http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 8 (2): 114-127, 2009
ISSN 1812-5638

Smart Parking System using Image Processing Techniques in Wireless Sensor Network Environment

M.Y.I. Idris, E.M. Tamil, Z. Razak, N.M. Noor and L.W. Kin
Faculty of Computer Science and Information Technology,
University of Malaya, 50603, Kuala Lumpur, Malaysia

Abstract: This study aims to improve parking facilities by the introduction of a new Smart Parking Systems that would reduce empty parking space searching time. Most of the recent parking technologies relies on intrusive sensor to detect empty parking space and did not specifically guide patrons to specific parking lot. Therefore, the author proposed the implementation of Smart Parking System using image processing technique, Wireless Sensor Network (WSN) and shortest path algorithm in order to help patrons in finding vacant parking space. The pre existing security surveillance (CCTVs) will be used as a sensing nodes to identify vacant parking space. The captured image will be processed through the RabbitCore® Microcontroller and the processed data will be transmitted via ZigBee® to a central computer to store and update the occupancy status of available parking space vacancies in the database. The system will automatically assigned a space to patrons using A-Star (A*) shortest path algorithm based on the point of nearest entrance of the building. The patron will be guided to the specified location by referring to variable massage sign and the map printed on the parking ticket. RFID technology will also be used to uniquely tag the reserved ID to the database. The information on the ID will be used to remind patrons of their parking location during payment upon leaving.

Key words: Smart parking system, WSN, CCTV, A*, microcontroller

INTRODUCTION

Finding a vacant parking space is a common problem in most urban cities which especially occurs in popular and well travelled places like shopping complexes, stadiums and other well travelled areas or tourist attraction spots. This situation has become more serious especially during their peak time, be it holiday seasons, sales carnivals or any other festivals. This problem arises as most of the time, as patrons come by their own transport, resulting in abundance or high number or transports competing for a few vacant parking spaces. The limited availability of vacant parking spaces often results in traffic congestion, as well as making a driver frustrated in finding an available parking space. In fact, it is one of the main problems which result to traffic congestion. Interesting enough, a research into drivers parking behavior however, indicates that this does not seem to prevent most drivers from still queuing and waiting at their favorite car park even for a significant period of time (Bong *et al*., 2008). As well as the limitation of a driver's capability in finding a vacant parking spaces, the lack of well organized and helpful parking system are also at fault for causing this problem. To tackle this problem, the smart parking system has been implemented through-out many countries in Europe, United Kingdom and even Asian country such as Japan, as early as the 1970s (Shaheen *et al*., 2005). The smart parking system concentrates on solving the problem of proper parking management by utilizing the advancement of technologies which will definitely help in alleviating, if not solving the current traffic problem.

CURRENT EXISTING SYSTEM

The term smart parking refer to the technology which allows people to dynamically reserve and pay for parking (Shaheen *et al*., 2005), whereas system is a set of computer component or orderliness. By general understanding, a smart parking system is a combination of intelligent actions using a combination of hardware, software and data communications to efficiently manage a vehicle parking area.

The increased rate of technologies advancement year by year can be considered as a revolution, enabling technologies like the smart parking system to be produced. This system mainly concentrates in solving the problem of parking management or to be precise, parking

Corresponding Author: Mohd. Yamani Idna Idris, Faculty of Computer Science and Information Technology, University of Malaya, 50603, Kuala Lumpur, Malaysia

area management. The smart parking system can be divided into five major categories which consist of Parking Guidance and Information System (PGIS), Transit Based Information System, Smart Payment System, E-Parking and Automated System (Shaheen *et al*., 2005).

The Parking Guidance and Information System (PGIS) is a system which provides information about the nearest car park and the number of vacancies available to drivers. This system can be commonly located in big urban cities. The Variable Message Display (VMS) and other methods such as radios and phones are used to provide information regarding parking spaces availability to the patrons. The information provides the occupancy status of car parks or selected car park around the city with a range of capability of displaying Full/Available at the entrance to guide the user to the respective vacant area. In order to detect the space usage in the car park, vehicle detectors are installed at the entrance, exits and/or at individual parking space. Common choices of detector used include loop detectors, machine vision, ultrasonic, infrared, microwave and lasers. An example of PGIS has been illustrated by Seong *et al*. (2008) in their paper which consists of a Wireless Sensor Network (WSN) based VDS (vehicle detection sub-system) and a management subsystem (Fig. 1).

Fig. 1: Example Variable Message Display (VMS) (Seong-Eun *et al*., 2008)

Fig. 2: Automated parking (Smith and Roth, 2003)

Another system which is similar to the PGI system is Transit Base Information System. This system provides parking space information and public transportation schedules in car parks and riding lot. The main purpose of this system is to encourage people in using public transportation as patrons can leave their vehicle in the provided car park at the public transportation site. The Smart Payment System also aimed to overcome the limitation of conventional payment method. It works by revolutionizing the various available ways for payment method in car park with various types of cards, RFID transponder (Pala, 2007) and other means such as mobile phones which can be used to pay the parking fee (Mingzhou and Weiwen, 2006).

E-Parking provides another way for drivers to reserve a parking space at their desired car park facility of choice to ensure a vacant parking space is available when they arrive. The reservation for a parking space can be made via SMS, phone call, through the internet and/or PDA. Geetha *et al*. (2007) discuss the transformation of Unified Modeling Language (UML) models into software execution models and simulate the performance prediction taking e-parking system as her case study.

Lastly, the Automated Parking as shown in Fig. 2 which utilizes a computer controlled mechanism that automatically places the vehicle into the parking space without the need for the drivers to enter the parking lot (Smith and Roth, 2003). A complex systems and number of severe accidents in automated parking has initiate Mathijssen *et al*. (2007) to apply verification techniques to develop a software design for an automated parking garage.

In the implementation of a smart parking system, various sensors play a crucial role in the smart parking management. With the various sensor technologies available for use, various aspects have to be considered when selecting the appropriate sensor to be used in the smart parking system. Several of the aspects include cost, size, reliability, robustness and most importantly the overall integration into the universal system design. Basically, the sensor can be categorized into two main categories which consist of the intrusive and the non-intrusive sensor. The intrusive sensors are sensors such as inductive loops, magnetometer, pneumatic road tubes, piezoelectric cables and weight-in-motion sensors, which are typically sensors that require invasive installation procedures. Whereas examples of non-intrusive sensors are such as video image processing, microwave radar, passive infrared, ultrasonic, laser radar and passive acoustic array sensors which can be installed easily by mounting the device on the ground or the ceiling of the car park (Yu *et al*., 2006).

