CampusSense - A Smart Vehicle Parking Monitoring and Management System using ANPR Cameras and Android Phones

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Abstract-- **Vehicle parking monitoring and management has become a big challenge for educational institutions with increasing enrollments, high percentage of vehicle ownership and decreasing parking supply which in result triggering blockage of vehicle, congestion, wastage of time and money. In university campuses particularly in Kingdom of Saudi Arabia, vehicle parking monitoring and management problem is getting worse and more frustrating due to the fact that majority of students, faculty and staff members own cars and drive through them to the university campuses. These common problems include finding out people (evidence) who are responsible for the damages (hitting, scraping, scratching and dents) to other cars and the blockage of car due to wrong car parking which takes much time to locate the owner of the car. Moreover, locating or forgetting their car park location another difficulty that is often faced by the students, faculty and staff members. The existing cameras located at the parking lots are only for video surveillance and cannot help in such situations as there is a lack of proper vehicle parking monitoring and management system. To cope with above mentioned problems and to ensure a better parking experience by accommodating increasing number of vehicles in a proper convenient manner, we propose a smart vehicle parking monitoring and management system called CampusSense. In CampusSense, Automatic Number Plate Recognition (ANPR) cameras and android based mobile application is developed to efficiently monitor, manage and protect the parking facilities at university campuses. Parking problems around the university campus faced by the students, faculty and staff members are analyzed by conducting a survey.**

Keywords—**Smart Vehicle Parking Monitoring and Management, Android based Mobile Phones, License Plat Recognition, Locating Vehicle, Mobile Sensing.**

I. INTRODUCTION

Vehicle parking monitoring and management is challenging problem due to the growing number of vehicles at university campuses and also for catching the responsible persons for damaging the vehicles (like scratches, dents, scraps etc.) of other people's inside a campus who remain anonymous and also result in confusion, annoyance and wastage of time.

Manuscript received Feb. 13, 2016. This work is a follow-up the invited journal to the accepted conference paper of the 17th International Conference on Advanced Communication Technology (ICACT2015).

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The problem is getting more severe day by day due to the fact that a the number of student enrolments is increasing year by year and a huge percentage of students and faculty own cars with the limited number parking lots. Blocking the other parked vehicles in the parking lots by people while parking their cars improperly is an important issue in vehicle parking. Due to this, finding the responsible persons and remain stuck and frustrated for the blocked vehicle owners until they get the vehicle out of the parking lot. The security guards at the parking lots are unable to help in this regard because of the lack of any monitoring and management enforcement systems and policies. Due to this, it takes much time in pursuing the responsible person which consequently results in the wastage of precious time of students as well as faculty and staff members. Another critical problem (that arises due to the reserved and limited number of vehicle parking lots) is that students (for whom no reserved parking is available) may damage other parked vehicles while improper and wrong vehicle parking. The damaged vehicle owners remain unsuccessful in finding out the responsible persons for damaging their vehicles and no one can help out in this concern because there is no proper monitoring system that can keep record of the in and out information (i.e. entrance and exit) of the vehicles and parking information (like parking location, parking duration) of vehicles. Moreover, in case of suspected vehicles (involved in any criminal activity) are unable to trace out by current system as there is no record or way to identify them. Another most common problem faced by students, faculty and staff members is they often forget where they have parked their vehicles in the parking lots. So, finding out a vehicle in such a scenario without any automated management system is results in anger, exasperation and wastage of time and it is also difficult and time consuming task.

Smart phones are now days the key computing and communication device and these mobile phones are equipped with a rich set of embedded sensors. These specialized sensors including ambient light sensor, accelerometer, digital compass, gyroscope, GPS, proximity sensor and general purpose sensors like microphone and camera. These sensors collectively enable new applications across a wide variety of domains like homecare, healthcare, social networks, safety, environmental monitoring, ecommerce and transportation [1-2]. Mobile sensing provides the opportunity to track dynamic information about environmental impacts and develop maps and understand patterns of human movement, traffic, and air pollution [3]. Using these extraordinary monitoring capabilities of smart phone sensors a wide range of mobile application are developed for traffic monitoring for example monitoring

road and traffic conditions, detecting road bumps, honks, potholes etc. Such traffic monitoring systems include [4-9].

