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

2014
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.
Acknowledgements

In completing this thesis for master degree in Electronics and Computer System Engineering, I would like to give my sincere appreciation and thanks to:

My supervisor Dr Ibrahim Al-Bahadly, who encouraged me at times of failure, gave useful advice, corrected errors, guided and supported me to the completion of my project, accompanied me through the entire project, providing useful advice and encouraging me when progress was slow.

The administration staff in the School of Engineering and Advanced Technology for their cheerful and friendly support in all the administrative matters needed in my project.
# Table of Contents

Abstract ................................................................................................................................... i

Acknowledgements .................................................................................................................. iii

List of Figures .......................................................................................................................... vii

List of Tables ............................................................................................................................ xii

List of Abbreviations ............................................................................................................... xiii

Chapter 1: Introduction ........................................................................................................... 1

1.1 Research topic .................................................................................................................. 1

1.2 Scope of research .......................................................................................................... 1

1.3 The organisation of the thesis ...................................................................................... 3

Chapter 2: Literature review .................................................................................................. 5

2.1 Advantages of a car parking management system ......................................................... 5

2.2 Safe, secure and easy for drivers ................................................................................. 6

2.3 Economical and efficient space utilization .................................................................... 6

2.4 Environmentally friendly parking system ....................................................................... 7

2.4.1 Deciding how to use the system .............................................................................. 7

2.4.2 Categories of the car parking management system ................................................. 8

2.5 Requirements ................................................................................................................ 12

2.6 Conclusion ..................................................................................................................... 13

Chapter 3: Investigation of the technology used for intelligent car park management ........15
3.1 Categorises of vehicle detection technology: .......................................................... 15

3.1.1 Intrusive sensors: ............................................................................................... 15

3.1.2 Non-intrusive sensors ...................................................................................... 21

3.2 Signal processing device .................................................................................... 26

3.3 Data processing devices ..................................................................................... 27

Chapter 4: Proposed method ....................................................................................... 28

4.1 Case study for four car parks in three different conditions ..................................... 28

4.1.1 Processing of template images ........................................................................ 30

4.1.2 Processing of template images ........................................................................ 35

4.1.3 Processing for decision .................................................................................... 40

4.2 Case study for 30 car parks .................................................................................. 44

4.2.1 System initialization ......................................................................................... 44

4.3.1 Spreadsheet with manually entered data displayed by a program ...................... 61

Chapter 5: Case study for a car park at Massey university ........................................ 67

5.1 Loading and converting images to HSV ............................................................... 67

5-2 Complete morphological processing ..................................................................... 69

5.3 Loading template image ....................................................................................... 73

5.4 Extraction and calculation of the green circle ...................................................... 76

5.5 Detect vacant parking lot and display the vacant parking lot ................................ 78

5.6 Showing the closest car park ................................................................................ 79
Chapter 6: Communication system, architecture and components

6.1 video camera with wireless transmitter and receiver

6.2 Image pre-processing module

6.3 Power sources

Appendix

Appendix
List of Figures

Figure 1-1 Intelligent car parking system management.................................................................2

Figure 2-1 Categories of the car parking management system..........................................................8

Figure 2-2 The counter based system ................................................................................................9

Figure 2-3 Image based system [4]...................................................................................................10

Figure 2-4 Wired sensor based system [5] .........................................................................................11

Figure 2-5 Wireless based system [6] ..............................................................................................12

Figure 2-6 Example of large car park ..............................................................................................13

Figure 3-1 Inductive detector [4].....................................................................................................17

Figure 3-2 Pneumatic tubes [6] ........................................................................................................18

Figure 3-3 Magnetometer sensors [7] ..............................................................................................19

Figure 3-4 The difference a metal object makes to the earth’s magnetic field [8] .........................20

Figure 3-5 Weight in motion detector system [9] .............................................................................21

Figure 3-6 Explanation of the operation of a microwave radar sensor [4] ..............................22

Figure 3-7 Ultrasonic sensors [10] ..................................................................................................23

Figure 3-8 Video image processor line of sight detection geometry [11] .................................25

Figure 4-1 system module ..............................................................................................................28