In this proposed system, the video image processing has been chosen to best suit the system because of its several advantages compared to other sensors. Video image processing detects vehicles by analyzing the video imagery and determines the changes between successive frames (Heidemann, 2005). It can also monitor multiple lanes and multiple zones or lane, at a lower maintenance cost compared to other sensors. Besides that, video image processing is generally a cost effective method, easy to be installed and modified for later use and covers a wide detection zones which are required within the field of view of the camera (Shaheen *et al*., 2005). Other sensor like microwave radar or passive infrared are not suitable to be used because the sensor cannot detect a stationary vehicle. A special sensor layouts and signal processing software are required and its antenna beam width and transmission waveform must be suitable for the application. Furthermore, some adjustment has to be made to reduce its sensitivity to vehicle in heavy rain and snow. All the above problem will increase the overall cost (Mimbela Luz Elena and Klein, 2000; Wolff, 2006).

SYSTEM FLOW

Even though various kind of smart parking system has been long implemented, they still have some drawback such as the system cannot tell and assist the patrons in finding the nearest parking space to the building entrance. This study is the continuation of our earlier work in (Idna *et al*., 2005, 2008; Idna and Tamil, 2006, 2007). In general, our proposed system operates to inform and guide patrons for any parking spaces vacancy within a car park area, upon entering the car park and within its area. Once informed of the availability of parking spaces vacancies within a parking area, patrons are required to select the desired parking destination location aided by graphical instructions on the display monitor before taking their parking ticket. Patrons will be asked to select their desired destination level and will be given the layout of the level together with the tenant of each respective parking lot. Graphical interface will be displayed to the user to ease the selection process. If users are indecisive and cannot make up their mind within 30 sec, the General option on the selection menu will be automatically chosen by the system and it will automatically assign and reserve an available vacant space for the patrons.

The A-Star (A*) algorithm is used to assign vacant parking spaces to patrons and this algorithm is based on the shortest path algorithm. The earliest paper on A-Star was presented by Hart *et al*. (1968) where heuristic information from the problem domain can be incorporated into a formal mathematical theory of graph searching and demonstrates an optimality property of a class of search strategies. The algorithm takes into consideration the entrance to the car park used by patrons and then the nearest vacancies to the building entrance from the location selected themselves by the patrons or selected by the system through the General option. Nearest vacancies to the building entrance is chosen by taking the assumption patrons would prefer shortest walking distance.

The assigned parking space number or parking number ID will be reserved for the specific user and encoded in their parking ticket. The identification of this reserved parking space will be updated in the database. The ID number will be used for validation during the payment of the tenant's duration of stay to calculate the parking fees. At the same time, map of the selected parking level together with the exact parking location will be displayed on the variable massage display and printed out with the ticket to assist the user in finding their parking space upon leaving.

The Close Circuit Televisions (CCTV) available in the car park will be utilized in detecting the status of each parking space to keep the database in the central computer updated. Besides that, the CCTVs also work in helping to detect the arrival of a car to its entitled parking space and changing the status of that particular parking slot from Reserved to Occupied. In the case of a patron parking elsewhere other than their assigned space, the status of the vacant space taken up by the driver will also be updated to Occupied as detected by the CCTVs.

If a car fail to arrive at their assigned parking space and cannot be detected at the assigned space after a grace period of 10 min, the ID number associated with the particular vacant space will automatically be considered as void, which then the vacant space identified in reference to the ID number identification is deleted from the database and the vacant space is again taken into consideration for the next patron going to the same location.

A RabbitCore® Microcontroller image processing modules will be connected to CCTV for vacant space detection. The data processed is transferred wirelessly via Zigbee Wireless Sensor Network (WSN) to the central computer for information updating. The computation is conducted on the microcontroller device due to the fact that image processing requires intensive computational

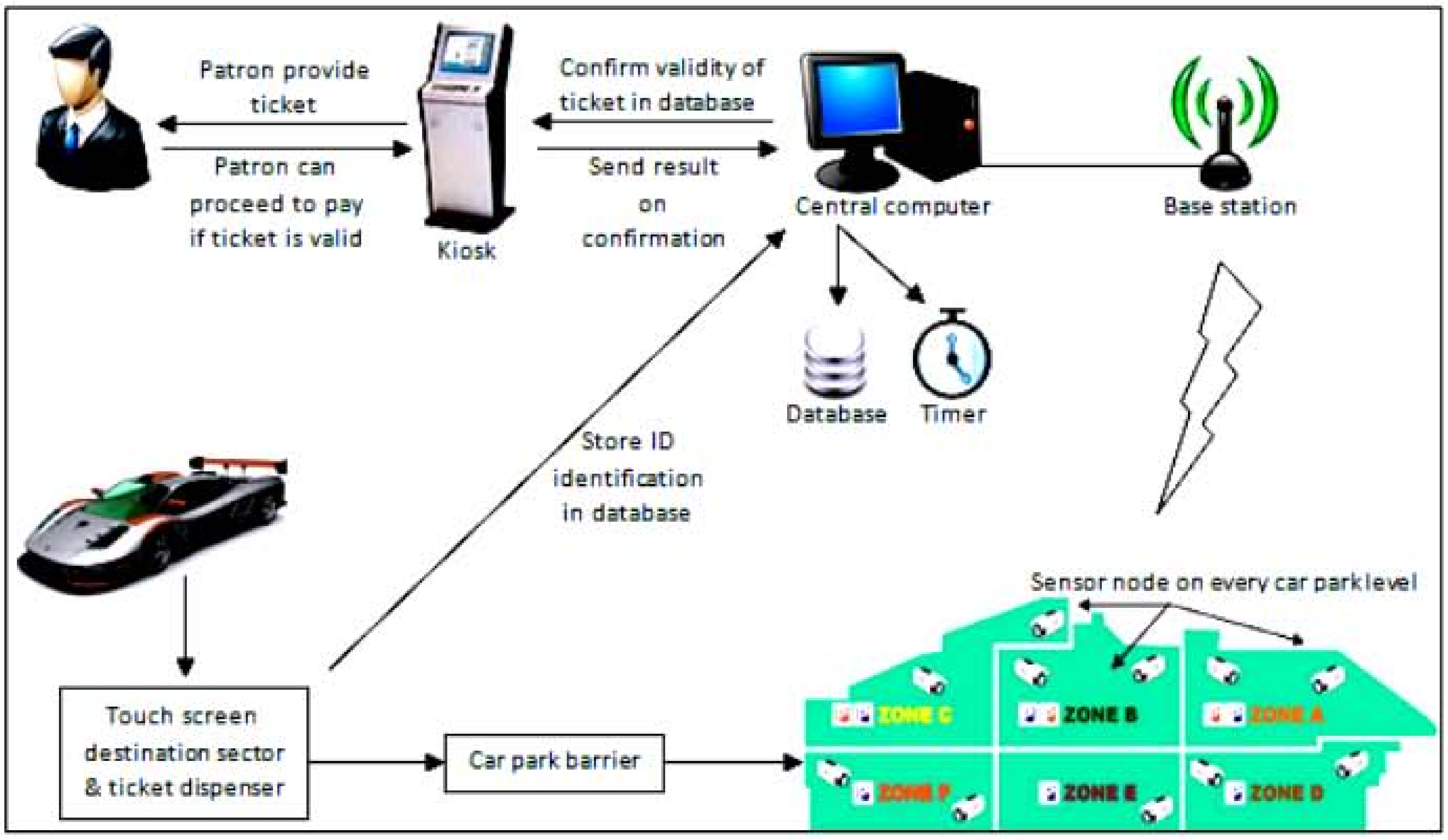

Fig. 3: System flow

power to run the image processing algorithms and this will avoids sending large volumes of raw images or data to and fro for computation purposes which makes it more efficient.