The current vehicle parking monitoring and management system at the Jazan University is fully manual which only allows the authorized vehicles that are registered by having the entrance sticker. The whole university area including entrance and exit gates, academic area, administrative and parking zones are all under video surveillance. But this can only serve for video capturing and storing and are not connected to any proper monitoring and management system.

In this paper we have proposed a smart vehicle parking monitoring and Management system called *CampusSense* to overcome the above mentioned problems which encountered while vehicle parking in the parking area of the University campus. We have also review the contribution in [10] and after further investigation the CampusSense system by discussing the design and the system features in more details. CampusSense consist of hardware (ANPR Cameras) and software components (Mobile Application and Management System) and can assist the security department to handle the parking problems more effectively such as locating the car if a person forgets its exact parking location or to locate and pursue the liable person for damaging or blocking some ones car while wrong car parking in the parking lot.

A quantitative questionnaire based survey is also conducted to investigate the problems encountered by the students, faculty and staff members. The results of the survey provide a confirmation of the above mentioned problems that the students, faculty and staff members are facing and thus our proposed system fulfills all the requirements that need to be addressed by providing appropriate solutions of these problems.

The proposed CampusSense system aims to provide an appropriate solution for all the problems which have been identified by analyzing the conducted survey. The aims and objectives of the proposed systems are as follows:

- To implement a vehicle parking monitoring and management system that will automate the existing parking management system by keeping all the in/out information and parking information of vehicles at university campus.
- To facilitate the security department in assuring the safety and satisfaction of the students, faculty and staff members while parking at the university campus.
- To develop a mobile application which will facilitate in reducing the frustration and annoyance of those who often forget the exact parking location of their cars.
- To assist the security department in finding out the car owners who have blocked other cars by parking cars improperly.
- To help the security department for tracing out the suspected or abundant (long term parked) vehicles at university campus.

The rest of the paper is organized as follows: Section II describes the existing parking management systems. Section III presents the design & working of the proposed system. In Section IV the survey statistics are discussed. Finally Section V concludes the paper.

II. RELATED WORK

In this section, first we have covered the Sensor and RFID based vehicle parking monitoring and management systems and secondly the mobile sensing applications related to traffic monitoring.

In the literature the available vehicle parking monitoring and management systems are either sensor based [11-13] or RFID [14-16] based and they mostly address the issue of finding a vacant parking location in the parking lot. These systems are only helpful in determining the occupancy status of parking space but are unable to figure out the solutions for the above mentioned problems like the information about responsible persons who either block or damage other cars while parking their own. So of the parking problem encountered at universities campuses are studied in [17].

The parking management systems based on sensors have a problem as mostly sensors are unable to detect obstacles that are not visible because of their flatness to the ground level and thus they cannot distinguish pedestrians or objects from the vehicles of interest, in result have more false positives. Another challenge in Sensor and RFID based systems is that they are prone to many attacks [18] like denial of service attacks (DoS)[19], selective forwarding attack[20-21], node replication attack[22-24], Sybil attack[25-26], wormhole attack[27], black hole attack[27] and Signal or Radio Jamming attack [29-30] etc. RFID based systems are also suspect to many attacks like [31-32]. Many mobile sensing based systems are proposed for traffic monitoring for example monitoring road and traffic conditions, detecting road bumps, honks, potholes etc, these systems include Nericell [4], VTrack [5], TrafficSense [6], Mobile Millennium [7], TARIFA [8] and Road Bump Monitor [9]. TABLE I shows the comparison of CampusSense with other mobile sensing system.

