University of Central Florida
Department of Electrical & Computer Engineering

UNIVERSITY OF
CENTRAL FLORIDA

Smart Parking System

EEL 4914 | Senior Design I | Spring 2022 | Group B

Initial Project and Group Identification Document
Divide and Conquer - Version 2.0

Oscar Acuna
Computer Engineering
oacuna@knights.ucf.edu

Jordan Johnson
Electrical Engineering
jordan614407@knights.ucf.edu

M. Ridwan
Computer Engineering
mridwan@knights.ucf.edu

Kyle Carpenter
Computer Engineering
kylecarpenter@knights.ucf.edu

Table of Contents

1.0 Project Description

1.1 Project Motivation

While the amount of students that attend UCF's campus increases every year, the amount of parking garages around campus do not. With a growing student body, naturally, there will be an increase in the amount of vehicles flowing in and out of campus throughout the day. During times of the day when there is a lot of overlap between class sessions that are either starting or concluding, a large number of students and faculty are entering and exiting the garages around campus which creates a bottleneck problem. This causes the garages to become quite congested as people navigate them. This congestion inside of the garages leads to a number of issues including long lines inside of and outside of parking garages, backed up traffic around the perimeter of the campus, and late arrivals to class due to difficulties finding a parking spot.

Our group has decided that UCF's current solution to these issues is ineffective. A website that indicates the percentage of open parking spots inside of each garage along with signs outside of the garages indicating whether it is open or full is simply not enough to ease the large flow of traffic that UCF's parking garages endure. Therefore, we will develop a smart parking system that aims to mitigate the problems described above.

1.2 Goals and Objectives

UCF is a growing school with more than 70406 students currently enrolled. With such a large number of students in attendance in addition to faculty, this leads to the parking garage issues that students and the faculty face every year.

With our project, the goal is to aid the UCF population by having a budget friendly smart parking system that reduces the time it takes to get in the garage, the time it takes to get out of the garage, and the time it takes to find a parking spot. The objectives we have to help reach this goal are listed below:

- Use either video camera embedded with machine learning concepts via open-cv, or sensors with embedded programming to detect open and occupied parking spots.
- Develop a website and mobile application where UCF students and faculty will be able to get a detailed description of the available parking spot in a timely manner.
- Use LED signs to communicate open parking spot locations for people navigating the garage.
- Develop our system in a way such that power consumption is low.
- Develop an IoT network for transmitting data between the different components in our project.

With a successful implementation of our smart parking system, we hope to be able to conquer the problem of crowded parking garages with great results. Our smart parking system would allow UCF's students and faculty to be able to visualize and access parking data in a more efficient manner and not have to waste their valuable time and energy focusing on parking issues any more. At the conclusion of our project, we aim to be successful in building a realistic, budget friendly smart parking system that uses low power consumption and is embedded with IoT.

1.3 Function of Project

The smart parking system should be capable of recognizing all vehicles entering and exiting the parking garages on campus and make real time analysis of available parking spots in order to direct vehicles to new open locations. Through the utilization of a camera system and computer vision, the vehicles can be tracked through portions of the garage. A notification system built into the garage that is comprised of LED signs that indicate open parking spots and how many are available on a specific section or level will be the primary guidance for the drivers.

Depending on whether stretch goals are achieved, the LED could vary in complexity. One of the target capabilities is showing available parking spot counts at each level of the garage, with a final stretch goal of having a complex LED system that guides drivers to individual parking spots. The LEDs would point to specific parking spots and make for a very unambiguous directing system.

In addition to physical signage in the garage there will also be a mobile app component of the parking status updates. The UCF parking app will be overhauled to feature higher accuracy of how many spots are available as well as additional details, like rate of vehicles entering the garage and which levels of the garage are most full.

2.0 Project Requirement Specifications and Constraints

2.1 Requirement Specifications

2.1.1 General

- Our system should be able to monitor at least 15 parking spots.
- System must be able to detect available spaces using OpenCV in less than 2 seconds.
- System must inform drivers of the number of available parking spots using an LED sign
- System should be hoisted a minimum of 14 feet above ground for more accurate video capture.
- Our system should be 100% accurate within 60 seconds of a change in # of open spots
- Our system should be 90% accurate within 30 seconds of a change in # of open spots

2.1.2 Hardware

- LED sign must have at least a 5,000 nit rating.
- LED sign must be at least 24 inches by 32 inches.
- A Microcontroller should have at least Wi-Fi and a communication module to drive the LED signs and transfer data to it.
- Camera must be OpenCV compatible.
- Camera must be able to see the required number of parking spots at a height of 14 feet.