When the patrons have finished running their errands and are ready to leave, they will be reminded of the location of their car as they make the payments at the payment machines available throughout the building according to the location encoded into the ticket. The payment machine verifies the ticket by checking the database to confirm its validity before accepting payments from the patron. If the ticket identification is voided, the patron would not be able to make payment and exit the car park. The whole flow of this system is shown as in Fig. 3.

SYSTEM DESIGN

In general, the Smart Parking System consists of five main modules which are crucial in the development of the system. It consists of the Shortest Path calculation algorithm, an Image Processing component, Status Updater, I/O and a Timer function which perform the main task in the system. Overall overview of this main system's design can be shown as in Fig. 4. The Smart Parking System also consist of three major subsystem which are the Administrator Management System, a Car Park-User Interface and also the Sensor Node Subsystem. I/O is a straight forward function with a main task to get an input from the patron of their selected parking space location aided by a user interface command. The module also utilize in the correction kiosk, in which patrons are required to provide their ticket for verification, in case of applying for grace period extension. The time will then reactivate, extending the reservation period of the parking space for patrons. For parking space reassignment, the Shortest Path Module and Database Update Module are invoked to allocate a new parking space availability status. A new parking ticket will then be dispensed to the patrons. Database Updater is used to directly update the parking space occupancy status in a database where the overall data is stored. It is also used when reassigning a parking space request, in which the information from I/O will be used to update the database.

Shortest Path calculation algorithm is used in assisting patrons to choose their parking destination by assigning patrons with a vacant parking space as shown in Fig. 5. Calculation is based on the patrons' point of entrance and the shortest distance for them to the building's entrance. A timer is used to keep track of the time elapsed as the car enters the car park and aiding in payment calculation. Lastly, Image Processing is implemented in manipulating the images captured by the CCTVs to track the occupancy status of any particular parking space.

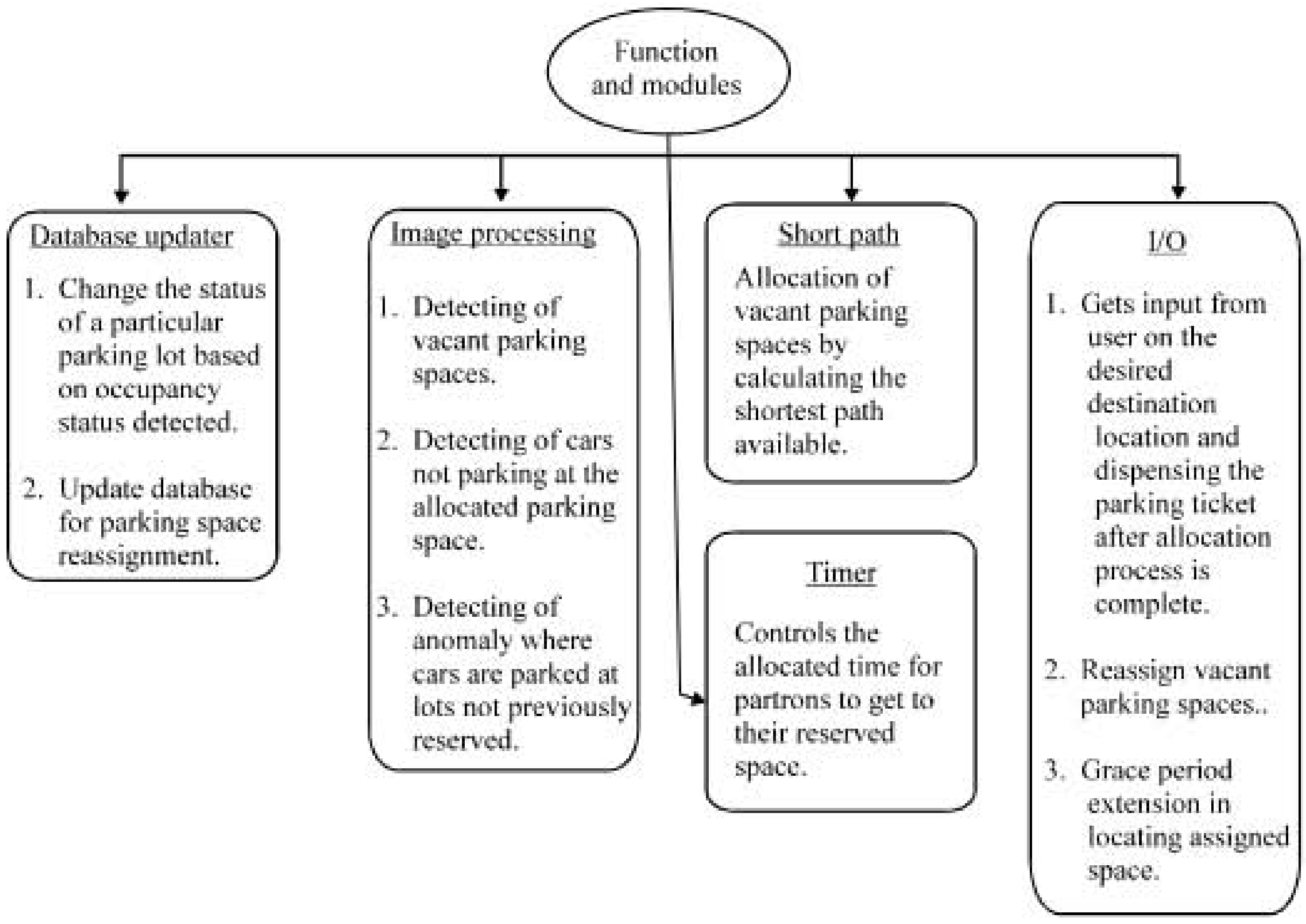

Fig. 4: Functions and modules implemented in the system

Fig. 5: Shortest path route

The major subsystems flow start with the Administrator Management System where it begins by displaying a welcome page to which then the administrator is required to login by using a specified username and password for security purpose. After that the system will prompt for the command of several activities, namely editing the map of the parking space or accessing the system directly. The administrator can choose to create a new map, edit an existing map or loading a predefined map from a library directory. Figure 6-8 shown below are the main menu, menu to search parked car and module to draw car park layout.