Prashanth Mohan et al. have proposed two systems Nericell [4] and TrafficSense [6] to detect potholes, bumps, braking, and honking using phones sensors like accelerometer, microphone, GSM radio, and/or GPS. The authors have used the idea of triggered sensing, where dissimilar sensors are used in tandem to conserve energy. The data is gathered through GPS-tagged cellular tower measurements during several drives over the course of 4 weeks. GPS-tagged accelerometer data measurements are also separately gathered on drives on some of the same routes over the course of 6 days. Cellular tower measurements are also gathered over the course of a few days in the Seattle area. The system could be used to annotate traditional traffic maps with information such as the bumpiness of roads, and the noisiness and level of chaos in traffic, for the benefit of the traffic police, the road works

TABLE I
COMPARISON OF CAMPUSSENSE WITH OTHER MOBILE SENSING BASED APPLICATION

Systems	Smart Mobile Phone Used	Software Used	Mode of Communication	Phones Sensor Used	Applications
NeriCell [11]	Nokia N95, HTC Typhoon	Perl, windows mobile 5.0,Windows mobile 2003, Python, C#	GSM, GPRS, UNTS, EDGE, Wifi, Bluetooth	Microphone, GSM Radio, GPS, Accelerometer, Camera	Bump, Breaking and Honking Detection
V-Track [12]	iPhone, Nokia N95	Not Mentioned	Wifi, Bluetooth	GPS	Detecting and Visualizing hotspots, Real time Route planning
TrafficSense [13]	HPiPAQ nw6965, HTC Typhoon	Windows mobile 5.0, Windows Mobile 2003	Bluetooth, Wifi, GSM	Microphone, Camera, GPS Sensor, Accelerometer, GSM Radio	Monitoring of Roads and Traffic Conditions
Road Bump Monitor [45]	HPiPAQ nw6965, Samsung SGHi780, HTC Adrantoge 7510,7501	MS Windows Mobile 5.0, 6.1, Windows 7, C#, C/C++	Bluetooth, GPRS, EDGE, 3G Radio	Microphone, Camera, GPS Sensor, Accelerometer	Road Bumps Detection
CampusSense	Any Android based smart mobile phone	Android Studio, C#, SQL Server	3G/4G, Wifi	GPS, Camera	Locate the vehicle using map, retrieve vehicle owner information form management system

department, and ordinary users. Nericell uses honk detection to identify noisy and chaotic traffic conditions like that at an unregulated intersection. TrafficSense monitor road and traffic conditions in complex varied road conditions (e.g., potholed roads), chaotic traffic (e.g., a lot of braking and honking), and a heterogeneous mix of vehicles (2-wheelers, 3-wheelers, cars, buses, etc.) called TrafficSense. The effectiveness of the sensing functions in Nericell and TrafficSense are evaluated based on experiments conducted on the roads of Bangalore, with promising results.

Arvind Thiagarajan et al [5] have proposed a system called VTrack. VTrack performs map matching, which associates each position sample with the most likely point on the road map, and produces travel time estimates for each traversed road segment. VTrack provides real-time estimates recent to within several seconds to users. It also compiles a database of historic travel delays on road segments. In VTrack data was gathered using iPhone 3G application, and from GPS and WiFi radios embedded in-car. It is shown that VTrack can tolerate significant noise and outages in these location estimates, and still successfully identify delay-prone segments, and provide accurate enough delays for delay-aware routing algorithms.

R. Herring et al. [7] have proposed a system called Mobile Millennium to estimate traffic on all major highways in and around the target area, as well as on major arterial roads. The Mobile Millennium architecture consists of a physical component: GPS-enabled smart phones onboard vehicles (driving public), and three cyber components: a cellular network operator (network provider), cellular phone data aggregation, traffic service provision and estimation. A back end server aggregates data from a large number of mobile devices and pushes the data to UC Berkeley estimation engine for data assimilation, which combines the cell phone data with other information such as loop detectors to produce the best estimate of the current state of traffic.