Figure 4-2 Parking image...............................................................................................................29
Figure 4-3 Processing steps of template image.................................................................31
Figure 4-4 Template image.............................................................................................32
Figure 4-5 Template image converted to HSV...............................................................32
Figure 4-6 Red segment of image..................................................................................33
Figure 4-7 The green circle, showing their centre and middle obtained from circle detection.34
Figure 4-8 Processing steps of edge images....................................................................35
Figure 4-9 Parking image converted to HSV image.......................................................36
Figure 4-10 HSV image showing how the background can be clearly found by looking at the red value.................................................................37
Figure 4-11 Colour segmented image..............................................................................37
Figure 4-12 Grey segmented image................................................................................38
Figure 4-13 Images after morphological process..........................................................39
Figure 4-14 Binary image..............................................................................................39
Figure 4-15 picking a circle and relative position...........................................................40
Figure 4-16 Available and occupied car slots.................................................................41
Figure 4-17 Cloudy Weather..........................................................................................42
Figure 4-18 Raining weather.........................................................................................43
Figure 4-19 Sunny weather...........................................................................................43
Figure 4-20 Empty car park used to initialize the location of car parks........................45
Figure 4-21 HSV image of empty car park....................................................................45
Figure 4-22 Grey scale format of the HSV image.........................................................46
Figure 4-23 Black and White images for empty car park

Figure 4-24 Eroded image for empty car park

Figure 4-25 Empty car park showing different colours for each object

Figure 4-26 Output for empty car park

Figure 4-27 Car park with green dots for car park spaces

Figure 4-28 Three dimensional graph of samples of RGB values from four images

Figure 4-29 HSV image of a car park with cars

Figure 4-30 Black and white image of HSV image

Figure 4-31 Left- real car park; right- black and white image for a light colours

Figure 4-32 Car park image for dark cars

Figure 4-33 Combination of HSV, dark and light images

Figure 4-34 Dilated image

Figure 4-35 Eroded image

Figure 4-36 Output for a car park with cars showing the park that was not detected

Figure 4-37 Undetected car

Figure 4-38 Comparison between the RGB image and the output produced from the HSV image

Figure 4-39 GUI for car park image reader

Figure 4-40 Images showing various modifications of an image

Figure 4-41 Excel spread Sheet of Massey car park using numbers to describe the areas
Figure 4-42 Car Park Reader program showing approximately 50% of the car park being full
..................................................................................................................................................

Figure 4-43 Car Park Reader program showing approximately 5% of the car park being full
..................................................................................................................................................

Figure 4-44 Car Park Reader program showing approximately 95% of the car park being full
..................................................................................................................................................

Figure 5-1 Processing steps of detecting car lots in a car park..............................................67

Figure 5-2 Car Park with some cars.......................................................................................68

Figure 5-3 Image in HSV colour with some cars .................................................................68

Figure 5-4 Image after morphological..................................................................................69

Figure 5-5 Masked image with some cars............................................................................69

Figure 5-6 Binary image with some cars .............................................................................70

Figure 5-7 Black and white image for parking....................................................................70

Figure 5-8 Grey image ........................................................................................................71

Figure 5-9 Grey Segmented image......................................................................................72

Figure 5-10 Segmented images..........................................................................................72

Figure 5-11 Template image for empty car park .................................................................73

Figure 5-12 HSV of template image.....................................................................................74

Figure 5-13 Black and white of template image .................................................................74

Figure 5-14 Eroded image of template image ...................................................................75

Figure 5-15 Grey image of template image .......................................................................75

Figure 5-16 Red segment of image....................................................................................76
Figure 5-17 Adaptive histogram of red..........................................................77

Figure 5-18 Colour segmented image..........................................................77

Figure 5-19 GUI for operators ..................................................................78

Figure 5-20 GUI for users.........................................................................79

Figure 5-21 Image showing car park closest to entrance............................79

Figure 5-22 The locations of the cameras in Massey University car park...............80

Figure 5-23 The field and angle of view for the camera at the lamp-post.............81

Figure 6-1 Process of transferring images to the computer...........................85

Figure 6-2 Video transmitter and receiver [24]...........................................86

Figure 6-3 The design flow of an Image pre-processing module......................88

Figure 6-4 Solar panel [27]......................................................................89

Figure 6-5 Outdoor power source for the car park ....................................89

Figure 6-6 Indoor power source for car park ...........................................90
List of Tables

Table 3.1  The strengths and weakness of intrusive and nonintrusive sensor technologies.....26

Table 4.1 Experiment for four car parks in three different conditions..............................29

Table 4.2 Representation of car park using numbers and colours.....................................63

Table 5.1  Total cost for the car park at Massey university for a fixed camera......................83

Table 5.2 Total cost for the car park at Massey university for a Movable camera...............83

Table 6.1 Features of the wireless video transmitter and receiver [25].............................87
List of Abbreviations

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