The administrator can use the selected map and start the system, but before that the appropriate sensor node to communicate with the system must be choosen and set. A CCTV is selected as the system's sensor which will be used to capture and compare the image immediately after the initiation message (Sta) was received. The resulting image from image comparison will be sent to a central computer to update the occupancy status of the parking spaces in the database. The administrator can initiate a stop message (Sto) if they want to stop receiving data from the sensor node. Overview of the subsystem's flow is as shown in Fig. 9.

The second subsystem is the Car Park-User Subsystem, which assist user in finding the available parking space to be reserved, via a helpful and user friendly interface. The process of this subsysytem involve

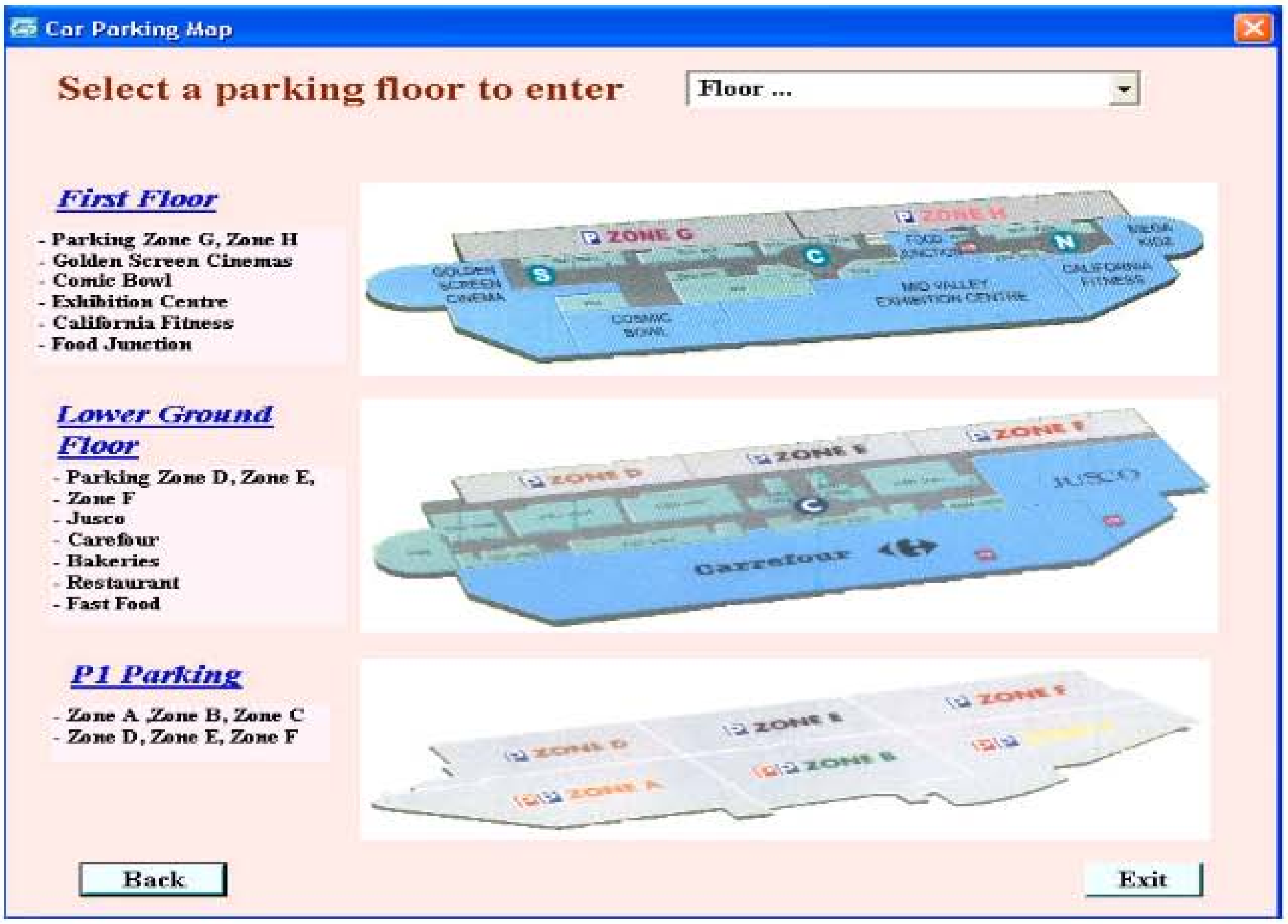

Fig. 6: Main menu

Fig. 7: Menu to search parked car

Fig. 8: Module to draw car park layout

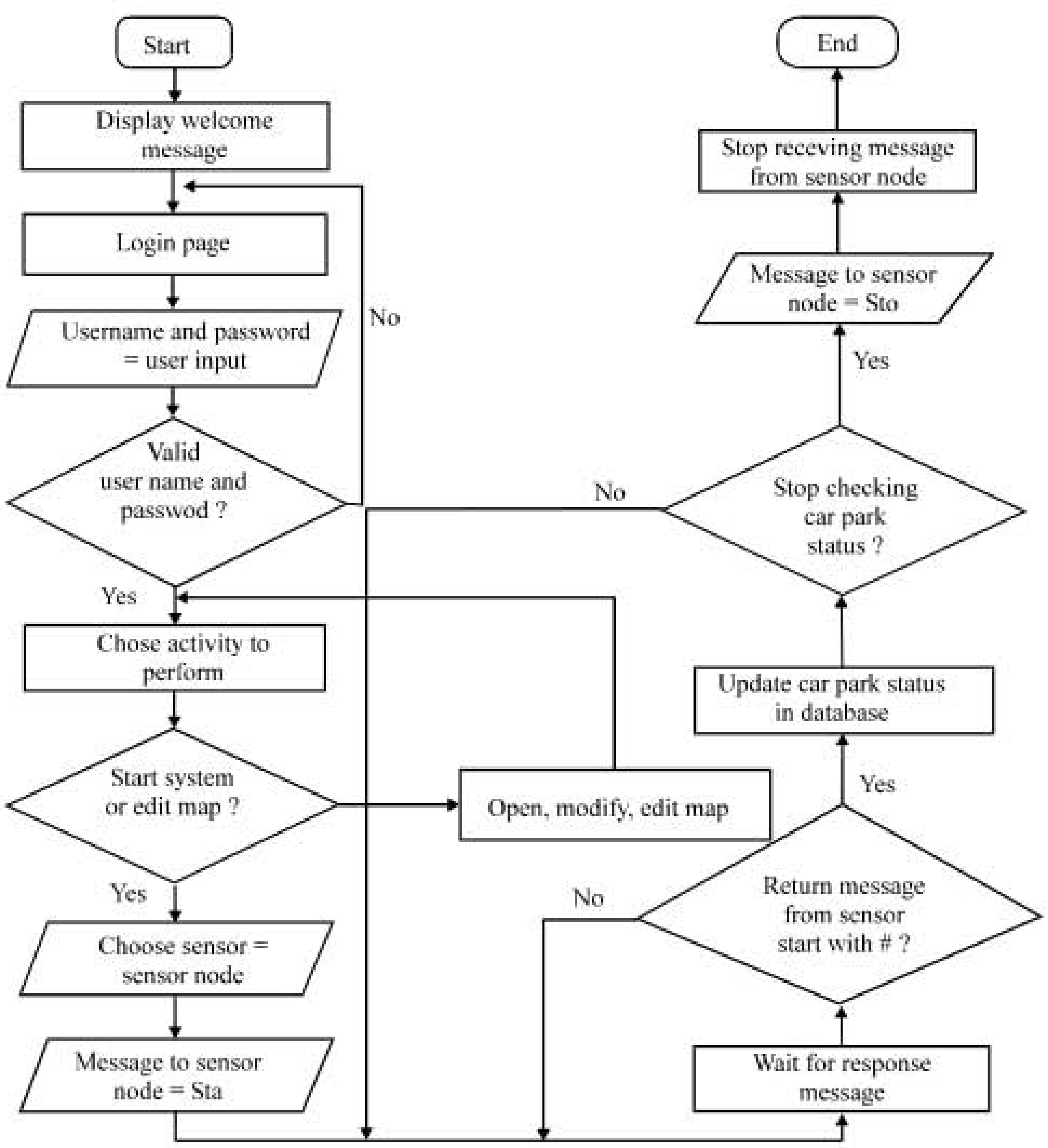

Fig. 9: Flowchart for the administrator subsystem

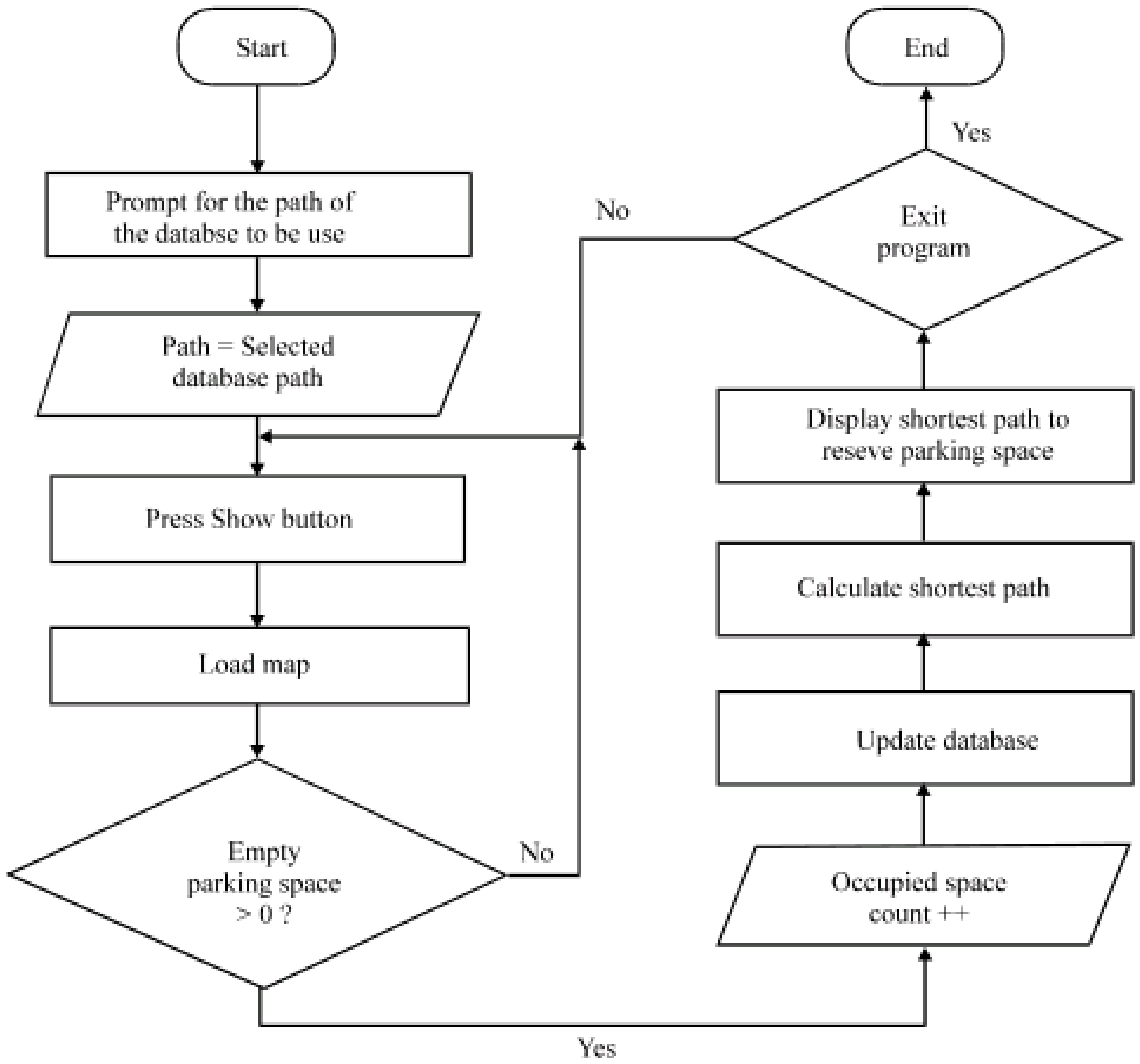

Fig. 10: Car park user subsystem

not only in displaying the available parking spaces and the most efficient parking space available, but it also will show the shortest path to the their reserved parking space. The map will also be printed out to be used as the patrons guidance to their allocated parking space. Overview of the subsystem's flow is as shown in Fig. 10.

Finally, the Sensor Node Subsystem completes the three major subsystems in the Smart Parking System. The Sensor Node Subsystem performs its very own specific task of processing all the data received from the selected system' s sensor via WSN, to determine the occupancy status in the car park. The sensor node involves two main microcontroller boards-the ZigBee® module and the camera module. The occupancy status is calculated by using a set threshold, which differentiate pixels that come from an empty parking space with an occupied parking space. The system will compare pixels between the existing background parking lot and the parking lot with a subsequent image. If the subsequent image's pixels are lower than the set threshold value, it implies an unoccupied lot, whereas if the subsequent image's pixels are higher than the set threshold value, it implies an occupied lot. Then the resulting interpreted data calculated will be sent to the management node. Overview of the subsystem' flows as shown in Fig. 11.