Georgios Adam et al [8] have proposed a system called TARIFA (Traffic and Abnormalities Road Instructor For Anyone) that estimates road traffic as well as road abnormalities, and makes the collected information available to anyone that has Internet access. This system is capable of spotting potholes and can also provide information for the traffic using the GPS receiver. The architecture of the system consists of two independent parts. A smart phone that is equipped with an accelerometer and a GPS receiver is placed inside a car. There is also a local database for the temporary storage of data. A heuristic algorithm is used to detect potholes and other surface abnormalities.

T. Das et al. have propose a system called Road Bump Monitor [9] which is an application of PRISM platform to detect and locate road bumps automatically without any user involvement. The sensed (accelerometer) data is processed locally on the phones to extract the desired information (the location of road bumps), before it is shipped back to the server. Then the road bump monitoring application was opportunistically deployed on the phones and the bumps detected by the application were compared with the manual recording of road bumps.

The existing car parking management system at the university is fully manual which only allows the authorized vehicles that are registered by having the entrance sticker. Security department provides three types of stickers for entering into the University, which are for students, faculty and staff members. The whole university area including Entrance and exit gates, academic zone, administrative and parking zones are all under video surveillance. But this can only serve for video capturing and storing and are not connected to any proper management and monitoring systems. In case of any acute incident, a sequential video search is required which is time consuming and unfruitful process. There are reserved (by name) parking lots for most of the staff members and dedicated areas (on first come first serve basis) are available for students and the faculty members.

III. CAMPUSSENSE

This section presents a smart vehicle parking monitoring and management system called CampusSense. The CampusSense is consist of both hardware and software components.

- The hardware component will consist of Automatic Number Plate Recognition (ANPR) cameras which are mounted on the entrance and exit gates and parking lots of the campus.
- The software components will include a parking management system and a mobile application.

CampusSense leverage ANPR cameras for capturing the license number plates of the vehicles instead of Sensor or RFID based existing vehicle parking management systems. These ANPR cameras are more advantageous than other technologies. ANPR cameras are known with different names like ALPR (Automatic License Plate Recognition), LPR (License Plate Recognition), CPR (Car Plate Recognition) and AVI (Automatic Vehicle Identification). It provides faster traffic management at parking areas, ability to automate access control systems with a setup of ticket free systems providing new and more effective law enforcement. ANPR cameras are suitable in all weather conditions and can be mounted at higher mounting locations to assure a wider field view of the whole parking lot.

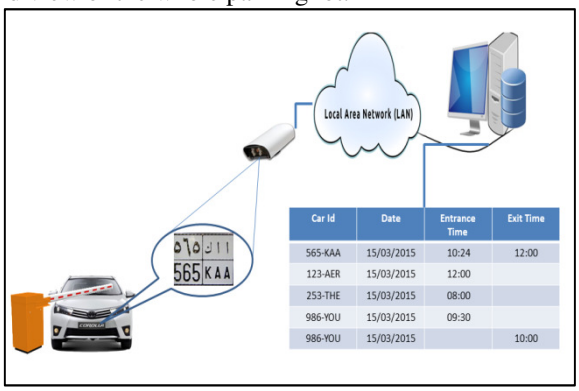

Fig. 1. Capture the vehicle license plate using camera at entrance and store it in the database.

The authorized vehicles will be registered in the parking management system along with their owner information. The information about the parking zones and parking lots will already be stored in the system with the other related information (e.g. which camera is monitoring the parking lot with their physical locations (x & y coordinates).

