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# **Intelligent Car Parking Management System**

**A thesis presented in partial fulfilment of the requirements for the  
degree of**

**Master of Engineering**

**in**

**Electronic and Computer System Engineering**

**at Massey University, Palmerston North**

**New Zealand**

**Hilal Al-Kharusi**

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## Abstract

Due to the increasing number of vehicles on the roads, traffic problems always exist. The current unmanaged car parks and transportation facilities make it difficult to accommodate the increasing number of vehicles in a proper, convenient manner so it is necessary to have a car parking management system in big car parks. This study is aimed at analysing a car parking management system. This system allocates available parking space to a given driver to park their vehicle, renews the availability of the parking space when the car leaves and computes the charges due. Implementing this system will increase parking utilization. The system does this by providing more efficient and effective parking enforcement. An image processing technique is used to implement an intelligent car parking management system at the Massey University car park. In this project a camera is used as a sensor to take photos to show the occupancy of car parks. The reason a camera is used is because with an image it can detect the presence of many cars at once. Also the camera can be easily moved to detect a different car park. By having this image, the particular car parks vacant can be known and then used to guide a driver to a car park. Software processes these images so that a driver or operator can know the vacant car parks.

Since most of the cars at Massey University are in one parking area, video cameras could be used efficiently to detect many of them. This Thesis presents how a system could be made that would detect the availability of car parks and tell a driver where the available car parks are.

Green circles are placed on car parks so that cameras can easily differentiate whether a car is parked in a spot or not. If there is a car on the spot then the green circle will not be seen. First an excel spreadsheet with test data was used to test, displaying where empty and full car

parks are. Then a program that created random data was used to quickly see how the display would look in different conditions.

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## List of Abbreviations

<b>FPGA</b>	Field-Programmable-Gate-Array
<b>GUI</b>	Graphical User Interface
<b>HSV</b>	Hue Saturation Value
<b>IDL</b>	Inductive Detector Loop
<b>PAN</b>	Personal Area Network
<b>PC</b>	Personal computer
<b>RFID</b>	Radio Frequency Identification
<b>RGB</b>	Red, Green and Blue
<b>WIM</b>	Weigh-In-Motion
<b>WSN</b>	Wire Sensor Network

# Chapter 1: Introduction

There are two types of parking management systems. First is a normal parking system and the other one is an automatic parking system. An automatic parking system is used to make the whole process of parking cars more efficient and less complex for both drivers and administrators. This can be done through sensors at the entrance and exit of the park, a computer system that manages the whole process and various display panels and lights that help the driver in parking his car. An example of such system which uses an automatic parking system [1] is shown in Figure 1.

## ***1.1 Research topic***

The aim of this research to implement an intelligent car parking management system at car parks to allow more cars to be parked easily within a small area. The topics of this research include:

- 1) The process of determining the presence of cars.
- 2) Explanation of the hardware that needs to capture a photo of a car park and send it to a processing computer, wireless communication system.
- 3) Description of the communication protocol used to transfer data from the camera to the computer.

## ***1.2 Scope of research***

Available parking space to a given driver to park their vehicle renews availability of the parking space when the car leaves and computes the charges due. An image processing technique is used to implement an intelligent car parking management system .A reason a camera is used is because with an image it can detect the presence of many cars at once. Also the camera can be easily moved to detect a different car park. By having this image, the particular car parks vacant can be known and then used to guide a driver to a

car park. Software processes these images so that a driver or operator can know the vacant car parks.

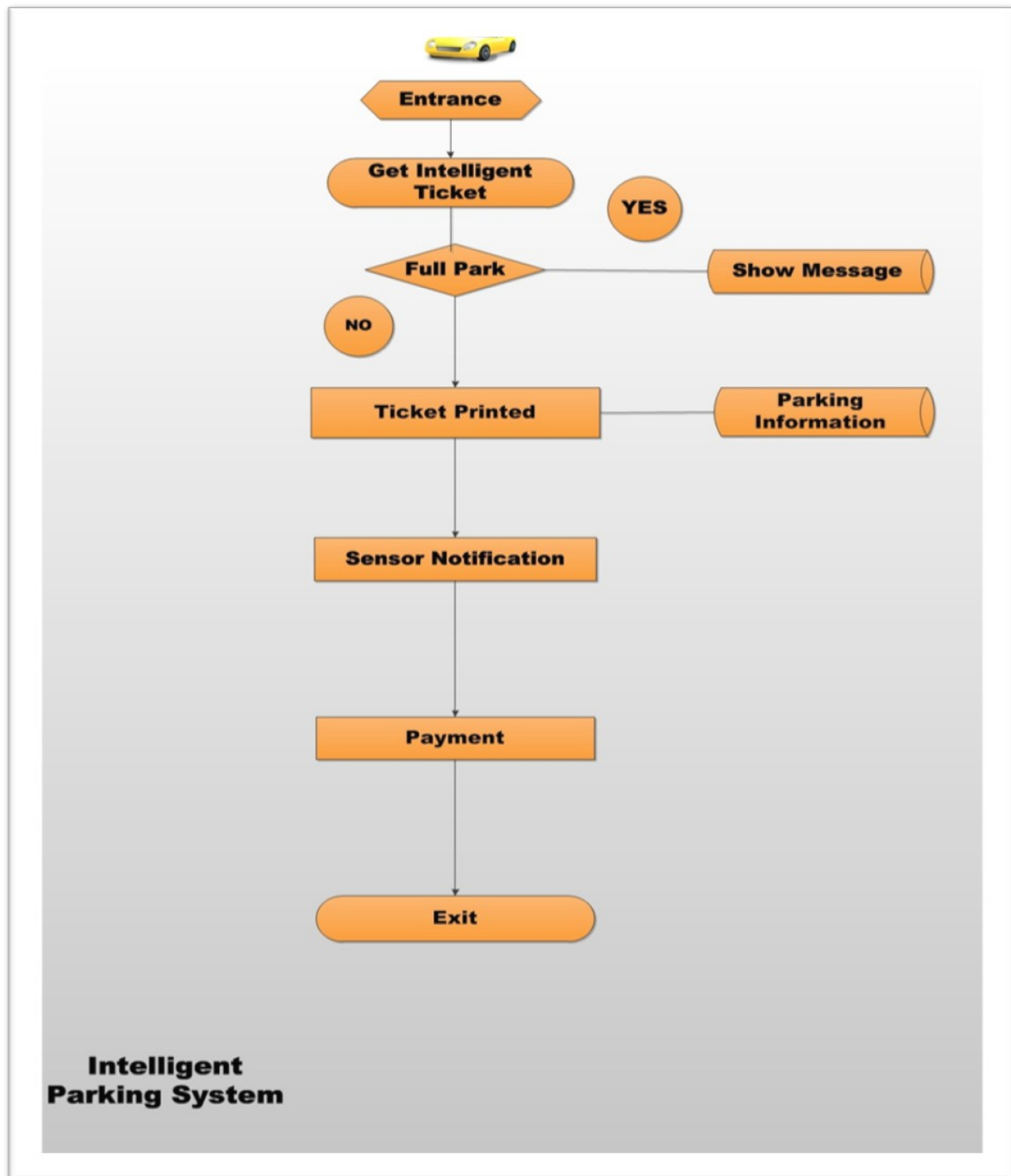


Figure 1-1 Intelligent car parking system management

Based on the literature survey of the research, the technologies available and the available finance, the scope of this research includes:

- 1) An explanation of how the hardware captures a photo and sends it to a processing computer.
- 2) A description of how the communication protocol is used to transfer data from the camera to the computer
- 3) A method of finding the availability of a car park at Massey University will be presented.
- 4) A Matlab program is going to be demonstrated that tested different occupancy levels of car parks to show how a driver can be guided to the closest park.
- 5) A method of analysing an aerial view of the car park will be clearly shown step by step.
- 6) The hardware and communication that could be used in the future will be clearly presented [1-5].

### ***1.3 The organisation of the thesis***

The thesis contains 6 chapters. Each chapter has a short introduction to give an overview of its content. Following is a summary of the chapters. Chapter 1 explains the topics of this research by stating its requirements, objectives and scope. Chapter 2 provides the literature review, showing the advantages of having a car parking system management that is safe, secure and easy for drivers, is economical and efficient in its use of space, environmentally friendly and principles to help the decision about how to use the system. Chapter 3 discusses the categories of vehicle detection technology, methodology used in this research to localise the car park lots and the requirements needed to implement the system. Chapter 4 continues by presenting four cases of implementing the system. It firstly mentions for four car parks in three different conditions. Finally, the process of implementing the system in a large car park

at Massey University by showing the steps of getting a template image and real image is shown in chapter 4. Chapter 5 presents a case study for 148 car parks with its process. Chapter 6 explains the methods of various communication systems, and the architecture and components of the system. Chapter 6 concludes with the research's future improvements and conclusions.

## **Chapter 2: Literature review**

Due to the increasing number of vehicles on the roads, traffic problems always exist. The current car parks and transportation facilities are unable to cope with the increasing number of vehicles so it is necessary to have a car parking management system in big cities. This study is aimed at analysing a car parking management system in big cities.

### ***2.1 Advantages of a car parking management system***

Before implementing such a system, it's benefit versus it's cost needs to be considered. The advantages of having a car parking management system as opposed to parking cars at an unmonitored car park are listed below

- 1) Allows more cars to be parked easily within a small area.
- 2) Reduces traffic congestion & accidents inside car parks and therefore reduce unnecessary use of cars.
- 3) Improved user options and quality of service
- 4) Improved design flexibility for areas requiring car parks,
- 5) Ability to accommodate new car park uses and respond to new demands.
- 6) Reduces detrimental environmental impacts.

There are some other advantages in terms of safety, security which makes it easier for drivers. Also, economical and efficient space utilization and environmentally friendly parking system [6-10].

## ***2.2 Safe, secure and easy for drivers***

By using a car parking management system, cars will spend less time moving around parts of a car park that have no spaces available and will be able to drive directly to the correct car parking space. Moving around car parks can be dangerous due to driver's vision being obstructed by other cars making it difficult to see other cars getting out of the car park or pedestrians moving between cars. Therefore, reaching a car park quicker will remove frustration among drivers and increase safety in the car park. This system will make parking more convenient for drivers and also increase the safety of their vehicles as they are monitored [11-13].

## ***2.3 Economical and efficient space utilization***

By using a car parking management system, cars can be allocated to a car park which can in turn move cars by itself, using conveyor belts, to a specified place in the car park. By doing this at least 30% more cars could fit into the area as compared to a conventional car park. This also removes the need for so much ground area as people won't need to climb stairways or move around cars. This enables the car park to fit more cars in within the same area. This would be especially useful in big cities where the area of land is expensive.

Although the system would cost money to maintain, expenses such as cleaning, ventilation, lighting, and fire protection would be eliminated since the parking area is classified as an "unoccupied" space [14-16].

## ***2.4 Environmentally friendly parking system***

By having a way of guiding vehicles within a car park, the amount that the cars will drive within the car park will reduce. This will reduce the fuel used and the amount of toxic gases such as carbon monoxide released into the atmosphere [17].

### **2.4..1 Deciding how to use the system**

When deciding how to use a car parking management system, a number of general principles are useful:

1. Drivers should have the ability to choose the most convenient car park that is available.
2. Information about the car park's availability could be given to users over the internet or through the cellular network.
3. The automatic system should cater for multiple uses at the same time.
4. Have knowledge of the number of car parks needed so that car parks are not unnecessarily built.
5. Flexibility - parking plans should accommodate uncertainty and change.
6. Prioritization - the most desirable spaces should be managed to favour higher-priority users.
7. Pricing - As much as possible, users should pay directly for the parking facilities.
8. Peak management - special efforts should be made to deal with peak-demand.
9. Quality vs. quantity - parking facility quality should be considered as important as quantity, including aesthetics, security, and accessibility and user information.

10. Comprehensive analysis - all significant costs and benefits should be considered in parking planning [4], [19-20].

### 2.4.2 Categories of the car parking management system

The four main categories of the car parking management system using different technologies [2] are shown in the figure 2-1.

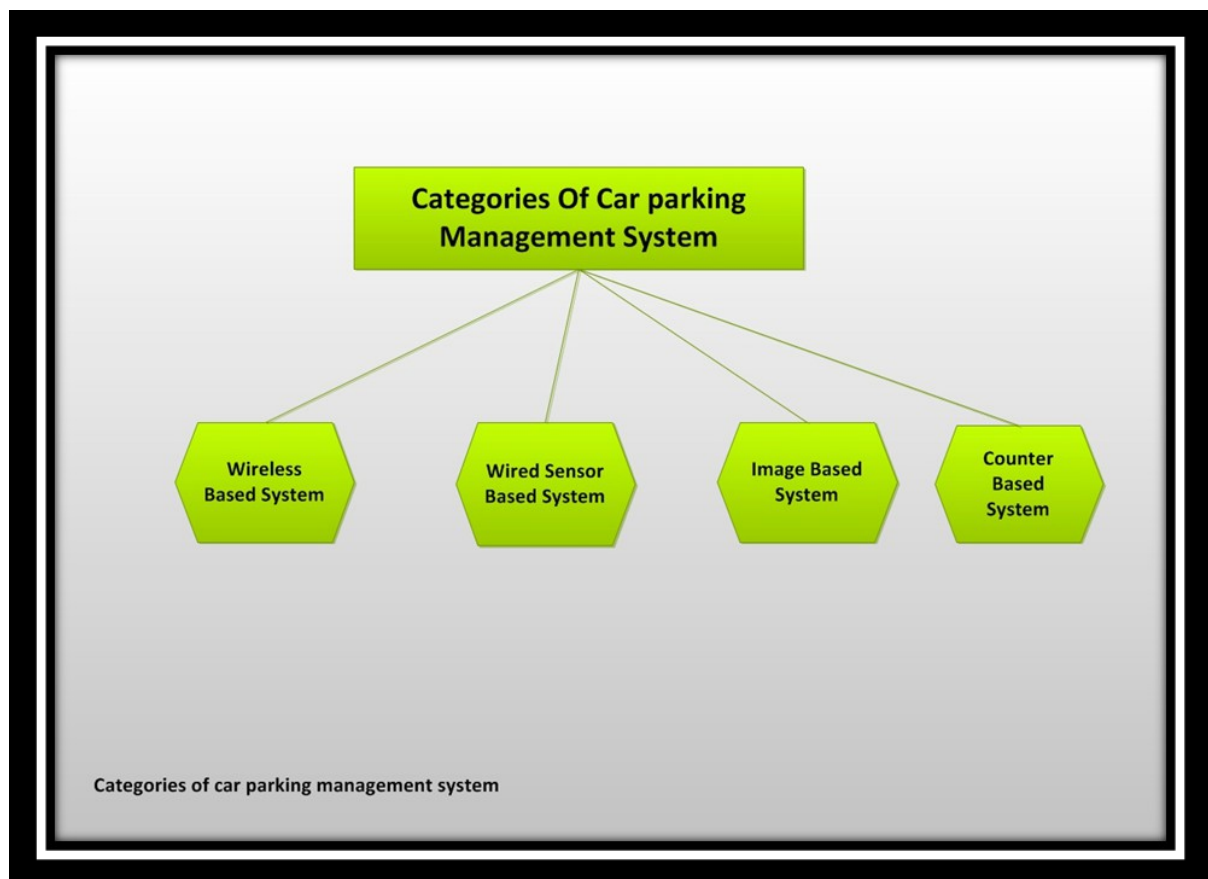


Figure 2-2 Categories of the car parking management system

### 2.4.2.1 The counter based system

The counter based system uses sensors located at the entrance and exit of the car part to count the number of cars that enter and leave the car park. This system simply calculates the number of available car parks in a section of the car park by the number of parks less the number cars that have entered the car park plus the number that has left it. Due to this, it cannot guide a driver where to park [21-23]. Figure 2-2 illustrates how a counter based system can display the number of available car parks on each level of a car park [3].

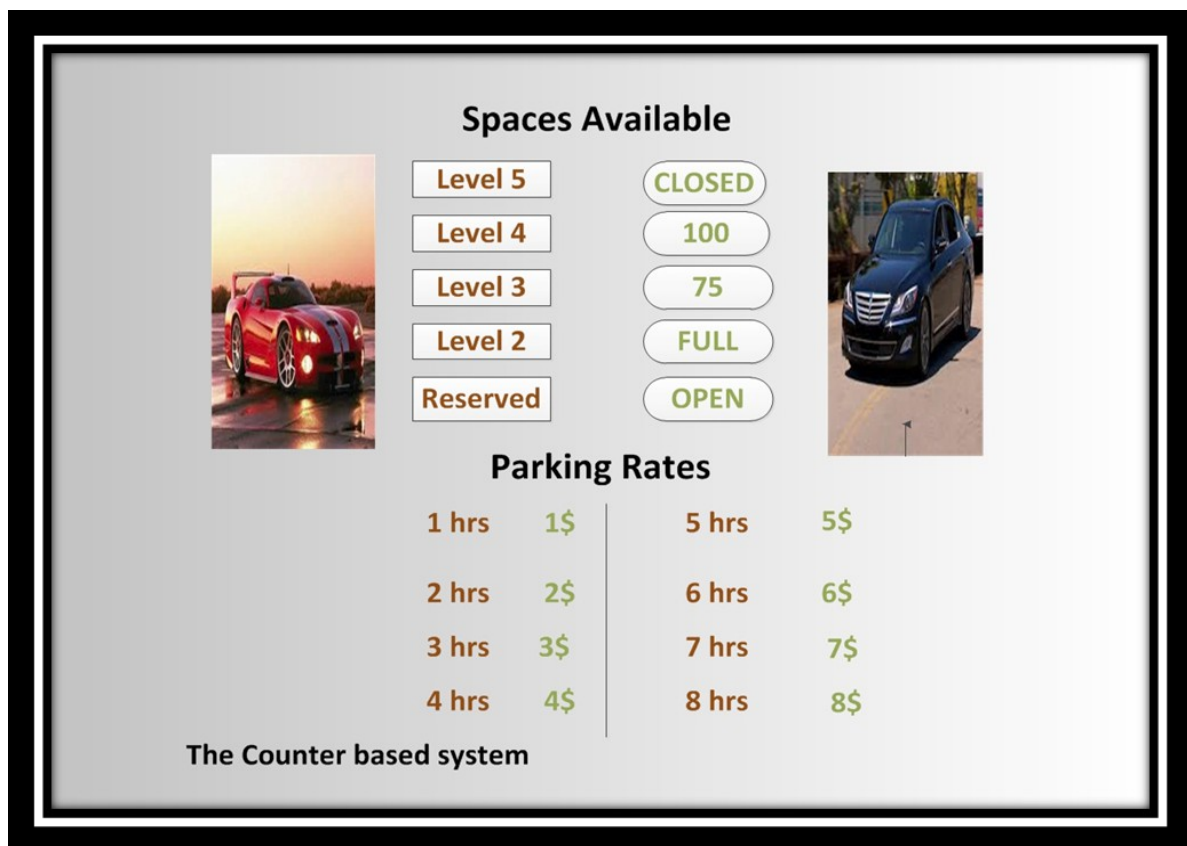


Figure 2-3 The counter based system

### 2.4.2.2 The image based system

The Image based technique uses a camera to take an image of the car park. This is useful because with this image, the particular car parks which are vacant can be known and then used to guide a driver to a car park. However, the amount of data captured from cameras is a lot and sensors can be expensive [24-26]. An example of this system is shown in Figure 2-3 the left side shows the availability of car parks, the middle column, the GUI display and the right column, the LCD display shown to the driver.



Figure 2-4 Image based system [4]

#### 2.4.2.3 The wired Sensor based system

The wired sensor based system has ultrasonic sensors at each car park with wires carrying their signal to a central processing unit. This system also provides data about the availability of individual car parks but is expensive as many sensors are needed and a lot of wiring is required [27-29]. Figure 2-4 illustrates an example of a wired sensor based system.



Figure 2-5 Wired sensor based system [5]

#### 2.4.2.5 The wireless based system

A wireless based system uses nodes located around the car park that communicate their data wirelessly. This eliminates the need for installation and maintenance costs and makes the system more flexible. Figure 2-5 demonstrates an example of a wireless system. This system uses nodes that have a light, acoustic, and temperature sensor and transmit their data over the

internet to a database where processing can be done and also to drivers who check on the car park's availability online [30-31].

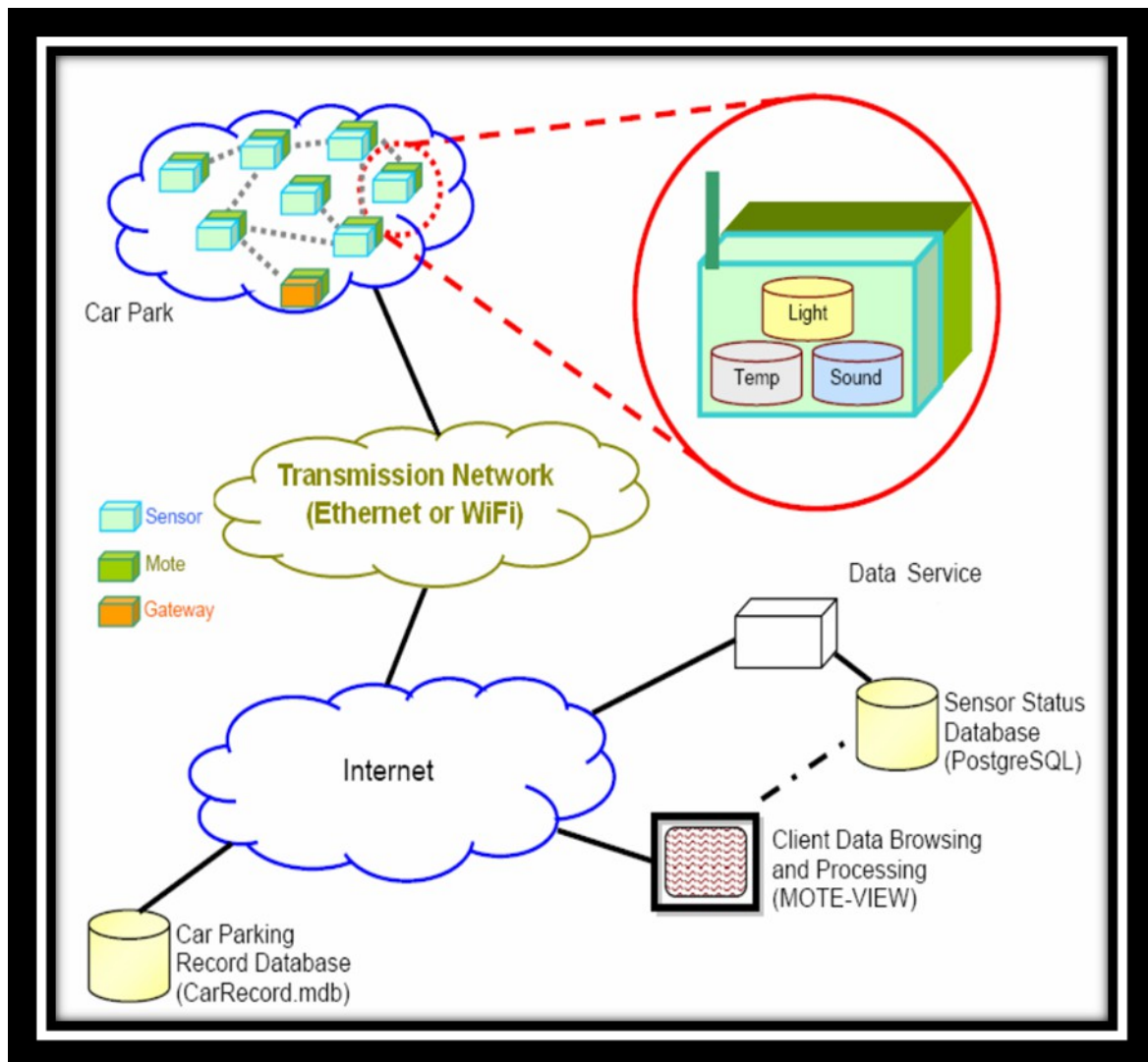


Figure 2-6 Wireless based system [6]

## 2.5 Requirements

Some important requirements applied to having a sufficient car parking management system that will make the project work smoothly are:

- (a) The location of the car park should be easy to find in the street.

- (b) The entrance of the car park should be easy to discover.
- (c) There should be more than enough number of car parks, there should be a lot available and each car park obtained should provide a large space to park a car in.
- (d) Easy to exit and to re-enter on foot.
- (e) Should be easy for the administrators and for the drivers [32-34].

Figure 2-6 illustrates an example of a convenient car park:



Figure 2-7 Example of large car park

## ***2.6 Conclusion***

From the discussion above, this differs from a car park with no monitoring of the cars which exit and leave it. Although more expensive, a car parking management system helps to remove congestion in a large car park where people may need to explore a bit to find a place to park their car.

There are four main types of systems used when managing a car park: a counter based system, in which cars entering and leaving the building are counted; an image based system, where images are taken of the cars inside the car parking spaces; a wired system, having sensors at each car parking spot that are wired to a central processing unit; and wireless sensors that have nodes that take the data from several sensors and transmits it to a processor.

To detect cars entering and leaving a car park, either intrusion or non-intrusion sensors can be used. Intrusion sensors require modification to be made either to the road or the side of it to install the sensor to detect the vehicles. Non-intrusion sensors do not but often are more costly and complicated.

The data from these sensors needs to be processed and sent to display units that give the necessary information to drivers (e.g., the number of available car parks in a level of a car park).

Each detector technology and particular device has its own limitations and individual capability. The successful application of detector technologies largely depends on proper device selection. Many factors impact detector selection, such as data type, data accuracy, ease of installation, cost and reliability.

## **Chapter 3: Investigation of the technology used for intelligent car park management**

In order to implement a car parking management system sensors are required at the entrance and exit of the car park. In some places sensors are also placed at the car parks themselves so that information about where are car parks are vacant can be known. Since the data from sensors may not be immediately useable by computers single processing is required so that signals can be transformed into a form which computers can read. The information received from all the sensors needs to be gathered and processed by a computer then sent to a display unit or a monitor so that drivers can know where available car parks are [4-35-36].

### ***3.1 Categorises of vehicle detection technology:***

There are two main types of vehicle detection sensors which are: intrusive and non-intrusive sensors. Intrusive sensors detect one vehicle at a time and placed below the vehicle or to the side of where it will pass. Non-intrusive sensors can detect several vehicles at the same time and be placed above at a place when many vehicles can be seen.

#### **3.1.1 Intrusive sensors:**

Intrusive sensors require a modification of the road or footpath beside it in order to detect vehicles. This modification could include such things as cutting a hole in the road, tunnelling under the road or attaching something on the side of the road. These modifications will require traffic to stop using the road while this work is done. Since the sensors are placed by the road, they will be in danger of being damaged by vehicles. Examples of intrusive sensors

include inductive loop, pneumatic road tube, Magnetometer, and Magnetic system sensors [37-39].

