PARKING LOT DETECTION USING TUNABLE TWO-MODE REGION OF INTEREST

NAJMI HAFIZI BIN ZABAWI

MASTER OF ENGINEERING
(ELECTRONICS)

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering (Electronics).

_____

(Supervisor's Signature)

Full Name :

Position :

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : NAJMI HAFIZI BIN ZABAWI

ID Number : MEL11001

Date : 22 December 2016

PARKING LOT DETECTION USING TUNABLE TWO-MODE REGION OF INTEREST

NAJMI HAFIZI BIN ZABAWI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Engineering (Electronics)

Faculty of Electrical and Electronics Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2016

ACKNOWLEDEMENTS

Alhamdulillah. My praise be only to **Allah SWT** the Almighty, the Most Gracious, and the Most Merciful, whose blessing and guidance have helped me to complete this thesis. In particular, I wish to convey my gratitude to my supervisors, Dr. Sunardi, Dr. Md. Rizal Bin Othman and Associate Professor Dr. Kamarul Hawari Bin Ghazali for guidance, encouragement, advice, ideas, and motivation. Without their help, of course, this thesis would not have been the same as presented here.

I also would like to express my appreciation to my family especially my beloved mother, father, wife, daughter and son for their understanding, support and pray for me to carry out and finish this research. My appreciation also goes to my fellows Mr. Azrul Bin Mahfurdz, Mrs. Sharmiza Binti Kamaruddin, Miss Norfarhana Binti Mohd Hashim, Miss Noramira Binti Mohd Rodzi and other friends for their idea and guidance that help me a lot in finishing this research.

I also would like to thank the Ministry of Education Malaysia and Department of Polytechnic Education for providing direct and indirect support during this study. My sincere appreciation also extends to all my colleagues either involved directly or indirectly in the success of this study. Only **Allah SWT** will bless you all.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

σ	standard deviation
$\in$	element of
$\cos^{-1}$	inverse cosine
min	minimum
max	maximum
x '	x prime – first derivative of x

LIST OF ABBREVIATIONS

AMR	Anisotropic Magneto Resistance
FLTK	Fast, Light Toolkit
GPS	Global Positioning System
GUI	Graphical User Interface
HSV	Hue, Saturation, Value
LBP	Local Binary Pattern
LBQ	Local Phase Quantization
LIDAR	Light Detection and Ranging
OpenCV	Open source Computer Vision
POLISAS	Politeknik Sultan Haji Ahmad Shah
RAM	Random Access Memory
RANSAC	Random Sample Consensus
REA	Relative Extremum Algorithm
RFID	Radio Frequency Identification
RGB	Red, Green, Blue
ROI	Region of Interest
SfM	Structure from Motion
SVM	Support Vector Machine
TB	Texton Boost
UMP	Universiti Malaysia Pahang
WSN	Wireless Sensor Networks
YUV	Y - Luminance, U and V - Chrominance

PARKING LOT DETECTION USING TUNABLE TWO-MODE REGION OF INTEREST

NAJMI HAFIZI BIN ZABAWI

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Engineering (Electronics)

Faculty of Electrical and Electronics Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2016