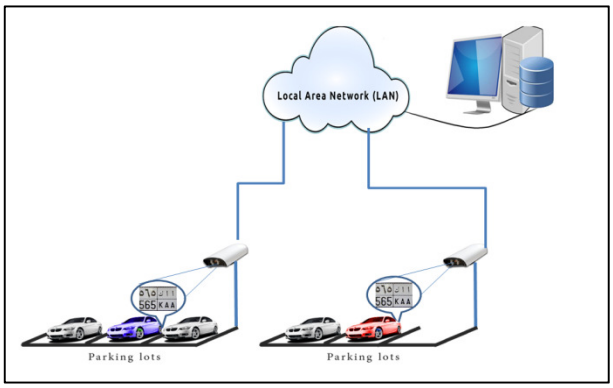

Fig. 2. Capture the vehicle license plate using camera at parking lots or when change the place then store it in the database.

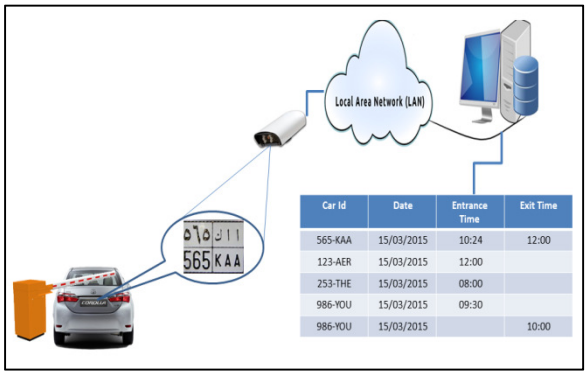

Fig. 3. Capture the vehicle license plate using camera at exit and store it in the database.

The vehicle license plate number will be capture using ANPR cameras on entering/exiting the gates and at the parking lots and will be store to vehicle management system. Fig. 1 and Fig. 3 show the capturing of vehicle license plate using camera at entrance/exit and store it in the database. Fig. 2. Shows the capturing of vehicle license plate using camera at parking lots or when change the place then store it in the database. A mobile application has two features. First, it is responsible for locating the car if a person forgets its exact parking location. This feature is for general purpose and can guide all the persons who are parking in the parking zones of the University. Second, it can assist the mobile security units to locate and pursue the liable person for damaging or blocking some ones car while wrong car parking in the parking lot. This feature is specifically built for security purposes that can aid the security department to ensure the safety of the students, faculty and staff members while car parking. Fig. 5 shows the working of the mobile application to retrieve the required information.

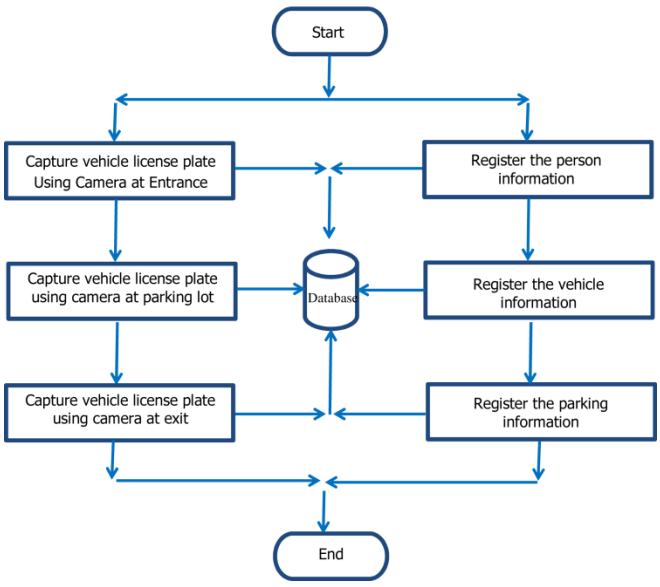

Fig. 4. Flow Chart for the working of ANPR Cameras integrated with vehicle management system.

