PARKING SEEKER

by

ParkoLogy

Final Report

14 December 2018

Faculty Advisor: Dr. Besma Smida

Members and Contributions

Alex Dai: Created Preliminary Design, wrote User Manual, Cost Analysis, arranging Appendices, and Final Report formatting.

Dara Chea: Final Design Sketch, Created & Evaluate Decision Matrix, Provides Design Solution Ideas, helped with Background Research & Survey Questionnaire.

Alfredo Ruiz: Created Table of Content, Created Survey 2, helped in Engineering Design Alternatives, Created Objective Tree, Initializing Assessment's with Google Doc

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I. Abstract

In today's urban environment vehicles have become a staple in transportation. One problem that always arises when driving a vehicle is parking, specifically the act of locating parking spaces. While there are existing technologies in place to assist in locating parking within designated parking lots, there does not exist any technology in place to assist drivers in locating parking spaces along the road sides, specifically areas designated for roadside parking.

The Parking Seeker is a device designed to assist drivers in locating parking spaces in those areas along the road side for parking. The device will take the user input constraints of their vehicle and then use that to compute the spaces that are available for them to park in. The device will know this by using an onboard camera that will scan the length of the parking area and calculate the available spaces using the image. This device will then provide a safe, efficient service for finding roadside parking.

II. Overview

1. **Project Goals**
   We hope to create a more efficient way of finding parking space along the streets. Our goal is to develop a system that provides users the information about the available spaces to park on different streets within the desired location. The project will reduce time spent looking for an available parking space. Nowadays, we needlessly waste so much time doing this task that could lead to interference with others lives and even bodily danger. This system will minimize the time people spend looking for parking. The concept of providing the drivers with the number of available spaces in a parking lot is not new, however, there is not an existing system or device that applies this concept onto street parking. By implementing the concept onto a system that, not only provide the number of space, but also applying it to any streets that can accomodate parking, specifically in the city areas, is an improvement upon that idea. In addition to providing the users with real-time report of the available spaces to park in, it also gives them additional informations depending on the type of vehicle that the users drives.

2. **Needs Statement**
   The current services for providing parking information are limited to only parking lots without mentioning the availability spaces along the streets. Often, the task of looking for parking spaces is time consuming and tedious. In a report by USA Today, “motorists spend an average of 17 hours a year searching for spots on streets, in lots, or in garages

[and] the hunt adds up to an estimated $345 per driver in wasted time, fuel, and emissions [1]". Along with the funds and time wasted there is also the possibility accidents between nearby pedestrians or vehicles due to the drivers being preoccupied with this task of looking for available spaces along the side of the road.

3. Objective Statement

The objective of the project is create a device or system that collects data along a particular street using sensors to perform calculations and then report back to the user. The data will be used to determine the number of available spaces on the street for parking. The system will also take into account the input of the type of vehicle that the users are driving and uses that information to determine the appropriate number of spaces available according to the length of the vehicle.

4. Background

What is the basic theory behind the concept?

The basic theory behind our idea is the use of sensors to record street side measurements in order to calculate parking spaces. Then return the information to the driver in order to facilitate greater efficiency in time spent looking for road side parking spots. Our target in this case will be, primarily, urban drivers.

With the many information networks available in urban areas, we want to utilize the IoT (internet of things) infrastructures that are in place for our service. Beginning from the installed sensors that collects the information on the street level we want send that information to the user through wireless communication to the smart devices that are endemic among the urban population [2].

We want to implement a system that incorporates the personal smart devices of the drivers, street sensors, along with the proper algorithm to create a smart parking system.[6] The algorithm will use the input data collected from the street sensors along with parameters, like vehicle type and vehicle size, to calculate the availability at a given location.

What are the limitations of the current designs or technology?

Currently, there are different varieties of smartphone applications that help users look for parking lots in different areas. They provide the location of the lots along with the distance of the respective lots from the desired destination [3], while some also provide the price range or rates of the lots.

However, there is not any actual device or system that looks for space availability along the street for parking. Most of the existing or proposed solutions use data gathered from parking garages and parking lots through the use of CCTV cameras installed at those places and provide them through phone apps that let the users know if there is availability of spots at those places and location of the parking lots or garage. Others use different kind of sensors to detect occupancy of each spots in the garage and lots, while some use magnetic detectors to scan as vehicles entering and exiting the lots to account for the total number of vehicles currently parked inside.

What are the similarities/differences between your concept and current systems?
There are a number of concepts and finished products existing currently that try to make is easier for users to find parking spots. One known concept/application is SpotHero. SpotHero finds parking spots in your city at a so called “discount” because it is a paid service. While this is a good way to find parking, so you don't have to drive around looking for a spot, our concept will have a different approach than just looking for spots at only various lots and garage close to the users’ destination.

Although SpotHero and our concept have the similarity of making parking spots easier to locate, our concept will provide a different result, for our concept aims to look for free and paid parking spots along the streets and to provide the users with the exact number of spots available depending on their vehicle type as a parameter. Furthermore, our concept does not require any data regarding the occupancy of the street-parking spots from other sources [5] or camera feeds from CCTV to process and provide results; our concept will be contained within our own system of our device and an interface for the users to input and to receive the result.

Are there existing or patented systems that are relevant to the design?Who are the current (direct, indirect) competitors?
A patent file by Conduent Business Services LLC (see Appendix G) focuses on using video from a camera to identify cars parked on the streets[4]. Their technology takes video footage and breaks it down to frames were it would scan the image for a licence plate to determine if a car is parked and when they leave the spot.

A direct competitor is Parknav. Parknav provides a service that allows the user to check where there is parking available. They have an application that estimates where they might be parking in the desired location. This competitor does not tell the user if they will find parking as it only gives an estimate that there may be spots, while we will use sensor to see when a parking becomes available within seconds.

User Survey 1 (See Appendix B)

How often do you park on the street?
From the response of the survey that we have gathered, it appears that 26.1% of replies said that they park in the streets daily. 26.1% said that they park less than 5 times a week and 47.8% park at least once a week on the streets. We can see that people would find the concept useful, no one likes to spend unnecessary time looking for a parking spot.

How long does it usually take you to find a parking space?
In our survey, 13.6% of the submissions drive an average of over 15 minutes finding parking. 27.3% said it took them 5 to 15 minutes and 59.1% said it took them less than 5 minutes. We could see that a small number of drivers looking for parking spend a lot of time looking for a parking spot. The more time someone spends on the road the higher the chances of them getting into an accident. With our concept we can get people out of their car as soon as possible. The faster a driver finds parking, the less fuel they also used.

A few short replies in our survey tell us of problems encountered during the process of finding a parking space. One being the availability of parking spots, and another similar is the inability to know where the closest parking spot maybe. The unknown factor is what this concept is trying to tackle. Giving information to the user and allowing them to see parking availability in the surrounding area.

User Survey 2 (See Appendix B)

How often do you park on the streets?
We conducted a second survey to continue to gather information on the concept. This was like the first one we conducted but with modified questions. In this survey we had a few more options to help us narrow the survey down. 21.4% of the people that took the survey said that they park daily on the streets. 14.3% from 6 to 4 times a week, and 21.4% 3 to 2 times a week. This along tell us that over 75% of people use public streets to park their vehicle.

How long does it usually take you to find a parking space?
The next question was about who long it took someone to find parking. We can see a few do not have issue finding parking spots, but some take over 10 minutes to fine parking. The majority 23.1% take between 6 to 10 minutes to find parking.

In this part we see that people waste a lot of time in the streets looking for a parking spot. The issue of reducing the time that the user spends in looking for parking spot. Our concept would focus on making the process of finding a parking spot more strime line.

5. **Marketing Requirements**
(See Appendix C for Objective Tree)
1. The device should report number of free spot.
2. The device should be accurate.
3. The device should be low-cost.
4. The device should be durable during raining and snowing weather.
5. The device should be compact.
6. The device should be lightweight for mounting on poles.
7. The device should allow users input of their vehicle type.
8. The device should not obstruct view of the streets.
9. The device must not cause distractions or interferences to surrounding environment.

