## CONTENTS

[CONTENTS 2](#_Toc469350614)

[Table of Tables and Figures 3](#_Toc469350615)

[ABSTRACT 5](#_Toc469350616)

[INTRODUCTION 9](#_Toc469350617)

[TECHNICAL BACKGROUND OF THE PROJECT 11](#_Toc469350618)

[Image Processing 11](#_Toc469350619)

[Edge Detection 11](#_Toc469350620)

[Filter Application and Convolution 12](#_Toc469350621)

[MQTT transmission 14](#_Toc469350622)

[END PRODUCT DEVELOPMENT 15](#_Toc469350623)

[The Model and its Design 15](#_Toc469350624)

[Script development 16](#_Toc469350625)

[Capturing the main image for cropping 17](#_Toc469350626)

[Using different filters and their effect on edge detection 20](#_Toc469350627)

[Original Colour filter 21](#_Toc469350628)

[Original B&W 22](#_Toc469350629)

[Laplacian 23](#_Toc469350630)

[SobelX filter 24](#_Toc469350631)

[Performance of the script 27](#_Toc469350632)

[COMMUNICATING TO THE MQTT BROKER AND TESTING 30](#_Toc469350633)

[Flexibility of capturing irregular shapes. 32](#_Toc469350634)

[CONCLUSION 40](#_Toc469350635)

[APPENDICES 44](#_Toc469350636)

[Appendix A – Results from the application of filters to the cropped image 44](#_Toc469350637)

[Appendix B – Output from memory tests during test run 44](#_Toc469350638)

[Appendix C – Project work log 47](#_Toc469350639)

[Appendix D - Testing of the Photoshop car park image. 50](#_Toc469350640)

[Appendix E – Feedback Report from the customer 50](#_Toc469350641)

[Appendix F – Co-ordinate files for the three development phases 54](#_Toc469350642)

[Appendix G - Phase 3 base line images cropped from main image 54](#_Toc469350643)

[Appendix H - Phase 3 - Images cropped from main image 55](#_Toc469350644)

[Appendix I – Project Plan and Gannt Chart 56](#_Toc469350645)

[Appendix J – Terms of Reference 57](#_Toc469350646)

[Appendix K – All scripts and images 57](#_Toc469350647)

[BIBLIOGRAPHY 58](#_Toc469350648)

|  |
| --- |
| Table of Tables and Figures |
| [Figure 1 Using the 'edge' functionality (OpenCV, 2016) 12](#_Toc469298315)  [Figure 2 An image is a grid of numbers (developer.apple.com,2016) 12](#_Toc469298316)  [Figure 3 Kernel Convolution (developer.apple.com,2016) 13](#_Toc469298317)  [Figure 4 Models illustrating how MQTT and broker interact (www.steves-internet-guide.com,2016) 14](#_Toc469298318)  [Figure 5 Pictures of the proof of concept model. 16](#_Toc469298319)  [Figure 6 Basic relationship between the webcam, Python and OpenCV 17](#_Toc469298320)  [Figure 7 CarCoord.csv 18](#_Toc469298321)  [Figure 8 Co-ordinated shown on main image 18](#_Toc469298322)  [Figure 9 Edge map of each cropped image 19](#_Toc469298323)  [Figure 10 Output from webcam script 19](#_Toc469298324)  [Figure 11 Original colour image captured from the webcam 21](#_Toc469298325)  [Figure 12 Image with B&W filter/kernel applied 22](#_Toc469298326)  [Figure 13 Image with Laplacian filter/kernel applied 23](#_Toc469298327)  [Figure 14 Image with SobelX filter/kernel applied 24](#_Toc469298328)  [Figure 15 Image Sobel Y filter/kernel applied 26](#_Toc469298329)  [Figure 16 Image overlay with the four filters/kernels 27](#_Toc469298330)  [Figure 17 Script output showing CPU percent increase 29](#_Toc469298331)  [Figure 18 Code sample with details of payload 31](#_Toc469298332)  [Figure 19 Payload message successfully published via the broker 32](#_Toc469298333)  [Figure 20 Having subscribed to the topic ‘VTLOG/1/PARJ1’, now monitoring incoming messages 32](#_Toc469298334)  [Figure 21 Successful transmission of space count 32](#_Toc469298335)  [Figure 22 Real life car park capture using standard rectangles 34](#_Toc469298336)  [Figure 23 Array file for corners and their how they are plotted 35](#_Toc469298337)  [Figure 24 Image with co-ordinates marked 35](#_Toc469298338)  [Figure 25 Real-life car park spaces. Empty and taken. 36](#_Toc469298339)  [Figure 26 Image taken from two combined masks 37](#_Toc469298340)  [Figure 27 Irregular 'cropped' baseline shape of empty space and edges 38](#_Toc469298341)  [Figure 28 Irregular 'cropped' shape of taken space and edges 38](#_Toc469298342)  [Figure 29 Multiple car park base-line image 39](#_Toc469298343)  [Figure 30 Cars in the bay 39](#_Toc469298344)  [Figure 31 Bay 0 baseline and image 40](#_Toc469298345)  [Figure 32 Sample from shell script 42](#_Toc469298346)  [Table 1 Colour filter Unit testing 22](#_Toc469298347)  [Table 2 B&W filter Unit testing 23](#_Toc469298348)  [Table 3 Laplacian filter Unit testing 24](#_Toc469298349)  [Table 4 SobelX filter Unit testing 25](#_Toc469298350)  [Table 5 SobelY filter Unit testing 26](#_Toc469298351)  [Table 6 Table showing overall values 27](#_Toc469298352) |