ABSTRAK

Kajian ini memfokuskan dalam pembangunan suatu sistem berdasarkan penglihatan yang mampu untuk mengesan kekosongan pada ruang parkir menggunakan teknik pemprosesan imej, iaitu melalui pendekatan penyesuaian ROI mod berkembar. Dalam menjalankan pengesanan ruang parkir, suatu program komputer khas telah dibangunkan menggunakan kombinasi antara kod-kod OpenCV dan FLTK. Program yang digunakan bersama kamera web dan komputer riba ini dikhususkan untuk melaksanakan semua teknik yang dirancangkan dalam kajian ini. Sistem yang dibangunkan ini disasarkan untuk mengesan ruang parkir ketika siang hari di persekitaran luar and mampu berfungsi dalam cuaca dan keadaan cahaya yang berbeza seperti di bawah sinaran terik matahari, ketika hari hujan dan keadaan teduh. Prosedur yang terlibat dalam menjalankan pengesanan ruang parkir dibahagikan kepada empat peringkat iaitu perolehan imej, pra-pemprosesan imej, penetapan ROI dan peringkat pengesanan warna. Dalam peringkat perolehan imej, tiga cara telah dikenalpasti sebagai kaedah untuk melakukan aktiviti perolehan imej, iaitu kaedah situasi sebenar, kaedah lalulintas, dan kaedah imej simpanan secara manual. Seterusnya, dalam peringkat pra-pemprosesan imej, imej yang diperoleh dikenakan dengan kesan pengaburan untuk mengurangkan faktor gangguan terhadap imej dan juga dijalankan dengan fungsi pengubahan. Fungsi pengubahan tersebut mengubah imej yang diperolehi yang secara asalnya dalam ruang warna BGR ke bentuk terkenal yang lain iaitu HSV dan YUV. Peringkat penetapan ROI sebaliknya melibatkan penentuan posisi ROI-ROI ke atas slot parkir yang dikehendaki dan mengenakan lingkungan warna yang mewakili warna latarbelakang ruang parkir terhadap ROI yang dikenali sebagai ‘lingkungan yang dibenarkan’ dalam tesis ini. Akhirnya, dalam peringkat pengesanan warna, ROI-ROI yang telah ditetapkan dijalankan dengan proses penganalisaan piksel yang membandingkan setiap piksel yang ada dalam ROI dengan lingkungan warna yang dibenarkan yang telah ditentukan dalam peringkat sebelum ini. Piksel-piksel yang mempunyai nilai warna di dalam lingkungan yang dibenarkan akan dikategorikan sebagai piksel ruang parkir dan selebihnya akan dianggap sebagai piksel milik kenderaan yang mana akan mencetuskan status pendudukan sebaik sahaja nilai ambang dicapai. Beberapa kaedah telah diperkenalkan dalam mengatasi isu-isu yang telah timbul dalam kajian ini. Antaranya termasuklah kaedah ROI tunggal dan kembar, operasi logik Boolean DAN dan ATAU, fungsi pemasa, fungsi ROI kawalan dan akhirnya fungsi penapisan bayang-bayang. Semua kaedah dianalisa untuk mengenalpasti kemampuan dan kecekapan dalam menyelesaikan kekangan yang timbul. Melalui kombinasi kaedah-kaedah yang telah dicadangkan, kadar kejayaan sebanyak 88.9% telah dapat dicapai. Baki 11.1% kadar kegagalan adalah disebabkan oleh masalah kekeliruan antara warna kenderaan dengan warna permukaan petak parkir dan sepatutnya akan dapat diselesaikan sekiranya lebih banyak ROI penyemak digunakan pada setiap petak parkir di masa hadapan.