III. Engineering Requirements

Marketing	Engineering Requirements	Justification
1,2,7	Accuracy of number of spot available must be >90% correct	The whole idea of the project is to report back number of available spots.
5, 6	Device must weigh < 1 kg	Devices need to be installed on street poles.
4	Device needs to have IPX4 proof. Splash will not damage the device.	This is an outdoor-device and installed along the streets, thus they need to be protected from rain and snow.
5,8, 9	Device must not contain bright color and/or loose parts dangling.	We do not want drivers to be looking at the devices while they are driving nor do we want any part of devices to interfere with the environment.

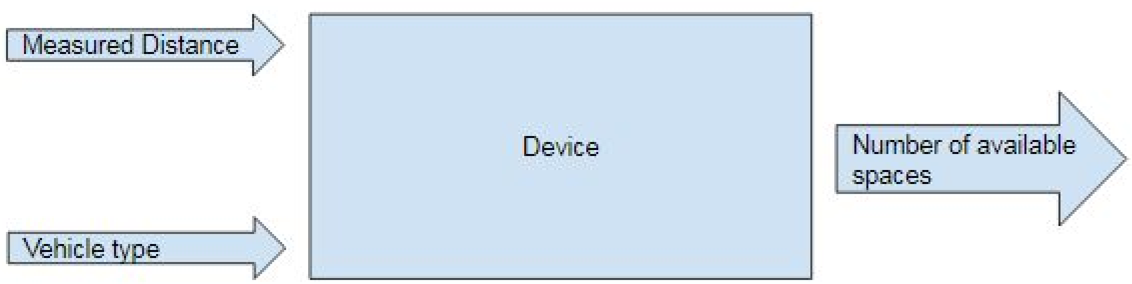
3	Device's cost must not exceed $250.	Not only that the cost should not exceed our budget, but we would want to deploy more devices in different areas to cover more ground, therefore larger quantity of the device would be needed.

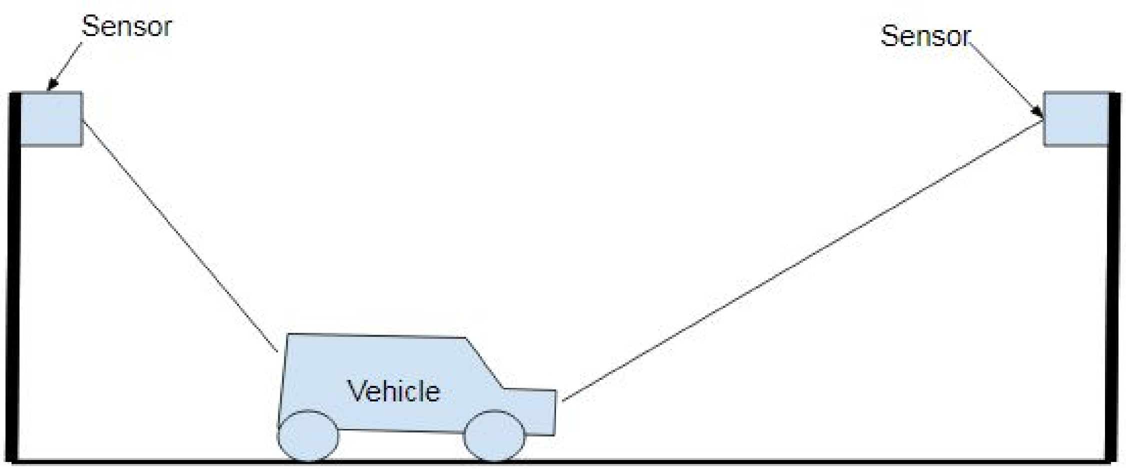
IV. Engineering Design Alternatives

(See Appendix D for Concept Maps for the following design alternatives.)

Design Alternative 1

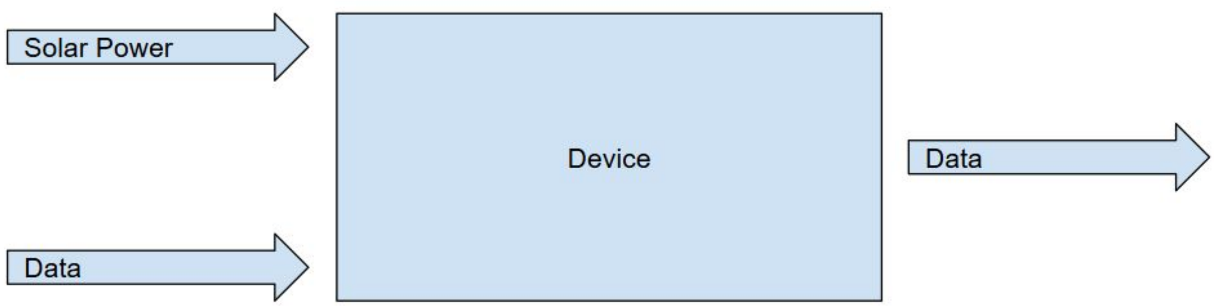
- Sensor: To measure distance and availability this design will implement laser as a sensor.
- Power: The main power supply to the device is going to be AC tap from the grid.
- Casing: A plastic will be use to shield components
- Data Transfer: Using Wires to connect the device to external peripherals.
- Implementation: Matlab will be use as a way to calculate the data and output information.

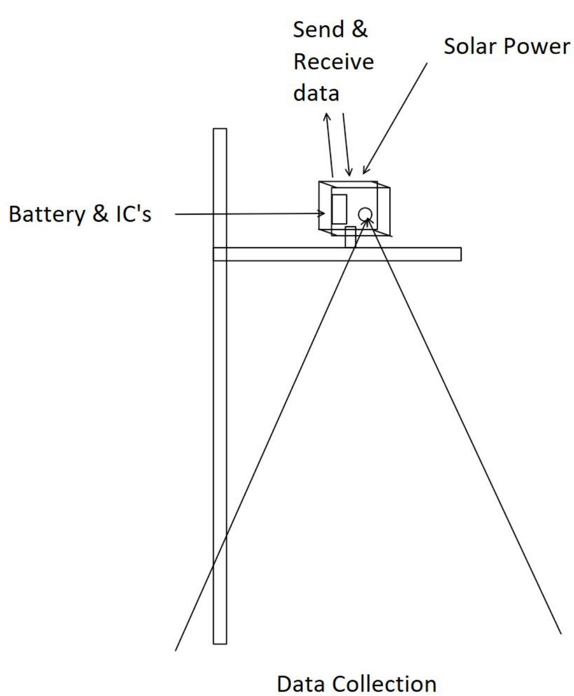




Design Alternative 2

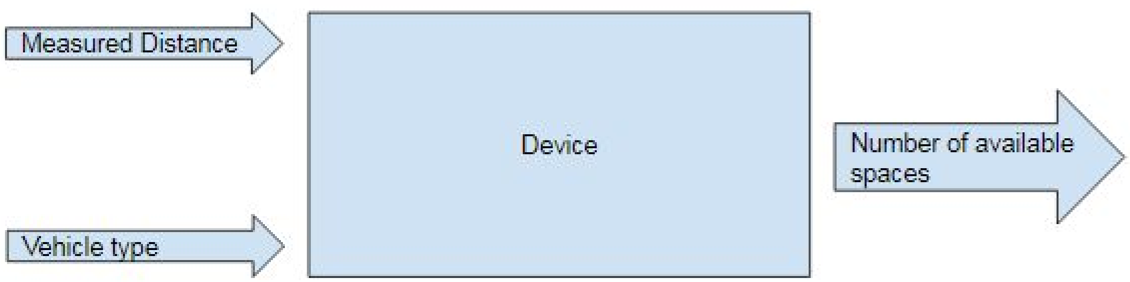
- Sensor: One of the sensor on board will be a camera to help measure distances and output car data. A secondary sensor could be implemented if the primary camera is not sufficient enough to capture the data needed to determine whether a parking space if available.
- Power: Solar power will be implemented to stay green. This will be the primary source of energy for the device functionality. A battery will be use when there is no sun available
- Casing: A plastic or metal casing will be use to shield components
- Data Transfer: Using Wires and Wireless to connect the device to external peripherals.
- Implementation: An Raspberry Pi type of board will be use to collect and calculated data.

