Enhanced Parking Space Monitoring System

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Problem Statement

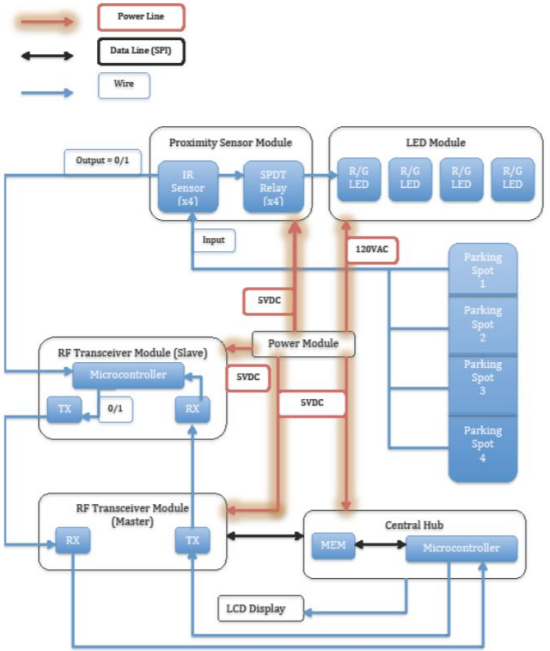
- Can be frustrating to find a spot in a parking garage
  - Extra time spent searching creates traffic and wastes fuel
  - Drivers searching for open parking spaces are distracted
    - Hazardous Environment for drivers and pedestrians

Overview of Original Project Solution

- Use IR sensors to detect presence of a parked vehicle
  - Green LED = Spot Vacant
  - Red LED = Spot Occupied

- Transmit data between Sensor Module and microcontroller via RF signal

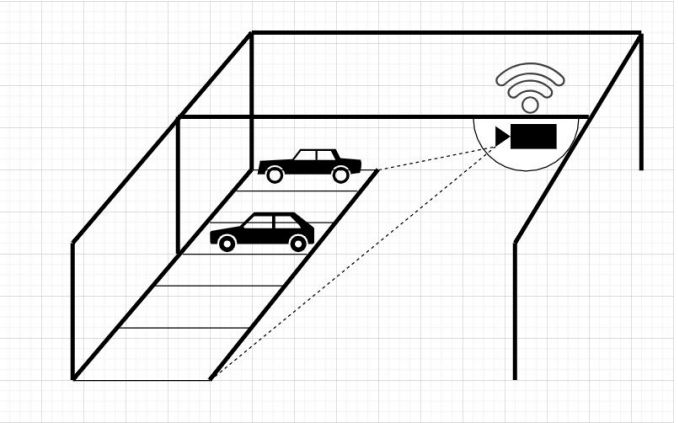
- LCD Display showing available space data to incoming drivers



Overview of New Project Solution

- Video Processing to detect presence of a vehicle in a parking spot
  - Green LED ON = Spot Vacant
  - Green LED OFF = Spot Occupied

- Transmit data via WiFi to a website to display data to users

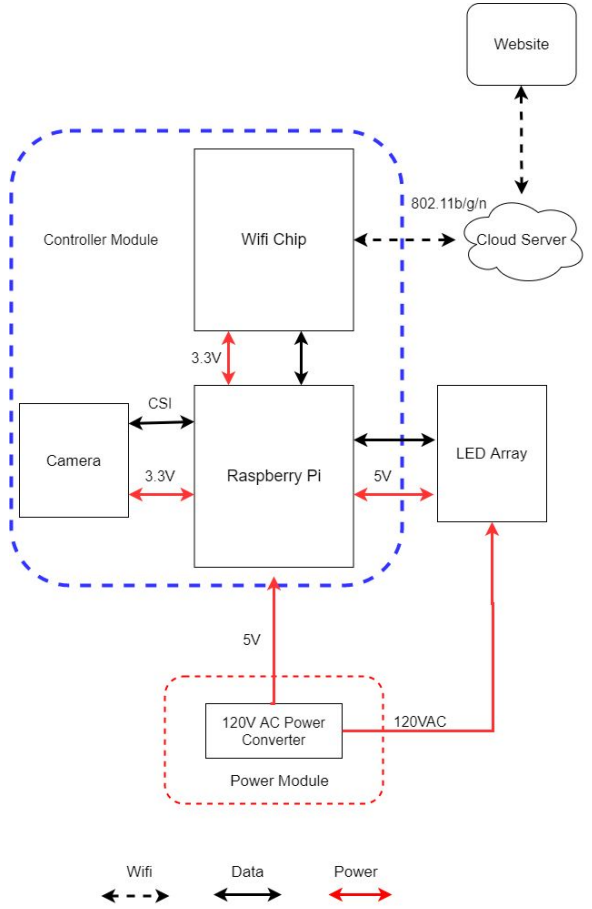


High Level Requirements

- Be able to differentiate a vehicle from other objects.
- Detect the presence of a vehicle in a parking space with 90% accuracy.
- Conveniently notify users of available parking spots through LEDs near the spots and a website containing an up-to-date map.