### 3.1.1.1 Inductive detector loop (IDL)

An Inductive loop detector is the most common intrusive sensor. A coil is placed under where the car will pass that has a signal with frequency with 10 to 50 Hz passing through it. When the car drives over the coil the metal in it decreases the inductance in the coil which then changes its frequency. When this frequency change is more than a certain threshold than a signal is sent that indicates a vehicle has passed by the time that a vehicle requires travelling between two detection points. Spot speed is measured by following equation:

$$\text{Speed} = \frac{l_{dist}}{t_2 - t_1} \quad (1)$$

Where,

$l_{dist}$  = Distance between two loops in meters

$t_1$  = Vehicle entry time at first loop in sec

$t_2$  = Vehicle entry time at second loop in sec [8], [40]

Figure 3-1 shows this principle of Inductive Detector Loop

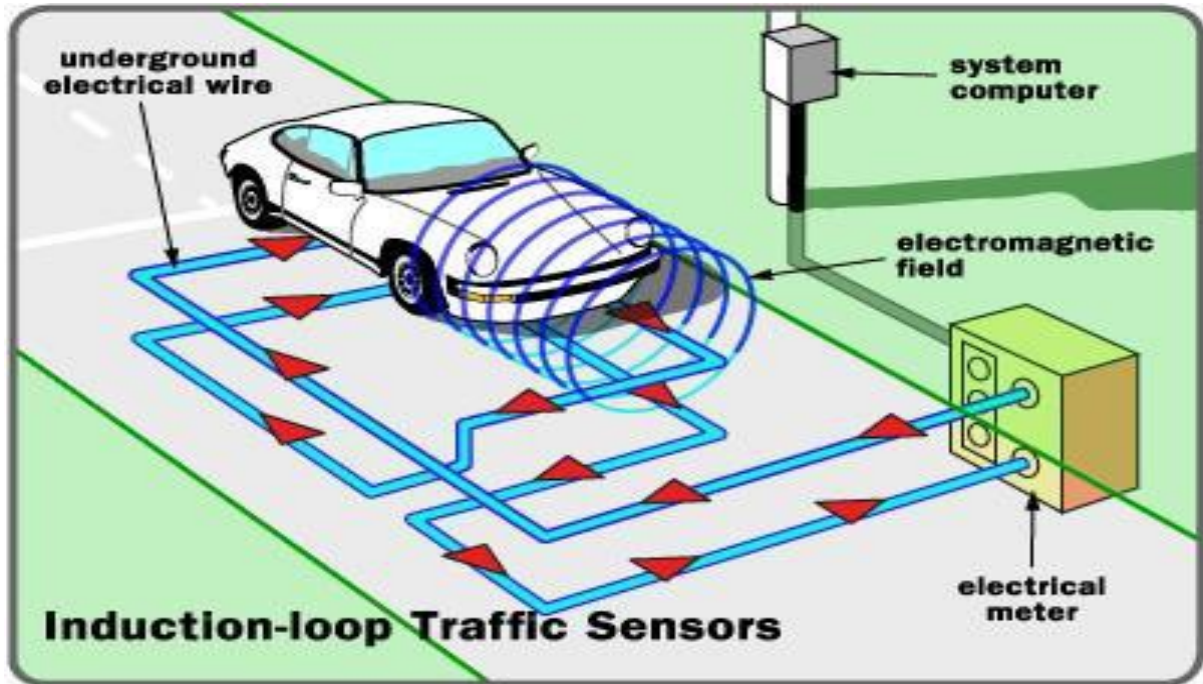


Figure 3-8 Inductive detector [4]

### 3.1.1.2 Pneumatic tube

A pneumatic tube is a simple and inexpensive method of counting cars that go past. A long rubber tube, placed perpendicular to the road's direction, is connected to a switch that can be measured by a processing unit. When a car passes it, the air pressure in the tube closes the switch thereby telling the processor that a car has passed. The disadvantage of this system is that it is sensitive to temperature, produces inaccurate readings when many buses and trucks pass it and can be easily vandalised. Figure 3-2 shows an example of a pneumatic Tube system [42].

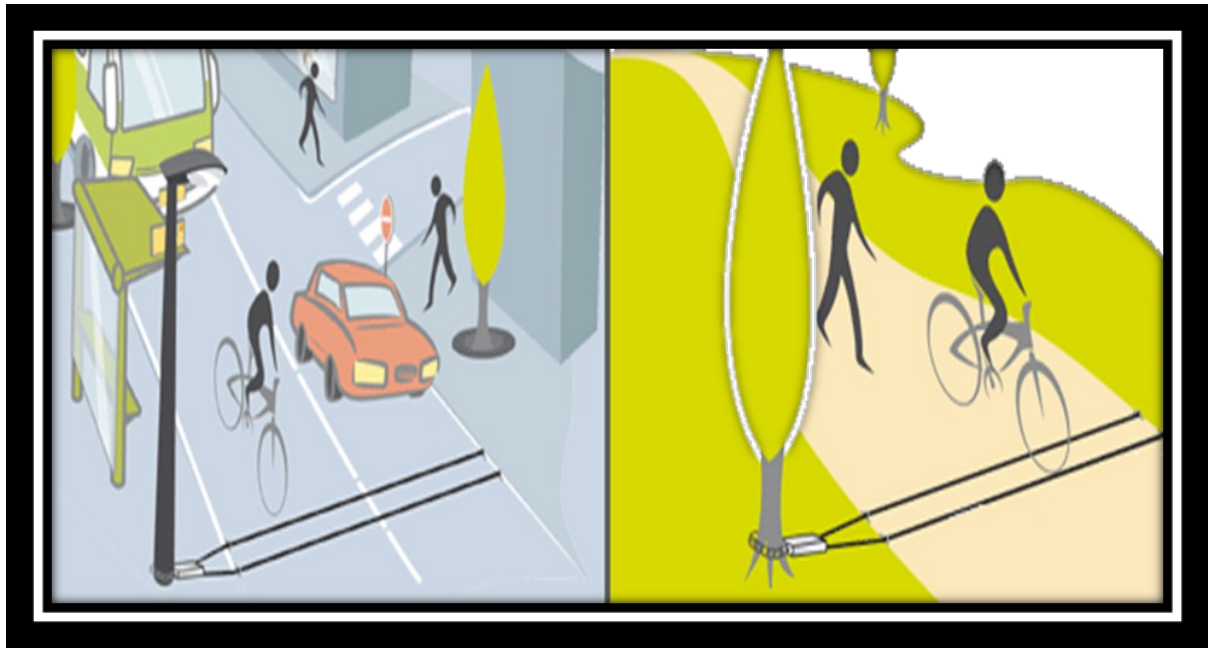


Figure 3-9 Pneumatic tubes [6]

### 3.1.1.3 Magnetometer sensors

The basic magnetometer consists of a sensor which produces a signal that is proportional to the strength of the magnetic field around it as it is shown in Figure 3-3. Another type of magnetometer uses a device called a fluxgate sensor. The fluxgate consists of a magnetic core which is periodically hard saturated by a first coil (much like the proton liquid), while a second coil senses the resulting electromagnetic field.

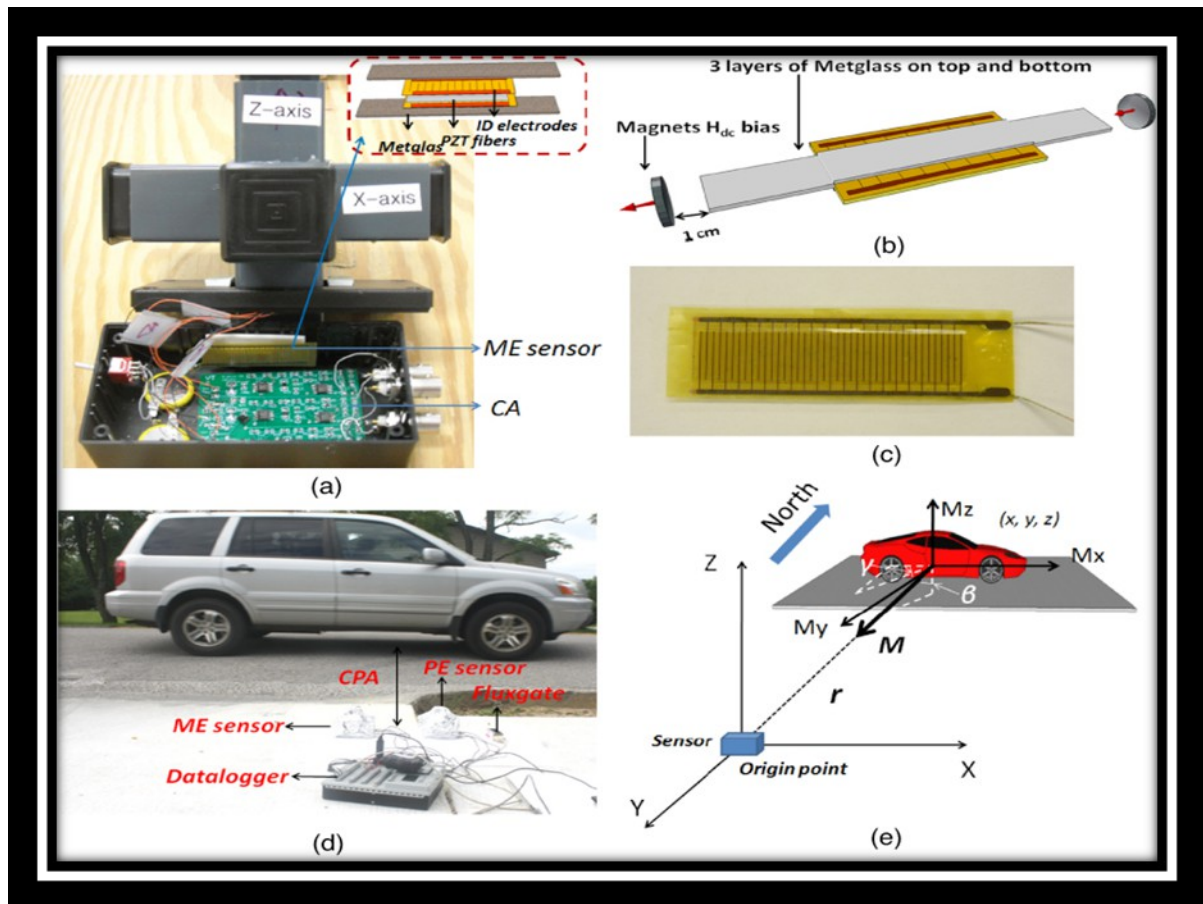


Figure 3-10 Magnetometer sensors [7]

#### 3.1.1.4 Magnetic sensors

In the magnetic methods of car detection, the disturbance in the earth's magnetic field caused by cars is measured and used to detect cars. This is shown in Figure 3-4, the middle part of Figure 3.4 shows the magnetic field produced by a metal car and the right side of Figure 3-4 shows the effect of this to the earth's magnetic field. The equation for it is shown in the following:

$$B_z = B_z^s + \Delta B_z \quad (2)$$

where  $B^z$  is the field produced by the isolated coil and  $\Delta B$  is the field change caused by the layered system [44].

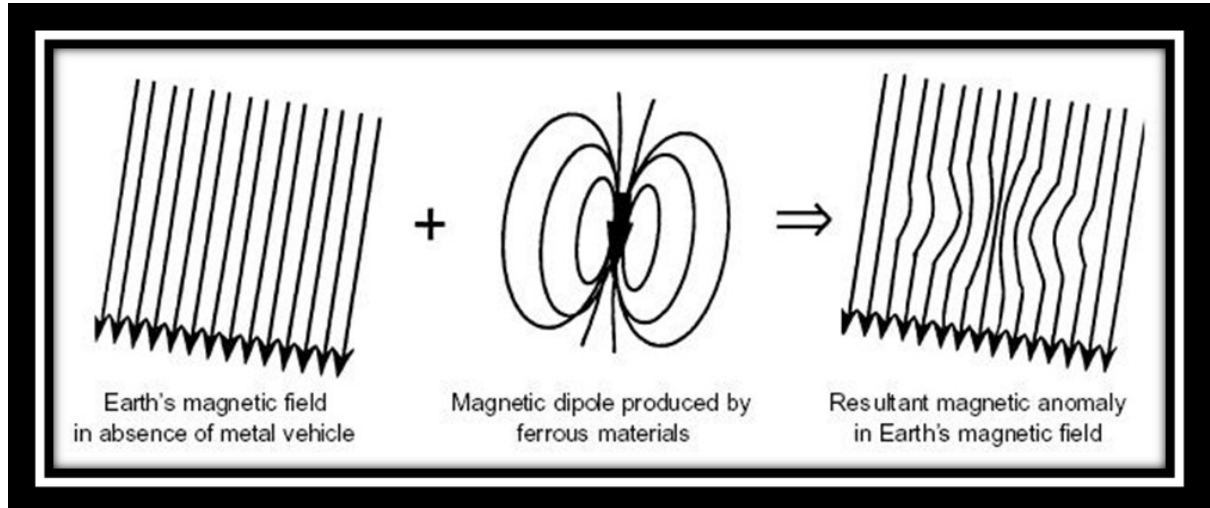


Figure 3-11 The difference a metal object makes to the earth's magnetic field [8]

### 3.1.1.5 Weigh-in-motion (WIM)

WIM consists of a piezoelectric sensor laid in a channel across the road. It can be used in specific locations for enforcement or access control. It is always combined with other systems, either intrusive or non-intrusive, to provide additional cross-checks on collected data [45].

Figure 3-5 shows that WIM detector consists of (bending-plate' or fiber-optic).

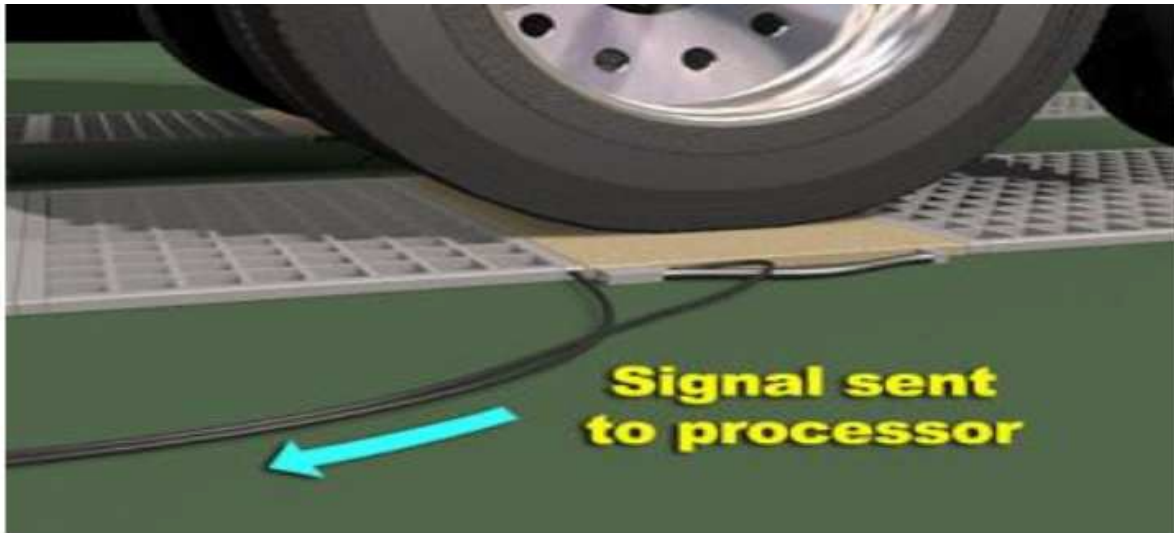


Figure 3-12 Weight in motion detector system [9]

### 3.1.2 Non-intrusive sensors

The installation and maintenance of non-intrusive sensors do not affect the road on which they monitor. This means that cars can still travel past the road on which they will monitor while they are being installed or modified. Types of non-intrusive sensors include microwave radar, passive acoustic array, passive infrared, RFID, and ultrasonic sensors. An image from a video camera can also be used to detect cars [46].

#### 3.1.2.1 Microwave radar

Microwave radar sensors emit an electromagnetic signal that has a frequency between 1-30 GHz and detects objects through their reflection of the signal as shown in Figure 3-6. It is better than other sensors in rainy weather since it is not affected by the rain as much as other sensors would be. It can detect vehicles travelling across multiple lanes and calculate the speed at which they travel. However, without an additional sensor a microwave radar sensor cannot detect stationary vehicles [47].

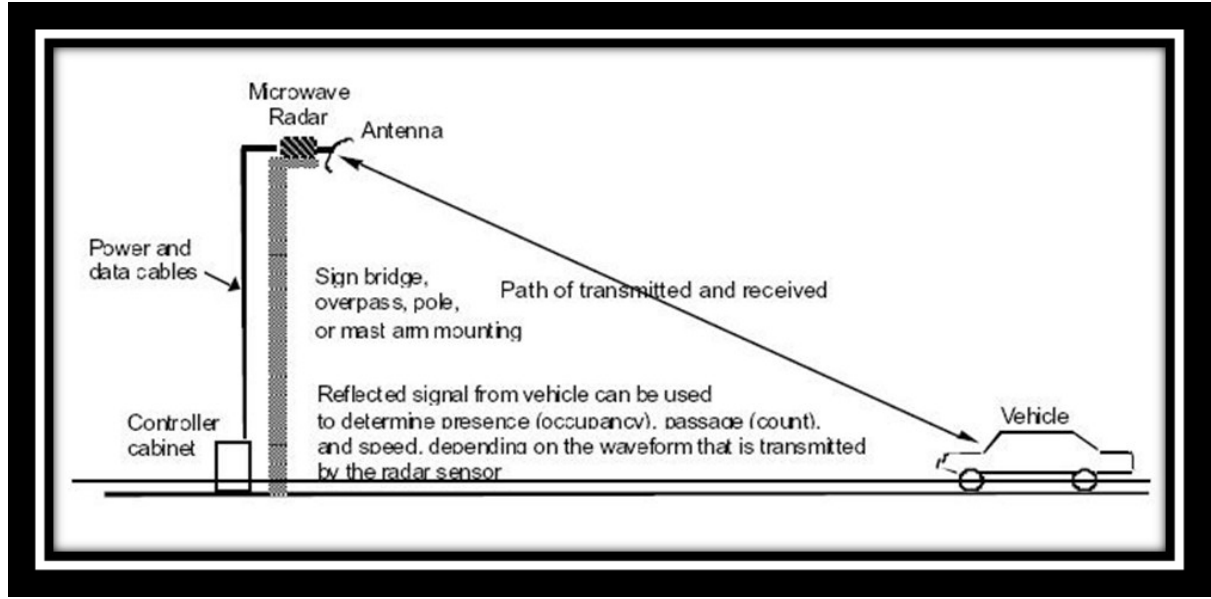


Figure 3-13 Explanation of the operation of a microwave radar sensor [4]

### 3.1.2.2 Active infrared sensors

Vehicles are detected using active infrared sensors in the same way as the microwave radar through the reflection of an electromagnetic signal. Infrared signals have a much lower frequency than microwave and are more sensitive to environmental conditions such as fog or snow. An infrared sensor can emit multiple beams to detect the position and speed of cars passing by more accurately [48].

### 3.1.2.3 Ultrasonic sensors

Ultrasonic sensors work in the same principle as microwave radar sensors. Their frequency is above a human's hearing range, between 25 and 50 kHz.

$$p_{(x,w)} = \frac{-i_{wp}}{2\pi} \int_S^1 v_z(y,w) \frac{\exp(i_{kr})}{r} d_S(y) \quad (3)$$

Where  $\rho$  is the density of the fluid,  $\omega$  the angular frequency,  $v_z$  the velocity in the z-direction and  $r = |x - y|$  is the distance between the evaluation point  $x$  and the source  $y$  on the surface of  $S$ . An example of such a sensor is shown in Figure 3-8 Shows a picture of a typical ultrasonic system setup [49].

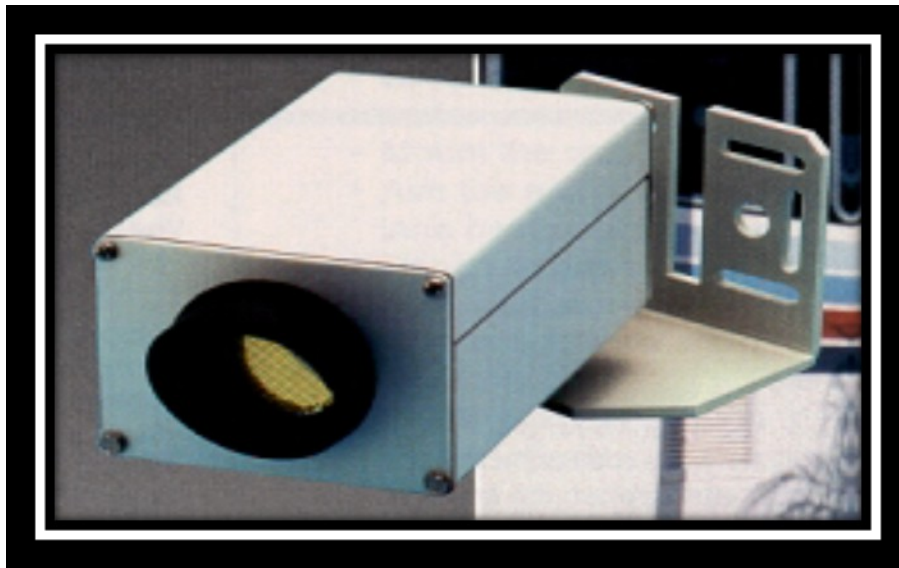


Figure 3-14 Ultrasonic sensors [10]

#### 3.1.2.4 Video image processing

One or more cameras are used for video image processing. Software is needed to process the images taken by the cameras. This processing is usually done by examining the difference between consecutive video frames. The area that a camera scans can be easily changed. Figure 16 shows the detection distance at which a VIP can differentiate two closely spaced vehicles along the surface of a road is a function of camera mounting height, inter-vehicle

distance or gap, and vehicle height. The maximum detection distance  $D_{max}$  along a roadway without a grade is given by

$$(4)$$

Where,  $h$  = camera mounting height,

$veh_{gap}$  = inter-vehicle gap, and

$veh_{height}$  = vehicle height.

Other factors to be considered when installing cameras used in VIP systems include:

- Vertical and lateral viewing angles,
- Number of lanes observed,
- Stability with respect to wind and vibration, and
- Image quality [50].

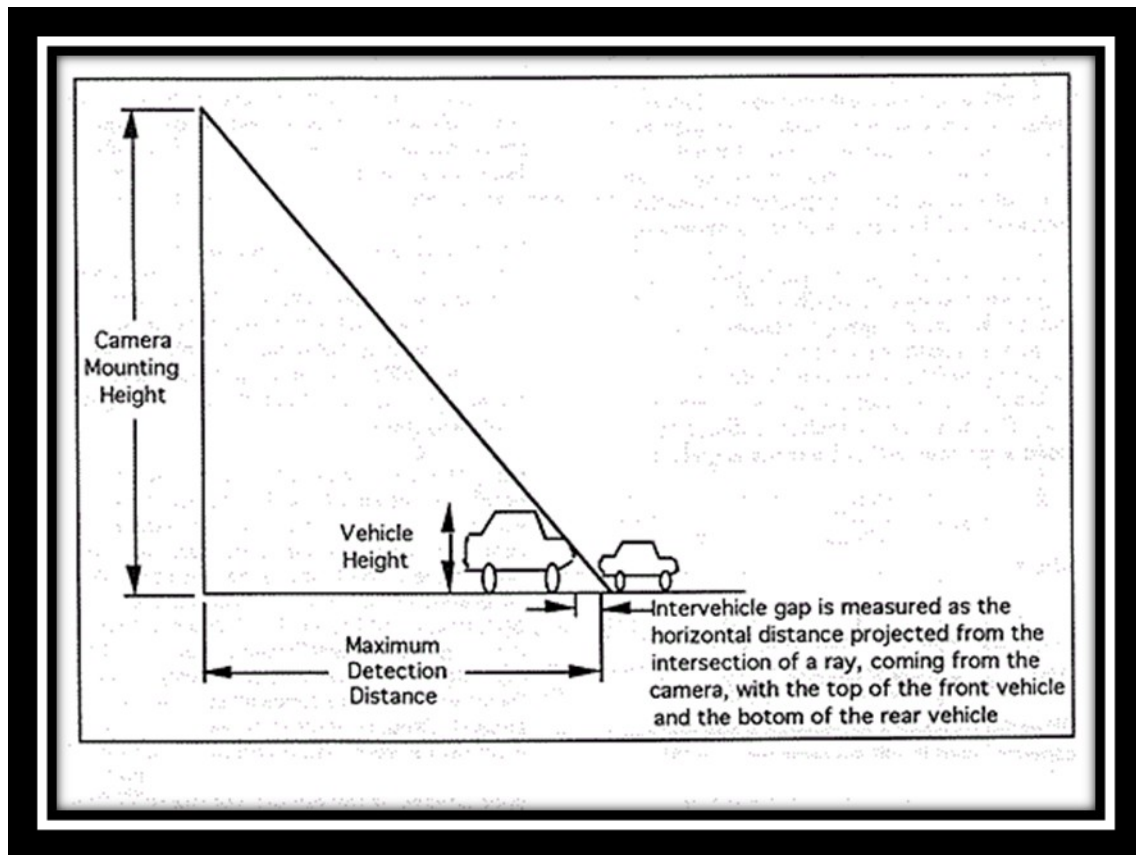


Figure 3-15 Video image processor line of sight detection geometry [11]

Table 3.1 shows the strengths and weakness of intrusive and nonintrusive sensor technologies [19]

Table 3.1 The strengths and weakness of intrusive and nonintrusive sensor technologies

Sensor Type	Strength	Weakness
Magnetometer	Some types support wireless radio making them portable Can handle difficult traffic conditions	Lanes need to be closed whenever they're installed or maintained as pavement is cut. This cut decreases the lifetime of the pavement
Magnetic	Some types do not need a cut in the pavement and can be placed where inductive loops cannot Can handle difficult traffic conditions	Cannot detect vehicles that are stationary Either pavement needs to be cut or a tunnel made under roadway
Inductive Loop	Can detect the volume of traffic, gaps between cars and the presence of stationary vehicles Technology being used for a long time so manufacturers have much experience. Due to this there are many designs that can be used in various applications	Often requires more than one device to detect cars at one location Traffic problems and temperature can affect readings Pavement needs to be cut to install (same problem as magnetometer)
Microwave Radar	Can detect vehicles travelling on several lanes of traffic and their speed Not usually affected by bad weather	Stationary vehicles cannot be detected
Ultrasonic	Able to detect vehicles on more than one lane	Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles travelling at moderate to high speeds. Some environmental conditions such as temperature change and extreme air turbulence can affect performance. Temperature compensation is built into some models.
Infrared	Multiple lane operation available. Multizone passive sensors measure speed. Active sensor transmits multiple beams for accurate measurement of vehicle position, speed, and class.	Passive sensor may have reduced sensitivity to vehicles in its field of view in rain and fog.
Video image processor	Easy to add and modify detection zones. Provides wide-area detection when information gathered at one camera location can be linked to another. Rich array of data available. Monitors multiple lanes and multiple zones/lane.	Inclement weather, shadows, vehicle projection into adjacent lanes, occlusion, day-to-night transition, vehicle/road contrast, and water, salt grime, icicles, and cobwebs on camera lens can affect performance. cost-effective if many detection zones are required within the field of view.

### 3.2 Signal processing device

The signals emitted by sensors need to be converted to a digital form that the computers that process their signal can use. Many modern sensors have components that process the data

into various outputs that a computer can use. Often several sensors may be connected to a microcontroller, a mini computer that takes in their data and sends it to the computer that processes the information [21],[23].