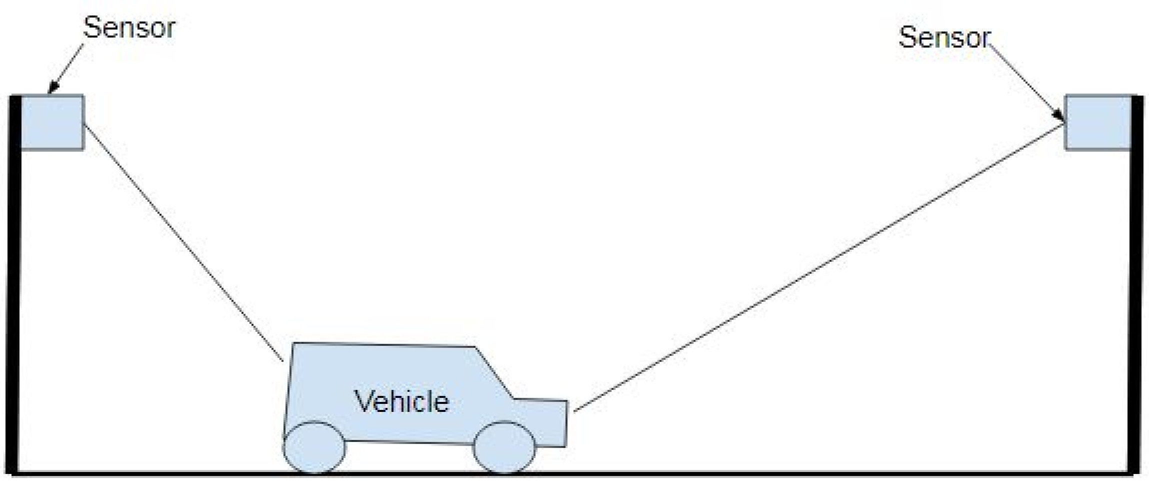




Design Alternative 3

- 2 Sensor: 1st laser sensor will be mounted on a pole, similar to that of the previous alternative, then there will be a second sensor mounted parallel to the first on the opposite end of the same street.
- Power: Device will use a rechargeable battery with a solar panel
- Casing: Use plastic casing to reduce the weight of device. Due to the device being mounted high up, a lighter weight will ensure better integrity of the mounting.
- Data Transfer: Use a RF transmitter connected to the device board to send data back to user. RF transmitters are cheap and readily available with the given budget constraint.
- Implementation: Use matlab program to recognize the data from the sensors and calculate the data to be returned.





Similarities and Differences

While most of our design share many similarities in the input and out section of the design. In our designs we have chosen a few different type of sensors to collect the data. For instance in the design alternative 1 we use a laser sensor implementation and in design 2 a camera will be use to collect data.

When it comes to powering the device we are implementing a few different methods. One is tapping into existing AC power pre-existing in the power polls. A secondary option is using solar panel and a battery to power the internal components. While design 1 and 3 are using plastic as a casing design 2 will be using metal to shield from the external environment.

Data transfer for our first and second designs use a wired interface to a nearby panel to transfer data between the user and device, while our last design uses a radio transmitter to transmit the data wirelessly to a personal device.

For implementation, in our first and last alternatives we use matlab to process our input data and return calculated data. In contrast, our second alternative will use an arduino board to compute and return the input and output, respectively.

Module	Device performing calculation
Inputs	Distance measurements (sensors) User's input of vehicle type
Outputs	Number of available spaces
Functionality	Taking measurements collected and performing calculation to produce number of available spaces as the result according to the input type of vehicle and unoccupied area on the streets. Users should be able to input different types of vehicle and the results should reflect on that.

V. Design Alternatives Evaluation Criteria

Criteria Number	Criteria Description	Justification
Criteria 1	Development Cost	One of the main criterias that we need to consider and has a huge impact on the decision as well as modifications that our project has to take into account is the cost of developing the design and its components. Different design alternatives that we have produced will require different combination of parts and components to build.

Criteria 2	Technical Knowledges	Different design will require our team's expertises and knowledges regarding the components and methods in creating the algorithm to calculate the number of available spots according to the input data (Sensor measurements, Captured image, etc.) along with the ability to put them together to achieve working system.
Criteria 3	Parts Availability	We will also need to consider the availability of parts and whether we can obtain them from the market or manufacturers.
Criteria 4	Completion Time	This will be crucial to our development as we need to guarantee that the project will be completed and achieving its goal as intended before the Expo.

VI. Selection of Design Alternative & Justification

(See Appendix E for Individual Pairwise Comparison Tables)

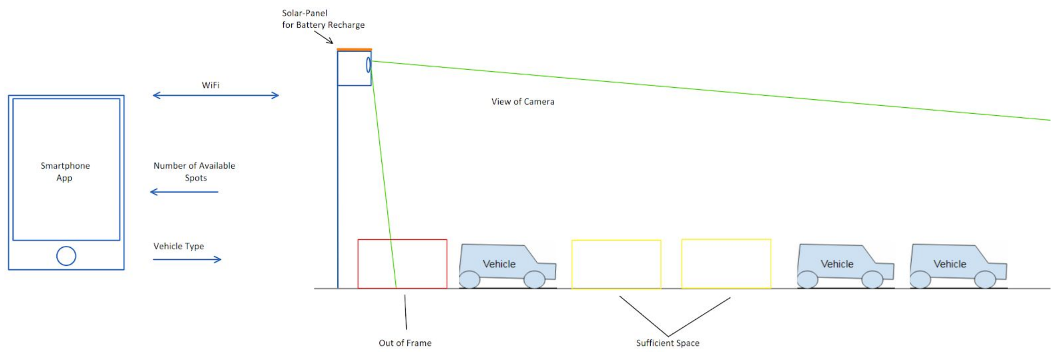
Score Computation for Alternatives

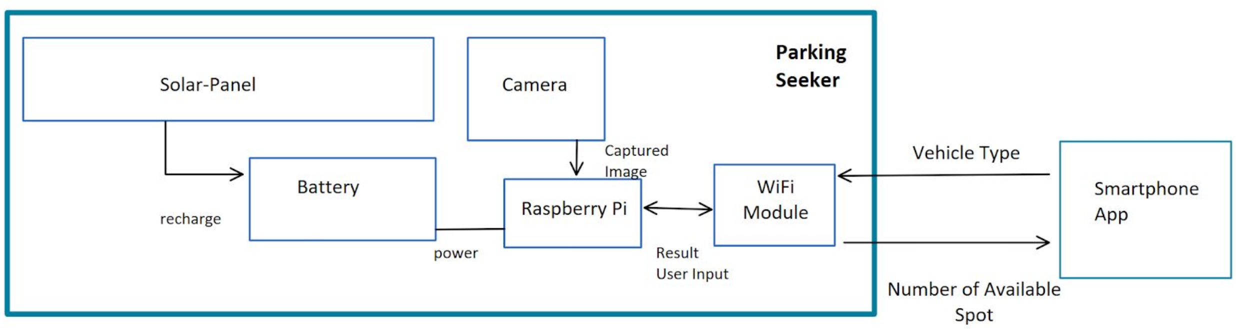
	Weight Average	**Alternative 1**	**Alternative 2**	**Alternative 3**
Criteria 1	0.16	2.67	3.33	3
Criteria 2	0.34	2	2.67	2.33
Criteria 3	0.12	2.67	4	3
Criteria 4	0.38	2.67	3	2.67
Score		2.44	3.06	2.65