Block Diagram

- Primary Modules:
  - Power
  - Controller
  - LED Array
  - Cloud Server
  - Website



Critical Requirements and Verifications

The Following systems have Requirements and Verification Tables which are viewable in the design document:

- Camera
- Raspberry Pi
- LED Array
- Wifi Chip
- Power Module
- Cloud Server
- Website

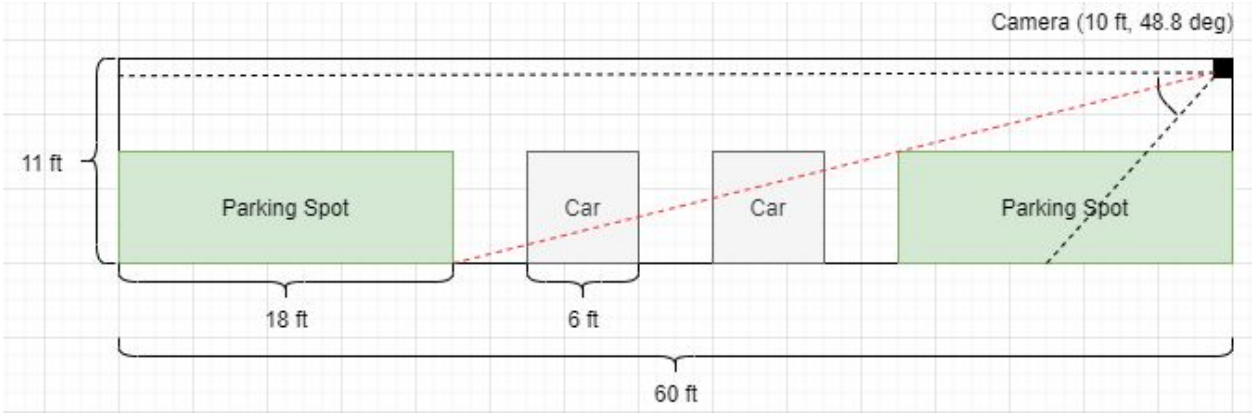
Analysis Demonstrating Solution Feasibility

- There currently exist a number of public projects accomplishing similar tasks
- Can be forked to adapt to project needs
- Achievable with models like YOLO and Mask R-CNN
- COCO dataset can be used for identifying common objects such as cars, bikes, and pedestrians
- Can train models on custom objects given enough input data
- Trained model can be used on low-performance hardware
- Software used in image at right claims 97% accuracy in complex environment

Deep-Neural-Network-based-parking-system Github at ankit1khare/

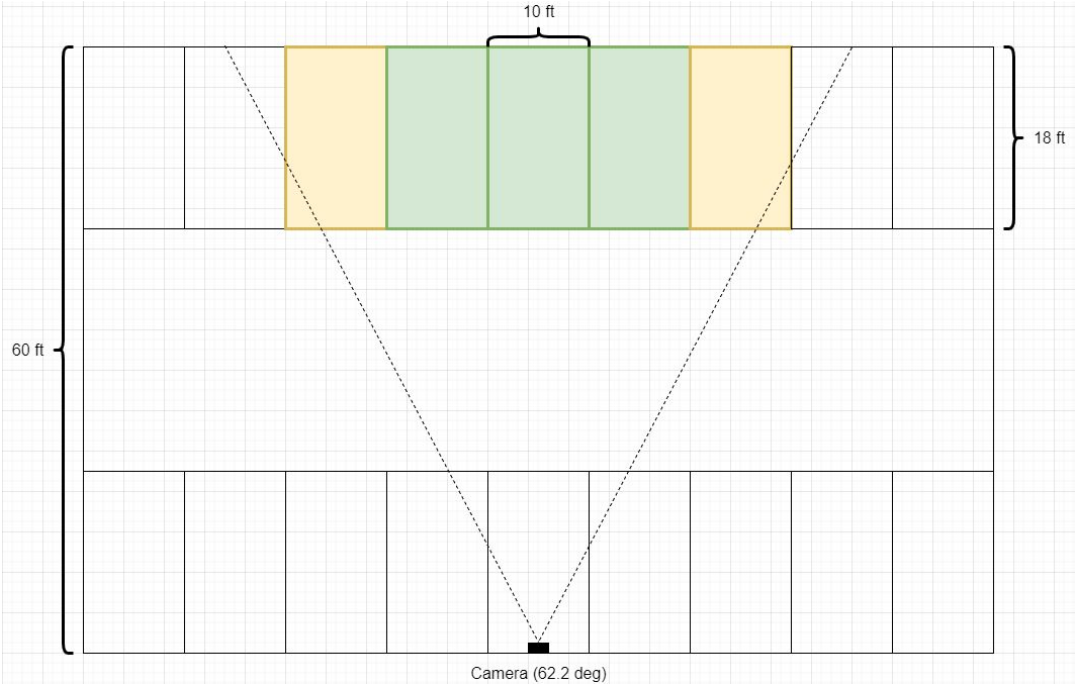
Tolerance Analysis

- Given that the camera has 48.8 degrees of vertical view-space, it will easily capture parking spots when placed against the opposite wall
- Due to height limitations of parking garages (about 10-11 feet), it is likely passing cars will obscure the parking spots
- Results are averaged over 10 seconds, so cars moving faster than about 2mph (3 ft/s) on average will not cause false positives (assuming cars around 15 ft in length)