SYSTEM TESTING

Image processing module: The image processing module to detect empty parking space work by using threshold technique where the system compares between the background and newly incoming image. An incoming object will change the value of the background image pixel and if the change is above the set threshold, the space is set to occupied (Fig. 12).

First, each parking slot is traced using administrator tools to get their pixel coordinate by selecting Get Coordinate button as shown in Fig. 13. The red dot is dragged to capture the pixel coordinate of the parking slot and given a lot ID. Figure 14 shows example of three parking slots coordinate attached to ID 1FG11, 1FG12 and 1FG13. The coordinate and ID are stored inside RabbitCore® microcontroller. When the camera module captures an incoming vehicle at each slot, the microcontroller will send the occupancy status to central computer via ZigBee® wireless communication. The information is captured by SerialReader program which read the serial data transferred by ZigBee® via communication port as shown in Fig. 15.

Vehicle guidance module: During this phase, the system will be tested by creating a scenario of a simulated parking

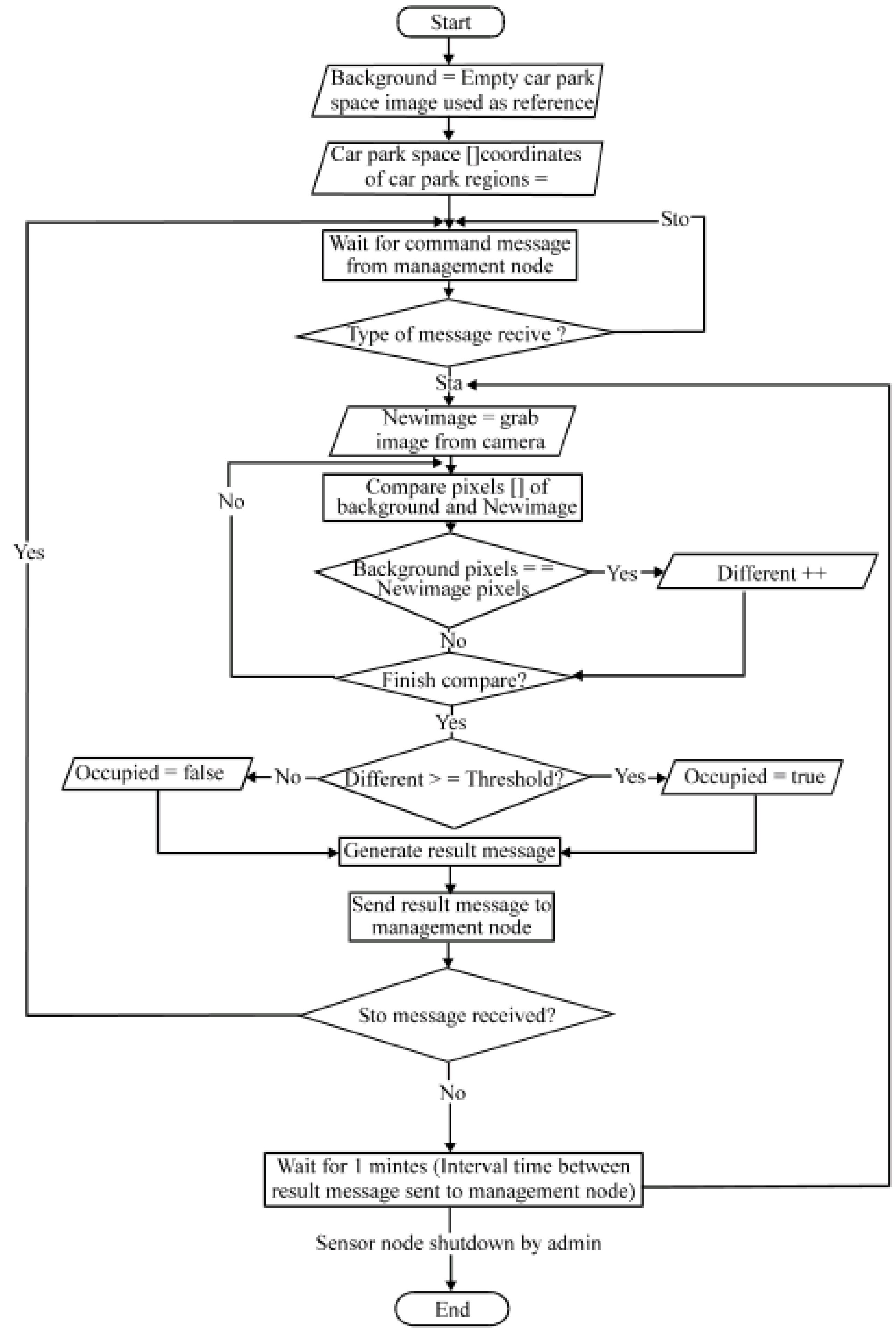

Fig. 11: Flowchart of sensor node subsystem

210	243	243	243	243	243	251	251	210	243	243	243	243	243	251	251
222	243	235	235	243	243	251	251	222	**58**	**58**	**58**	**58**	**58**	**63**	251
222	241	235	235	222	251	241	251	222	**58**	**58**	**58**	**58**	**58**	**63**	251
222	241	235	235	222	210	251	241	222	**63**	**56**	**58**	**60**	**56**	**63**	241
222	235	235	235	222	251	251	251	222	**63**	**56**	**63**	**60**	**56**	**63**	251
222	251	241	241	241	241	241	230	222	**65**	**56**	**60**	**60**	**60**	**55**	230
222	251	210	210	210	251	251	251	222	**65**	**56**	**65**	**65**	**65**	**55**	251
222	251	210	210	210	251	251	251	222	**65**	**56**	**65**	**65**	**65**	**55**	251

Fig. 12: Original background (left), occupied space (right)