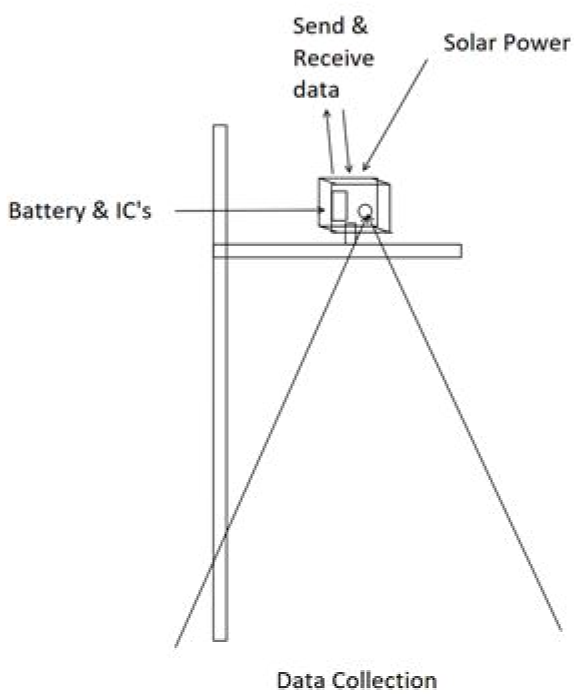
From the score above, it appears that Design Alternative 2 has scored the highest in every criteria and produced the best score of the three. However, after discussions and considerations of all the aspects and parts of the design, we have come to the conclusion that we will use Design Alternative 2 as a template and make modifications to the design with some of the design choices from the other alternatives for our Final Design. Moreover, having fewer moving parts and components will increase the fluidity and correctness of the device as well as keeping the development cost low. We will be making modifications to the design such as using only one camera to capture an image for our program algorithm to do an analysis of vehicle occupancy of the street and having a wireless module that connects the device to our app, in where the user interface resides. Power will come from rechargeable solar-panel battery.

VII. Preliminary Design

Level 1 Schematics



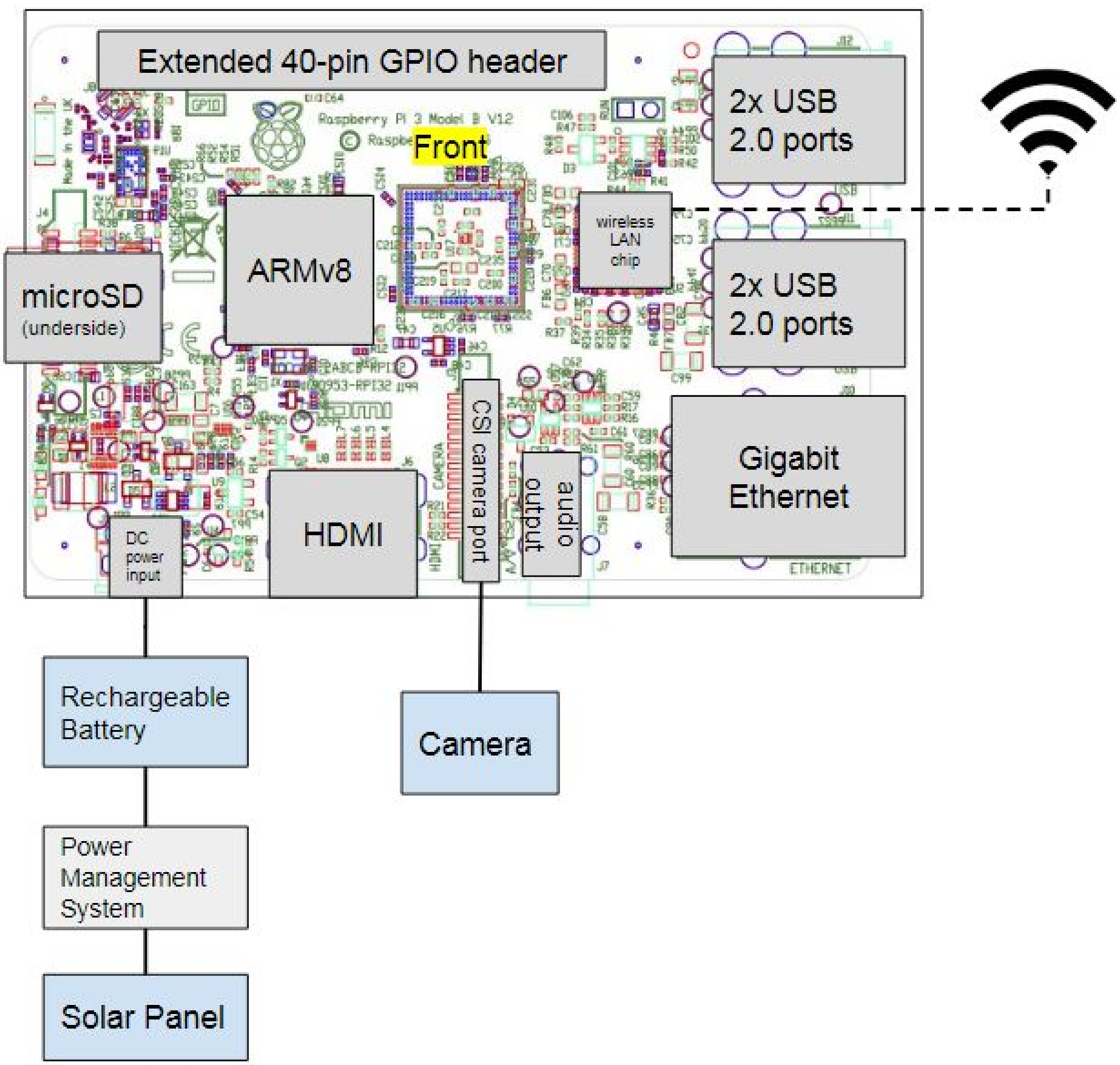




The schematic pictured above represents the level 1 schematic of our design. This shows the general functionality of the device when implemented. We will have the device mounted high above to provide greater line of sight for the onboard camera. Not shown here is the functionality of the software that will be implemented with the device, which will be presented later on in this section.

As an overview, this device will use a Raspberry Pi board that will act as the main interface for our hardware. The information that is scanned in from the camera will be stored on this device and then all interaction between the device and the user will be transferred using an onboard LAN chip and antenna.