### ***3.3 Data processing devices***

The data taken from all the sensors needs to be processed by a central computer and then converted into data that can be shown to drivers. This data would include information such as the available car parks in a section of the car park and how to guide a vehicle to an available car park for systems that provide guidance [24],[25].

## Chapter 4: Proposed method

This chapter describes the use of a car parking management system in many scenarios in Palmerstone North and the Massey University car park.

The video image technique has five modules [12], they are shown in Figure 4-1

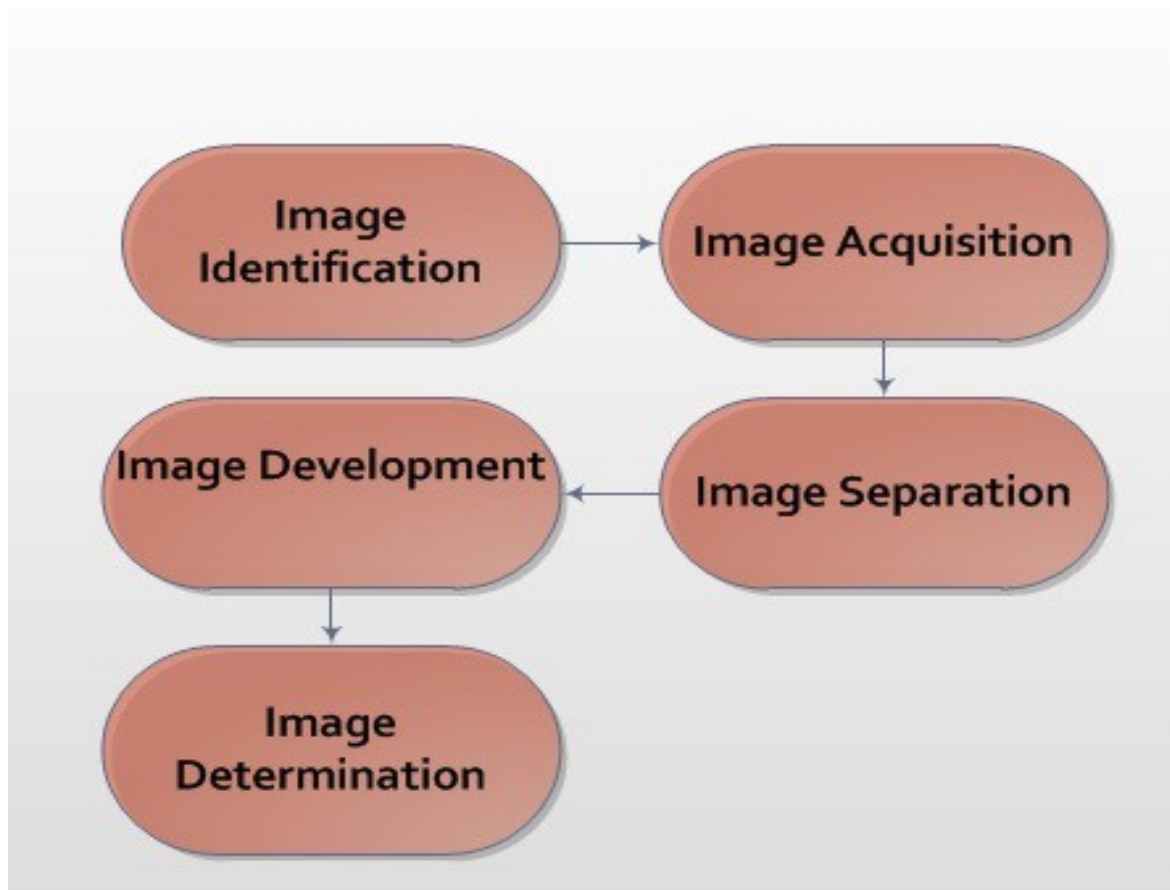


Figure 4-16 system module

### ***4.1 Case study for four car parks in three different conditions***

Most car parks today are not run efficiently. This means that on busy days drivers may take a long time driving around a car park in order to find a free parking space. There are numerous methods of detecting cars in a car park such as Magnetic sensors, Microwave Radar, Ultrasonic sensors and image processing. This project describes the process of determining

the presence of cars at car spots from a camera image at the Massey university car park. There are two different methods of implementing this system: either applying point detection with the canny operator method or applying the edge detection with the boundaries condition method for image detection module. In this project Matlab is used as software. A row at the Massey car park is shown in Figure 4-2

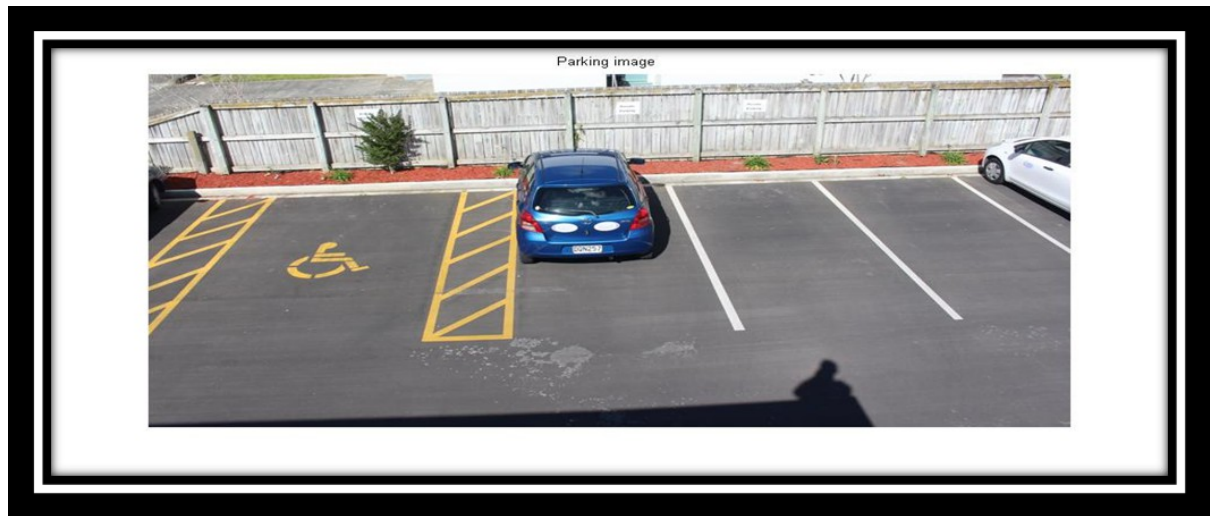


Figure 4-17 Parking image

The images were all taken in different times and different conditions as they are shown in Table 4.1.

Table 4.2 Experiment for four car parks in three different conditions

No of EXP	Date	Time 7am-5pm	Condition	Total Of Car Park
1	16/6	10	Sunny	4
2	19/6	11	Cloudy	4
3	27/6	8	Rain	3
4	4/7	12	Sunny	4
5	5/7	3	Cloudy	4

6	9/7	9	Rain	3
7	15/7	7	Sunny	4
8	19/7	12	Rain	3
9	20/7	4	Cloudy	4
10	27/7	2	Rain	3
11	4/8	10	Cloudy	4
12	6/8	1	Sunny	4
13	9/8	5	Sunny	4
14	11/8	2	Rain	3
15	15/8	8	Cloudy	4
16	20/8	3	Cloudy	4
17	25/8	11	Rain	3
18	1/9	5	Sunny	4
19	3/9	1	Cloudy	4
20	9/9	9	Sunny	4

#### 4.1.1 Processing of template images

The aim of this project is to detect the existence of any car in each park slot. It is required to prepare a template image which shows the location of each parking slot. The Processing of preparing a template Image technique has five steps [13] as they are shown in Figure 4-3.

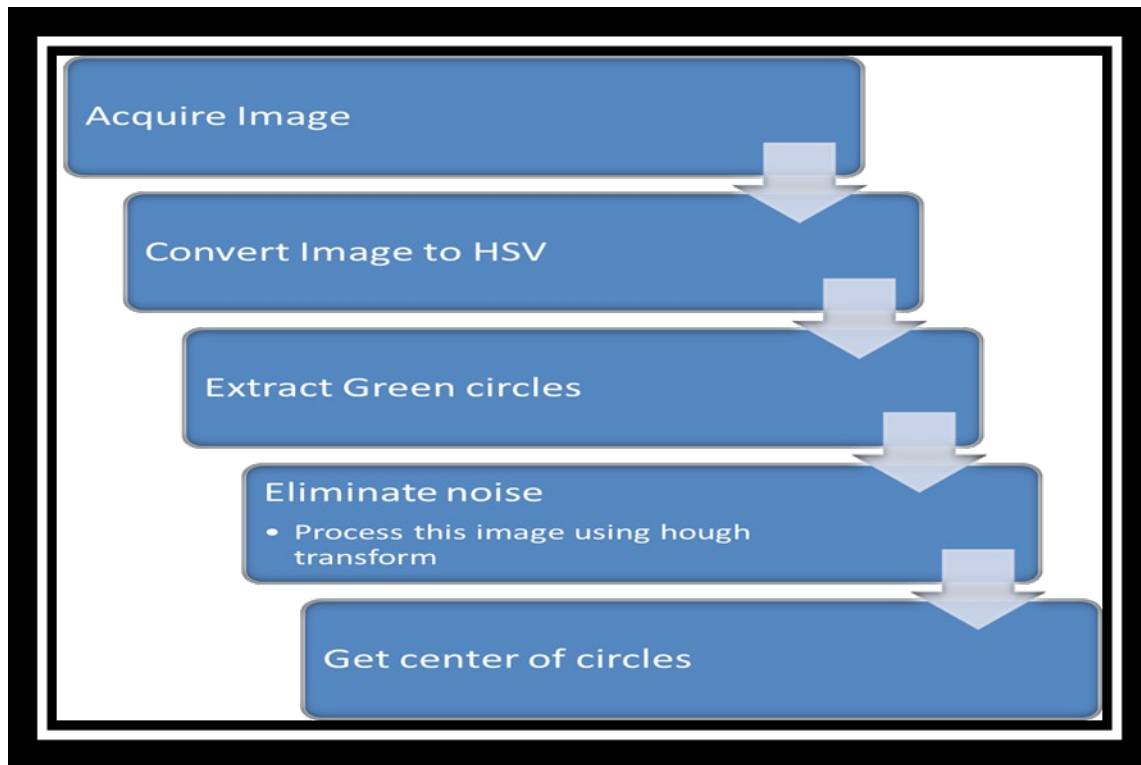


Figure 4-18 Processing steps of template image

#### 4.1.1.1 Acquire image

First an image of the car park could be taken when there are no cars in the car park as is shown in Figure 4-4. This would be used for the system to record the location of all the car parks. The RGB value can be used to find where green circles are that represent empty car spaces. With these the system will know where to look for cars in the future.



Figure 4-19 Template image

#### 4.1.1.2 Convert image to HSV

For the empty car park, to get the location of the green dots, the image is converted into an HSV image as is shown in Figure 4-5. This is done through using the 'rgb2hsv' command in Matlab.

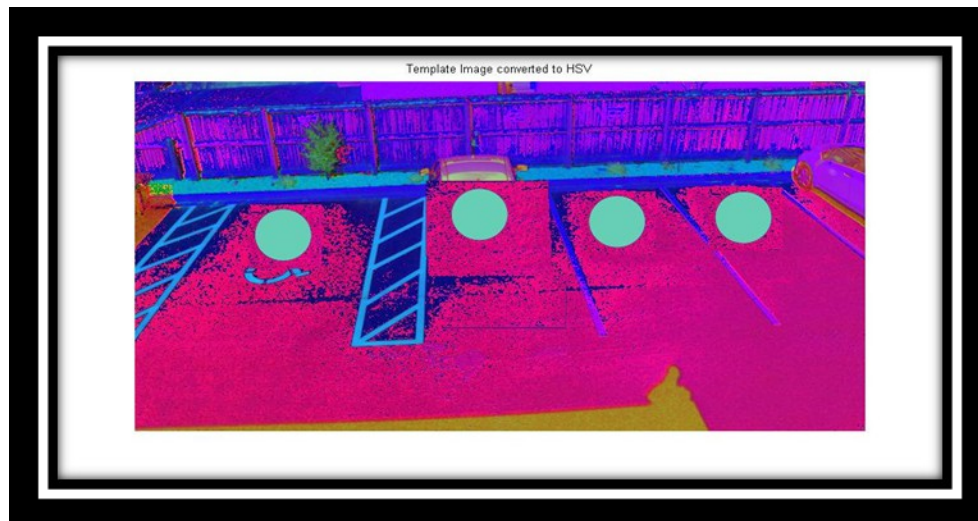


Figure 4-20 Template image converted to HSV

#### 4.1.1.3 Extract green circles

Green circles can be extracted by choosing certain values of pixels H, S and V.

In this case a range of pixels is set so that pixels in this range will be extracted.

#### **4.1.1.4 Circle detection**

The circle detection processes require the Hough transform. The Hough transform is a feature extraction technique that will be used to extract the circles, their radii, along with their centres.

#### **4.1.1.5 Red pixels**

First of all the red segment of the image is extracted because as we know, red pixels are the most powerful segment of the image as it is shown in Figure 4-6.

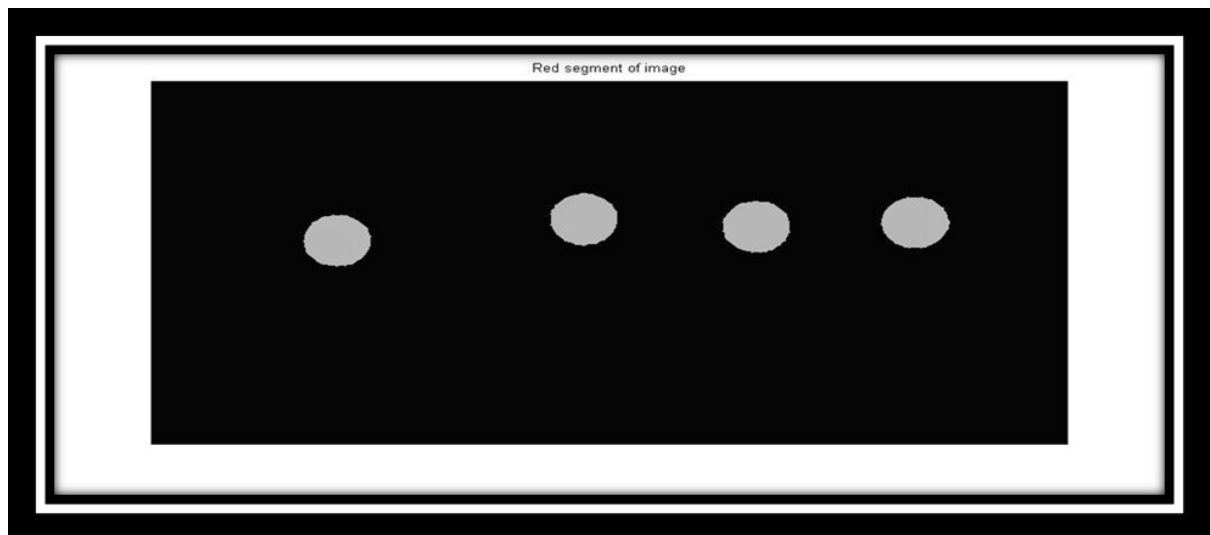


Figure 4-21 Red segment of image

#### **4.1.1.7 Eliminate noise**

If there are objects in the environment that have the same value of red pixels that will be displayed in the extracted image as well. This will be noise for the extracted image and may create an inaccurate result to be obtained when using the Hough Transform. Therefore, parts that do not match the shape of the dot or circle that is being looked at should be trimmed away.

#### 4.1.1.8 Circle detection using hough transform

The process of circle detection is shown in the following points:

- Create a accumulator space relative to the pixels and set these values to the zero
- For each edge, increment all values according to the circle equation
$$((i-a)^2 + (j-b)^2 = r^2) \quad (5)$$
- This will give the variable 'a' in the equation
- Now for all possible values of 'a' find the values of 'b' which satisfy the equation
- Search for local maxima. These are the points which have higher probability than others
- These maxima are the location of the circles
- Draw a circle using rect command in matlab to obtain Figure 4-7.

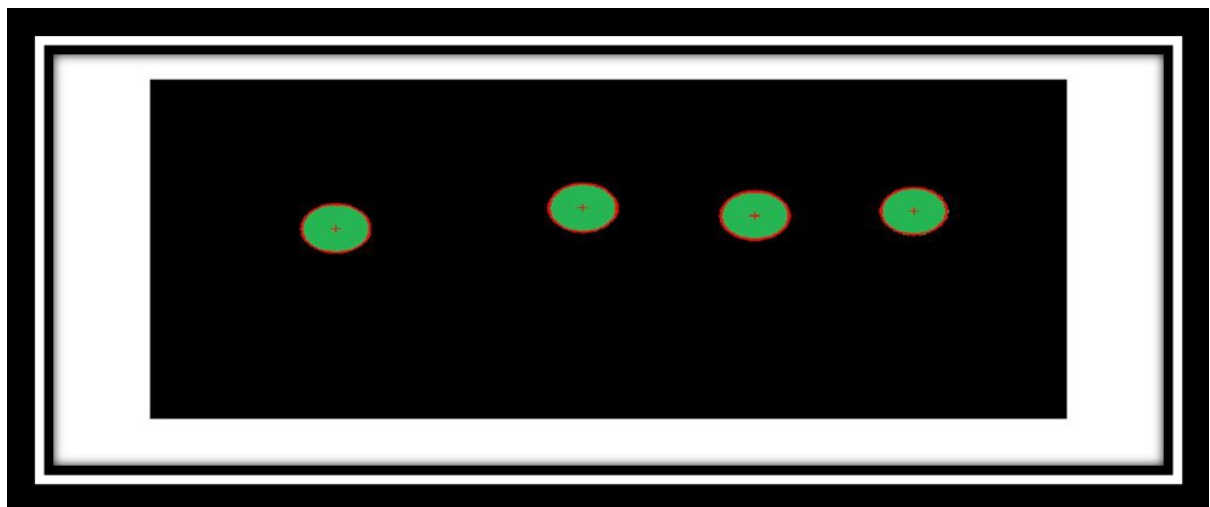


Figure 4-22 The green circle, showing their centre and middle obtained from circle detection

### 4.1.2 Processing of template images

There are many ways to differentiate different objects and extract them but all the processes have their limitations. A process considered here is back ground eliminations. As many car parks have the same road which here is defined as its background. The background can be extracted and hence objects like cars can easily be detected. The Processing of Edge Image technique has five steps [13] as they are shown in Figure 4-8.



Figure 4-23 Processing steps of edge images

#### 4.1.2.1 Converting to HSV

First the image is converted to HSV because it is easy to differentiate different coloured pixels in HSV space. In the Figure 4-9, it can be clearly seen that the red looking colours are back ground.

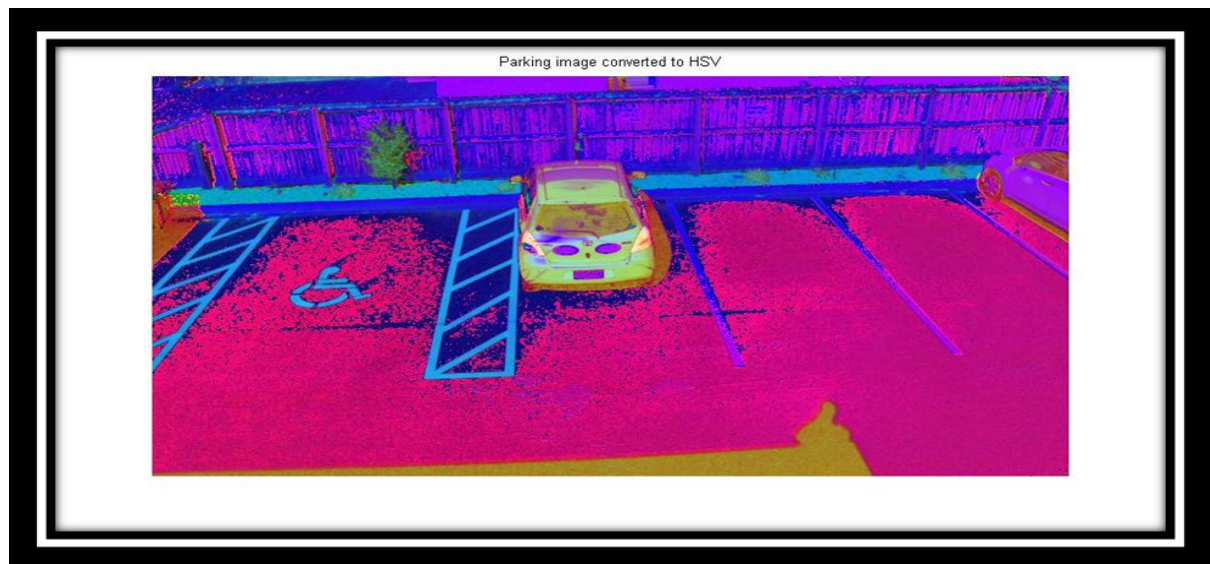


Figure 4-24 Parking image converted to HSV image

By looking at the pixels in the Figure 4-10 it becomes clear that pixels for the background fall within a specified range of colours. By executing the following code, the background can be obtained.

```
hue = (Img_HSV(:,:,1) >= 0) & (Img_HSV(:,:,1) <= .9);

saturation = (Img_HSV(:,:,2) >= .01) & (Img_HSV(:,:,2) <= .1);

value = (Img_HSV(:,:,3) >= .2) & (Img_HSV(:,:,3) <= 0.55);

Temp = uint8(hue & saturation & value);

Temp = imclose(Temp, strel('disk', 5));

Red_pixel = Temp .* Org_Img(:,:,1);

Green_pixel = Temp .* Org_Img(:,:,2);

Blue_pixel = Temp .* Org_Img(:,:,3);

Color_Img = cat(3, Red_pixel, Green_pixel, Blue_pixel);
```

```
figure,imshow(Color_Img)
```

```
title('color segmented image')
```

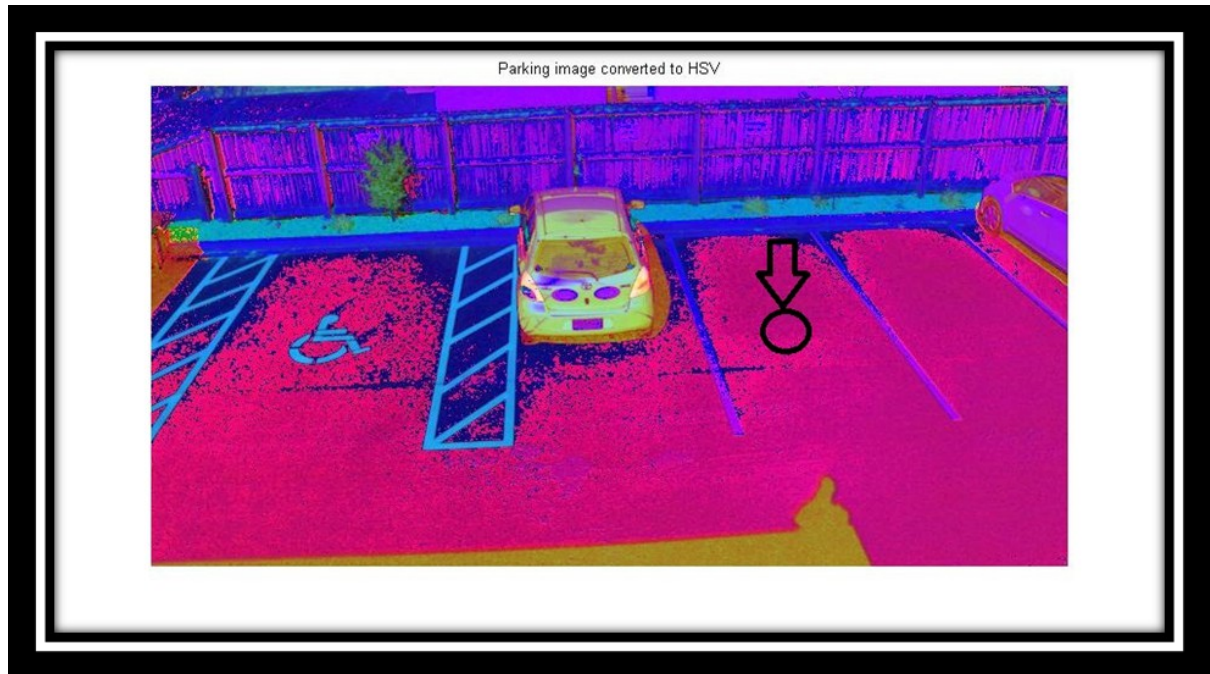


Figure 4-25 HSV image showing how the background can be clearly found by looking at the red value

The object is eliminated In the Figure 4-11



Figure 4-26 Colour segmented image

The image is converted to a grey image as shown in Figure 4-12



Figure 4-27 Grey segmented image

#### 4.1.2.2 Morphological processing

This is non-linear process which is related to shape and morphology of image. It is relative to ordering of pixel value not their numerical values as it is shown in the Figure 4-13

```
se=strel('disk',2);
```

```
I=imopen(Gray_img,se);
```

```
disp('Morphological process completed')
```

```
figure,imshow(I)
```

```
title('Image after Morphological process')
```

```
% I=imfill(I,'holes');
```

```
% se=strel('disk',5);
```

```
% I=imopen(I,se);
```

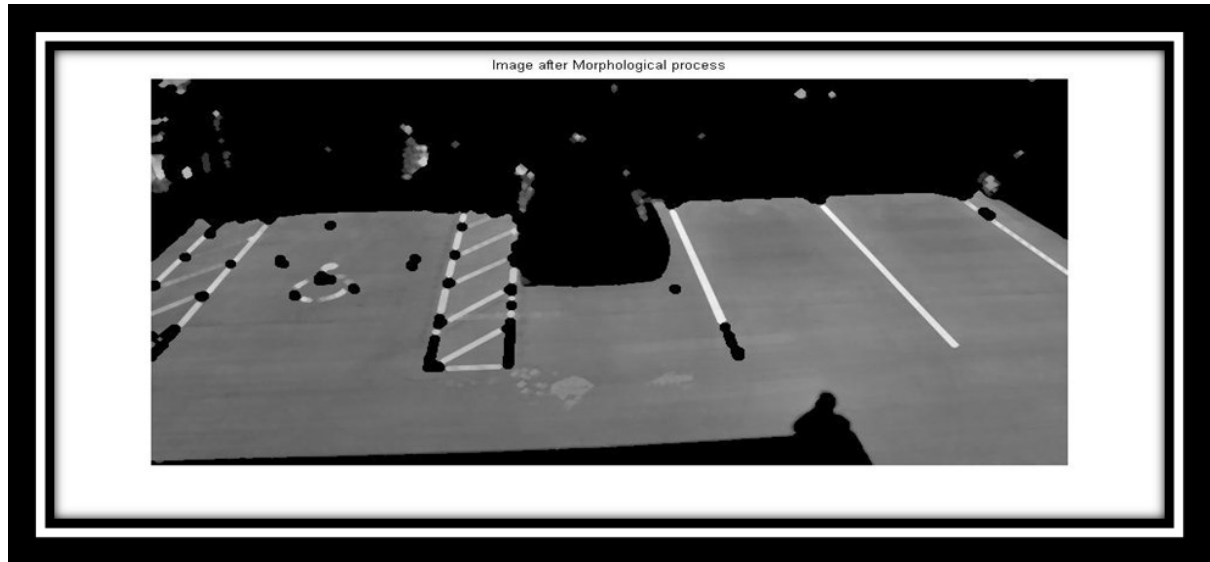


Figure 4-28 Images after morphological process

Then the image is converted to binary image as it is shown in the Figure 4-14.