2.1.3 Web Application and User Interface Integration

- Easily maneuverable Graphics interface to help end-user navigate and connect with the implemented video transmission technology.
- Stream real-time video footage of parking spots for better navigation aid.
- Display the total number of vacant parking spots within the designated area.
- Allow end users to be able to reserve parking spots.

2.1.4 OpenCV

- OpenCV must detect when a parking spot is free or occupied.
- Train OpenCV overtime to be able to successfully differentiate between the vacant and non-vacant parking spots.
- GIS must be implemented to monitor the parking spot outlines and keep count of the total parking spots.

2.1.5 Wifi Connectivity

- Camera, PCB, and local server will all need to connect to a local network via Wi-Fi with a speed of at least 5 Mbps using the 2.4GHz frequency.
- A Wi-Fi router/access point will provide a local network for the cameras, microcontrollers, custom PCBs, and LED signs to connect to the local server. It should provide at least 10 Mbps upload/download speed in the 2.4GHz frequency.
- A ethernet switch with PoE enabled ports or PoE injectors will be implemented to provide power to the cameras.

2.1.6 Power

- Camera must be able to be powered by ethernet cable (Power over Ethernet)
- PCB must be battery powered

2.2 Constraints

With less than a year to deliver this project, time is the primary constraint that our group must adhere to. To be sure we are making considerable progress in a reasonable amount of time, we have created a list of project milestones that we will follow over the next year. Additionally, since our project will consist of some expensive components, we must make sure that our budget does not get out of control. Our group has agreed that we will spend no more than $2,000 and an initial budget is shown in section 4.0. Additional constraints that we must adhere to in order for our system to work properly are listed below.

- System must be able to work in the day time as well as night time. For night time, the camera must be able to work with at least 0.001 lux.
- Local Server must be able to be accessed remotely. If Windows OS or a Linux OS is used, software such as TeamViewer allows controlling the server remotely.
- Internet access of at least 5Mbps must be provided by the site.

2.2.1 Standards

- All electronics must be enclosed in cases designed following the IP65 standard to protect the equipment from dust and water.
- Cameras will be powered using Power over Ethernet standard 802.3af.
- Wi-Fi network must be standard 802.11ax to provide 2.4GHz network connectivity.
- Energy source of 120V/60Hz must be provided by the site
- Network communication of cameras and LED signs should use TCP/IP standard.

3.0 Project Block Diagrams

This section shows some basic block diagrams highlighting the components of our project as well as the group member leading that portion of the project. See Figures 1 through 4 for details.