ABSTRACT

This research focuses on development of a vision-based system that able to detect the vacancy of parking spaces using image processing technique, namely through the adaptive twin ROI mode approach. In performing the parking space detection, a special computer program called 'detector' has been developed using the combination of OpenCV and FLTK libraries. The program which is used with web camera and notebook computer is dedicated to perform all methods that are proposed in this research. The system that has been developed is targeted to detect the parking space during daytime in outdoor environment and can work in different weather and lighting conditions such as under bright sunlight, during rainy day or in shady surroundings. The procedure in performing the parking space detection is divided into four stages namely the image acquisition, image preprocessing, ROI setting and colour detection stage. In the image acquisition stage, three ways have been identified as the method to perform the image acquisition techniques, which they are the real situation, traffic-type and offline image file technique. Next, in image preprocessing stage, the acquired image is applied with blurring effect to reduce noise and also applied with conversion function. The conversion function converts the acquired image which originally in BGR colour space into the other popular formats namely the HSV and YUV. The ROI setting stage involves assigning the position of the ROIs onto the desired parking slots and applying the range of colour that represents the parking space background colour to the ROIs which is called as 'allowable range' in this thesis. Finally, in the colour detection stage, the ROIs that have been properly set are performed with pixels analysis that compares each of the pixels inside the ROI with the allowable range defined in previous stage. The pixels which their colour value is inside the allowable range will be categorized as the parking space pixels and the rest will be assumed as the vehicle's pixels which will trigger the occupation status once the threshold value is exceeded. Several methods are introduced in overcoming the issues that have arisen in this research. Some of them include the single and twin ROI mode, the AND and OR Boolean logical operators, timer function, control ROI function and finally the shadow filtering feature. All of the methods are analyzed to view their capability and efficiency in solving the arisen issues. Through the combination of the proposed methods, it can be seen that the result of the parking space detection achieved 88.9% of success rate. The rest of 11.1% failure rate is caused by the confusion of the detector with the vehicle and parking space colour and should be overcome if more checking ROIs per parking space are implemented in the future.

REFERENCES

Afrisal, H., Faris, M., Utomo P., G., Grezelda, L., Soesanti, I., & Andri F., M. (2013). Portable smart sorting and grading machine for fruits using computer vision. Proceeding - 2013 International Conference on Computer, Control, Informatics and Its Applications: "Recent Challenges in Computer, Control and Informatics", IC3INA 2013, 71–75. https://doi.org/10.1109/IC3INA.2013.6819151

Almeida, P., Oliveira, L. S., Silva, E., Britto, A., & Koerich, A. (2013). Parking space detection using textural descriptors. Proceedings - 2013 IEEE International Conference on Systems, Man, and Cybernetics, SMC 2013, 3603–3608. https://doi.org/10.1109/SMC.2013.614

AlSaeed, D. H., Bouridane, A., ElZaart, A., & Sammouda, R. (2012). Two modified Otsu image segmentation methods based on Lognormal and Gamma distribution models. 2012 International Conference on Information Technology and E-Services, 1–5. https://doi.org/10.1109/ICITeS.2012.6216680

Ang, J. T., Chin, S. W., Chin, J. H., Choo, Z. X., & Chang, Y. M. (2013). ISCAPS - Innovative smart car park system integrated with NFC technology and e-Valet function. 2013 World Congress on Computer and Information Technology, WCCIT 2013. https://doi.org/10.1109/WCCIT.2013.6618762

Banerjee, S., Choudekar, P., & Muju, M. K. (2011). Real time car parking system using image processing. ICECT 2011 - 2011 3rd International Conference on Electronics Computer Technology, 2, 99–103. https://doi.org/10.1109/ICECTECH.2011.5941663

Bian, J., Yang, R., & Yang, Y. (2012). A novel vehicle's shadow detection and removal algorithm. 2012 2nd International Conference on Consumer Electronics, Communications and Networks, CECNet 2012 - Proceedings, 822–826. https://doi.org/10.1109/CECNet.2012.6202144

Bin, Z., Dalin, J., Fang, W., & Tingting, W. (2009). A design of parking space detector based on video image. ICEMI 2009 - Proceedings of 9th International Conference on Electronic Measurement and Instruments, 2253–2256. https://doi.org/10.1109/ICEMI.2009.5274579

Boda, V. K., Nasipuri, A., & Howitt, I. (2007). Design considerations for a wireless sensor network for locating parking spaces. Conference Proceedings - IEEE SOUTHEASTCON, 698–703. https://doi.org/10.1109/SECON.2007.342990

Caliskan, M., Barthels, A., Scheuermann, B., & Mauve, M. (2007). Predicting Parking Lot Occupancy in Vehicular Ad Hoc Networks. 2007 IEEE 65th Vehicular Technology Conference VTC2007Spring, 277–281. https://doi.org/10.1109/VETECS.2007.69

Camera, A. (2011). The Simulation of an Auto-parking System, 249–253.