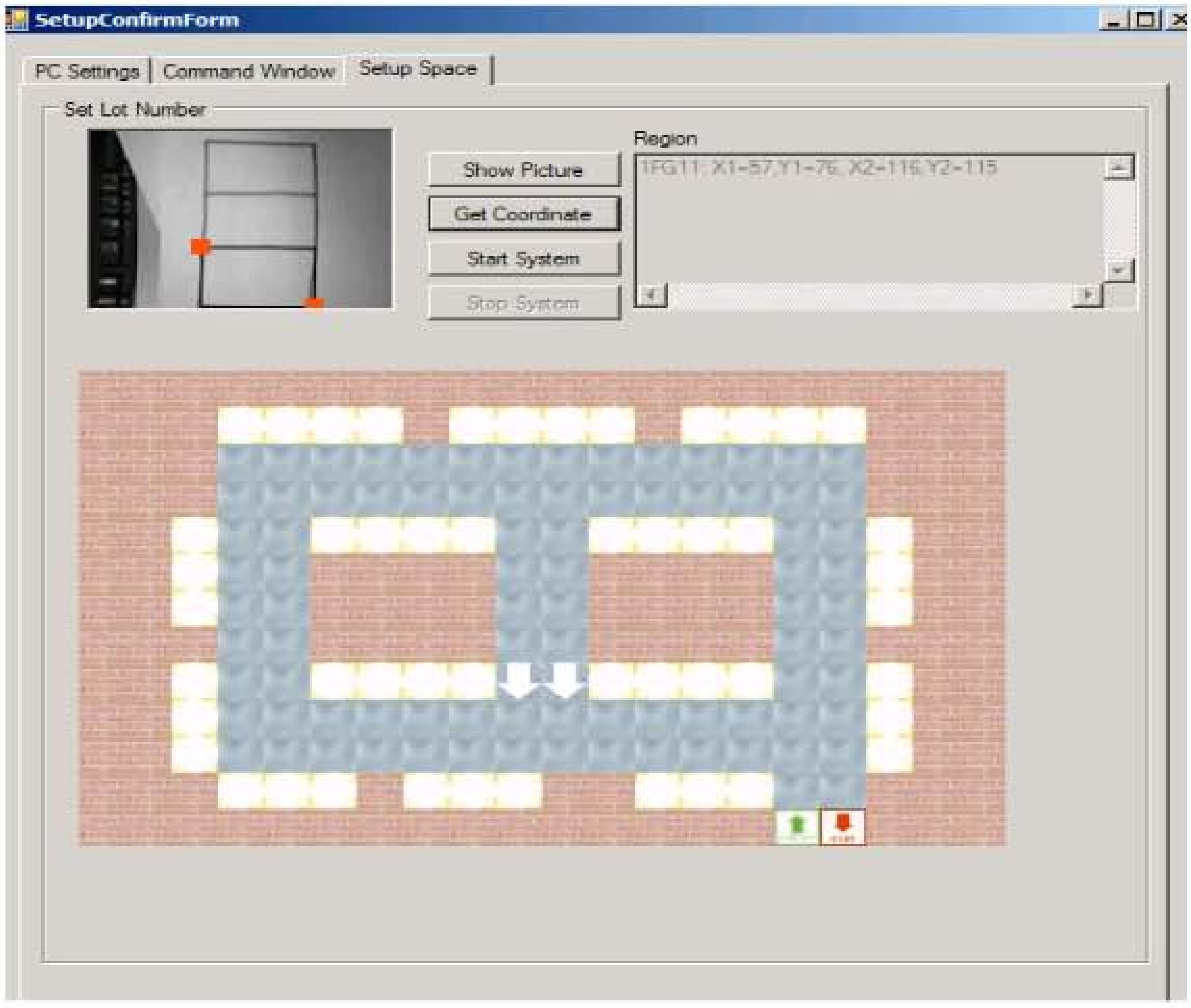

Fig. 13: The parking space coordinate region

```
prealloc = 0;

//preset coordinate
x1[0] = 57;
y1[0] = 76;
x2[0] = 116;
y2[0] = 115;

x1[1] = 37;
y1[1] = 14;
x2[1] = 62;
y2[1] = 64;

x1[2] = 83;
y1[2] = 66;
x2[2] = 127;
y2[2] = 91;
//end

//preset lot name
strcpy(name[0], "1FG11\0");
strcpy(name[1], "1FG12\0");
strcpy(name[2], "1FG22\0");
//end

for(i = 0; i < SPACE;i++)
{
```

Fig. 14: Camera C program

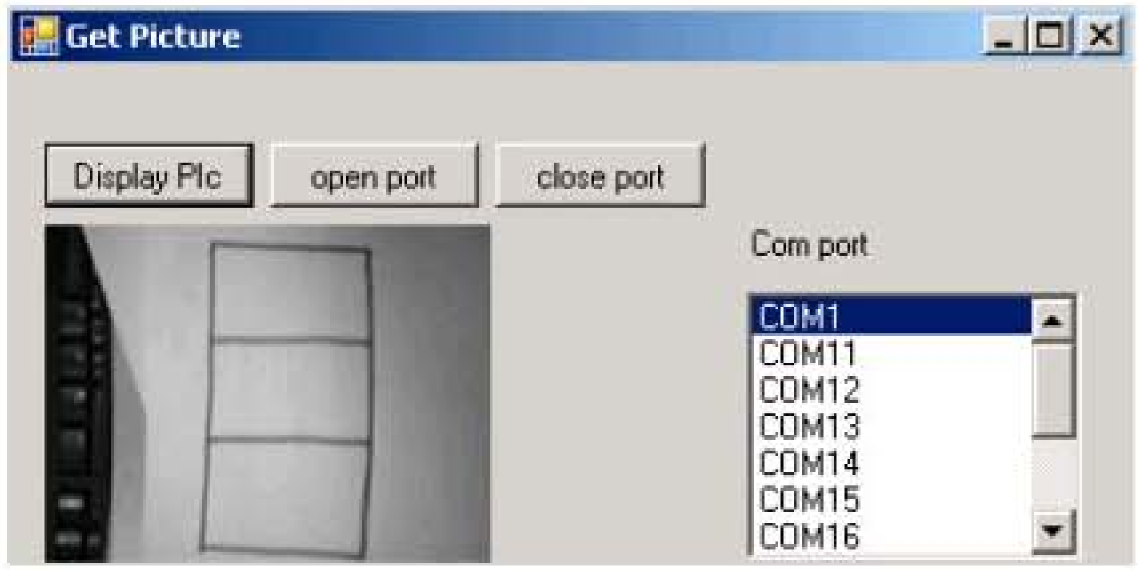

Fig. 15: Serial reader program

Fig. 16: 1st patron arrive at entrance parking space

Fig. 17: 2nd patron arrive at entrance parking space

Fig. 18: After the reservation period expired

Fig. 19: 3rd patron arrive at entrance parking space

space. For this scenario, only three parking spaces are available for occupancy with ID 1FG11, 1FG12 and 1FG22. When a patron arrives at the parking space entrance, he or she will press the Show button and a layout will be shown at the monitor as show in Fig. 16. The system will then guide the patron to the available parking space and will reserve the parking space for 10 min.

If there are no updates in the database within the 10 min time period, it will not change the reservation parking space status and the next patron who arrives at the parking space entrance will be assigned into another parking space as shown Fig. 17.

After the 10 minute reservation period, if the 1FG22 reserve parking lot is still unoccupied, the sensor node will send a message to the management node informing it of the current status and then the database will update the status of the parking space ID 1FG22, the reserved icon at map will hide, as shown in Fig. 18. Subsequently, when the next patron arrives at the parking space entrance and press the Show button, he or she will be assigned straight to the parking space ID 1FG22, as shown in Fig. 19.