Hardware Block Diagram - Overview

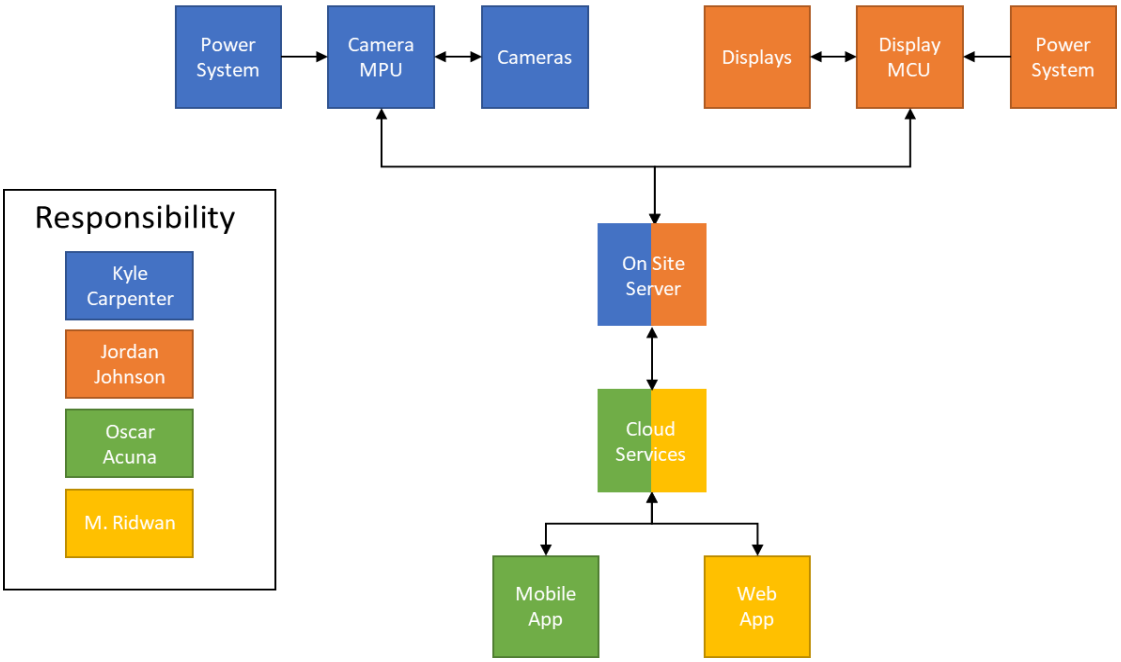

Figure 1

LED Display – Software Overview

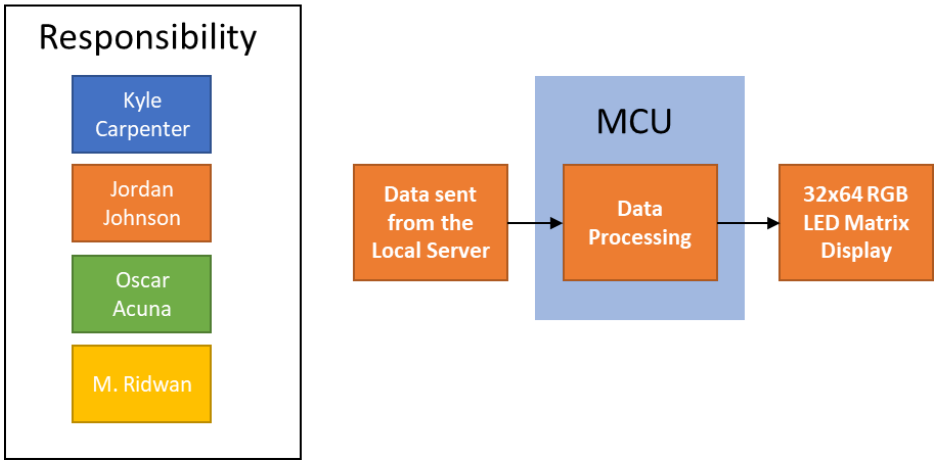

Figure 2

Web and Mobile App – Software Overview

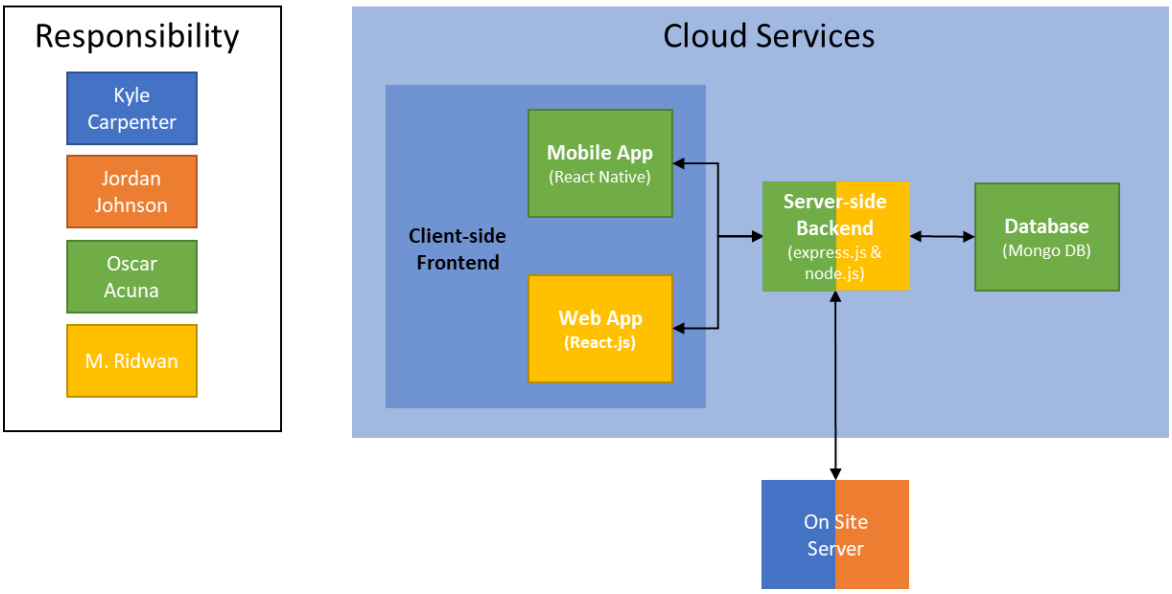

Figure 3

Parking Space Detection Diagram – Software Overview

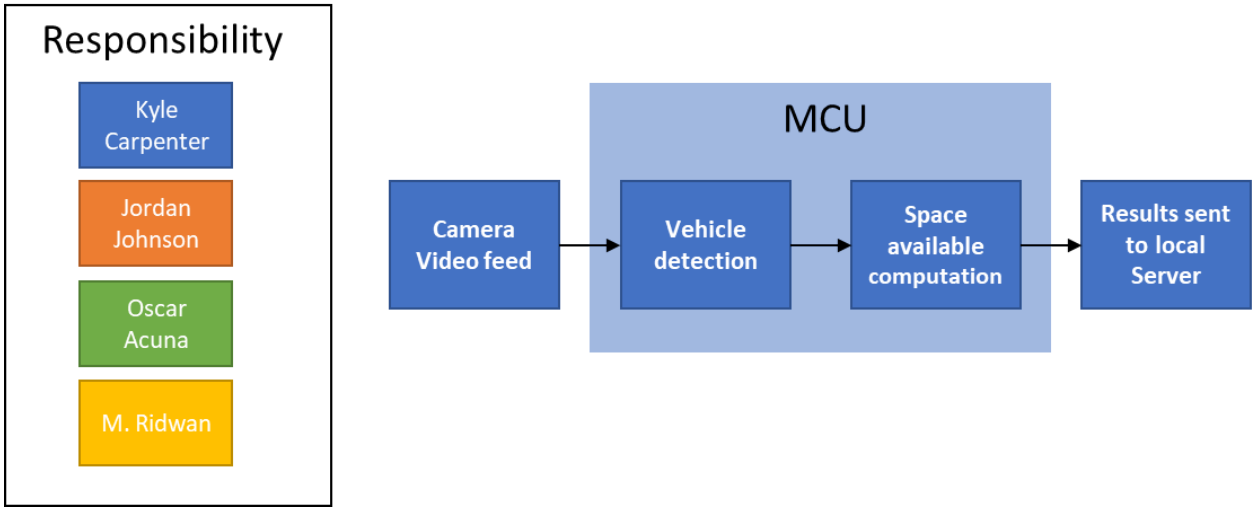

Figure 4

4.0 Project Budgeting and Financing

The estimated budget is about $1,500; a breakdown is presented in Table 1 below. All financing will be provided out-of-pocket by the team members.

Table 1. Budget Breakdown

Item	Description	Qty	Availability	Unit Price	Price
Cameras	Raspberry Pi HQ Camera Module	2	Out of Stock	$50.00	$100
MPU for the cameras	Raspberry Pi 4 Model B (8GB)	2	Out of Stock	$75	$150
Power Supply (For Raspberry Pi)	Raspberry Basic Kit (SD Card, Power supply,	2	Available	$44.95	$89.90
LED Displays	RGB LED Matrix Panel - 32x64	2	Available	$49.95	$91.90
MCU for LED Displays	Arduino Mega 2560 R3	2	Available	$39.95	$79.90
Power Supply (for MCU and LED Displays))	Power Supply 12V/5V (2A)	2	Available	$10.95	$21.90
WiFi Modules	WiFi Module - ESP8266	4	Available	$6.95	$27.80
Local Server	Custom Built	1	Available	$500	$500
Cloud Services	MongoDB, Heroku platform	1	Available	$100	$100
Miscellaneous		1	Available	$300	$300
	Total --->				**$1,461**

5.0 House of Quality

The house of quality, shown in Table 2, shows the positive and negative correlations between engineering and marketing requirements. In addition, the table helped in determining the engineering-marketing trade off. In Table 3, the engineering tradeoff are shown which clearly indicates how one category affects others.