Figure 4-29 Binary image

### 4.1.3 Processing for decision

The images of both the car parking template and the car park are now processed. The Car parking template image contain the locations of car parking in the lot as a circle and the information about circle radius and its centre is also known. The car park image after its processing now contains road images and has eliminated any other objects.

An algorithm is set to check whether at a particular parking lot an object is present or not. It can be simply checked by seeing the pixel value at a particular parking lot. For example as it is seen in the Figure 4-15 ,the first image pick a circle and see it's relative position to the second image, if the second image contains a white space then the parking lot is empty if it contains a black pixel then the space is occupied.



Figure 4-30 picking a circle and relative position

#### 4.1.3.1 Drawing the empty space

In this algorithm free parking lot is calculated it can be drawn simply be drawn using rectangle command in mat lab as it is shown in the Figure 4-16

```
figure,imshow(Org_Img);
```

```
hold on;
```

```

% plot(circen(:,1), circen(:,2), 'r+');

i=1;

for ii = 1 : size(circen, 1)

    if (I(round(circen(i,2)),round(circen(i,1))))~=0)

        rectangle('Position',[circen(ii,1) - cirrad(ii), circen(ii,2) - cirrad(ii), 2*cirrad(ii),
2*cirrad(ii)],...

        'Curvature', [0.8,0.4], 'edgecolor', 'b', 'linewidth', 1,'FaceColor','b');

    end

    i=i+1;

end

hold off;

disp('Displayed free parking lot')

```

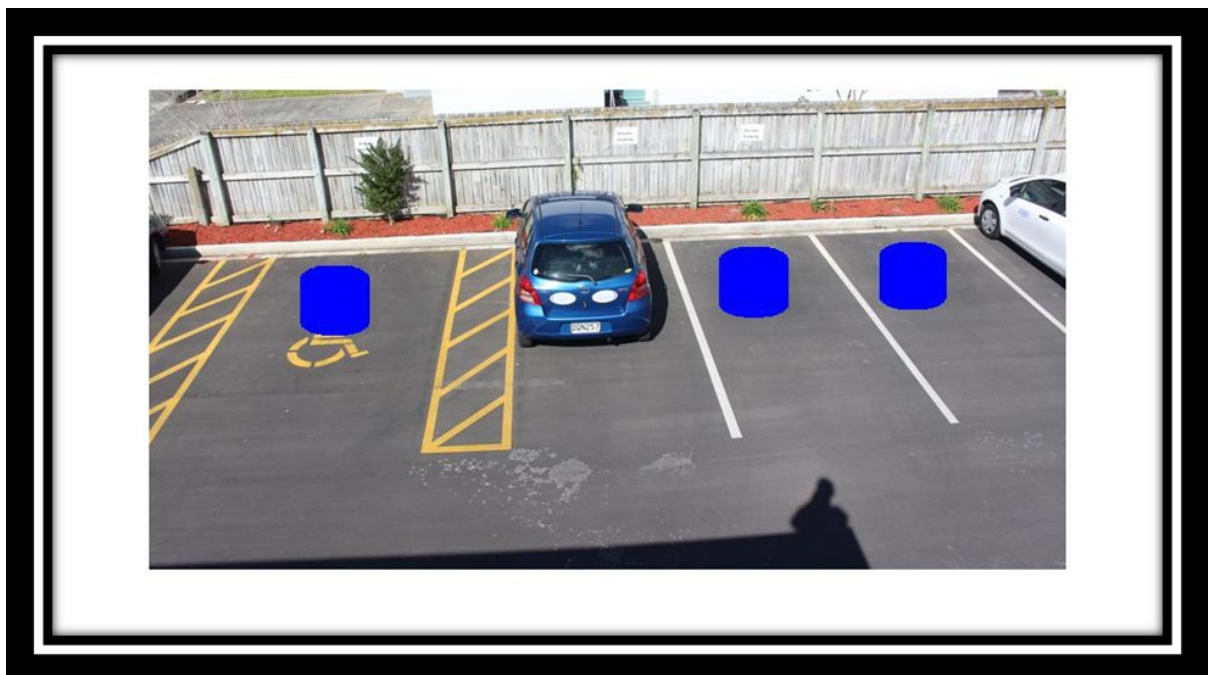


Figure 4-31 Available and occupied car slots

#### 4.1.3.2 Car park display (Monitor)

To test different scenarios of car parking for four parks, a program was made that generated car park positions which were empty and filled cars in different weather conditions. In this way, the graphical user interface could be tested with a differing number of cars parks in different positions. When the weather is cloudy the GUI will be as shown in Figure 16.

If the user wants to see what the car park would look like when it is raining. This would produce Figure 4-17.

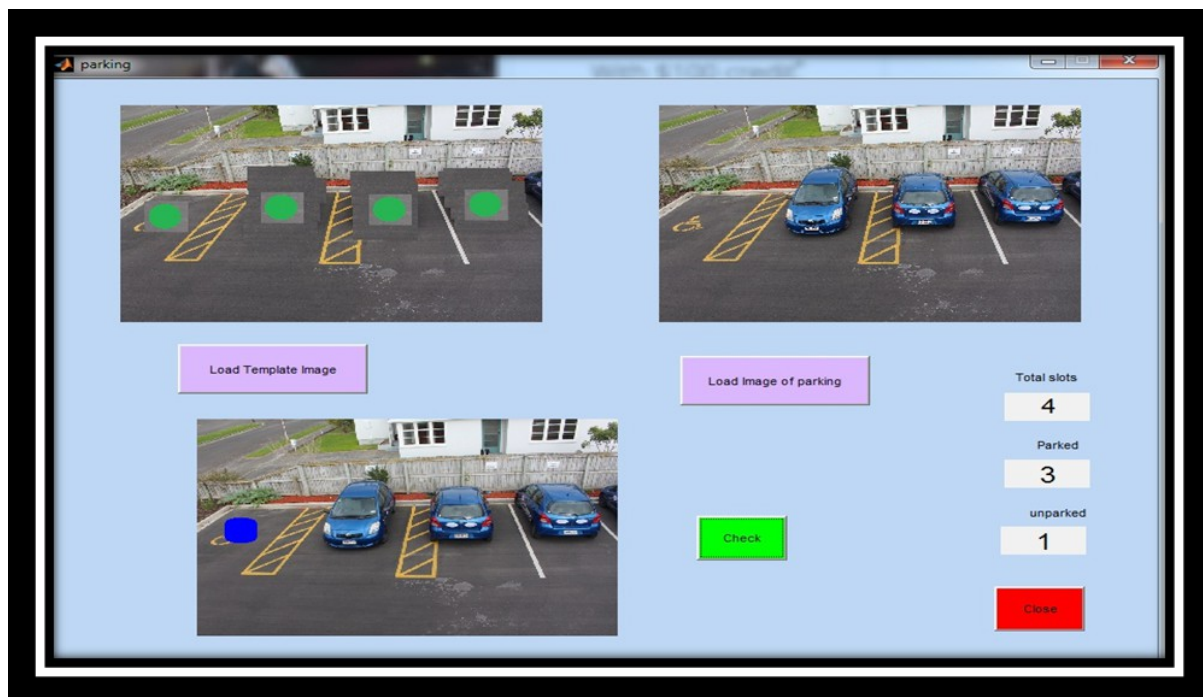


Figure 4-32 Cloudy Weather

If the user wants to see what the car park would look like when it is raining. This would produce Figure 4-18

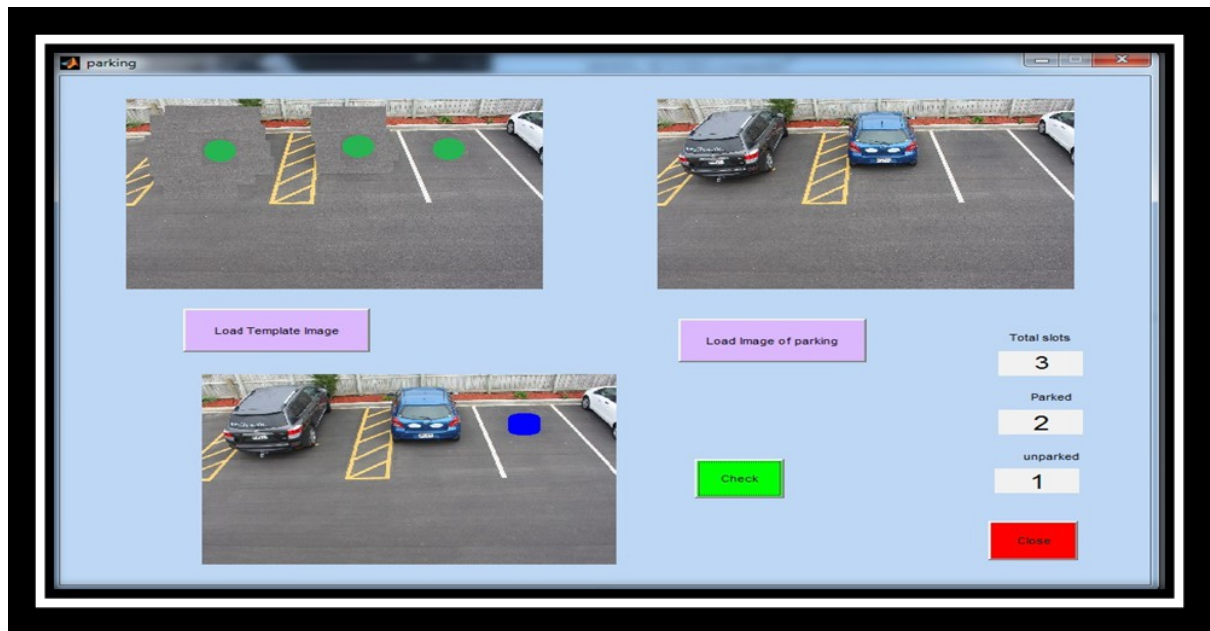


Figure 4-33 Raining weather

If the weather is clear the car park would look like as it produce in Figure 4-19

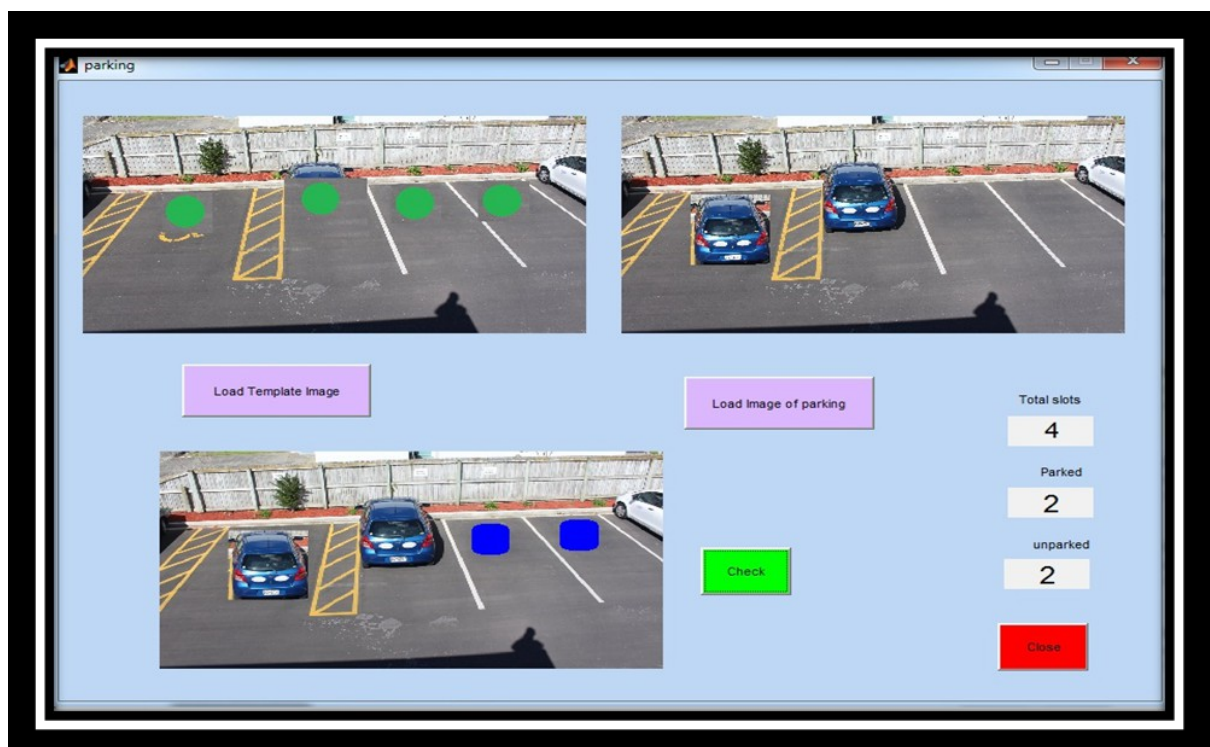


Figure 4-34 Sunny weather

#### **4.1.4 Conclusion**

A method of finding the availability of four parks has been presented. A Matlab program has been demonstrated that tests different scenarios which are cloudy, raining and sunny. A method of analysing an aerial view of the Template Images and Edge Images has been presented step by step. This consists of acquiring image , converting the image HSV, extracting green circles, circle detection, getting red pixels ,removing noise, applying morphological processing and determining whether car parks are vacant or filled [4].

### ***4.2 Case study for 30 car parks***

#### **4.2.1 System initialization**

First an image of the car park could be taken when there are no cars in the car park as in Figure 4-20. This would be used for the system to record the location of all the car parks. The RGB value can be used to find where green circles are that represent empty car spaces. With these the system will know where to look for cars in the future [13].

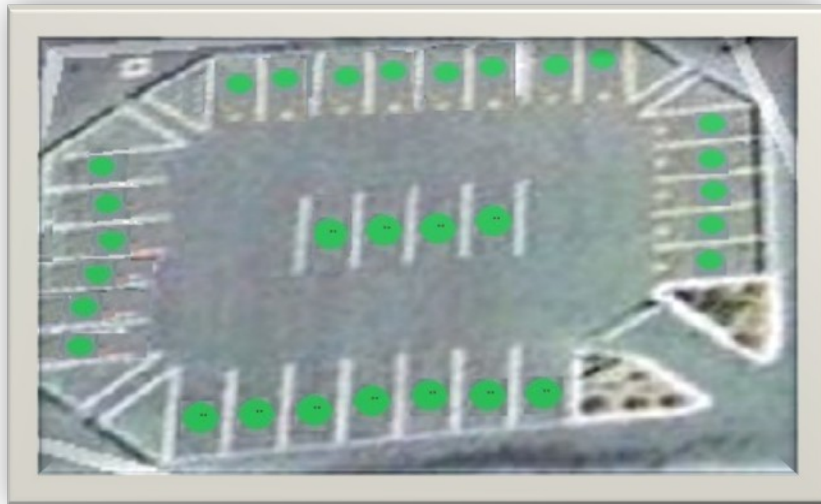


Figure 4-35 Empty car park used to initialize the location of car parks.

For the empty car park, to get the location of the green dots, the image is converted into an HSV image as is shown in Figure 4-21. This is done through using the `rgb2hsv` command in Matlab.

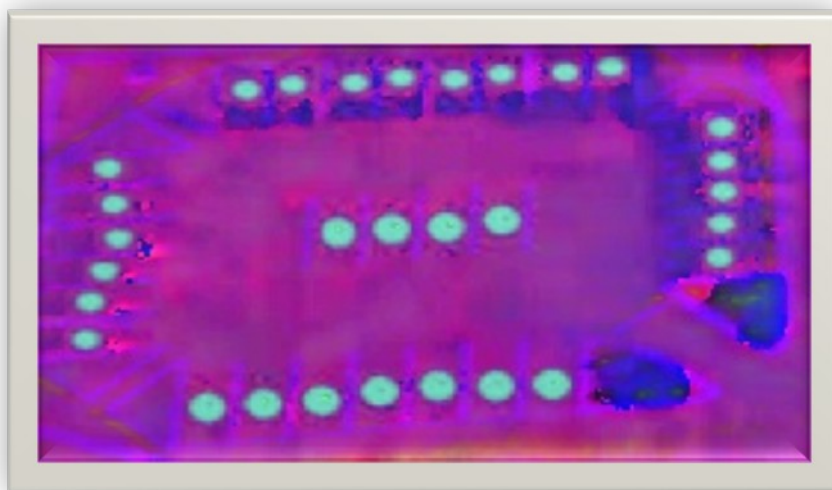


Figure 4-36 HSV image of empty car park.

This is simplified to a black and white binary image that is easier to deal with by making the pixels white where the threshold is more than 40%. In order to do this the HSV image needs to be converted to a grey scale format so that each pixel can be easily compared with the threshold as it is shown in Figure 4-22. [14] The equation to do this is shown in equation 6. The `rgb2gray` command is used to do this.

$$\text{Grey} = (0.299 * R + 0.587 * G + 0.114 * B) \quad (6)$$

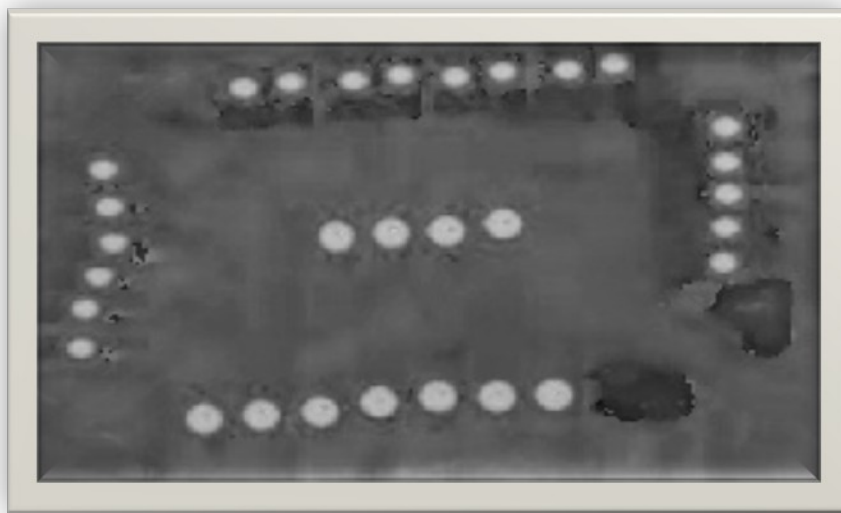


Figure 4-37 Grey scale format of the HSV image

As can be seen from Figure 4-23 the green circles are noticeably lighter than anything else in the image. Therefore the image can be easily converted to a black and white image by using `im2bw` command with the second argument being 0.4. This means if the pixel is less than the threshold the colour of it will be black. Otherwise it will be white [16].

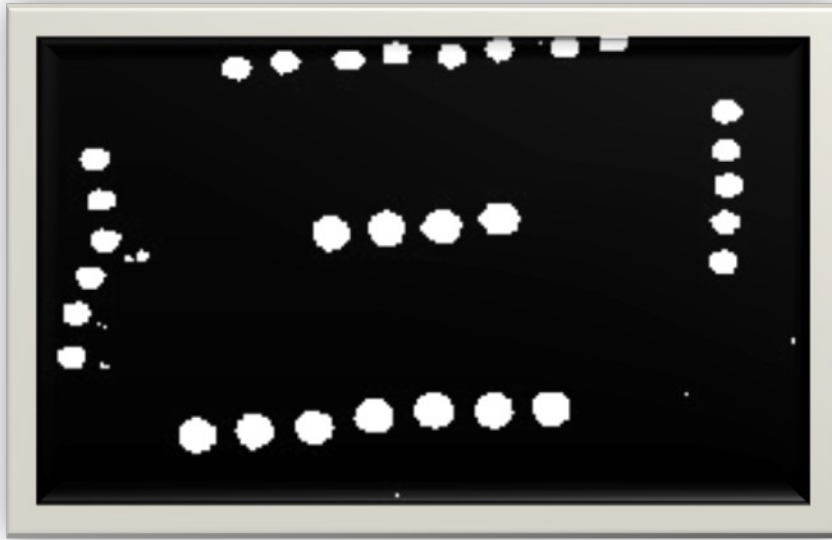


Figure 4-38 Black and White images for empty car park

As can be seen in Figure 4-23, there are some small white parts of the image. These can be removed by using the erode function as it is shown in Figure 4-24. The `imerode` command is used to remove the small dots in the image. The object used to erode the image was created through using the following command:

```
se3 = strel('disk', 3)
```

This creates a disc with a radius of three that is used by the erode function. The result of using this function is shown in Figure 4-24 [52].

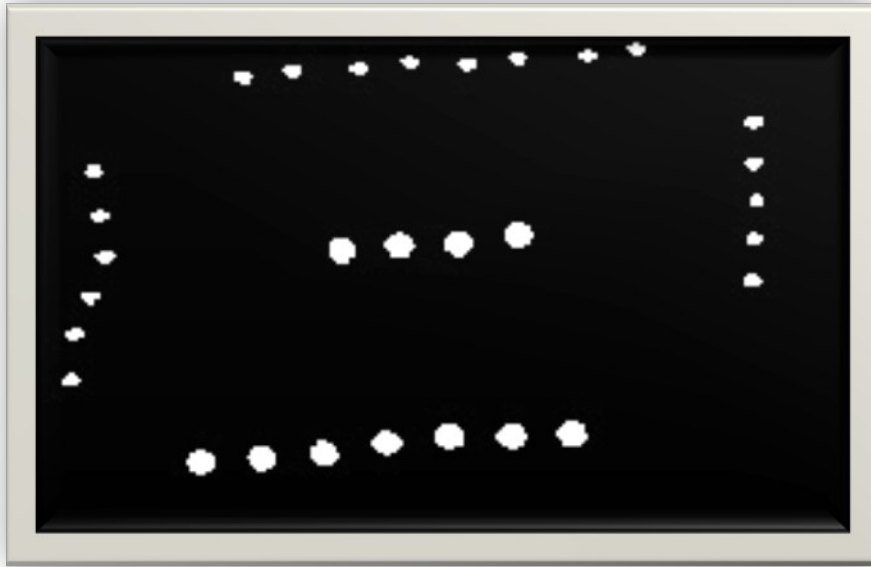


Figure 4-39 Eroded image for empty car park.

The `bwlabel` command is used to give different values to separate objects. For example the first object is composed completely of 1s and the second of 2s. As a result an image can be created with different colours for each object as shown in Figure 4-25 [18]. In order to find the coordinate of each car park, represented by the green circles, the top, bottom, left, and right edges needed to be found. In order to find the left edge of each object the program starts to the top left corner and goes down column by column. When a value greater than zero is reached, then a matrix that stores all the left edges is queried to find whether that an object has been detected already. The matrix, named 'e', stores the edges by using the index specified by the `bwlabel` function mentioned previously. Therefore if at the index indicated by pixel itself, an 0 is present, then that object has not been seen before. In this case, the x current coordinate is stored as the left edge of the object. The following code shows how this is done:

```
if (newmatrix(y,x) > 0) %an object is there

    if (e(newmatrix(y,x)) == 0) this object has not been seen
```

```

e(newmatrix(y,x)) = x; make the value and index 3 equal to the current X
coordinate.

end

end

```

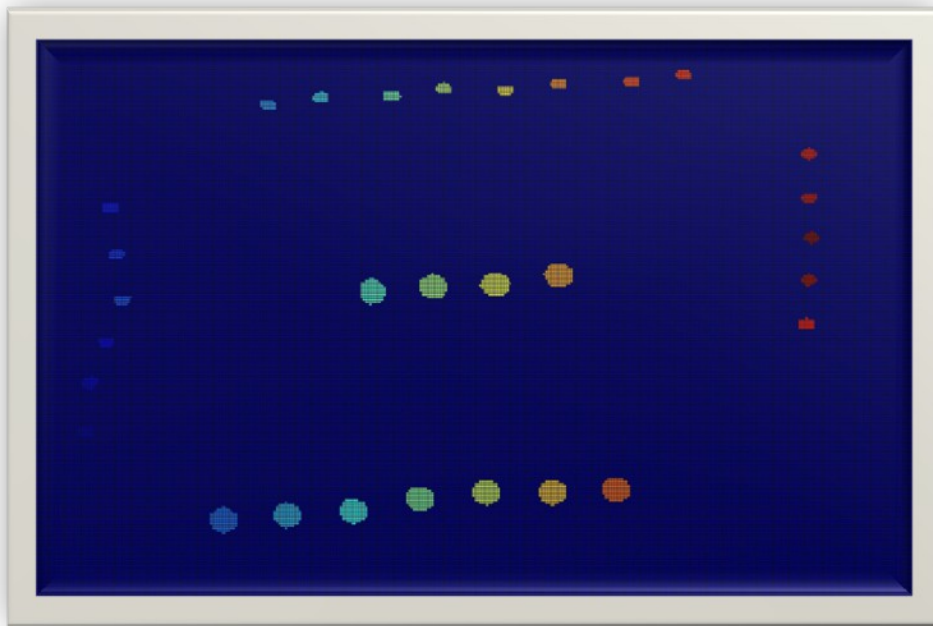


Figure 4-40 Empty car park showing different colours for each object.

These coordinates will be used when analysing an image with cars in it as described in the following sections [53].

The values of the coordinates are divided by 1.5 times the average diameter of each dot. Each of these car parks slots is given the same value and are displayed in a pcolor chart as shown in Figure 4-26.

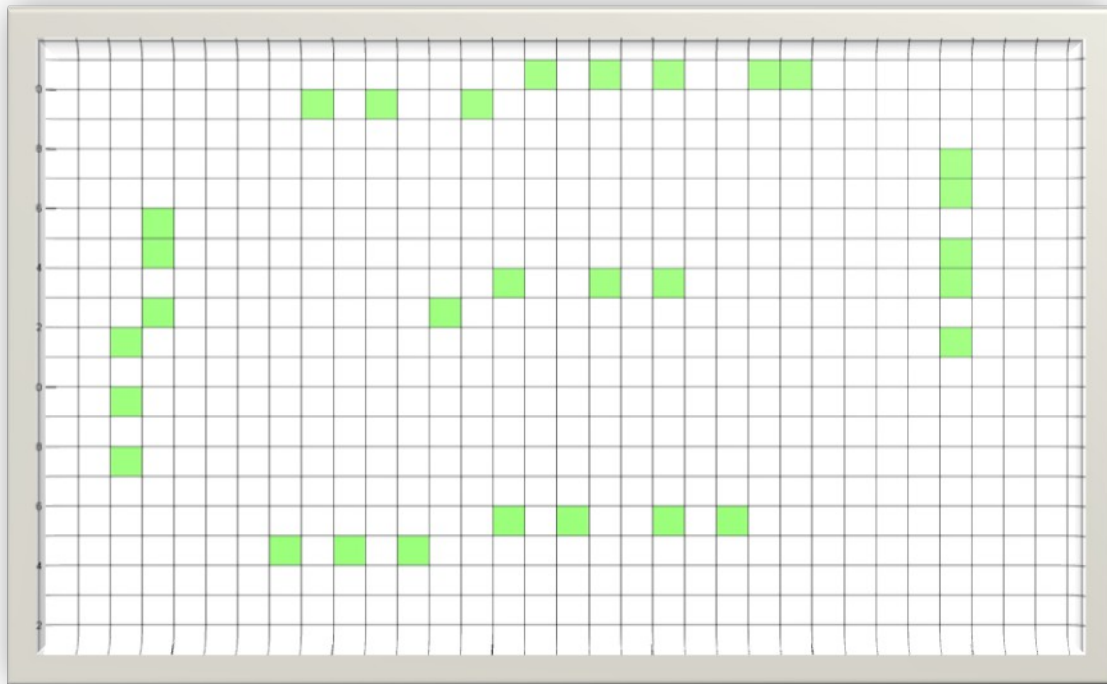


Figure 4-41 Output for empty car park

### 4.2.2 Image acquisition

A camera placed at a fixed position above the cars will be used to acquire the image used to calculate the vacancy of the car parks. This camera should be in a position where it can clearly see all the car parks and not be obstructed by any objects. Figure 4-27 shows an example of what an image may look like.