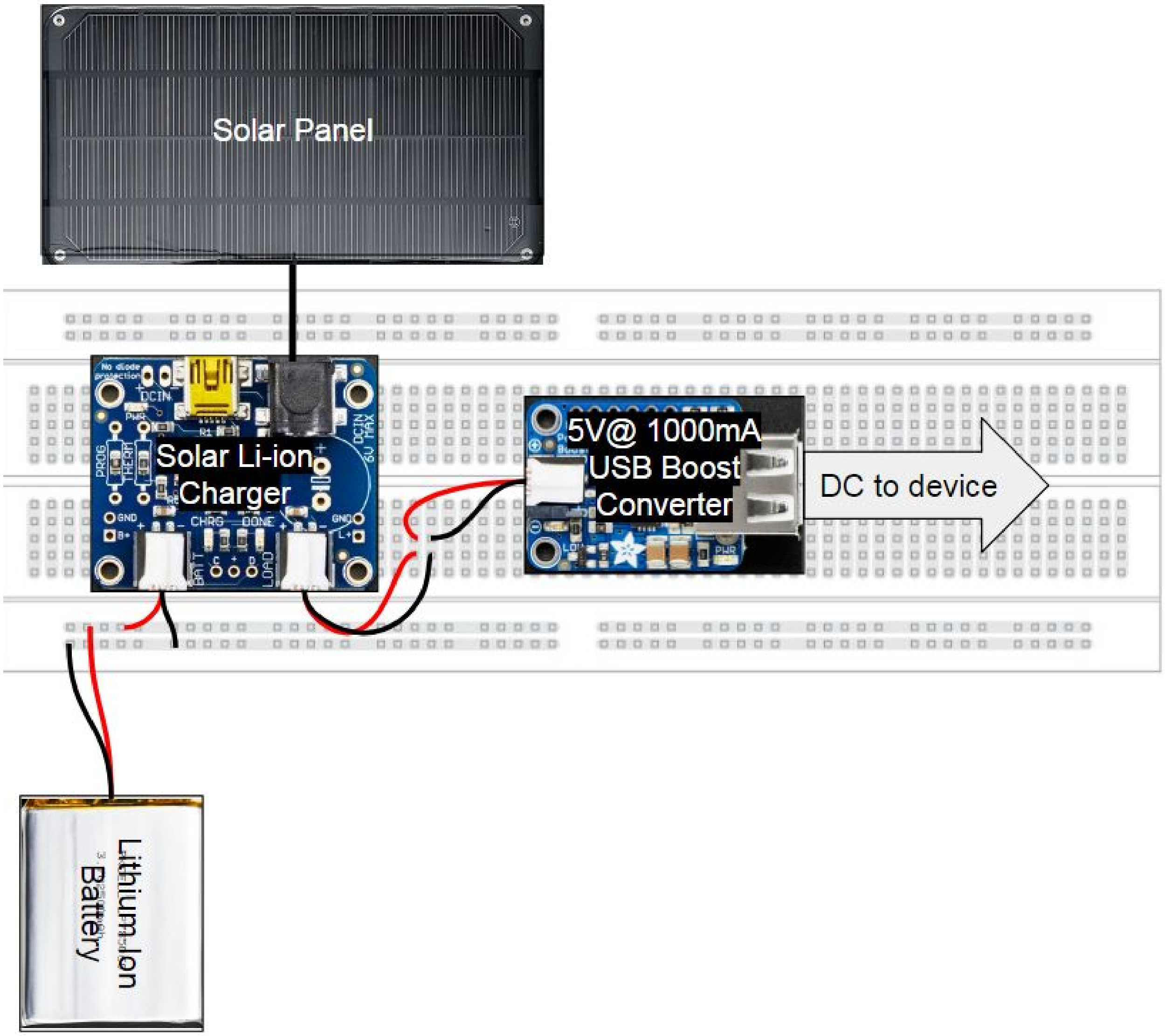
Hardware Design



The schematic pictured above represents the layout of all device components and where they will be attached on our interfacing board.

The most important detail of this schematic is the power supply in the lower left corner of the schematic. We have attached a rechargeable battery to a solar panel in order to power the device hardware indefinitely. In between our battery and panel there is a power management system in order to properly manage the rate of charge into the battery.

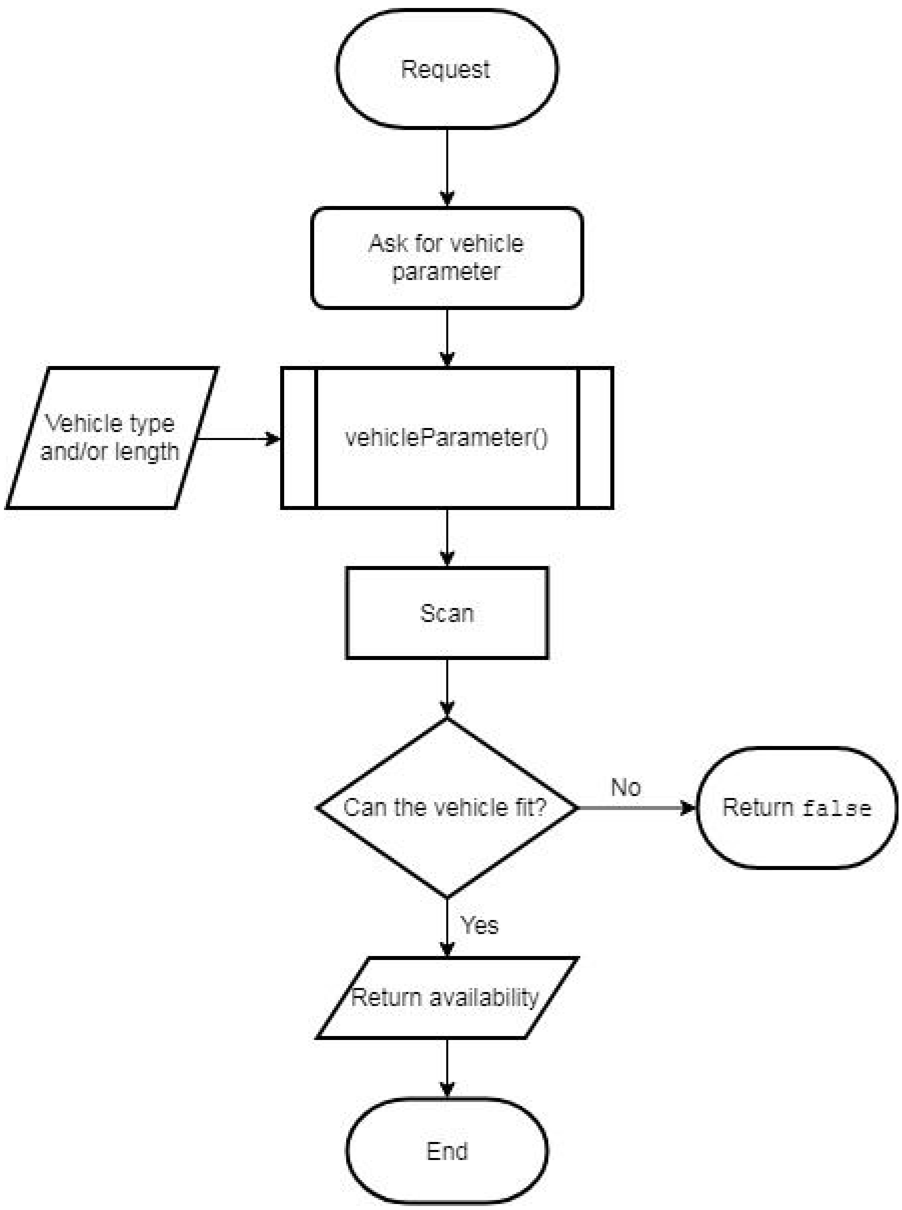
Power Management System



Shown above is the system to regulate the voltage level and current that will be supplied to the device. The solar panel is connected to a lithium ion charger in order to charge the battery. The charger will then send the power from the battery to a boost converter in order to regulate the voltage and current to a safe limit for the Raspberry Pi.

Software Design

For our software, we have chosen to use Matlab to program the software that will be used analyze the image captured by the camera. The code will be loaded onto the Raspberry Pi device and will execute once a request is made wirelessly. The user inputs their vehicle model or length and then camera will analyze an image of the parking area to see if if there is a space in between any vehicles or at the ends that will fit the parameter. The result is returned to the user.



VIII. Product Cost Analysis and Budget

Part Name	Quantity	Cost/Quantity	Total
Raspberry Pi 3 Model B+	1	35.00	35.00
Camera Module for Raspberry Pi 3 w/ night vision support	1	21.99	21.99
2.1mm DC Jack Adapter Cable	2	0.95	1.90
Medium 6V 2W Solar panel	1	29.00	29.00
Lithium Ion Polymer Battery - 3.7v 2500mAh	1	14.95	14.95
USB / DC / Solar Lithium Ion/Polymer charger	1	17.50	17.50
PowerBoost 1000 Basic - 5V USB Boost @ 1000mA	1	14.95	14.95
Mini USB WiFi Module 802.11b/g/n	1	11.95	11.95
		Total	147.24

IX. Task Allocation and Timeline

Spring 2019 Semester Timeline

	TASK(S)	COMMENTS	LEAD
WEEK 1	-Submit Parts Order -Initial Meeting with Proj. Advisor	Set up meeting time and place with Advisor and add to timeline	Alex
WEEK 2	-App UI Implementation -If parts arrive, begin setting up device	May need to inquire guides from faculty with App Implementation	Dara
WEEK 3	-Setting up device -Writing Program		Dara
WEEK 4	-Cont. Working on Program -Construct Small Scale of road strip and pole for device mounting		Dara

WEEK 5	-Designing Case for Device -Acquire models vehicle replicas		Dara
WEEK 6	-First Testing without Case		Dara
WEEK 7	-App should be > 90% completed	Optimistically hoping; possibly not met until later date	Dara
WEEK 8	-Submit Case Design to be made to Maker Space -Start Designing EXPO poster		Dara
WEEK 9	-Design Labels -Design Team & Project logos	Logo: “Parking Seeker”	Dara
WEEK 10	-Integrate Device & App Connection -Second Testing	Hopefully case will be completed at this point and ready to be tested for water proof	Dara
WEEK 11	-Spring Break -Work on Earlier tasks if not done last week	It’s not really a break.	-To be determined
WEEK 12	-Submit Label Designs to be printed -App Completion		Dara
WEEK 13	-Everything should be completed and put in places -Submit Poster to be printed	Device should appear/contain/work as it should be	

WEEK 14	-Final Testing -Device Completed		Dara
WEEK 15	-Final Thorough Check -Prepare for EXPO -Have fun at EXPO!	Dress professionally, Talk professionally	All Team Members

X. Appendices

Appendix A: User Manual

1. Overview

This device was designed for ease of use in mind. All the necessary components are contained within the package. The only preliminary step is to connect the battery to the main board, this is easily done by connecting the micro USB connector.