The working of the ANPR cameras can be easily comprehended by the flow chart in Fig. 4. It shows that the ANPR cameras that are mounted on the entrance and exit gates of university and placed as well in all the parking lots will first capture the License plate number while entering/exiting/parking of the vehicles and then store it in the database. The ANPR cameras are integrated with the Vehicle Parking Management System which contains the

records of entrance and exit timing information of the authorized vehicles along with the parking location and their owner's information. In case when any parked car is damaged by the some other car, the information about the vehicle and liable person for damaging the parked car in the parking lot can be found by the system records. This can be done by searching out the information about the timing and parking location of the cars nearby the damaged car/vehicle.

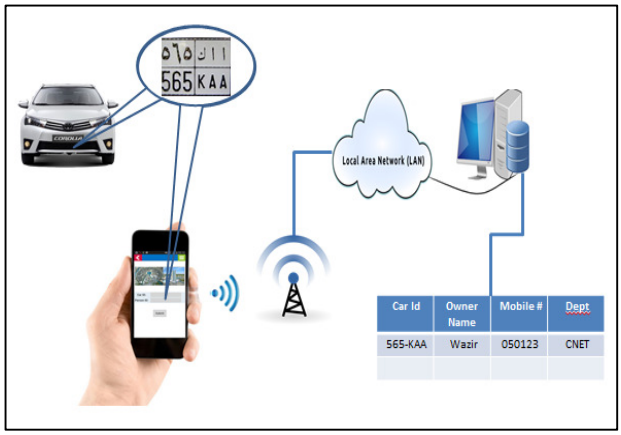

Fig. 5. Working of the mobile application to retrieve the required information.

The working of a mobile application can be shown in the form of a flow chart as in Fig. 6. This mobile application can assist the security manger to handle two problematic situations during car parking in the university campus. In case if any car is blocked by wrong car parking then this application can locate the owner of the car who has blocked the other parked car. This application can also help the persons who often forget the exact location of their parked cars. This mobile application keeps the personal information about the vehicle owners as a secret and only the security department personnel are able to see that information. For developing the prototype mobile application Android Studio is used and for parking management system the database is developed in SQL Server and the user interface is design & developed in C#.

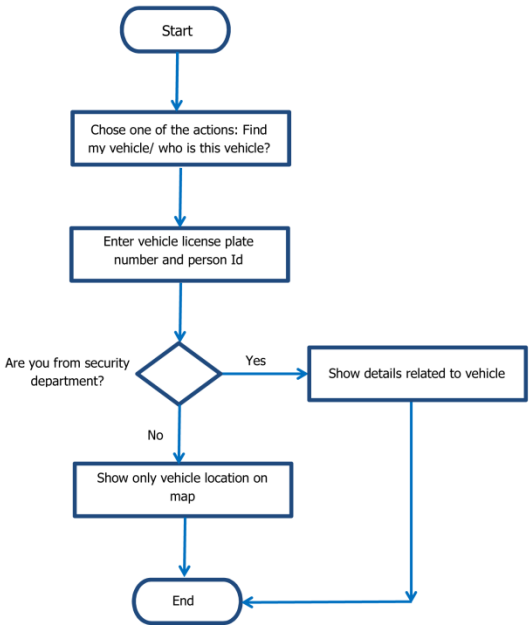

Fig. 6. Flow Chart for the working of the mobile application.

The screen shots of the proposed prototype mobile application are shown below in Fig. 7. These screen shots show the two main features of the prototype application i.e. locating the exact parking location of the car (*Find my Car*) and finding out the owner of the vehicle who has blocked another car (*Who is this Car*).

Fig. 7. Screen shots of the prototype mobile application.

The Proposed CampusSense has following benefits:

- Helps the security department to find out the responsible for the damages (hitting, scraping, scratching and dents) to other cars.
- Helps the security department to locate the owner of the car which cause blockage.
- Helps the students, faculty and staff to locate their cars on forgetting their car park location.
- Helps in finding out the owner of those cars that are parked from many days.
- The security department can retrieve all the history of any particular car.