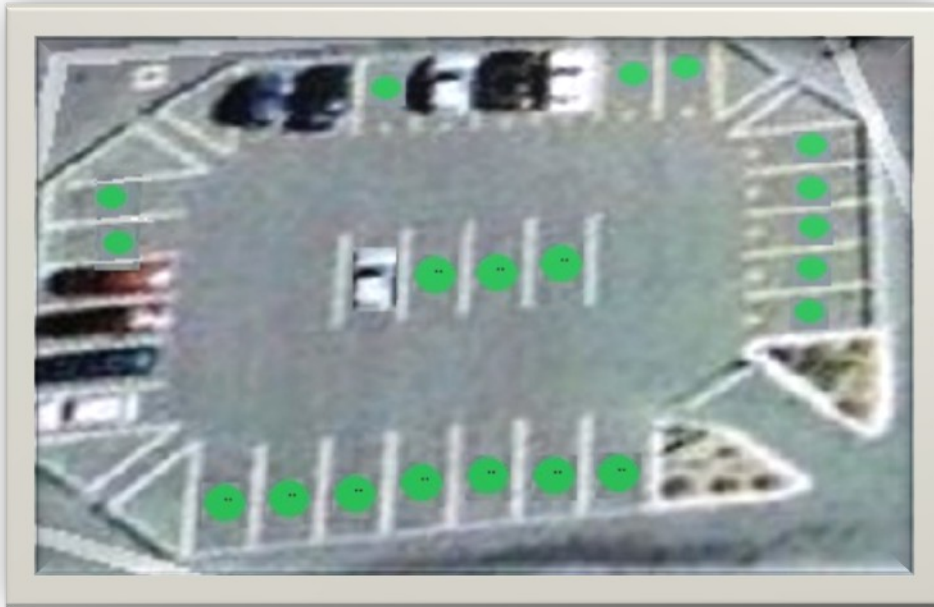


Figure 4-42 Car park with green dots for car park spaces

### 4.2.3 Image segmentation

There are many different ways to differentiate the different objects (cars, dots, surface, white road markings) in an image. One way is to take a sample of the RGB image and see where clusters form in a 3 dimensional graph. This was done for four images and produced Figure 4-27. As it can be seen in Figure 4-28 the red dots form a cluster which means they could be easily distinguished from other objects. These represent the green dots. These dots are all high in green and low in blue. A cube could be made that encompasses only these dots. Then, if the average colour of an object is within this cube, it could be said that it is a green dot.

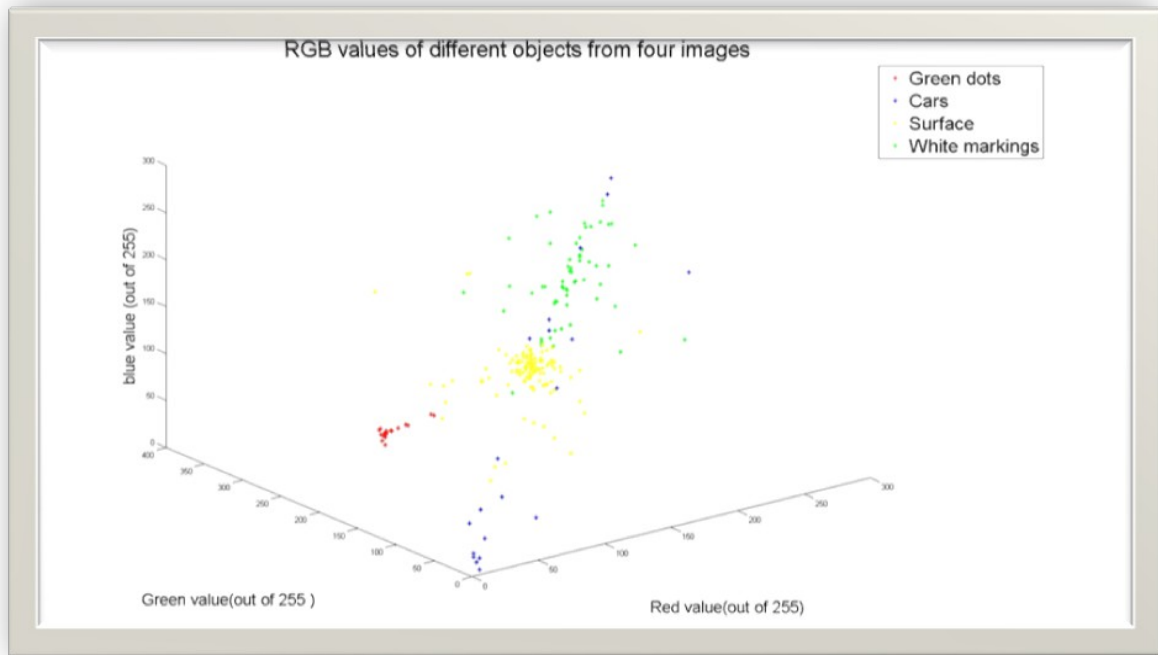


Figure 4-43 Three dimensional graph of samples of RGB values from four images.

A simpler method of finding the green dots was found as explained in the previous section. This involved using the HSV image of the car park. As it can be seen in Figure 4-29, the empty car parks are still very bright compared with other objects.

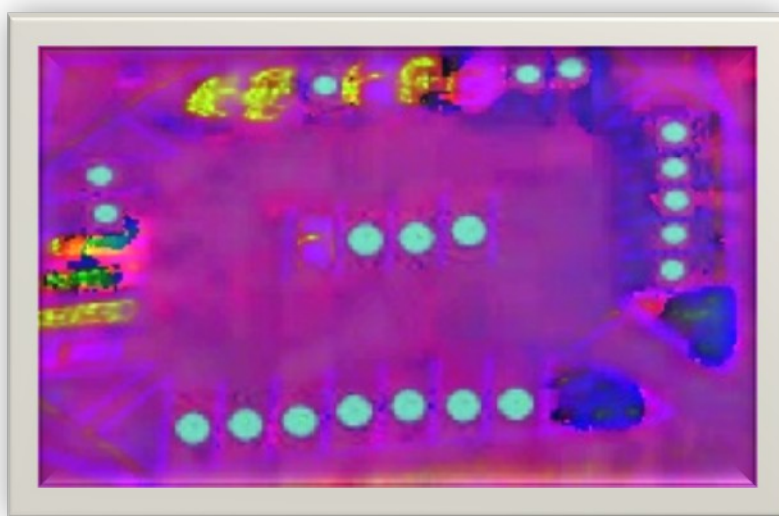


Figure 4-44 HSV image of a car park with cars

This image was converted to a grey image and then to a black and white image (Figure 4-30) by using the same 40% threshold mentioned in initialization section [31].



Figure 4-45 Black and white image of HSV image.

To avoid getting the surface of the car park, which is grey, the bright and dark colours are obtained. To detect light colours such as white (to get white cars and white road markings) a high threshold of 70% is used to form a black and white image as shown in Figure 4-31.

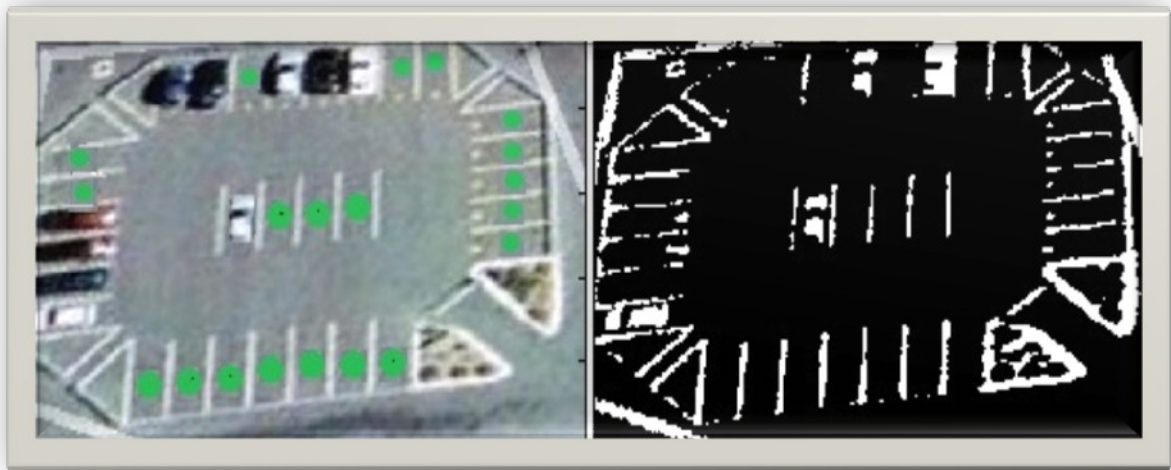


Figure 4-46 Left- real car park; right- black and white image for a light colours.

Dark colours are detected by using a threshold of 10% and inverting the result. This is done in Matlab using

$$\sim \text{im2bw}(C, 0.1)$$

where 'C' refers to the RGB image and '~' refers to the invert symbol as it is shown in the figure 4-32.



Figure 4-47 Car park image for dark cars

In order to see all the objects the three black and white images are combined. This is done by using the OR function as shown in the code below (where ‘|’ is the OR operator):

```
mix = HSVBWObject | lightObject | DarkObject;
```

The combination of the three shown in Figure 4-33.

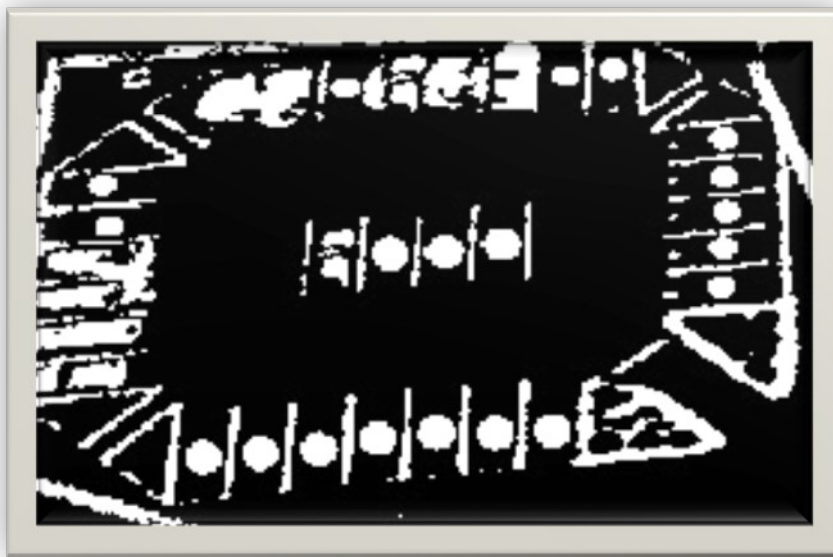


Figure 4-48 Combination of HSV, dark and light images

#### **4.2.4 Image enhancement:**

After obtaining the segments for the objects used, the noise in the image needs to be removed. This can be done through dilation and erosion. Dilation increases the boundary of the objects in the image. This causes a problem in this image as shown in figure 4-34. The problem is that objects merge together so it is hard to distinguish one object from another. However this is good to fill up holes in objects.

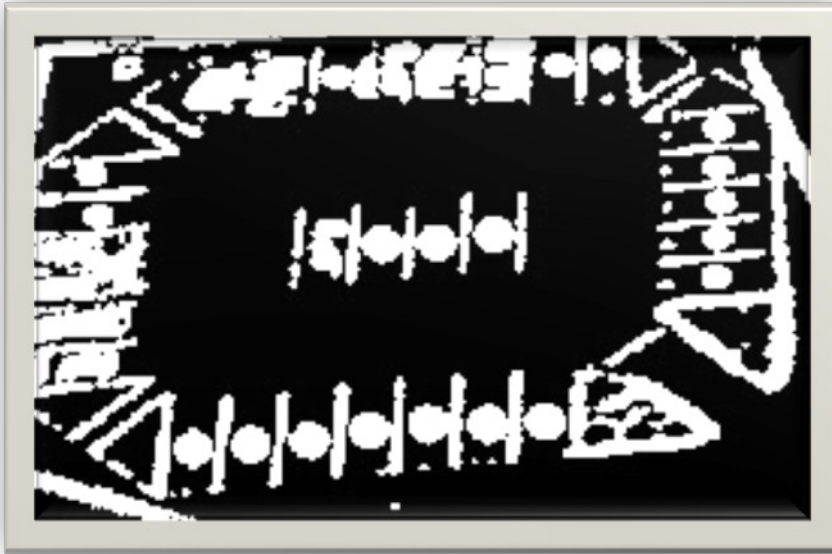


Figure 4-49 Dilated image

Erosion decreases the boundary of the objects so that they can be easily distinguished from one another. Figure 4-35 demonstrates the usefulness of this function. After erosion objects are more distinguishable from each other and small dots are removed. This prepares the image to identify whether parks are empty or filled.

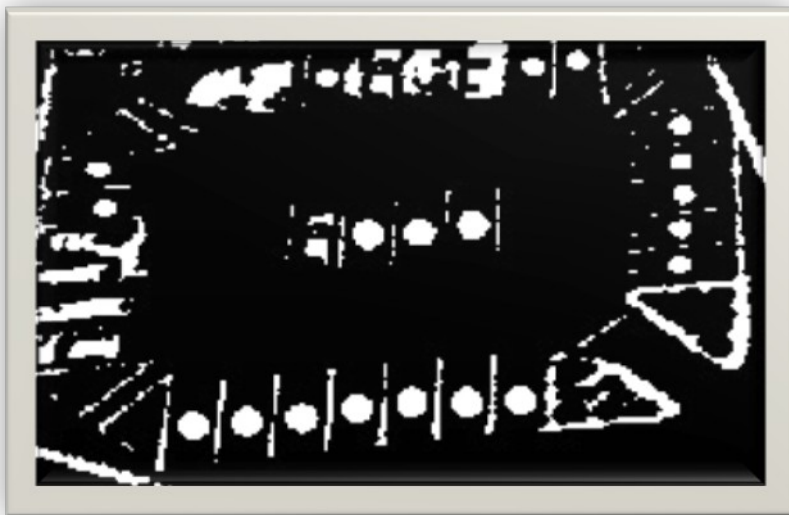


Figure 4-50 Eroded image

### 4.2.5 Image detection module

By using the coordinates found in the initialization of the car park, each car park slot can be analysed to determine whether a car is there or not. There were three methods used to determine whether car parks were full or not. If the height, width or size of the connected object at the car park coordinates were either too big or too small then the object was considered to be a car. In this case the car park was given the value 5 meaning it is occupied. This information was displayed as shown in Figure 4-36. One car was not detected using this method due to its having a black window screen with the sun shining off part of it which was a grey colour as shown in Figure 4-37.

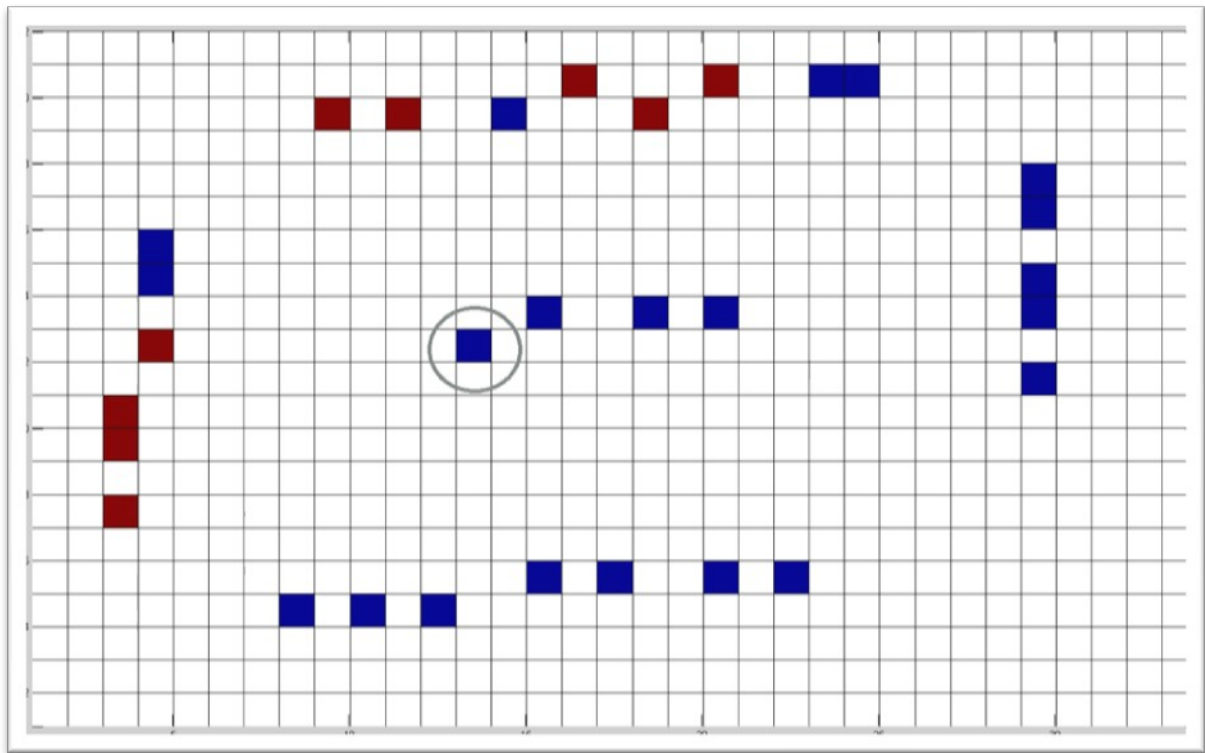


Figure 4-51 Output for a car park with cars showing the park that was not detected



Figure 4-52 Undetected car

The above figures used the combination of HSV, light and dark black and white images. When only the HSV image was used a better output was produced as shown in Figure 4-38 where there are no mistakes.

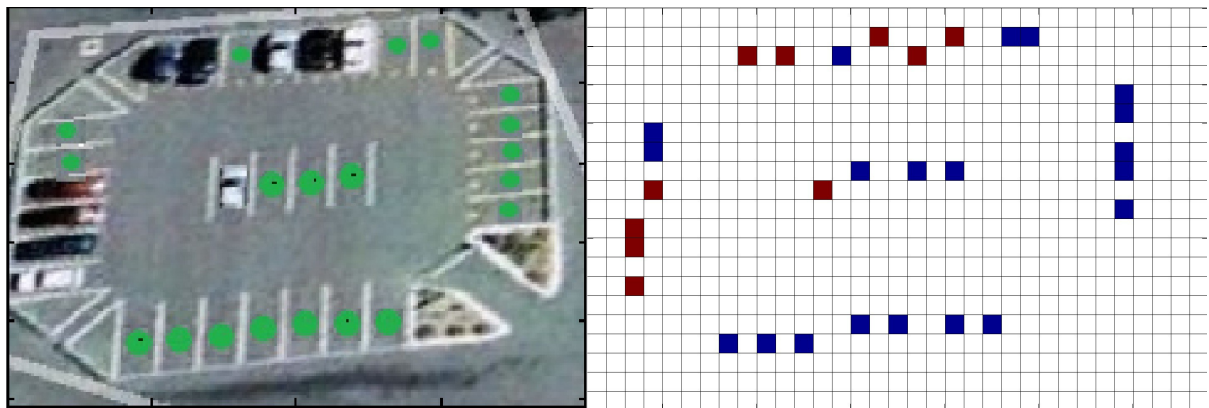


Figure 4-53 Comparison between the RGB image and the output produced from the HSV image

The GUI used to run the matlab program that opens the image and produces an output as is shown in Figure 4-39. The method to use to prepare the image for display can be typed and the user can specify the file path for the image to read. The program also generate it 10 images that shows various ways of manipulating the image as is shown is Figure 4-40.

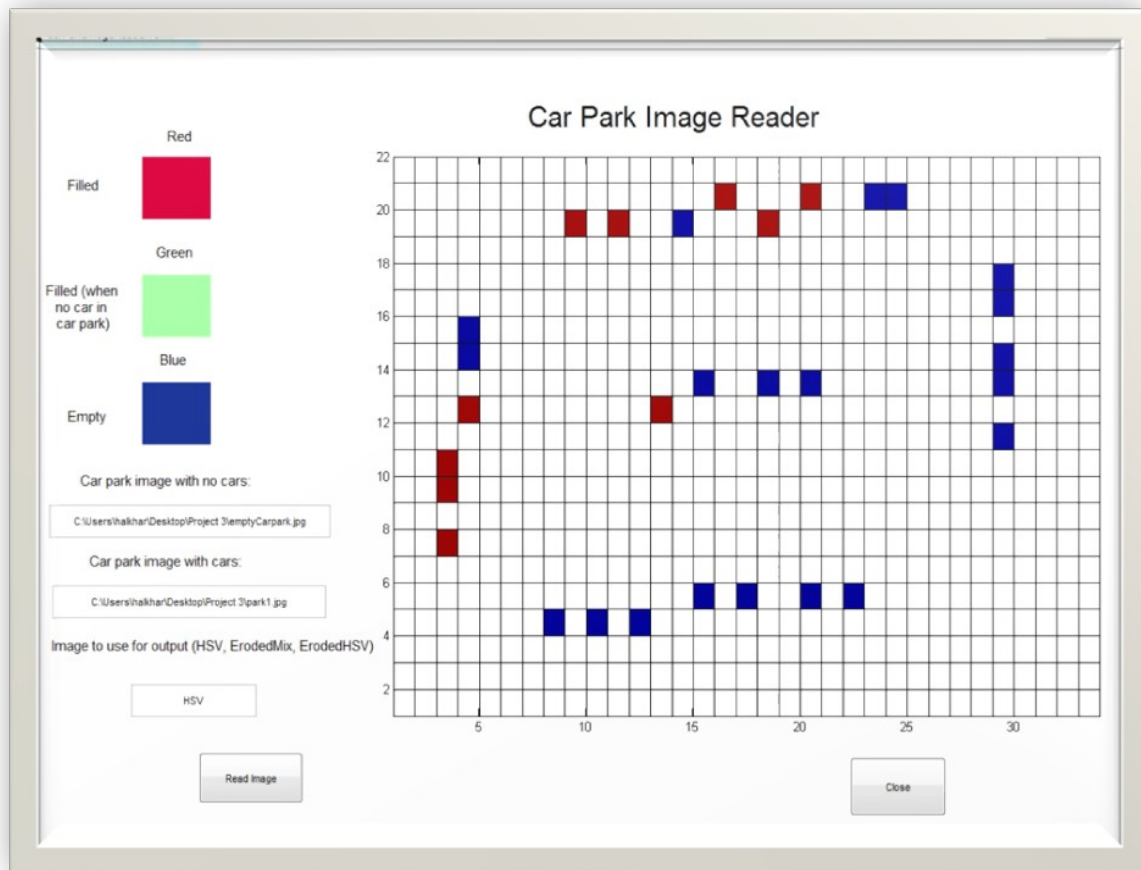


Figure 4-54 GUI for car park image reader

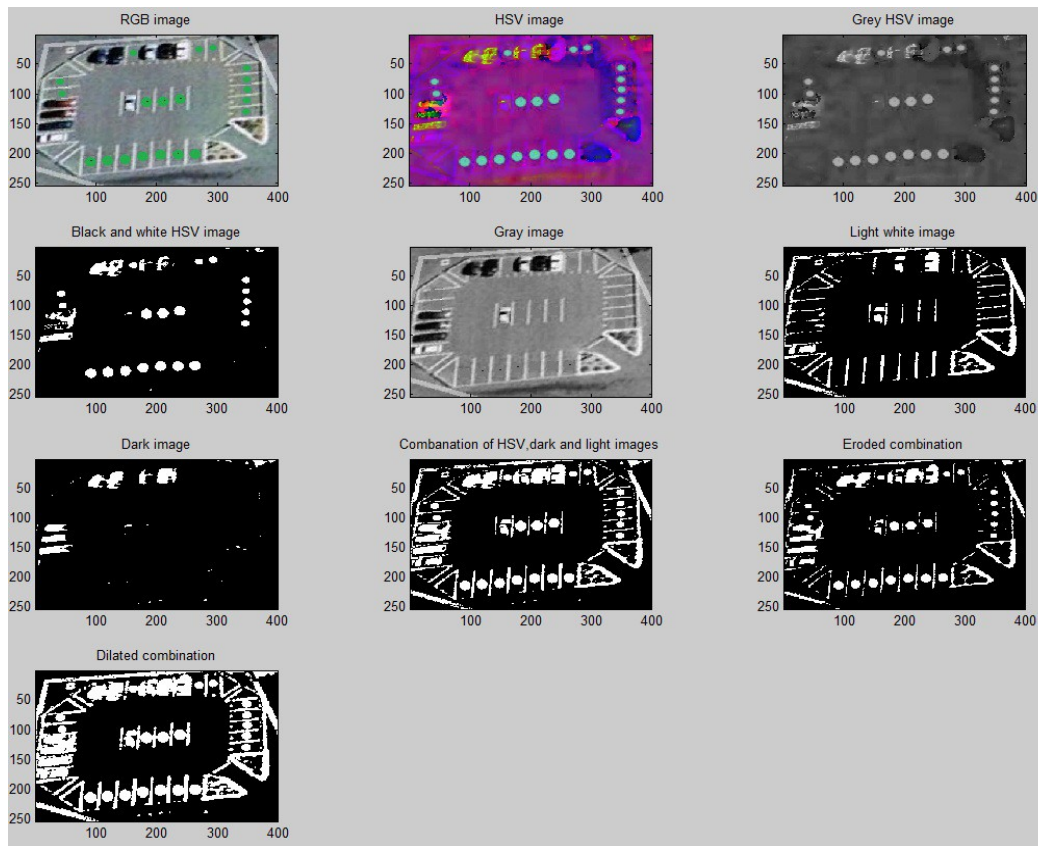


Figure 4-55 Images showing various modifications of an image

## 4.2.6 Conclusion

A method of finding the availability of a car park at Massey University has been presented. A Matlab program has been demonstrated that tests different occupancy levels of car parks to show how a driver could be guided to the closest park. A method of analysing an aerial view of the car park has been presented step by step. This consists of finding car park coordinates from an empty car park, acquiring an image with cars, converting the image to black and white for simple analysis, removing noise and determining whether car parks are vacant or filled. The hardware and communication that could be used in the future has been presented. In the future a real camera will need to be set up to take images of a real car park that will be

sent to a computer for processing. Image processing methods will need to be improved to become more robust to cope with various different images.