Chen, L. C., Hsieh, J. W., Lai, W. R., Wu, C. X., & Chen, S. Y. (2010). Vision-based vehicle surveillance and parking lot management using multiple cameras. Proceedings - 2010 6th International Conference on Intelligent Information Hiding and Multimedia Signal Processing, IIHMSP 2010, 631–634. https://doi.org/10.1109/IIHMSP.2010.160

Chen, P., Bai, X., & Liu, W. (2014). Vehicle color recognition on urban road by feature context. IEEE Transactions on Intelligent Transportation Systems, 15(5), 2340–2346. https://doi.org/10.1109/TITS.2014.2308897

Chiu, M. Y., Depommier, R., & Spindler, T. (2004). An embedded real-time vision system for 24-hour indoor/outdoor car-counting applications. Proceedings - International Conference on Pattern Recognition, 3, 338–341. https://doi.org/10.1109/ICPR.2004.1334536

Choeychuen, K. (2012). Available car parking space detection from webcam by using adaptive mixing features. JCSSE 2012 - 9th International Joint Conference on Computer Science and Software Engineering, 12–16. https://doi.org/10.1109/JCSSE.2012.6261917

Cook, D. J., Morris, T., Morellas, V., & Papanikolopoulos, N. (2014). An automated system for persistent real-time truck parking detection and information dissemination. Proceedings - IEEE International Conference on Robotics and Automation, 3989–3994. https://doi.org/10.1109/ICRA.2014.6907438

Delibaltov, D., Wu, W., Loce, R. P., & Bernal, E. A. (2013). Parking lot occupancy determination from lamp-post camera images. IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, (Itsc), 2387–2392. https://doi.org/10.1109/ITSC.2013.6728584

Dong, Y., Pei, M., & Qin, X. (2015). Vehicle color recognition based on license plate color. Proceedings - 2014 10th International Conference on Computational Intelligence and Security, CIS 2014, 264–267. https://doi.org/10.1109/CIS.2014.63

Fabián, T. (2008). An algorithm for parking lot occupation detection. Proceedings - 7th Computer Information Systems and Industrial Management Applications, CISIM 2008, 165–170. https://doi.org/10.1109/CISIM.2008.53

Fifik, M., & Turán, J. (2010). Real Time Recognition System for Traffic Sign Detection and Classification. Pace Pacing And Clinical Electrophysiology, 284–287.

Fredembach, C., & Finlayson, G. (2006). Simple shadow removal. Proceedings - International Conference on Pattern Recognition, 1, 832–835. https://doi.org/10.1109/ICPR.2006.1054

Ghimire, D., & Lee, J. (2011). Nonlinear transfer function-based local approach for color image enhancement. IEEE Transactions on Consumer Electronics, 57(2), 858–865. https://doi.org/10.1109/TCE.2011.5955233

Guan, H., Wang, X., Wu, W., Han, Z., & Wu, Y. (2016). Real-time lane-vehicle detection and tracking system. Proceedings of the 28th Chinese Control and Decision Conference, CCDC 2016, 4438–4443. https://doi.org/10.1109/CCDC.2016.7531784

Guo, R., Dai, Q., & Hoiem, D. (2011). Single-image shadow detection and removal using paired regions. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2033–2040. https://doi.org/10.1109/CVPR.2011.5995725

Hanche, S. C., Munot, P., Bagal, P., Sonawane, K., & Pise, P. (2013). Automated Vehicle Parking System using RFID, 89–92.

Hofmann, P. (2013). Object Detection and Tracking with Side Cameras and RADAR in an Automotive Context.