IV. SURVEY STATISTICS

A survey from 26th to 30th of October 2014 was conducted by filling out a quantitative questionnaire. A total of 88 persons participated in the survey out of which 53 were students and 35 were faculty and staff members. A number of questions were asked from the participants. Fig. 8 (a) shows the percentages of the different age groups of the staff/ faculty members and Fig. 8 (b) shows the percentages of the different age groups of students the. The survey results show that majority of the participants from staff and faculty were above 26 years old (91%) and on other side majority of students were between 22 to 25 years old (66%).

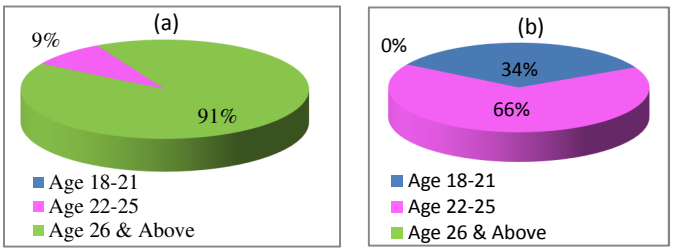

Fig. 8. Percentages of different age groups of the participants.

Fig. 9 (a) shows the percentages of different modes of transportation for reaching the university campus used by the staff/ faculty members and Fig. 9 (b) shows the

percentages of different modes of transportation for reaching the university campus used by the students. The survey results show that majority of the participants from staff and faculty come to campus by their own vehicles (88%) and on other side majority of students who own cars were (81%).

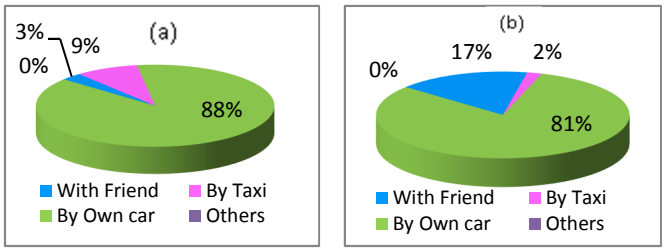

Fig. 9. Percentages of modes of different transportation.

Fig. 10 (a) shows the percentages of the staff/ faculty members whose vehicles were damaged by other vehicles while wrong parking at university campus and Fig. 10 (b) shows the percentages of student whose vehicles were damaged during parking. The survey results show that majority of the student vehicles were damaged during parking (65%) as camper to faculty/ staff (29%). The reason was no reserve parking for students at university campus.

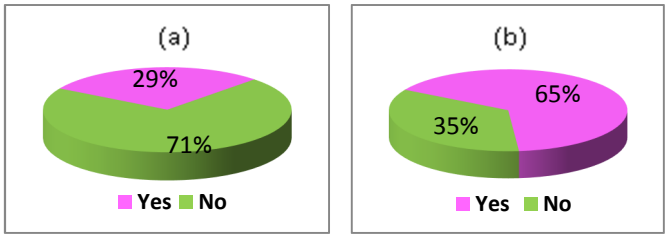

Fig. 10. Percentages of vehicle dames during parking.

Fig. 11 (a) shows the percentages of staff/ faculty members whom are able to find the responsible persons for damaging their vehicles in the parking lot and Fig. 11 (b) shows the percentages of the students whom are able to find the responsible persons for damaging their vehicles in the parking lot. The survey results show that majority of the participants were unable to find the responsible persons who damaged their vehicles (i.e. 71% faculty/ staff and 65% students).

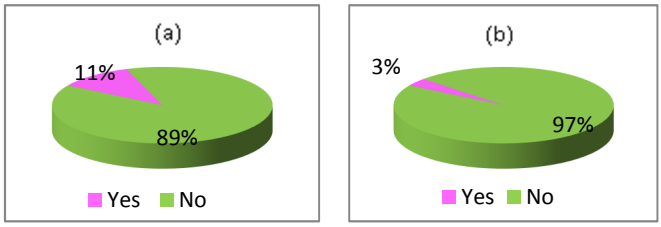

Fig. 11. Percentages of persons who have found responsible persons for damaging other cars.