### ***4.3 Case Study for Massey car park***

It would be helpful for a driver or car park operator to see an aerial view of the car park showing which car parks are empty and which are occupied.

#### **4.3.1 Spreadsheet with manually entered data displayed by a program**

To test this, a Matlab program opening an excel spreadsheet was made. The data in the spreadsheet consisted merely of numbers that indicated different parts (entrances, non-parking areas, exits) and states (empty or full) of the car park. An Excel spreadsheet was made to represent the Massey University main car park as shown in Figure 4-41. In this way, a spreadsheet can represent the data processed from a photo of the car park.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Car park											
2		7	7	0	5	0	0	0	5	3	3	0	5
3													
4	0			0	0			0	5			0	5
5	0			0	0			0	5			5	0
6	0			0	0			0	0			0	0
7	0			5	0			0	0			0	0
8	5			0	0			5	5			0	0
9	0			0	0			0	0			0	0
10	0			0	0			0	5			0	0
11	0			0	0			0	0			5	5
12	0			0	0			5	0			0	0
13	0			0	0			0	0			0	0
14	0			0	0			0	5			0	0
15	5			5	5			5	0			5	0
16	0			0	0			0	0			5	0
17	5			5	5			0	0			0	0
18	0			0	0			5	5			0	5
19	0			0	0			0	0			0	0
20	5			5	5			5	5			0	0
21	5			0	0			5	0			0	0
22	0			0	0			0	0			5	0
23	0			0	5			0	0			0	0
24	5			0	0			5	5			0	5
25	0			5	0			0	0			5	0
26	0			0	5			0	5			0	0
27	5			5	0			0	0			0	0
28	0			0	0			0	5			5	0
29	0			0	5			0	0			5	0
30	5			5	0			5	0			0	5
31	0			0	0			0	0			0	0
32	0			5	0			0	0			0	0
33	0			0	5			5	0			0	0
34	7												
35	7												
36	0			0	0			5	5			0	0
37	0			0	0			0	0			0	0
38	0			0	0			5	0			0	0
39	0			5	5			0	0			0	5
40	0			5	0			0	0			0	0
41	0			0	0			0	0			0	0
42	0			0	0			0	0			0	5
43	0			5	0			5	0			5	0
44	0			0	0			0	0			0	0
45	5			0	0			0	0			0	0
46	0			0	5			0	5			5	5

Figure 4-56 Excel spread Sheet of Massey car park using numbers to describe the areas

Matlab opened this spreadsheet and stores its data into a matrix of numbers. This data is then displayed on a figure using the 'pcolor' command which simply plots a figure with different colours for different numbers in its array.

This command does not display the first row and the first column of the matrix it uses. Therefore a new row and a new column were added to the beginning of the matrix. The code to do this is shown below:

```

% Processing matrix to be displayed by pcolor
% 'm' stores the number of rows and 'n' stores the number of columns
[m,n] = size (newmatrix);
% new row and column are needed as they are not used by pcolor
% create an empty row for data
newrow = zeros(1, n);
% create an empty column for data
newcolumn = zeros (m + 1, 1);
% new data has an extra row
newdata = [newrow; newmatrix];
% new data has an extra column
newdata = [newdata newcolumn];
% flip data vertically (using flipud) so that it is seen the same way % as displayed in the
spreadsheet
flipdata = flipud(newdata);
% display flipped data
h = pcolor(flipdata);

```

Table 4.2 shows the different numbers used to represent different states and parts of the car park. The colour of the writing shows the colour 'pcolor' displays for that particular number.

Table 4.3 Representation of car park using numbers and colours

Number	Representation
0	Empty car space
5	Full car space
3	Car park entrance
7	Car park exit
2	Closest empty car park to the entrance
(empty)	Road space (white colour)

### 4.3.2 Different scenarios tested

To test different scenarios of car parking, a program was made that randomly generated car park positions. In this way, the graphical user interface could be tested with differing number of cars parked in different positions.

In the program made, the approximate percentage of full car spaces in the car park can be specified by the user. The program then randomly generates a number from 0 to 1 and compares it with the percentage value the user gave (which is made from 0 to 1 too). Through

this, the car park is filled with a random arrangement of car parks according to the percentage specified by the user. This allows different scenarios to be quickly tested.

Figure 4.42 shows the basic form of the program made using Matlab. On the left side is the option for changing the number of full car parks and a key showing what each colour represents. Below the filled and empty car park key, the number of actual filled and empty car parks is displayed. As can be seen from Figure 4-42, although the car park is set to be filled approximately 50%, since the data is random, the actual number of filled cars is less than 50%.

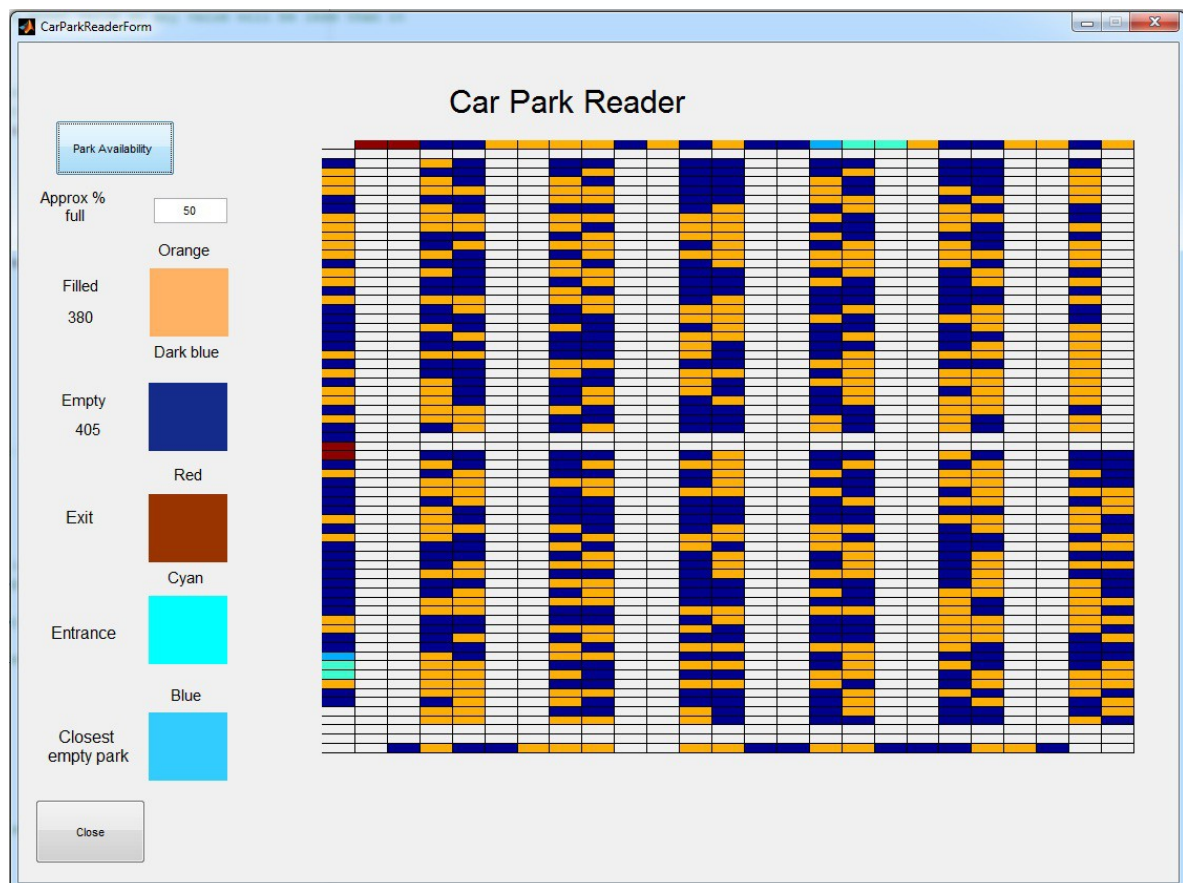


Figure 4-57 Car Park Reader program showing approximately 50% of the car park being full

If the user wants to see what the car park would look like with few cars they could set the percentage to be 5 %. This would produce Figure 4-43

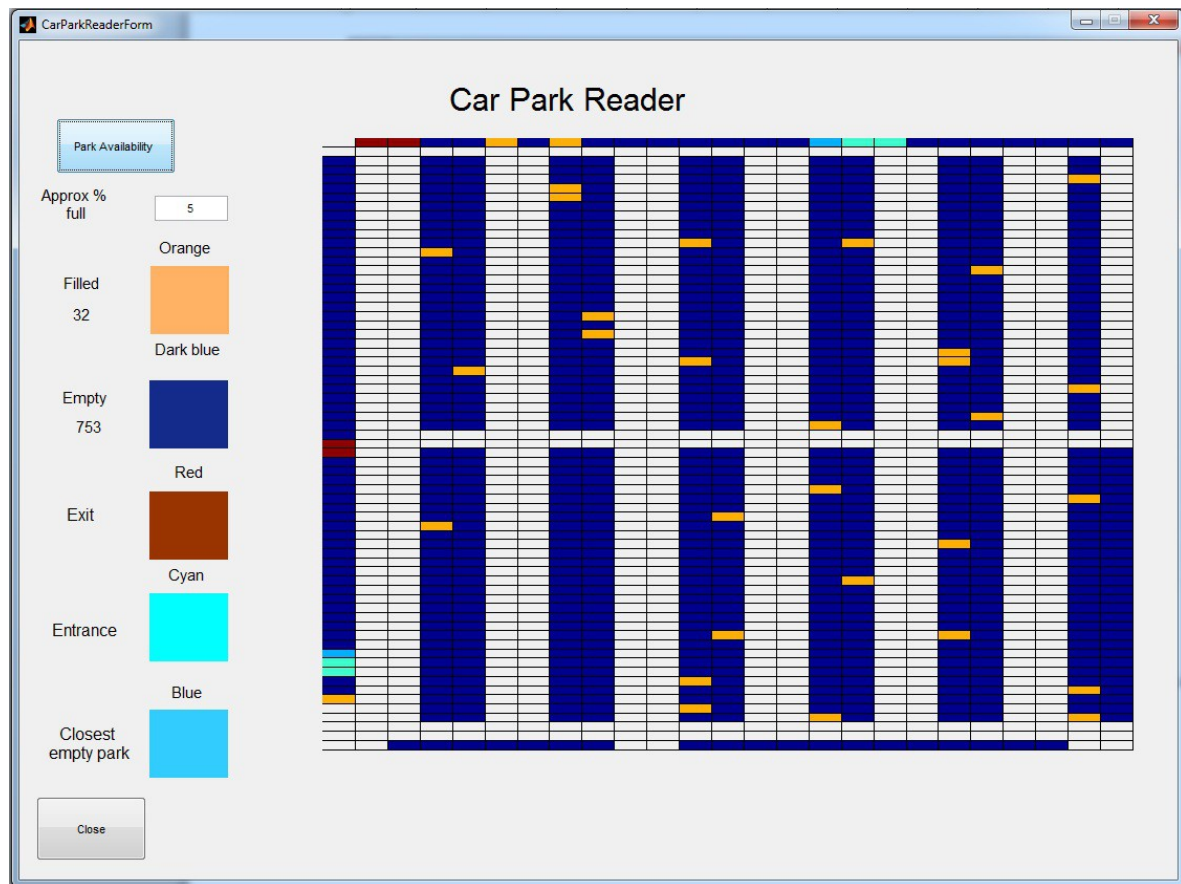


Figure 4-58 Car Park Reader program showing approximately 5% of the car park being full

If the user wants to see what the car park would look like with many cars they could set the percentage to be 95 %. This would produce Figure 4.44. This would be useful for a user to quickly find the best car park to go to when at an entrance.

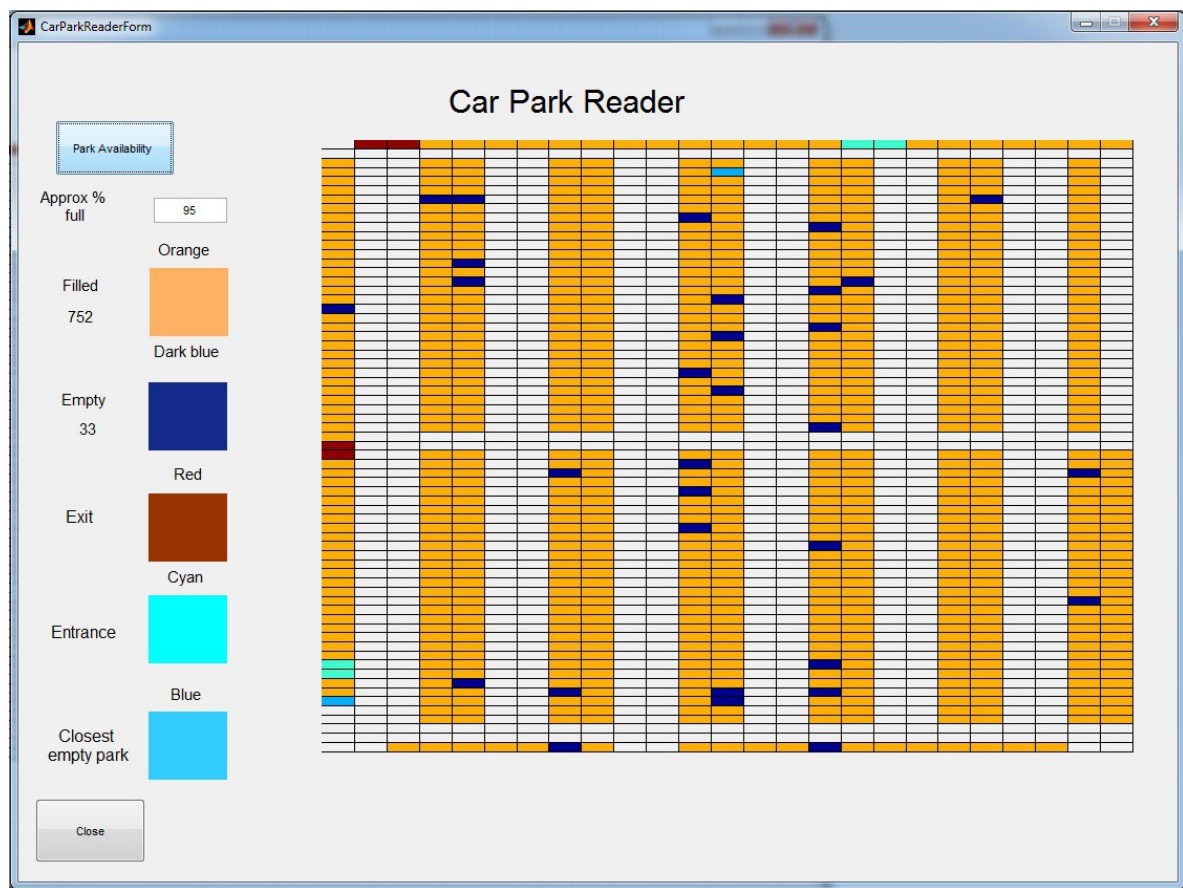


Figure 4-59 Car Park Reader program showing approximately 95% of the car park being full

### 4.3.3 Conclusion

A simple program has been presented that can produce a simple GUI from a manual spreadsheet of data and another that randomly varies the position of cars in a car park depending on the full level you require.

## Chapter 5: Case study for a car park at Massey university

The objective of this Case is to detect the existence of any car in each park slot at Massey university. It is required to prepare a template image and edge Images which show the location of each parking slot. The Processing of this project [4] is shown in the Figure 5-1.

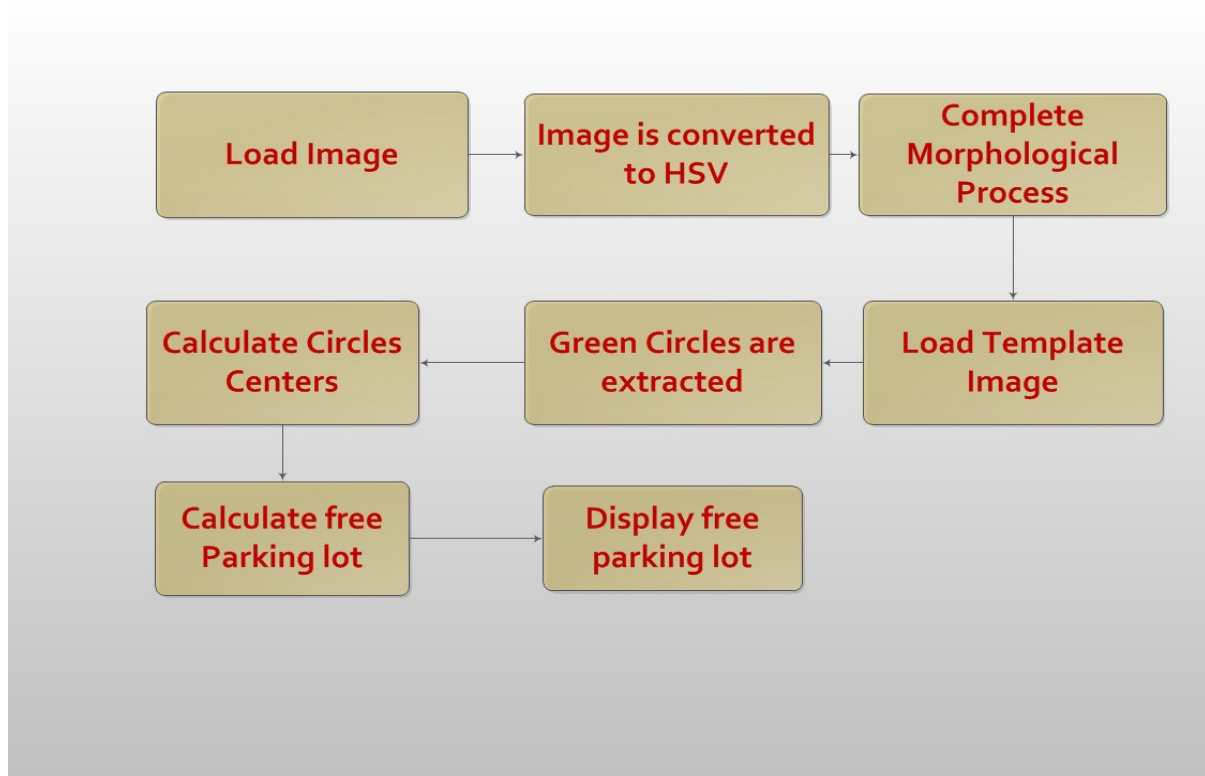


Figure 5-60 Processing steps of detecting car lots in a car park.

### ***5.1 Loading and converting images to HSV***

An image of the car park could be taken when there are some cars in the car park as is shown in the Figure 5-2.



Figure 5-61 Car Park with some cars

In the Figure 5-3 It shows that the pixels become clear that pixels for the background fall within a specified range of colours.

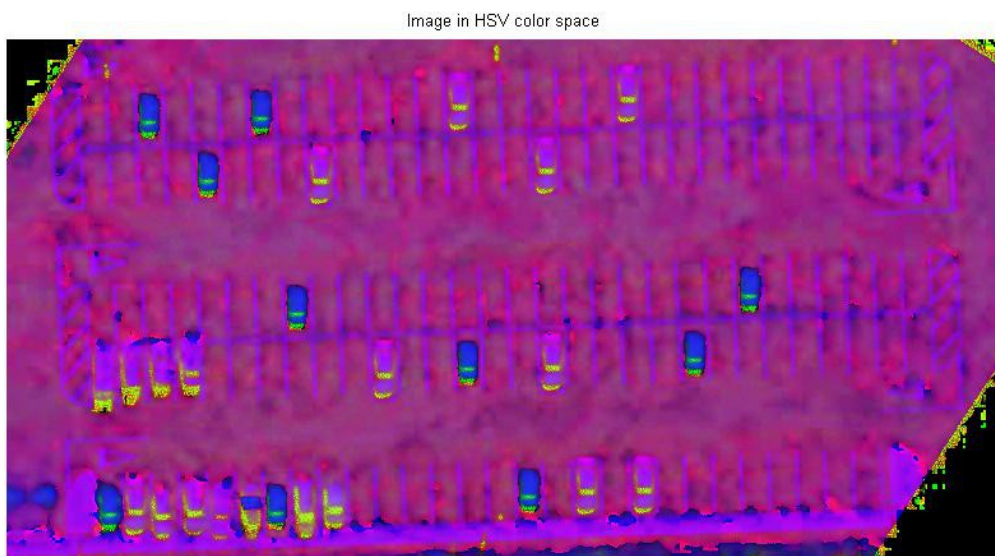


Figure 5-62 Image in HSV colour with some cars

## 5-2 Complete morphological processing

This is non-linear process which is related to the shape and morphology of the image. It is relative to ordering of pixel value not their numerical values as is shown in the figure 5-4 .

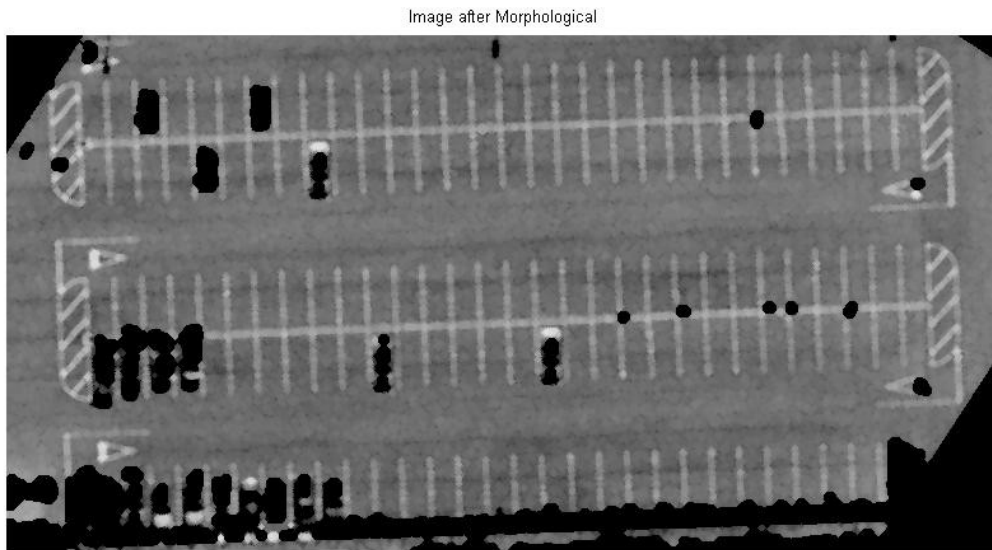


Figure 5-63 Image after morphological

Then the image is converted to Masked Image as is shown in the Figure 5-5

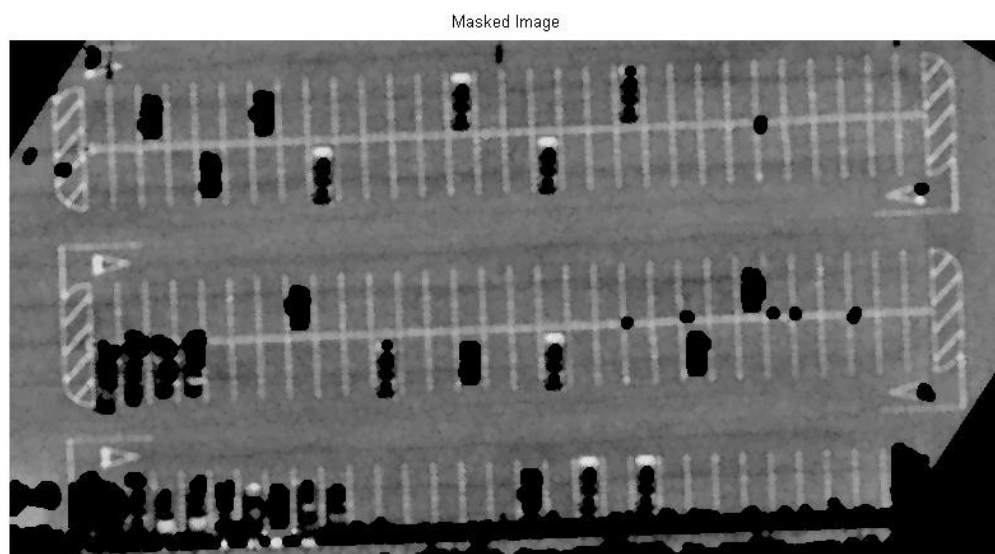


Figure 5-64 Masked image with some cars

After that the image is changed to Binary image as is shown in the Figure 5-6

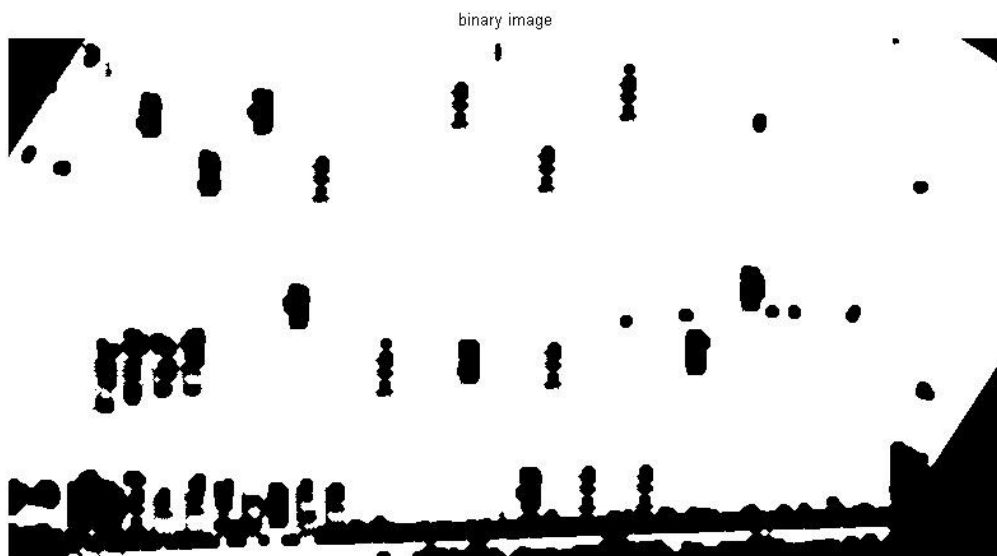


Figure 5-65 Binary image with some cars

Then the image is converted to the Black and White as is shown in the Figure 5-7

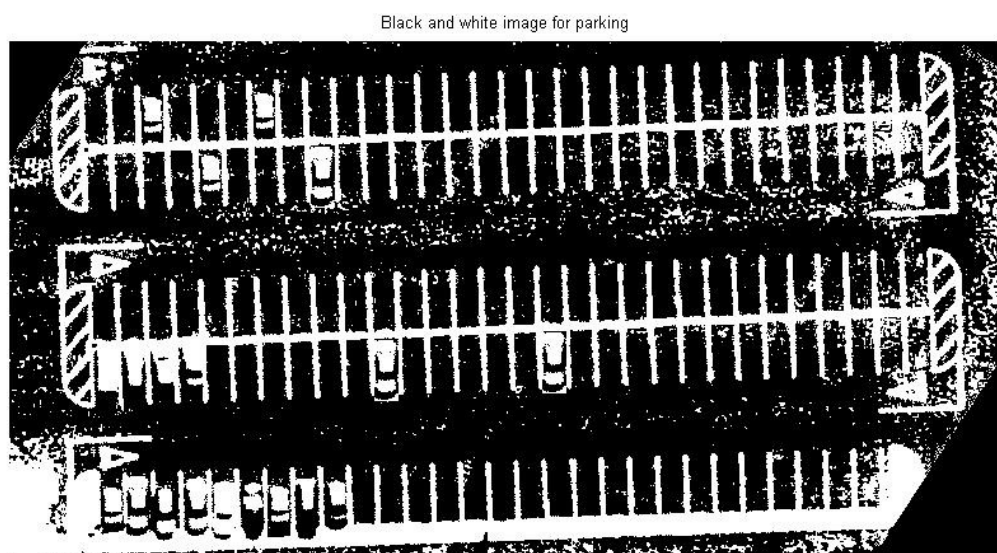


Figure 5-66 Black and white image for parking

Then the image is converted to the Grey Image as is shown in the Figure 5-8

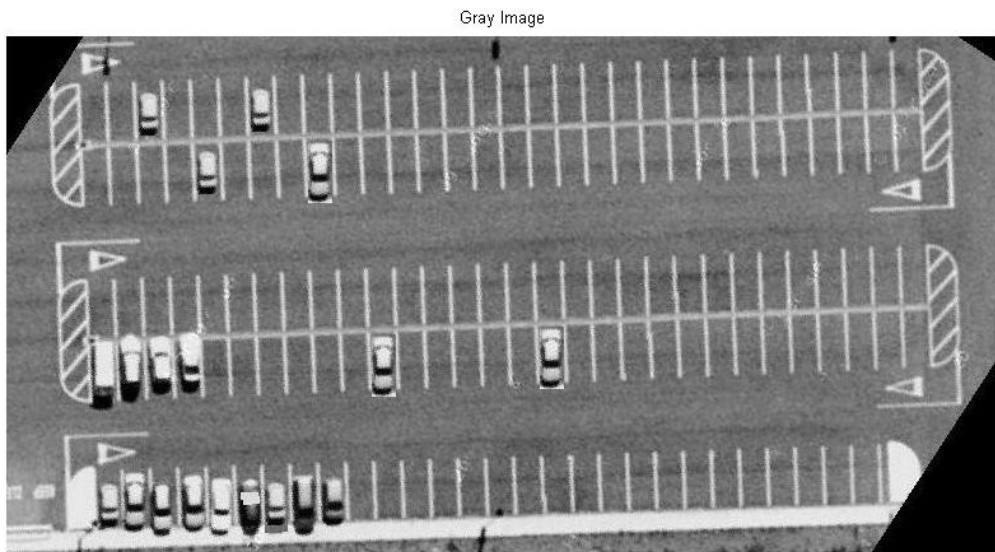


Figure 5-67 Grey image

After that image is converted to the Grey Segmented as is shown in the Figure 5-9