Huang, C. C., Dai, Y. S., & Wang, S. J. (2012). A surface-based vacant space detection for an intelligent parking lot. 2012 12th International Conference on ITS Telecommunications, ITST 2012, 284–288. https://doi.org/10.1109/ITST.2012.6425183

Huang, C., Wang, S., Chang, Y., & Chen, T. (2008). A BAYESIAN HIERARCHICAL DETECTION FRAMEWORK FOR PARKING SPACE DETECTION Department of Electronics Engineering , National Chiao Tung University , Hsinchu , Taiwan . Department of Electrical and Computer Engineering , Carnegie Mellon University , Pittsburgh. System, 1, 2097–2100.

Ibisch, A., Stumper, S., Altinger, H., Neuhausen, M., Tschentscher, M., Schlipsing, M., … Knoll, A. (2013). Towards autonomous driving in a parking garage: Vehicle localization and tracking using environment-embedded LIDAR sensors. IEEE Intelligent Vehicles Symposium, Proceedings, (Iv), 829–834. https://doi.org/10.1109/IVS.2013.6629569

Ichihashi, H., Notsu, A., Honda, K., Katada, T., & Fujiyoshi, M. (2009). Vacant parking space detector for outdoor parking lot by using surveillance camera and FCM classifier. IEEE International Conference on Fuzzy Systems, 127–134. https://doi.org/10.1109/FUZZY.2009.5277099

Jermsurawong, J., Ahsan, M. U., Haidar, A., Dong, H., & Mavridis, N. (2012). Car parking vacancy detection and its application in 24-hour statistical analysis. Proceedings - 10th International Conference on Frontiers of Information Technology, FIT 2012, 84–90. https://doi.org/10.1109/FIT.2012.24

Khang, S. C., Hong, T. J., Chin, T. S., & Wang, S. (2010). Wireless mobile-based shopping mall car parking system (WMCPS). Proceedings - 2010 IEEE Asia-Pacific Services Computing Conference, APSCC 2010, 573–577. https://doi.org/10.1109/APSCC.2010.116

Kianpisheh, A., Mustaffa, N., Limtrairut, P., & Keikhosrokiani, P. (2012). Smart Parking System (SPS) architecture using ultrasonic detector. International Journal of Software Engineering and Its Applications, 6(3), 51–58.

Kim, J., Baek, J., & Kim, E. (2014). On-road precise vehicle detection system using ROI estimation. 17th International IEEE Conference on Intelligent Transportation Systems (ITSC), 2251–2252. https://doi.org/10.1109/ITSC.2014.6958041

Lee, S., Yoon, D., & Ghosh, A. (2008). Intelligent parking lot application using wireless sensor networks. 2008 International Symposium on Collaborative Technologies and Systems, 48–57. https://doi.org/10.1109/CTS.2008.4543911

Li, D., Liang, B., & Zhang, W. (2014). Real-time moving vehicle detection, tracking, and counting system implemented with OpenCV. ICIST 2014 - Proceedings of 2014 4th IEEE International Conference on Information Science and Technology, 631–634. https://doi.org/10.1109/ICIST.2014.6920557

Li, T. H. S., Yeh, Y. C., Wu, J. Da, Hsiao, M. Y., & Chen, C. Y. (2010). Multifunctional intelligent autonomous parking controllers for carlike mobile robots. IEEE Transactions on Industrial Electronics, 57(5), 1687–1700. https://doi.org/10.1109/TIE.2009.2033093

Li, X., & Ranga, U. K. (2009). Design and Implementation of a Digital Parking Lot Management System, 10(1).