Fig. 12 (a) shows the percentages of those staff/ faculty members those whom cars are blocked by others cars that are parked wrong and Fig. 12 (b) shows the percentages of those student whom vehicles are blocked by others vehicles that were parked wrong. The survey results show that majority of the students vehicles were the blockage (85%) as compared to faculty/ staff member (58%). The reason is the reserve parking for staff/ faculty members at university campus.

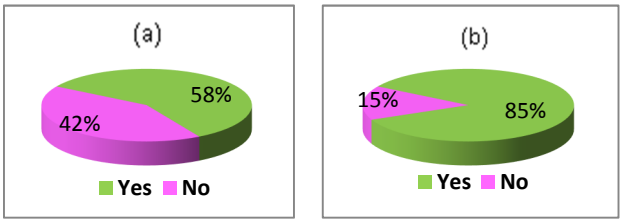

Fig. 12. Percentages of car blockage.

Fig. 13 (a) shows the percentages of staff/ faculty members whose vehicles were blocked and they have waited until clearance of blockage and Fig. 13 (b) shows the percentages of time taken to clear the blockage vehicles by the students. The survey results show that majority of the students waited more than 30 min to clear the blockage (67%) as compared to faculty/ staff member (50%).

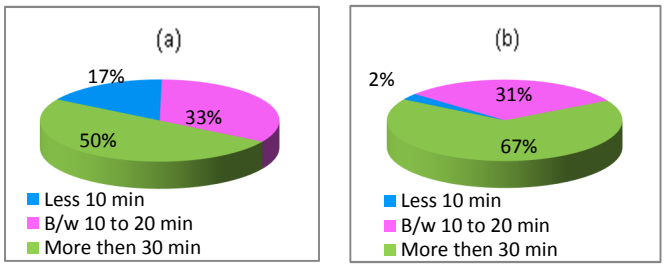

Fig. 13. Percentages of time consumed due to car blockages.

Fig. 14 (a) shows the percentages of staff/ faculty members those who have found difficulties in finding their vehicles in the matter of forgetting the location where they parked their vehicles and Fig. 14 (b) shows the percentages of those students who forget their vehicles in the parking lot. The survey results show that majority of the students forget their vehicles most of the time (65%) as compared to faculty/ staff member (35%). The reason is the reserve parking for staff/ faculty members at university campus.

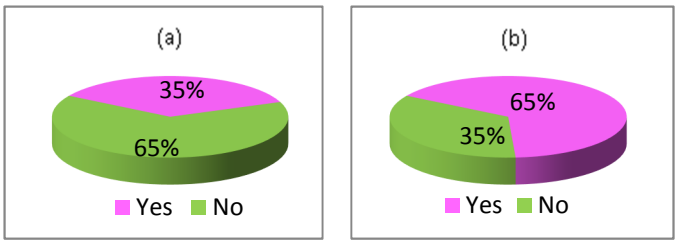

Fig. 14. Percentages of participants forgetting the location of their parked cars.

V. Conclusion and Future Work

Parking problems at university campuses continue to prevail and have become a major concerning issue. In this paper we have proposed a smart Vehicle Parking Monitoring and Management System called CampusSense for Jazan University whose students, faculty and staff members are facing parking problems while parking their cars in parking lots of the University. The key concern of our proposed system is to automate the existing manual parking management system with efficient and effective use of the parking lots. This system contributes to reduce the frustration and annoyance of the students, faculty and staff members while car parking in the University parking zones. We have also conducted a survey by distributing the questionnaire to the students, faculty and staff members. The results of the survey confirm the car parking problems faced by the participants. Our future research includes the real-

time implementation of our proposed system with additional features like searching for vacant parking spaces in an effective manner and also automating the mobile application by adding some OCR techniques to take vehicle number plates form camera images instead of entering it manually.

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