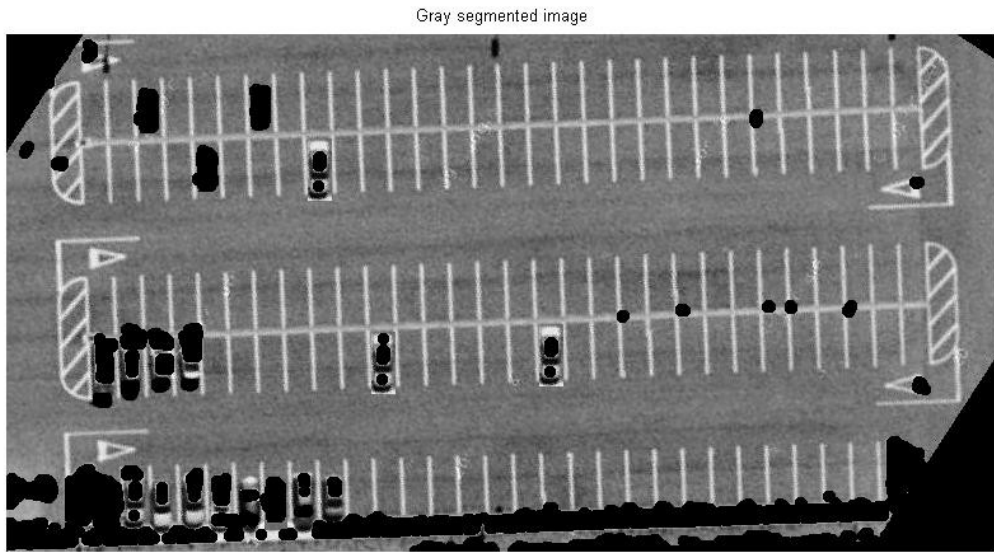


Figure 5-68 Grey Segmented image

After that image is converted to the Segmented Image as is shown in the Figure 5-10

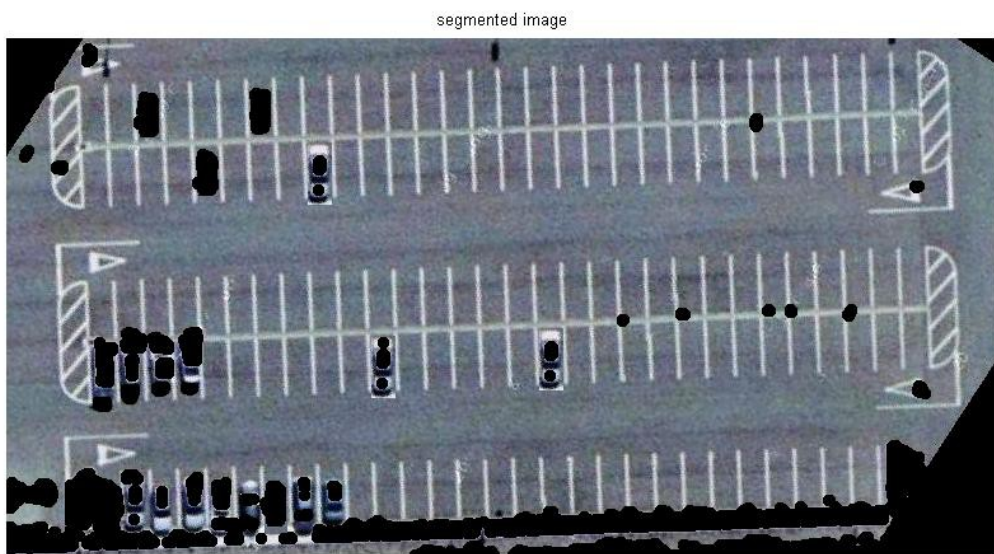


Figure 5-69 Segmented images

### ***5.3 Loading template image***

The image of the car park could be taken when there are no cars in the car park as is shown in the Figure 5-11. This would be used for the system to record the location of all the car parks.



Figure 5-70 Template image for empty car park

The RGB value can be used to find where the green circles are that represent empty car spaces as is shown in the Figure 5-12. With these the system will know where to look for cars in the future

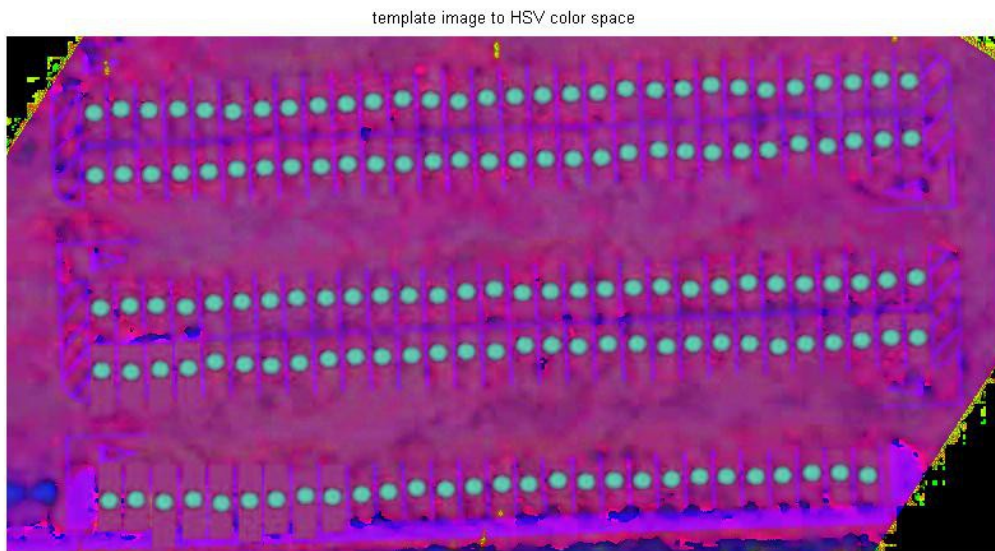


Figure 5-71 HSV of template image

After that the Template image is converted to the Black and White Image as is shown in the Figure 5-13

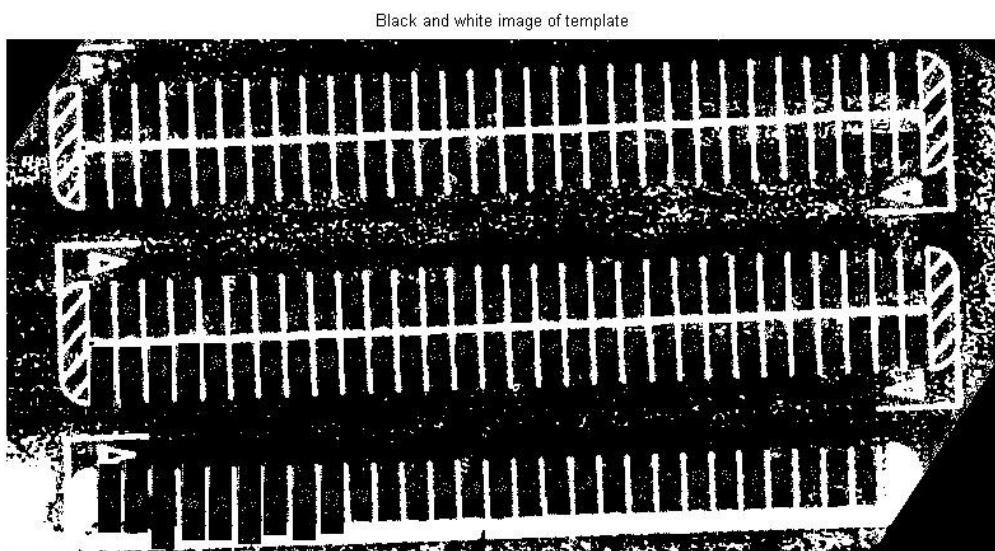


Figure 5-72 Black and white of template image

After that the Template image is converted to the Eroded Image as it shown in the Figure 5-14

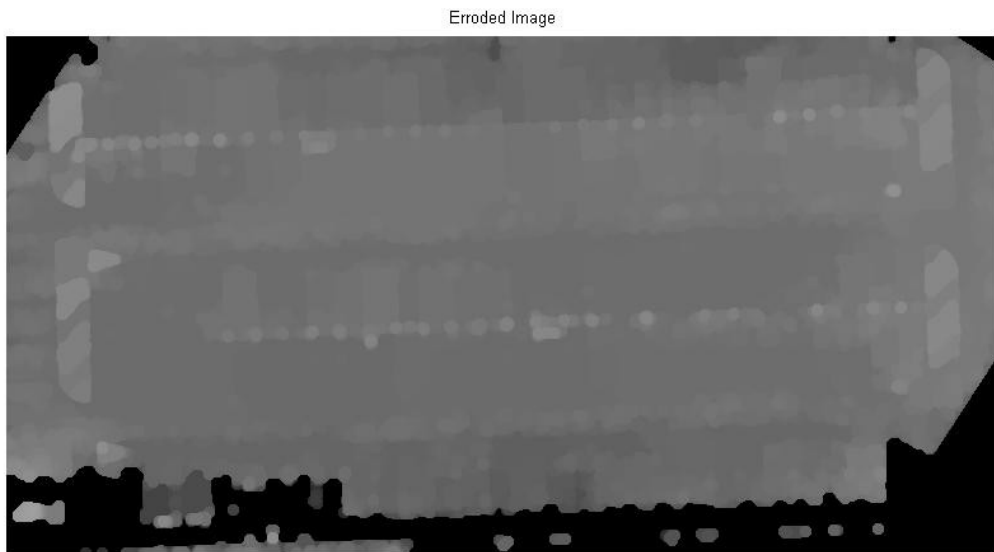


Figure 5-73 Eroded image of template image

After that the Template image is converted to the Gray Image as is shown in the Figure 5-15

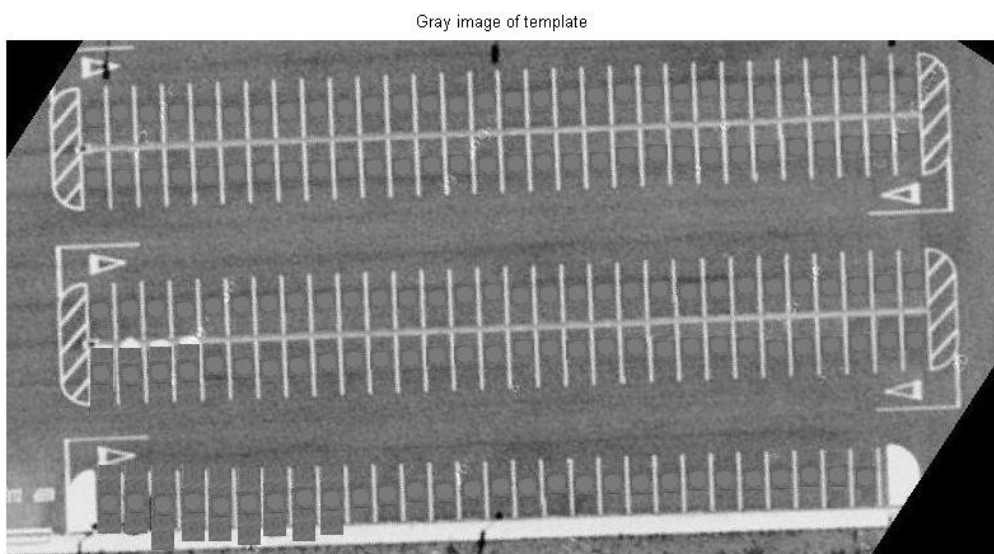


Figure 5-74 Grey image of template image

## ***5.4 Extraction and calculation of the green circle***

Green circles can be extracted by choosing certain values of pixels H, S and V.

In this case a range of pixels is set so that pixels in this range will be extracted. The circle detection processes require the Hough transform. The Hough transform is a feature extraction technique that will be used to extract the circles, their radii, along with their centres. First of all the red segment of the image is extracted because as we know, red pixels are the most power full segment of the image as is shown it the Figure 5-16

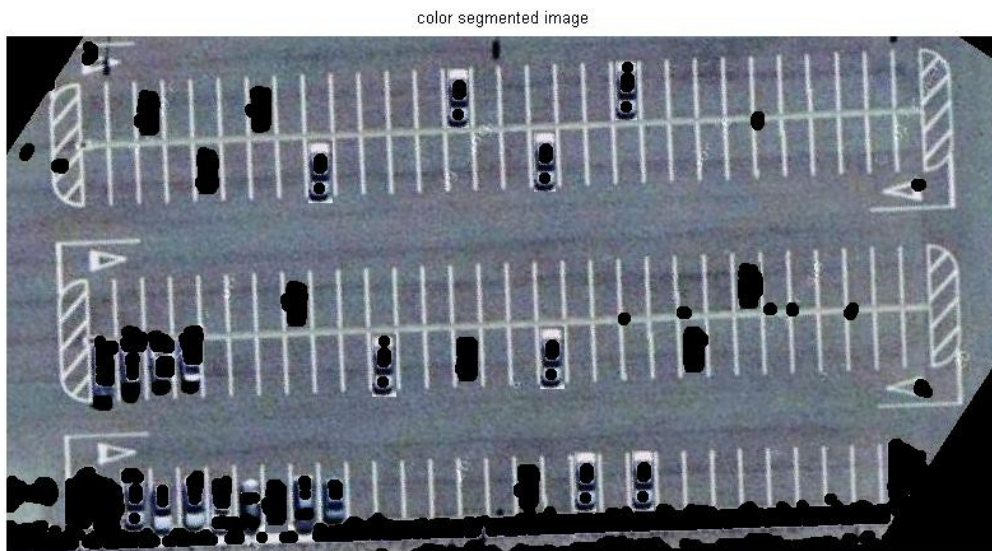


Figure 5-75 Red segment of image

Then the image is adapted to the Histogram of Red as is shown in the Figure 5-17

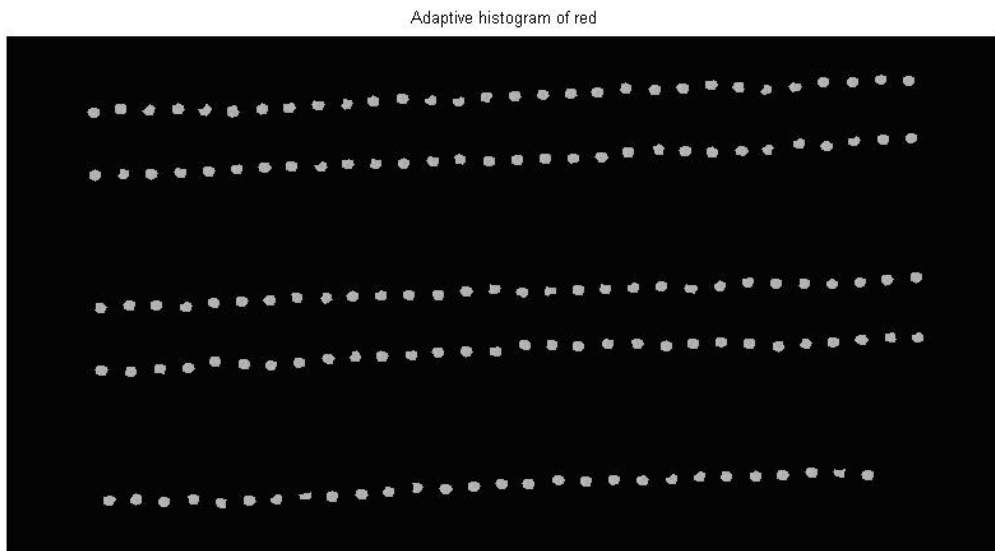


Figure 5-76 Adaptive histogram of red

The image is extracted to the colour segmented Image as it is shown in the Figure 5-18

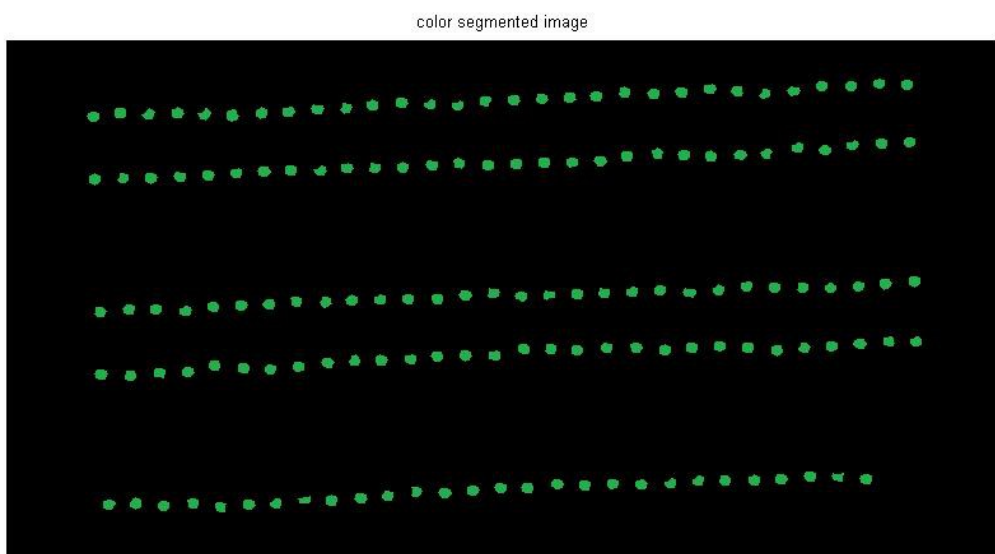


Figure 5-77 Colour segmented image

## 5.5 Detect vacant parking lot and display the vacant parking lot

To test different scenarios of a car parking lot a program was made that generated car park positions with empty and filled cars. In this way, the graphical user interface could be tested with differing number of cars parked in different positions for the operators and users as is shown in the Figure 5-19

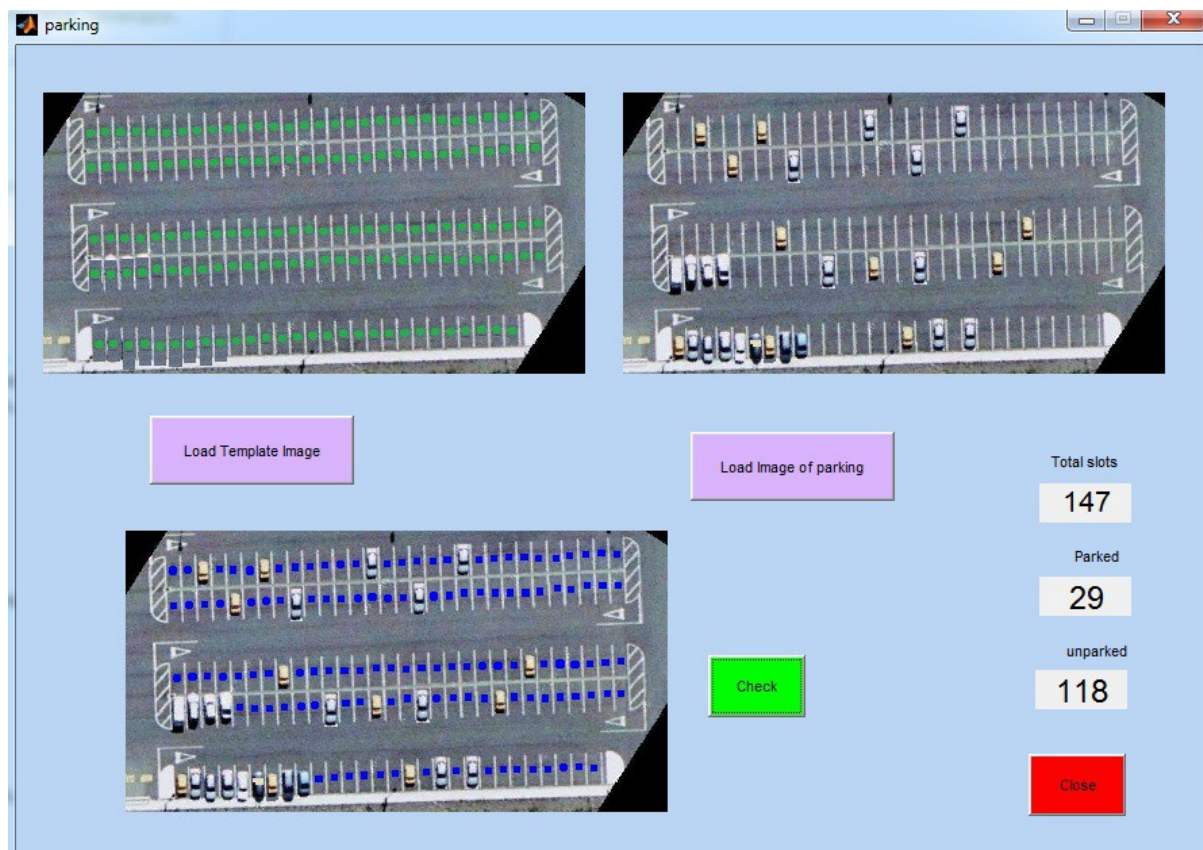


Figure 5-78 GUI for operators

The graphical user interface could be tested with differing number of cars parked in different positions for the users as it shown in the Figure 5-20

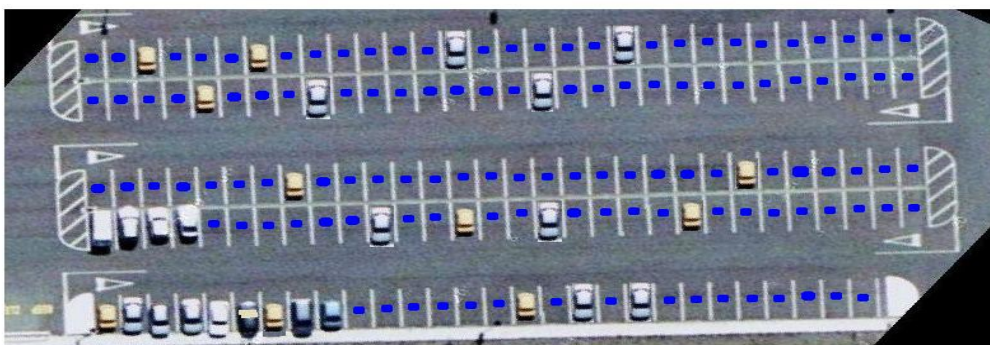


Figure 5-79 GUI for users

## 5.6 Showing the closest car park

An addition was made to the program so that it would show the closest car park to the entrance. The car park entrance was made to be the top left and bottom left corner of the image in the example shown in Figure 5-21

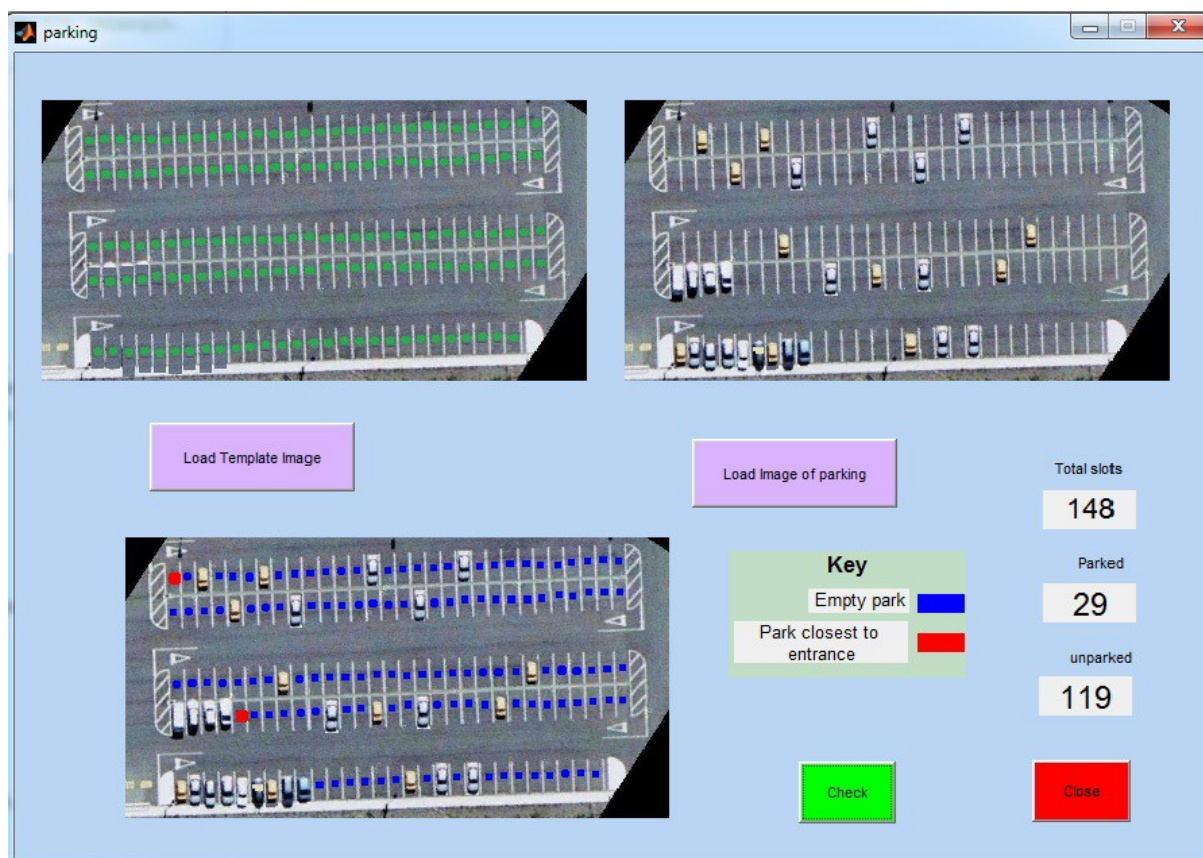


Figure 5-80 Image showing car park closest to entrance

## 5.7 Showing the locations of the cameras in the lamp-posts

There are 12 parallel lines in the park. The total numbers of the car lots are 764. Also there are 14 lampposts already in the park, the high of each lamp is 5 m. each lamp can cover 60 cars slots by 1 camera angle which is half of the two parallel lanes, 2 cameras are required

to cover 2 parallel lanes so 12 parallel lanes can covered by 12 cameras. The locations of the cameras in the lampposts and the capturing area for each camera are shown in Figure 5-22.