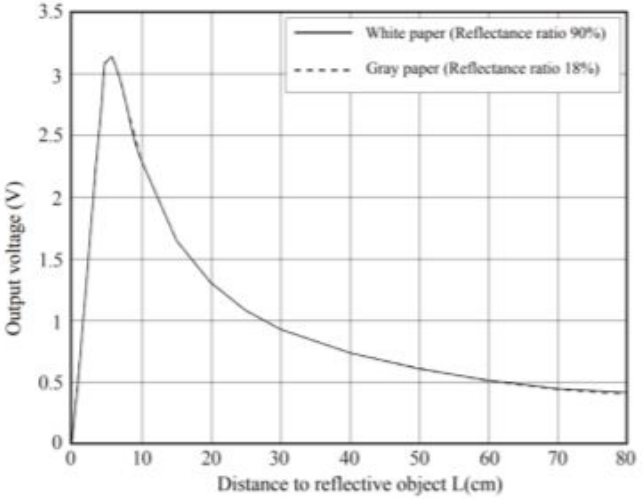
Tolerance Analysis (continued)

- Camera has 62.2 degree horizontal viewing angle
- Right figure shows typical parking garage dimensions
- 3 center spots fall fully within camera view, and 2 outer spots get clipped
- Robust software should identify all 5 (or 4 if shifted non-optimally to either side)



Tradeoffs Between Original and New Solutions

- Cost
  - Monitoring 4 parking spots
    - Original Solution: $149.50
    - New Solution: $155.48
- Accuracy
  - Original Solution
    - Only offers around 80cm range
    - No false positive reduction
  - New Solution
    - 97% detection accuracy in software tests
    - Will not detect pedestrians as vehicles



Tradeoffs Between Original and New Solutions (cont.)

- Convenience
  - Original Solution
    - LCD Display at entrance
  - New Solution
    - Website available anywhere
- Waste
  - Original Solution
    - At least one LED running at all times
    - Sensor Module required for every spot

Cost

- Highest unit cost is Raspberry Pi, but cheaper unit may be used pending testing
- Most cost will be LEDs, as the count is determined by number of parking spots
- Total part cost for 4 parking spots is **$155.48**

Description	Part Number	Manufacturer	Module	Price
Raspberry Pi 4 Model B (4GB)	B07TC2BK1X	Raspberry Pi	Control	$61.70
Raspberry Pi Camera Module V2-8	B01ER2SKFS	Raspberry Pi	Control	$27.50
Wifi Chip	ESP8266 ESP-12E NodeMCU	MakerFocus	Control	$9.39
Green LED x4	A19 Christmas Led Light Bulbs	NOVELUX	LED Array	$25.94
Voltage Regulator	296-20778-2-ND	Texas Instruments	Power	$2.39
E26 Light Bulb Socket x4	99770033	BROAN	LED Array	$23.60

Schedule

Week	Ben	Patrick	John
1	Begin website development	Work on Parking Spot Program	Begin website development
2	Get website to display parking data in a text-based format	Work on Parking Spot Program	Test parts when they arrive to assure operation within requirements
3	Website Debug week	Work on Parking Spot Program	Get Power Module operating as required and link LED array to Raspberry Pi
4	Begin server development.	Test program on Raspberry Pi with preloaded video	Debug Power module and LED array
5	Make sure server can send data to website.	Hook up Camera to Raspberry Pi and switch to live feed processing	Debug circuit design

Schedule (continued)

6	Make sure server can receive data from hardware.	Hook up Raspberry Pi to Wifi Chip	Start making website more user friendly(css/add map).
7	Server debug week	Connect Wifi Chip to server	Continue website development.
8	Help make website more user friendly(css/add map)	Ensure end-to-end functionality with camera and website	Continue website development.
9	Finish website development and begin final testing and debugging testing	Hardware and Wifi debugging	Finish website development and begin final testing and debugging testing
10	Finish final testing and debugging testing	Finish final testing and debugging testing	Finish final testing and debugging testing

Ethics and Safety

- All wireless protocols will be followed, communications will be secure, and data gathered by our sensor will be the sole property of the intended user of the device (ACM 2.9)

- Parking garage is a public place where one does not have a reasonable expectation of privacy, so cameras are allowed to record without any posted signage by law. User is advised to post signage indicating cameras.

- User is advised to post signage indicating to either pull over vehicle and stop while accessing the website or have a passenger navigate to the website

Conclusions

The new design offers:

- Better detection range
  - High accuracy (97%)
- Increased options for consumers to find spots
  - Website with map of open spots
- Only 4% increase ($6) over the previous design to monitor 4 spots.

Future development:

- Expand the design scope from parking garages to parking lots in general.