Li, Y., Li, G., & Zhao, X. (2013). Approach for Parking Spaces Detection Based on ARM Embedded System. 2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics, 406–409. https://doi.org/10.1109/IHMSC.2013.244

Liu, D., & Yu, J. (2009). Otsu method and K-means. Proceedings - 2009 9th International Conference on Hybrid Intelligent Systems, HIS 2009, 1(2), 344–349. https://doi.org/10.1109/HIS.2009.74

Liu, J., Mohandes, M., & Deriche, M. (2013). A multi-classifier image based vacant parking detection system. Proceedings of the IEEE International Conference on Electronics, Circuits, and Systems, 933–936. https://doi.org/10.1109/ICECS.2013.6815565

Liu, W. M., Wang, L. H., & Yang, Z. F. (2010). Application of self adapts to RGB threshold value for robot soccer. 2010 International Conference on Machine Learning and Cybernetics, ICMLC 2010, 2(July), 704–707. https://doi.org/10.1109/ICMLC.2010.5580563

Md_Fendy_Bin_Md_Fazeli_TJ223.P76.M33_2009-24_pages.pdf. (n.d.).

Monwar, M. M., & Kumar, B. V. K. V. (2013). Vision-based potential collision detection for reversing vehicle. IEEE Intelligent Vehicles Symposium, Proceedings, (Iv), 88–93. https://doi.org/10.1109/IVS.2013.6629452

Nallamuthu, A., & Lokala, S. (2008). Vision based parking space classification. Report, Clemson University, Department …, 1–5. Retrieved from http://www.ces.clemson.edu/~STB/ece847/projects/Parking_Space_Classification.pdf

Network, S., & Sha, L. (2013). Design of Vehicle Detection System Based on ZigBee and AMR, 223–226.

Norpel, D., Dalaikhuu, S., & Tseveenjav, K. (2014). Traffic surveillance system based on computer vision and its application. Proceedings - 2014 7th International Conference on Ubi-Media Computing and Workshops, U-MEDIA 2014, 101–104. https://doi.org/10.1109/U-MEDIA.2014.68

Ostojic, G., Stankovski, S., & Lazarevic, M. (n.d.). Lot Access Control System. System.

Pala, Z., & Inanc, N. (2007). Smart parking applications using RFID technology. RFID Eurasia, 2007 1st Annual, 1–3. https://doi.org/10.1109/RFIDEURASIA.2007.4368108

Park, W., Kim, B., Seo, D., Kim, D., & Lee, K. (2008). Parking Space Detection Using Ultrasonic Sensor in Parking Assistance System, 1039–1044.

Ran, X., Wang, J., Li, Z., & Yao, G. (2010). Design of parking guidance system based on embedded internet access technology. 2010 Chinese Control and Decision Conference, CCDC 2010, 4167–4171. https://doi.org/10.1109/CCDC.2010.5498406

Riaz, M., Kang, G. K. G., Kim, Y. K. Y., Pan, S. P. S., & Park, J. P. J. (2008). Efficient Image Retrieval Using Adaptive Segmentation of HSV Color Space. 2008 International Conference on Computational Sciences and Its Applications, 491–496. https://doi.org/10.1109/ICCSA.2008.55

Ripka, P., Vyhnanek, J., Janosek, M., & Vcelak, J. (2013). AMR proximity sensor with inherent demodulation. IEEE SENSORS 2013 - Proceedings, 14(9), 3119–3123. https://doi.org/10.1109/ICSENS.2013.6688289

Russell, M., & Fischaber, S. (2013). OpenCV based road sign recognition on Zynq. IEEE International Conference on Industrial Informatics (INDIN), 596–601. https://doi.org/10.1109/INDIN.2013.6622951

Schmid, M. R., Ates, S., Dickmann, J., Von Hundelshausen, F., & Wuensche, H. J. (2011). Parking space detection with hierarchical dynamic occupancy grids. IEEE Intelligent Vehicles Symposium, Proceedings, (Iv), 254–259. https://doi.org/10.1109/IVS.2011.5940476

Sen, E. J., Deepa Merlin Dixon, K., Anto, A., Anumary, M. V., Mieheal, D., Jose, F., & Jinesh, K. J. (2014). Advanced license plate recognition system for car parking. International Conference on Embedded Systems, ICES 2014, (Ices), 162–165. https://doi.org/10.1109/EmbeddedSys.2014.6953109

Suhr, J. K., & Jung, H. G. (2014). Sensor fusion-based vacant parking slot detection and tracking. IEEE Transactions on Intelligent Transportation Systems, 15(1), 21–36. https://doi.org/10.1109/TITS.2013.2272100

True, N. (2007). Vacant parking space detection in static images. University of California, San Diego. Retrieved from http://cseweb.ucsd.edu/classes/wi07/cse190-a/reports/ntrue.pdf

Tschentscher, M., & Neuhausen, M. (2010). Video-based parking space detection, (2007).