2. Troubleshooting

This device was designed for easy troubleshooting in mind. All components used are modular, all are readily available to the public and can be replaced if needed. With that being said, a basic understanding of electronics is required to perform modifications of this device. No soldering is required for the replacement of any of the parts. However, some splicing may be required to replace the wire from solar panel to charger if an appropriate adapter cannot be found.

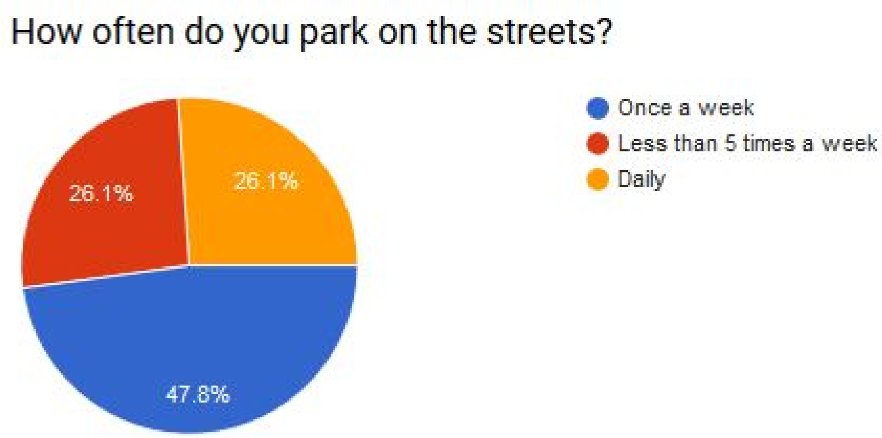
3. Installation

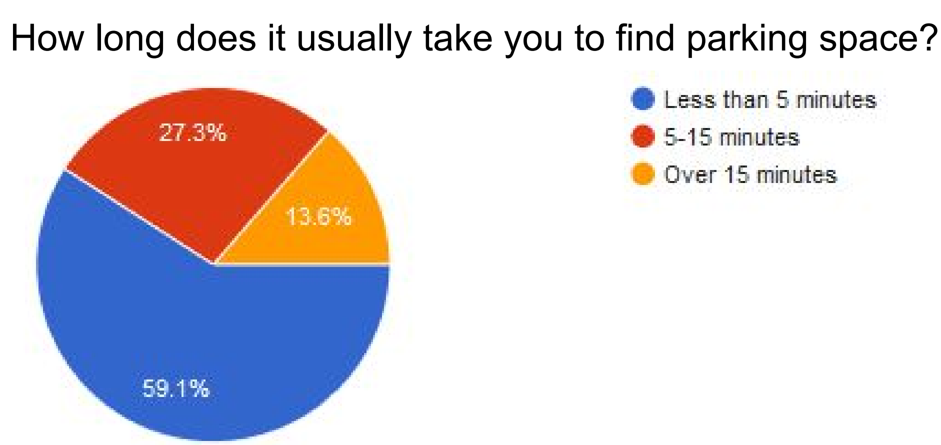
1. Before mounting device, open the encasing chassis and connect the battery micro USB to the main Raspberry Pi board.
2. Then reclose the the chassis before the device is mounted.
3. Device should be installed in at a point high above with a clear line of sight the designated parking area.
4. Device should be pointed at the designated parking area and ONLY at that area. It should avoid lines of sight directed towards residencies and private entrance ways.

5. Position of device should be in a place with unobstructed sunlight and do not cover the device.
6. To use the device, download the accompanying application software to an appropriate mobile device and enter the parameters of the vehicle.
7. Make sure to be near the device when using application.