Figure 5-81 The locations of the cameras in Massey Universtiy car park

The total cameras which are needed to cover the whole park are 13 cameras. The Figures 5-23 shows what the field and angle of view are for one camera at the lamp-post.

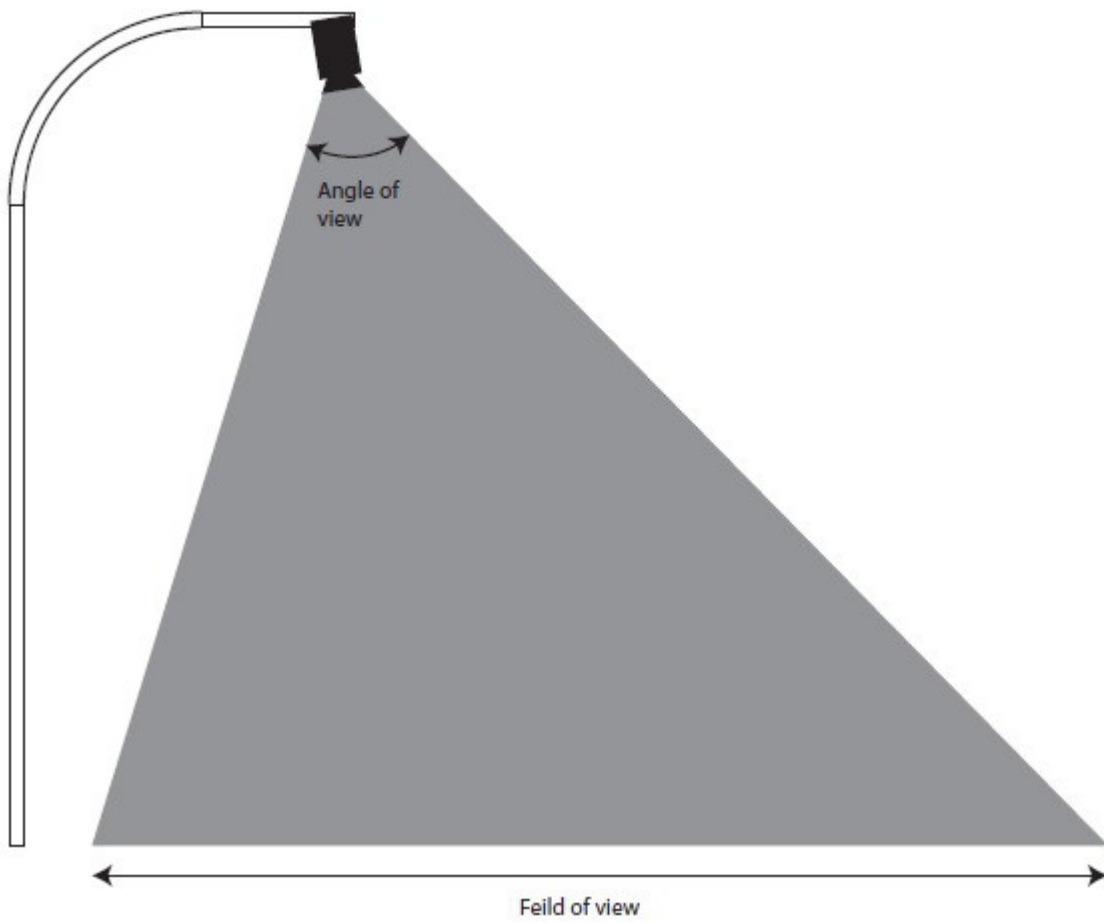


Figure 5-82 The field and angle of view for the camera at the lamp-post

### ***5.8 Estimated cost for the proposed system***

To build the system which captures and notifies a user which car parks are available, several components are necessary. There are three main places where the components of the system will be: the camera at the car park, the entrance of the car park where a display for a driver to be directed by will be and the station of an operator, who manages the system. The last two components will be similar. They both will receive information from the camera process it, and display it to a human user. The first component has two options either applying a fixed camera or a movable camera. The fixed camera process unit will consist of a fixed camera and a transmitter. The movable camera process will consist of a movable camera, motor, microcontroller and a transmitter. The Lamp-post power supply will provide a power to the camera system where it is fixed or movable. The camera will draw a continuous supply from the Lamp-post's source and send continuous data through the transmitter (also powered by the Lamp-post). For a fixed camera, there will be 13 transmitters and 39 cameras. The cost will be 455 NZD and 2340 NZD respectively. That would make a total of 2795 NZD for the camera circuit. For a moveable camera, there will be 13 transmitters, 13 cameras, 13 motors and 13 microcontrollers. The cost will be 455 NZD, 780 NZD, 325NZD and 624 NZD respectively. That would make a total of 2184 NZD for the camera circuit. The last two components will be similar for a fixed camera or a movable camera. At the entrance of the car park, there'll need to be some sort of display to indicate to the user where the available car parks are and preferably indicate the best one to go to. This display will need a receiver to receive information from the camera, a computer to process it and a computer for the operator who manages the system. This may be powered by the main gird. Two cheap monitors, two simple computers and two receivers. This would cost 250NZD, 600NZD and 200 NZD to make a total of 1050 NZD. This would make this cheaper.

Table 5.1 shows the cost for the car park at Massey university if a fixed camera is applied and table 5.2 shows the cost for the car park at Massey university if a moveable camera is applied.

Table 5.4 Total cost for the car park at Massey university for a fixed camera.

<b>Component</b>	<b>Quantity</b>	<b>Cost of Each</b>	<b>Total</b>
<b>Camera</b>	<b>39</b>	<b>60</b>	<b>2340</b>
<b>Transmitter</b>	<b>13</b>	<b>35</b>	<b>455</b>
<b>GUI</b>	<b>2</b>	<b>125</b>	<b>250</b>
<b>Computer</b>	<b>2</b>	<b>300</b>	<b>600</b>
<b>Receiver</b>	<b>2</b>	<b>100</b>	<b>200</b>
<b>Total</b>			<b>3845NZD</b>

Table 5.5 Total cost for the car park at Massey university for a Movable camera.

<b>Component</b>	<b>Quantity</b>	<b>Cost of Each</b>	<b>Total</b>
<b>Camera</b>	<b>13</b>	<b>60</b>	<b>780</b>
<b>Transmitter</b>	<b>13</b>	<b>35</b>	<b>455</b>
<b>Motor</b>	<b>13</b>	<b>25</b>	<b>325</b>
<b>Microcontroller</b>	<b>13</b>	<b>48</b>	<b>624</b>
<b>GUI</b>	<b>2</b>	<b>125</b>	<b>250</b>
<b>Computer</b>	<b>2</b>	<b>300</b>	<b>600</b>
<b>Receiver</b>	<b>2</b>	<b>100</b>	<b>200</b>
<b>Total</b>			<b>3234NZD</b>

Obviously, the higher up a camera can go and the better resolution it has, the more cars a unit can see, and therefore the less cameras are needed.

Different transmitters will have different frequencies sending the data different ranges. Which frequency is used to transmit a signal would depend on the distance from a car park to an operator. When the distance from the car park cameras to the entrance of the car park or to the operator of it are large, repeaters may be useful. Repeaters simply receive the signal and amplify it so that it travels further.

## Chapter 6: Communication system, architecture and components

In order to transfer the image to the computer, a wireless system is used. This is composed of a video camera that captures the image, a transmitter sends the images to the receiver in the control room, the receiver will send signals to a computer, the computer will process the signals and send them to the indoor transmitter. The computer has a FPGA platform attached that creates a filter to filter out the noise in the image [4]. The indoor transmitter sends the signals wirelessly to the receiver attached with the monitor or display [22] as it is shown in Figure 6-1.

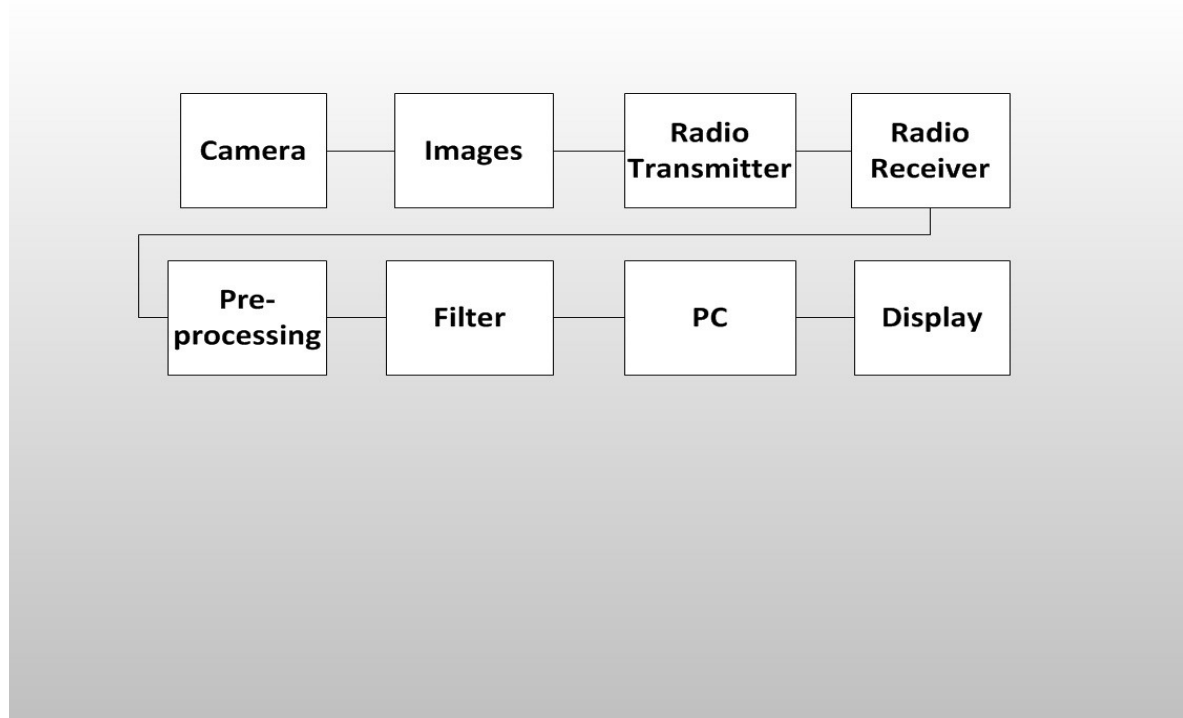


Figure 6-83 Process of transferring images to the computer

## ***6.1 video camera with wireless transmitter and receiver***

To transmit video images and data from a video camera to a PC, an in-expensive compact wireless video camera is used to transmit video from one location to another without using traditional expensive and messy wiring; this is shown in Figure 6-2. It has the benefit of working with all types of AV devices like video camera (NTSC or PAL), TV, recorder and so forth. The transmission range is up to 1,000 feet (300 metres) with high gain omni-directional antenna of 12 db Bi gain or higher, or 3000 feet (3 km) with Yagi or some other high gain directional antennas. Table 6.1 shows more Features about wireless video transmitter and receiver [54-56].



Figure 6-84 Video transmitter and receiver [24]

Table 6.6 Features of the wireless video transmitter and receiver [25]

Profile	Receiver	Transmitter
Demodulation/Modulation	FM	
AV output/input	RCA output jacks for video and audio	RCA input jacks for video and audio
Number of channel	4 channels. Selectable by switch.	
Antenna connector	SMA (F)	
Antenna included	standard antenna - SMA (M)	
Antenna length	11.8 cm foldable	
Operating power	DC 12V (100~240V regulated power supply included)	
Dimensions	80(W) x 115(D) x 20(H) mm	60(W) x 35(H) x 63(D) mm
Weight	149 gm	163 gm
Video output/input	75 Ohm 1V p-p	
Power voltage/consumption	DC12V / 350mA	DC12V / 500 mA 0.6A
Sensitivity/Output power	Sensitivity: -90 dBm	Output power: 1W
Impedance	50 $\Omega$	
Preset channel frequencies	<b>Channel 1:</b> 1080, <b>Channel 2:</b> 1120, <b>Channel 3:</b> 1160, <b>Channel 4:</b> 1200 <in MHz>	
Highest resolution supported	NTSC: 768(H) x 494(V) / PAL: 752(H) x 582(V)	
Operating temp/RH	-10~+50°C / 20~80%	
Transmission distance	Distance may vary substantially depending on the actual operating environment. Line of sight transmission range up to 1,000 feet (300 meters) with high gain omni-directional antennas of 12dBi gain or higher, or 1.8 miles (3 km) with Yagi or other high gain directional antennas.	

## 6.2 Image pre-processing module

An Image Pre-processing module is mostly about the design of filter. It is achieved in the FPGA. The whole design [26] is shown in Figure 6-3. A filtering window creating module creates filtering windows that are required by the use of follow-up modules. The noise estimate module estimates the type of noise, so that the best kind of filtering approach can be decided [32]. It counts the rows and columns of the input data to determine whether the

window can be legitimately done by the counter's function and then to count the lawful window data to determine the output data in an image location. The last image data are sent to the next level of processing equipment [55-58].

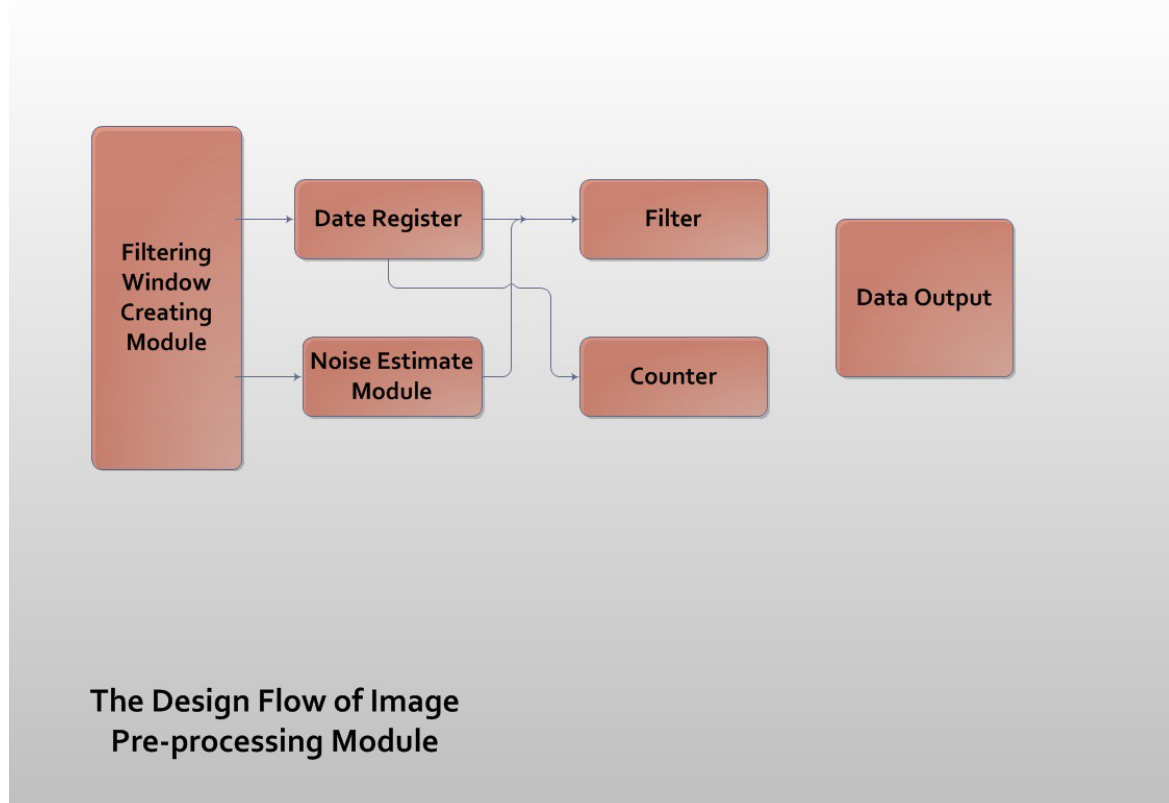


Figure 6-85 The design flow of an Image pre- processing module

### 6.3 Power sources

The lifetime of the video camera, transmitter, receiver, PC and the monitor depends on the power source. In this project a lamppost power is used as an outdoor power source. It supplies the power to the transmitter, receiver and monitor through a 12v DC battery. For in case a solar panel can be used instead of the lampposts. The solar panel image is shown in Figure 6-4.



Figure 6-86 Solar panel [27]

A whole process of an Outdoor power source for the car park if a solar panel is used instead of lampposts [30] as is shown in Figure 6-5

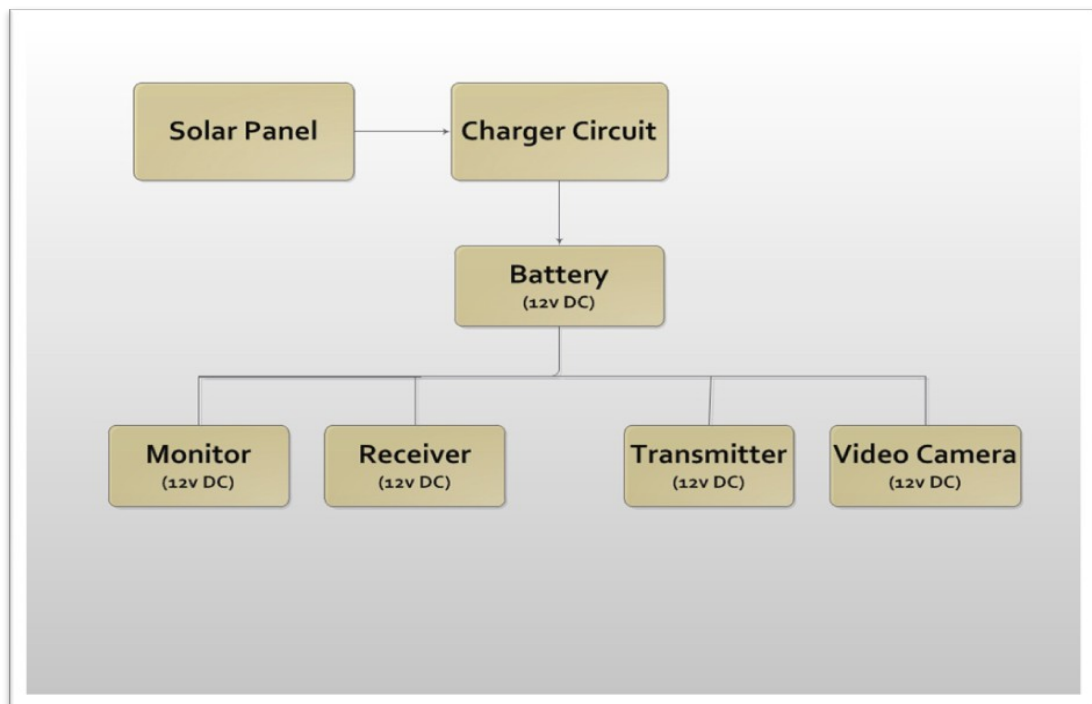


Figure 6-87 Outdoor power source for the car park

Also a domestic power supply is used as an indoor power source. It supplies the power to the computer transmitter and receiver

A whole process of indoor power sources [35] is shown in Figure 6-6

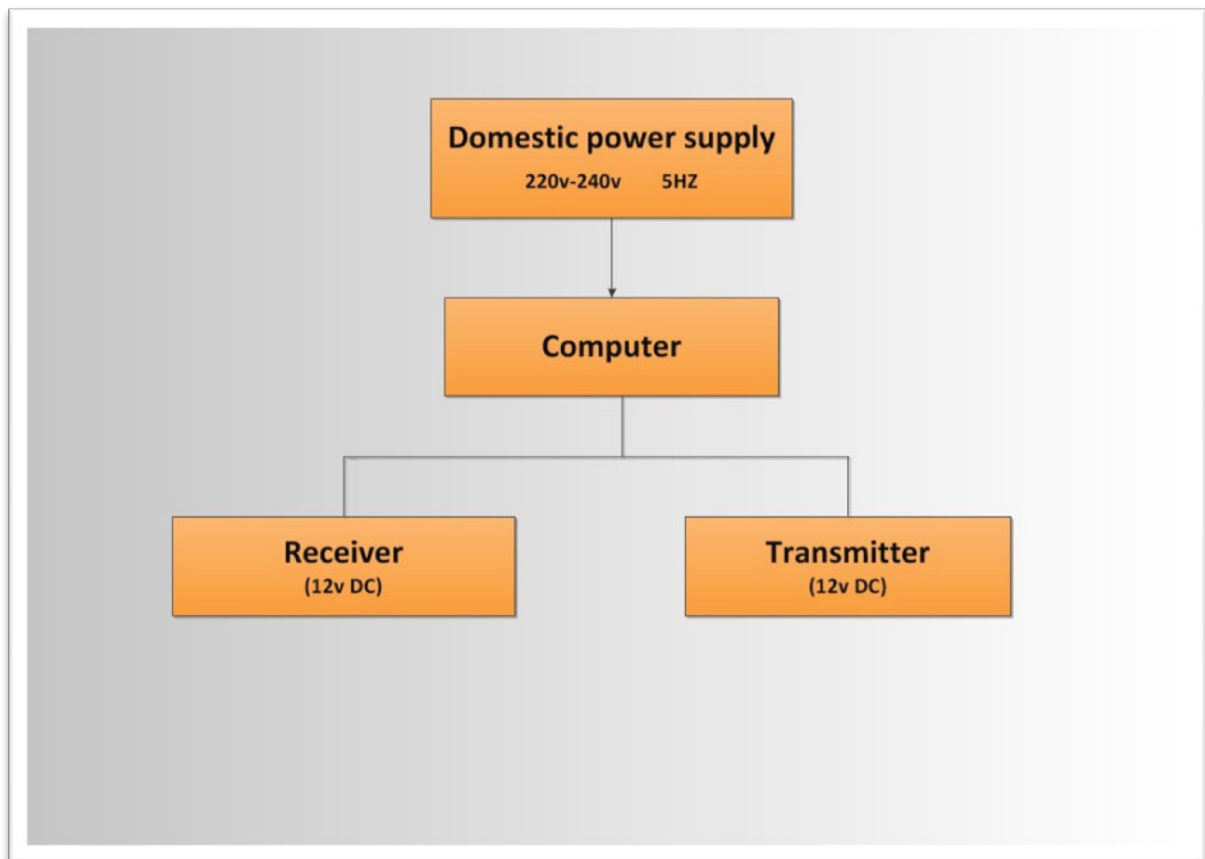


Figure 6-88 Indoor power source for car park

## **Chapter 7 Conclusions:**

From the discussion above it is shown that a car parking management system differs from a car park with no monitoring of the cars which exit and leave it. Although more expensive, a car parking management system helps to remove congestion in a car park where people may need to explore a bit to find a place to park their car.

There are four main types of systems used when managing a car park: a counter based system, in which cars entering and leaving the building are counted; an image based system, where images are taken of the cars inside the car parking spaces; a wired system, having sensors at each car parking spot that are wired to a central processing unit; and a wireless system that has nodes that receive data wirelessly from several sensors located also at individual parks and transmit this to a processor.

To detect cars entering and leaving a car park, either intrusion or non-intrusion sensors can be used. Intrusion sensors require modification to be made either to the road or the side of it to install the sensor to detect the vehicles. Non-intrusion sensors do not but often are more costly and complicated.

The data from these sensors needs to be processed and sent to display units that give the necessary information to drivers (e.g., the number of available car parks in a level of a car park and the closest available car park to the driver).

Each detector technology and particular device has its own limitations and individual capability. The successful application of detector technologies largely depends on proper device selection. Many factors impact detector selection, such as data type, data accuracy, ease of installation, cost and reliability.

A method of finding the availability of four parks has also been presented. A car park is used where green circles are placed in the centre of each car park so that they're easily recognized by image processing from a camera's image. A Matlab program has been demonstrated that tests images of a car park from a camera in cloudy, raining and sunny weather conditions. A method of analysing an aerial view of the Template Images and Edge Images has been presented step by step. This consists of acquiring images, converting them to HSV, extracting green circles, circle detection to find where empty car parks are, getting red pixels, removing noise, applying morphological processing and determining whether car parks are vacant or filled.

A larger scale practical need - finding the availability of a car park at Massey University has also been presented. A Matlab program has been demonstrated that tests different occupancy levels of car parks to show how a driver could be guided to the closest park. A method of analysing an aerial view of the car park has been presented step by step. This consists of finding car park coordinates from an empty car park, acquiring an image with cars, converting the image to black and white for simple analysis, removing noise and determining whether car parks are vacant or filled. The hardware and communication that could be used in the future has been laid out. In the future a real camera will need to be set up to take images of a real car park that will be sent to a computer for processing. Image processing methods will need to be improved to become more robust to cope with various different images. A simple program has been presented that can produce a simple GUI from a manual spreadsheet of data and another that randomly varies the position of cars in a car park depending on the full level you require.

The closest park for a driver to go to is important information for a driving entering a park. A Matlab program has been demonstrated that tests different occupancy levels of car parks to show how a driver could be guided to the closest park. A method of analysing an aerial view of the car park has been presented step by step. This consists of finding car park coordinates from an empty car park, acquiring an image with cars, converting the image to black and white for simple analysis, removing noise and determining whether car parks are vacant or filled. The hardware and communication that could be used in the future has been presented. In the future a real camera will need to be set up to take images of a real car park that will be sent to a computer for processing. Image processing methods will need to be improved to become more robust to cope with various images.

This report has presented a car parking management system. This differs from a simple car park without any monitoring. Although more expensive, a car parking management system helps to remove congestion in a car park where people may need to explore a bit to find a place to park their car and makes it a nicer experience for drivers using the car park.

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