Tschentscher, M., Neuhausen, M., Koch, C., König, M., Salmen, J., & Schlipsing, M. (2013). Comparing Image Features and Machine Learning Algorithms for Real-Time Parking Space Classification. Computing in Civil Engineering, (August), 363–370. https://doi.org/10.1061/9780784413029.046

Tsung-Ying, S., Shang-Jeng, T., & Chan, V. (2006). HSI color model based lane-marking detection. Intelligent Transportation Systems Conference, 2006. ITSC '06. IEEE, 1168–1172. https://doi.org/10.1109/ITSC.2006.1707380

Wang, Z., & Cai, B. G. (2012). A ROI setting method for vehicle detection in urban environment. Proceedings of the 2012 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications, APWC'12, 1205–1208. https://doi.org/10.1109/APWC.2012.6324962

Wei, H., Zhou, G., & Zhang, Y. (2013). Guangxi Key Laboratory for Spatial Information and Geomatics , Guilin , Guangxi , PRC 541004 State Key Laboratory of Remote Sensing Science , Jointly Sponsored by Beijing Normal University and the Institute of Remote Sensing and Digital Earth of Chinese A, 86(773), 4002–4005.

Wu, Q., & Zhang, Y. (2006). Parking lots space detection. Machine Learning, Fall. Retrieved from http://pdf.aminer.org/000/346/665/event_classification_for_automatic_visual_based_surveillance_of_parking_lots.pdf

Xiangke Guan, Zusheng Zhang, Jingquan Zhou, & Fengqi Yu. (2013). A vehicle detection algorithm based on wireless magnetic sensor networks. 2013 8th International Conference on Communications and Networking in China (CHINACOM), 669–674. https://doi.org/10.1109/ChinaCom.2013.6694677

Xiaoling Wang, Li-Min Meng, Biaobiao Zhang, Junjie Lu, & Du, K.-L. (2013). A video-based traffic violation detection system. Proceedings 2013 International Conference on Mechatronic Sciences, Electric Engineering and Computer (MEC), (February), 1191–1194. https://doi.org/10.1109/MEC.2013.6885246

Xu, B., Wolfson, O., Yang, J., Stenneth, L., Yu, P. S., & Nelson, P. C. (2013). Real-time street parking availability estimation. Proceedings - IEEE International Conference on Mobile Data Management, 1, 16–25. https://doi.org/10.1109/MDM.2013.12

Yin, Y., & Jiang, D. (2013). Research and Application on Intelligent Parking Solution Based on Internet of Things. 2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics, 101–105. https://doi.org/10.1109/IHMSC.2013.171

Yusnita, R., Fariza, N., & Norazwinawati, B. (2012). Intelligent Parking Space Detection System Based on Image Processing. International Journal of Innovation, Management and Technology, 3(3), 232–235. Retrieved from http://www.ijimt.org/papers/228-G0038.pdf

Zhou, J., Navarro-Serment, L. E., & Hebert, M. (2012). Detection of parking spots using 2D range data. IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, 1280–1287. https://doi.org/10.1109/ITSC.2012.6338706

Zhu H., Yu F., He Z., Chen L., Zhang Z. (2014). A Robust Vehicle Detection Algorithm Based On Wireless Sensor Network. 4th IEEE International Conference on Information Science and Technology (ICIST). 84 - 87, https://doi.org/10.1109/ICIST.2014.6920337