Appendix B: User Survey Results

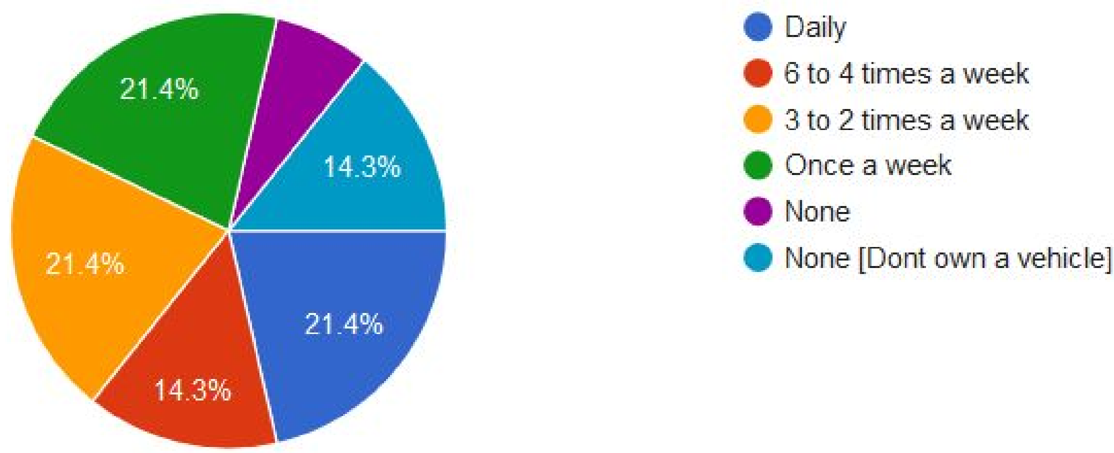
User Survey 1



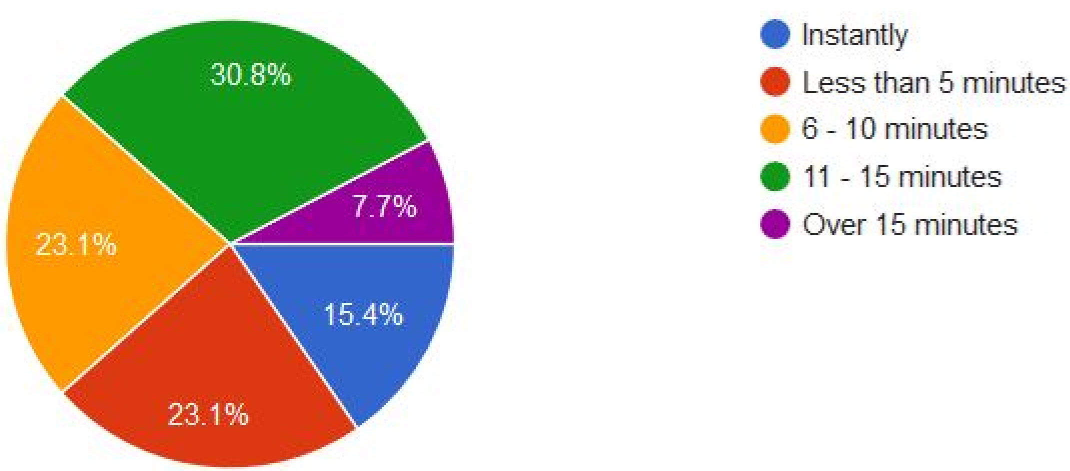


User Survey 2

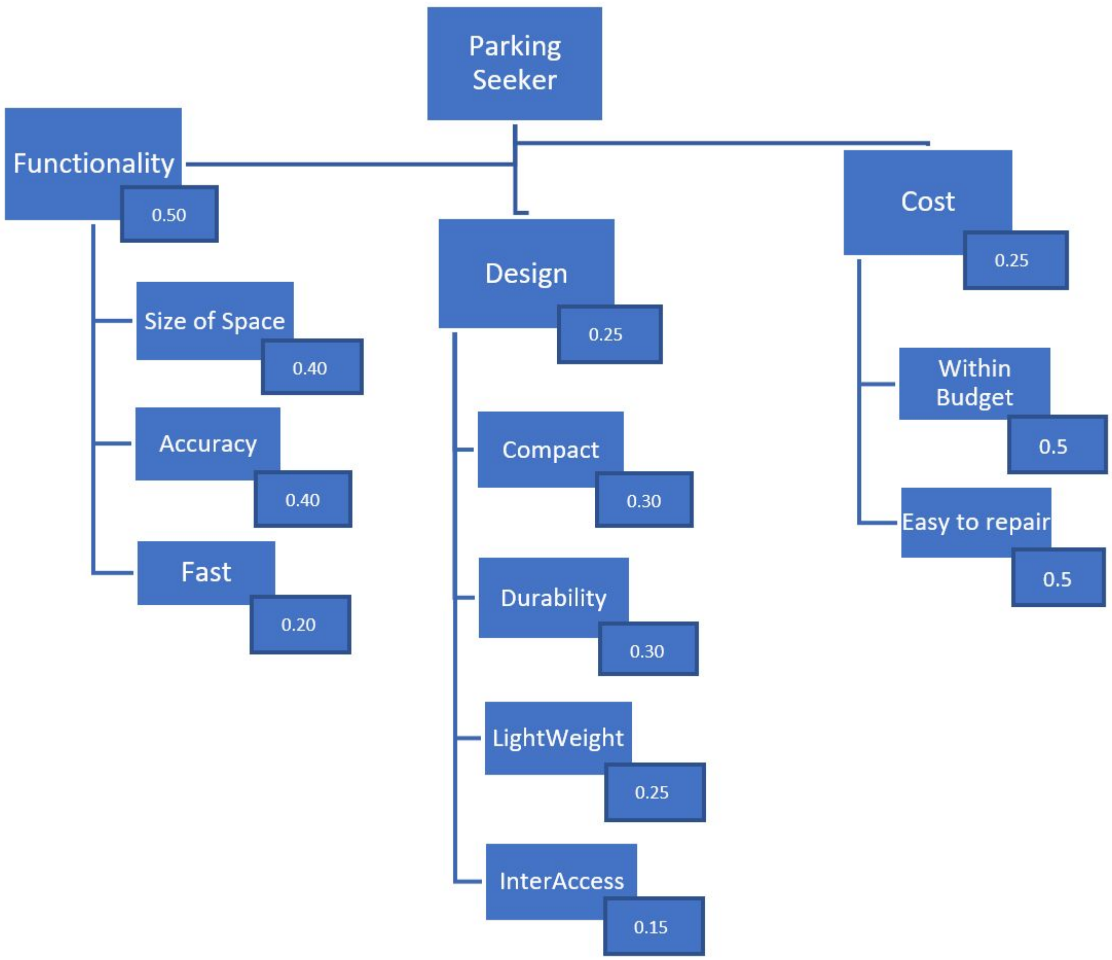
How often do you park on the streets?



How long does it usually take you to find parking space?



Appendix C: Objective Tree



Appendix D: Design Alternatives

Basic Concept Map Used

User Interface	Sensor	Power	Casing	Data Transfer	Implementation
Mobile App	Ultrasonic	Battery	Metal	WiFi	MatLab
Mapping	Laser	Solar	Plastic	Radio Frequency	Object Recognition
List of Directions	Video	AC tap	Aluminum	Wired	Python, OpenCV
Address	Proximity		Fiberglass		Arduino
Display			Foam Casing		Tensorflow, Python, C++

Design Alternative 1

User Interface	**Sensor**	**Power**	**Casing**	**Data Transfer**	**Implementation**
Mobile App	Ultrasonic	Battery	Metal	WiFi	MatLab
Mapping	Laser	Solar	Plastic	Radio Frequency	Object Recognition
List of Directions	Video	AC tap	Aluminum	Wired	Python, OpenCV
Address	Proximity		Fiberglass		Arduino
Display	Camera		Foam Casing		Raspberry Pi
Keypad					C, C++

Design Alternative 2

User Interface	Sensor	Power	Casing	Data Transfer	Implementation
Mobile App	Ultrasonic	Battery	Metal	WiFi	MatLab
Mapping	Laser	Solar	Plastic	Radio Frequency	Object Recognition
List of Directions	Video	AC tap	Aluminum	Wired	Python, OpenCV
Address	Proximity		Fiberglass		Arduino
Display	Camera		Foam Casing		Raspberry Pi
Keypad					C, C++

Design Alternative 3

User Interface	Sensor	Power	Casing	Data Transfer	Implementation
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Mapping	Laser	Solar	Plastic	Radio Frequency	Object Recognition
List of Directions	Video	AC tap	Aluminum	Wired	Python, OpenCV
Address	Proximity		Fiberglass		Arduino
Display	Camera		Foam Casing		Raspberry Pi
Keypad					C, C++

Appendix E: Individual Pairwise Comparison Tables

Criteria Number	Criteria Description	Justification
Criteria 1	Development Cost	One of the main criteria that we need to consider and has a huge impact on the decision as well as modifications is that our project has to take into account the cost of developing the design and cost its components. Different design alternatives that we have produced will require different combination of parts and components to build.
Criteria 2	Technical Knowledges	Different designs will require different expertise and knowledge regarding the components and methods in creating the algorithm to calculate the number of available spots according to the input data (Sensor measurements, Captured image, etc.) along with the ability to put them together to achieve a working system.
Criteria 3	Parts Availability	We will also need to consider the availability of parts and whether we can obtain them from the market or manufacturers.
Criteria 4	Completion Time	This will be crucial to our development as to guarantee that the project will be completed and achieving its goal as intended before the Expo.

Alex	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Geo. Mean**	**Weights**
Criteria 1	1	1/5	1	1/7	0.41	0.08
Criteria 2	5	1	3	1	1.97	0.40
Criteria 3	1/3	1/3	1	1/3	0.44	0.09
Criteria 4	7	1	3	1	2.14	0.43

Alex	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**
Alternative 1	3	1	4	3
Alternative 2	3	3	5	3
Alternative 3	5	3	5	3

Dara	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Geo. Mean**	**Weights**
Criteria 1	1	2/3	3	2	1.41	0.29
Criteria 2	3/2	1	5	4	2.34	0.48
Criteria 3	1/3	1/5	1	1/2	0.43	0.09
Criteria 4	1/2	1/4	2	1	0.71	0.14

Dara	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**
Alternative 1	2	3	2	2
Alternative 2	4	3	4	3
Alternative 3	1	2	2	2

Alfredo	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Geo. Mean**	**Weights**
Criteria 1	1	1/3	1	1/5	0.51	0.10
Criteria 2	3	1	1/3	1/3	0.76	0.15
Criteria 3	1	3	1	1/5	0.88	0.17
Criteria 4	5	3	5	1	2.94	0.58

Alfredo	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**
Alternative 1	3	2	2	3
Alternative 2	3	2	3	3

Alternative 3	3	2	2	3

Average

	Weights
Criteria 1	0.16
Criteria 2	0.34
Criteria 3	0.12
Criteria 4	0.38

	Criteria 1	**Criteria 2**	**Criteria 3**	**Criteria 4**
Alternative 1	2.67	2	2.67	2.67
Alternative 2	3.33	2.67	4	3
Alternative 3	3	2.33	3	2.67