Table 2. House of Quality

			Engineering Requirements				
			Power	Waterproof	Daytime/Nighttime Functionality	Accuracy	Cost
			-	+	+	+	-
Marketing Requirements	Speed	+	↑			↓	↓
	Outdoor Functionality	+	↓	↑↑	↑↑	↑	↓↓
	Visual Indicators	+			↑		↓
	Area Coverage	+	↓		↓	↑	↓↓
	Mobile/Web Application	+				↑	↓
	Cost	-	↑	↓	↓↓	↓	↑↑
	Target Engineering Requirements			≥ IP65	≤ 0.001 lux	90% in 30s,| 100% in 60s	≤ $2000

Table 3. Engineering Tradeoff Matrix

		Power	Waterproof	Daytime/ Nighttime Functionality	Accuracy	Cost
		-	+	+	+	-
Power	-			↓	↓	↑
Waterproof	+					↓
Daytime/ Nighttime Functionality	+					↓
Accuracy	+					↓
Cost	-					

6.0 Initial Project Milestones for Each Semester

6.1 Semester 1 (Senior Design 1)

The milestones for senior design 1 has been broken down mostly into weeks as shown in Table 4.

Table 4. Senior Design 1 Milestone

Week #	Dates (Sunday - Saturday)	Milestones
1	1/9/2022 - 1/15/2022	Form Project Group
2	1/16/2022 - 1/22/2022	Begin thinking of project ideas to pursue
		Attend SD Bootcamp on Thursday (1/20)
3	1/23/2022 - 1/29/2022	Submit Bootcamp Assignment on Friday (1/28)
		Begin working on DCV1
4	1/30/22 - 2/05/2022	Finalize DCV1 and submit on Friday (2/4)
5	2/06/22 - 2/12/2022	Attend a meeting with Dr. Richie on Wednesday at 8 AM (2/9)
		Begin working on DCV2
6	2/13/2022 - 2/19/2022	Finalize DCV2 and submit on Friday (2/18)
7, 8, 9, 10	2/20/2022 - 3/19/22	Begin working on 60 page draft SD1 Documentation
11	3/20/2022 - 3/26/2022	Finalize 60 page draft SD1 Documentation and submit on Friday (3/25)
12	3/27/2022 - 4/2/2022	Receive feedback on 60 page draft SD1 Document
		Begin working on next 40 pages of SD1 Document
13	4/3/2022 - 4/9/2022	Finalize 100 page draft SD1 Documentation and submit on Friday (4/8)
14, 15	4/10/2022 - 4/23/2022	Begin working on the final 20 pages of the SD1 Document
16	4/24/2022 - 4/30/2022	Finalize and submit Final Documentation on Tuesday (4/26)

6.2 Semester 2 (Senior Design 2)

The milestones for senior design 2 have been broken down into weeks. Although the dates and week numbers were left to be determined, the actual milestone have been described, as shown in Table 5 below.

Table 5. Senior Design 2 Milestone

Week #	Dates (Sunday - Saturday)	Milestone
Prototype Phase		
TBD	TBD	Begin acquiring materials for construction of first prototype
TBD	TBD	Construct first prototype and begin testing on hardware and software
		If need be, make revisions to the design, requirement specifications, and functions of our project
TBD	TBD	Finalize any software development needed for the final product
		Construct updated prototype and begin final design testing on hardware and software
Final Product Phase		
TBD	TBD	Work with updated prototype to create the final working product
TBD	TBD	Work on conference paper
		Make updates to SD1 documentation to finalize SD2 documentation
TBD	TBD	Prepare for final presentation (Final Demo, Critical Design Review, Final Presentation PowerPoint)
		Present and conclude project

6.0 Conclusion

The smart parking system that we have presented in this paper would bring all of our team members' skills to test in addition to allowing us to see how all of our skills would complement each other. The implementation of sensors would aid us in learning about embedded system programming along with chip and power design. Implementation of a video camera would broaden our horizon of skills into machine learning and artificial intelligence development. Our website would pose as an effective outlet to show creativity in web development through UI-UX design.

With the ambitious range of this project, we hope to grow as engineers as well as provide value to not only UCF but a solution that could potentially be able to be utilized globally. A successful completion of every aspect of this project will open up this significant problem for tons of new solution upgrades in the near future. In the simplest form, the goal of the project is to assist everyone in making a part of their significant lives easier. As engineers we hope to accomplish this goal and serve the community as well as learn new technologies and become a better version of ourselves in the future.