it waits for polling instructions from the master RF unit. The module will transmit the data associated with its attached IR sensors to be processed by the central data hub.

2.4.1 Microcontroller

We will use a microcontroller to convert the voltage signal (0/5V) into a digital binary output (1 - vehicle present, 0 - no vehicle present). This digital data is then passed into the TX channel, which will transfer the information to the master RF unit when requested.
Requirement: Must perform A/D conversion for each attached proximity sensor input (5V - 1, 0V - 0)

Requirement: Must create a message containing the data from proximity sensors formatted in a binary array for transmission

Requirement: Must transmit data message only when polled by the master RF unit

2.3.2 TX/RX

These channels are used for the transmission and receiving the information between slave and master units. TX will transmit the data to master and RX will receive the data from master.

Requirement: Must transmit at an adequate RF signal strength to be received the central RF unit.

2.4 RF Transceiver Master Module

This is the master RF unit that polls the slave RF units to request the proximity sensor data. The polling is controlled by the central data collection microcontroller.

Requirement: Must transmit polling request from central hub to the appropriate slave RF unit.

Requirement: Must receive data from slave RF units to be passed to the microcontroller.

2.5 Central Data Collection Module

This is the central hub and control unit that controls the sequences of the data transmission and reception. This unit is passed data from the master RF transceiver after requesting data from a slave unit and stores that information into onboard memory. This aggregated data will be passed to LCD display module to provide a visual interface for drivers.

2.5.1 Microcontroller

We will use a microcontroller that will receive data from the master RF transceiver module and store it in the onboard memory. This microcontroller will be responsible for periodically polling the slave RF transceivers. The microcontroller will also transfer this information to the LCD display so that the status of vacant spots per floor is displayed to drivers.
Requirement: Must store aggregated data from master RF transceiver module in onboard memory.

Requirement: Must generate a periodic polling sequence for the master RF transceiver to poll the slave units.

Requirement: Must output parking space data to the LCD display

2.5.2 MEM

We plan to use onboard memory for this project since there is minimal data that needs to be stored at any given time but we will also explore other options of using external memory like SD vehicle if onboard memory turns out to be not the best option for this project.

Requirement: Must have at least 1KB of storage space for collecting data.

2.6 LCD Display Module

The LCD display module is used to visually display the status of open spots in a parking garage to an incoming driver. It will tell how many spots are open on a specific floor and also total number of spots. It will show something like “Floor 1: Open Spots = 36/60”. This is just an example as the exact nature of the visual display is subject to change.

Requirement: Must display the number of vacant spots on each level of the parking lot in an simple format

2.7 Risk Analysis

The RF communication modules pose the most difficulty to the completion of the project. Because the RF transceivers will be transmitting on the same frequency, it is vitally important that the polling protocol works as intended. Otherwise, if multiple transmissions are attempted simultaneously, data will be dropped at the master RF receiving unit.
3 Ethics and Safety

There are no serious issues or concerns of safety for this project. Perhaps the only concern during development would be dangers that could arise from using the soldering iron to build our modules. At least one of us in our group is already heavily experienced with using soldering irons, and we will follow any and all safety and lab use guidelines to minimize the risk of danger. While the project is actually in use, there are no physical dangers to be aware of. Customer interaction is strictly limited to viewing the LCD display which does not contain any physical hazards.

We do not foresee any ethical concerns with this project. We cannot think through any scenarios where the project could be misused in direct violation of the IEEE or ACM Code of Ethics.
References