Appendix F: Data Sheets

Raspberry Pi 3 B+ Specifications

Specifications

Processor:	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4 GHz
Memory:	1GB LPDDR2 SDRAM
Connectivity:	■ 2.4 GHz and 5 GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE ■ Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps) ■ 4 × USB 2.0 ports
Access:	Extended 40-pin GPIO header
Video & sound:	■ 1 × full size HDMI ■ MIPI DSI display port ■ MIPI CSI camera port ■ 4 pole stereo output and composite video port
Multimedia:	H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics
SD card support:	Micro SD format for loading operating system and data storage
Input power:	■ 5 V/2.5 A DC via micro USB connector ■ 5 V DC via GPIO header ■ Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment:	Operating temperature, 0–50 °C

Camera Module for Raspberry Pi 3 w/ night vision support

Specifications:
CCD size : 1/4 inch
Aperture (F) : 1.8
Focal Length : 3.6MM (adjustable)
Diagonal : 75.7 degree
Sensor best resolution : 1080p
4 screw holes
Used for attachment
Provides 3.3V power output
Supports connecting infrared LED and/or fill flash LED
Dimension : 25mm * 24mm

Medium 6V 2W Solar panel

FILE DETAILS	SUBSTRATE	HARDWARE
PRODUCT NAME: **2W 6V 112x136mm**	SIZE: 112x136mm	WIRE: Male 3.5x1.1mm 260mm
DWG. NO. 2_6_112x136_R1	MATERIAL: 3.0mm AL-Plastic Composite	WIRE COLOR: Red
DWG. TYPE: Production	COLOR: Silver / Charcoal / Orange	WIRE NO. Wire 17
SCALE: 1:1.5 UNITS: MM TOLERANCE: ±0.1mm SHEET: 1/1	COATING: Urethane	STRAIN RELIEF: None
CREATED BY: TK DATE: 2017/7/3	TAPE: 3mm + 4mm Black	SCREWS: C-MPSCRS028X0079-KM#
REV. 1 CHANGE: DATE: CHK'D BY: SM	TEMP. RANGE: -40*C - 85*C [-40*F - 185*F]	NUTS: None

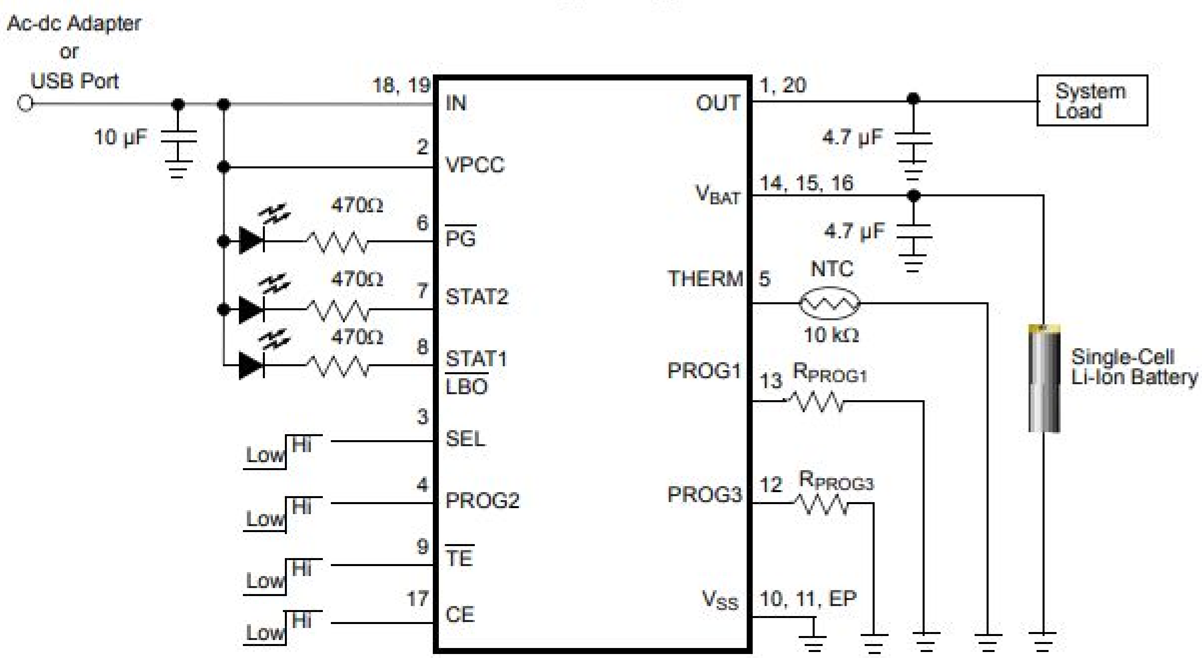
POWER		
Spec. Tolerance: ±10% (Vp,Ip)		
Cell Supplier: Solar World		
Cell: Efficell M C4 3BB 4.59W		
Cell Efficiency:+19.1%		
MC	12	pcs
Voc	7.7	V
Vp	6.5	V
mAsc	370	mA
mAp	340	mA
Wp	2.2	W

Lithium Ion Polymer Battery - 3.7v 2500mAh

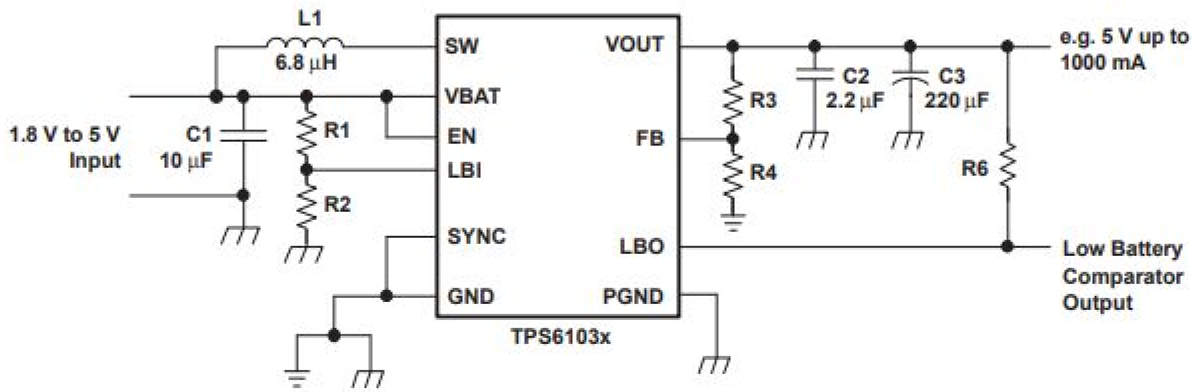
Item		Specifications	Remark
Nominal Capacity		2500mAh	0.2C_5A discharge，25℃
Nominal Voltage		3.75V	Average Voltage at 0.2C_5A discharge
Standard Charge Current		0.2 C_5A	Working temperature：0～40℃
Max Charge Current		1C_5A	Working temperature：0～40℃
Charge cut-off Voltage		4.2V	CC/CV
Standard Discharge Current		0.5C_5A	Working temperature：25℃
Discharge cut-off Voltage		2.75V	
Cell Voltage		3.7-3.9V	When leave factory
Impedance		≤35mΩ	AC 1KHz after 50% charge,25℃
Weight		Approx:46g	
Storage temperature	≤1month	-10～45℃	Best 20±5℃ for long-time storage
	≤3month	0～30℃	
	≤6month	20±5℃	
Storage humidity		65±20% RH	

USB / DC / Solar Lithium Ion/Polymer charger MCP73871 chip

MCP73871 Typical Application



PowerBoost 1000 Basic - 5V USB Boost @ 1000mA TPS61030 chip



Appendix G: Relevant Patent(s)

"Computer Implemented System and Method For Managing Motor Vehicle Parking and Reservations"

https://patents.google.com/patent/US8799037B2

XI. References

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[6] P. Sadhukhan, “An IoT-based E-Parking System for Smart Cities,” *2017 International Conference on Advances in Computing, Communications and Informatics*, pp. 1062–1066, Dec. 2017.

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