SYSTEM EVALUATION

A large building or a parking area will have many entrances available. Problem can arise in cases when too many cars arrive at the same time using different entrances, triggering conflict of assigning which vacant spots to which patrons. Thus the assignment of guiding patrons to vacant spaces must be synchronized and this can be solved by using a centralized, single database system. A centralized and single data based system can avoid the critical error of assigning a vacant spot to several users who come at the same time.

Problem can also arise when patrons do not park their car specifically in their assigned parking spot and park at other vacant space instead. This illegal parking is minimized by the implementation of shortest path algorithm which guides patrons to their reserved slot. The shortest distance would give the patron advantage to be the first one to park. Other method would be the enforcement implementation (e.g., clamp, penalty ticket).

In certain situation with poor lighting condition, images in the parking space will produce shadow from various surrounding object such as other vehicle, wall and other objects. Problem will arise when the image processing component capture a parking space but misunderstood the shadows from various object as a vehicle. Then the central computer will update the database and considered the parking space as occupied. This problem can be solved by using the keypoint extraction technique like Scale Invariant Feature Transform (SIFT) technique. This technique is used to automatically and accurately recognize an object and thus it can be used to trace whether the image actually contains a shadow or the actual vehicle at the parking space.

To aid user to recall their specific parking space after completed their business, Radio Frequency Identification (RFID) is used. The unique ID in the RFID card contains the parking lot ID which able to show patrons where they have parked when leaving the facility. RFID card also contains the duration information to be used to calculate the parking fee.

CONCLUSION

This study shows the efficient use and method of the Smart Parking System in alleviating and solving the common problem of allocating parking space in busy areas in big cities such as shopping complexes, stadiums and other popular places, especially during their peak hour. The Smart Parking System also offers a better and more efficient alternative for car park management. By using Image Processing Technologies to determine the availability status of parking spaces in a Wireless Sensor Network environment, the proposed Smart Parking System offers a better solution for car park management. Apart from all the technologies, the Smart Parking System is a user based and also user friendly system which prioritize itself in assisting users, from their time of arriving in the car park until the moment they leave. With the introduction of the Radio Frequency Identification (RFID) technologies, users will easily locate their vehicle even they have forgotten or taking other exits.

ACKNOWLEDGMENTS

The authors would like to thank Ms Yong Yoke Leng and Mr. Mohd Firdaus Abdul Rahman for their help and University of Malaya for funding this project (Grant No: SF035-2007A and FS255/2008B).

REFERENCES

Bong, D.B.L., K.C. Ting and K.C. Lai, 2008. Integrated approach in the design of car park occupancy information system (COINS). IAENG Int. J. Comput. Sci., 35: 7-14.

Geetha, D.E., C.R.M. Reddy, T.V.S. Kumar and K.R. Kanth, 2007. Performance modeling and evaluation of e-commerce systems using UML 2.0. Proceedings of the 8th ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD 2007), July 30 2007-Aug. 1 2007, Washington, DC, USA., pp: 1135-1140.

Hart, P.E., N.J. Nilsson and B. Raphael, 1968. A formal basis for the heuristic determination of minimum cost paths. IEEE Trans. Syst. Cybernetics, 4: 100-107.

Heidemann, J., F. Silva, W. Xi, G. Giuliano and H. Mengzhau, 2005. Sensor for Unplanned Roadway Events-Simulation and Evaluation (SURE-SE). Report METRANS Project 04-08. http://www.isi.edu/~johnh/PAPERS/Heidemann05d.html.

Idna, M.Y., N.M. Noor, Z. Razak and M.N. Ridzuan, 2005. Parking system using chain code and a-star algorithm. International Conference on Intelligent Systems, ICIS2005, (Endorsed by the IEE), December 1-3, Sunway Lagoon Resort Hotel, Kuala Lumpur, pp: 1-5.

Idna, M.Y. and E.M. Tamil, 2006. An intelligent parking information system. 3rd International Conference on Artificial Intelligent in Engineering and Technology (ICAIET 2006), November 22-24, Sabah, Malaysia, pp: 1-7.

Idna, M.Y. and E.M. Tamil, 2007. Parking information system using GPS and shortest path algorithm. Proceedings of the SCORED 2007, May 14-15, Universiti Tenaga Nasional, Malaysia, pp: 1-7.

Idna, M.Y., Y.L. Yong, E.M. Tamil and N.Z Haron, 2008. Parking guidance system using RFID and image processing techniques in WSN environment. 4th International Colloquium on Signal Processing and its Applications, March 7-9, Royale Bintang Hotel, Kuala Lumpur, pp: 1-6.

Mathijssen Aad, A. and P. Johannes, 2007. Verified design of an automated parking garage. Lecture Notes Comput. Sci., 4346: 165-180.

Mimbela Luz Elena, Y. and L.A. Klein, 2000. A summary of vehicle detection and surveillance technologies used in intelligent transportation systems. Federal Highway Administration, Intelligent Transportation Systems Joint Program Office (2000). http://www.fhwa.dot.gov/ohim/tvtw/vdstits.pdf.

Mingzhou, J. and G. Weiwen, 2006. EZ M parking system. Transport. Res. Record, 1944: 67-71.

Pala, Z. and N. Inanc, 2007. Smart parking applications using RFID technology. 1st Annual RFID Eurasia, Sept. 5-6, Istanbul, pp: 1-3.

Seong-Eun, Y., C. Poh Kit, K. Taehong, K. Jonggu and K. Daeyoung *et al*., 2008. PGS: Parking guidance system based on wireless sensor network. 3rd International Symposium on Wireless Pervasive Computing, (ISWPC 2008), May 7-9, IEEE Xplore, pp: 218-222.

Shaheen, S.A., C.J. Rodier and A.M. Eaken, 2005. Smart parking management field test: A bay area rapid transit (bart) district parking demonstration. http://pubs.its.ucdavis.edu/download_pdf.php?id=44.

Smith, L. and H. Roth, 2003. Parking Systems Technology Report ITS Decision Partners for Advanced Transit and Highways. 1st Edn., University of California, Berkeley.

Wolff, J., J. Heuer, T. Haibin, G. Weinmann, M. Voit and S. Hartmann, 2006. Parking monitor system based on magnetic field senso. IEEE Intelligent Transportation System Conference, (ITSC'06), Toronto, Ont., pp: 1275-1279.

Yu, Y., V.K. Prasanna and B. Krishnamachari, 2006. Information Processing and Routing in Wireless Sensor Networks. 1st Edn., World Scientific Publishing Company, USA., ISBN-10: 981270146X, pp: 204.