International Journal of Engineering & Technology, 7 (4) (2018) 2765-2772

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i4.16159
Research paper

New approach for self-parking management system

Hicham Lahdili [1] *, Zine El Abidine Alaoui Ismaili [1]

[1] *ENSIAS/ Information, Communication and Embedded Systems Team, University Mohammed V- Rabat, Morocco*
**Corresponding author E-mail: dh.lahdili@gmail.com*

Abstract

The parking operation is considered the most stressful task amongst all driving experiences, and during this operation a considerable number of accidents are occurring each day. As a result, Parking Assistance Solutions (PAS) are widely used nowadays. Unfortunately, those systems are not fully automated and their role is limited to assisting the driver during the parking operation. This paper presents a proposal of a low cost, fully automated self-parking management solution. This proposal is a combination of two subsystems that will be collaborating to achieve a fully automated system; the first part is composed of an indoor navigation system, based on the adaptation of the available surveillance camera network in the parking area. This system will locate vehicles in the parking area and provide their current position in real time. And based on the localization information in addition to available free parking lots a server will generate navigation consigns. Those consigns (speed, rotation angle and direction) will be used by an auto-parking kit (that represent the second part of our proposal) to control the parking vehicle, that will drive itself to its reserved place.

Keywords: *Smart parking; self-parking; Indoor Navigation; Real Time.*

1. Introduction

Smart cities is a new concept that describes brilliant solutions that are supposed to solve nowadays cities problems. One of those major challenges is parking management. According to the International Parking Institute [International Parking Institute, 2012] about 30 percent of the cars circling a city at any given time are doing so as drivers looking for parking, especially in crowded places such as city centers. Nowadays the simple operation of looking for a free parking spot is becoming a stressful and time wasting task. This problem is especially related to different factors such as:

- Insufficient parking places,
- The large number of accidents due to, the false parking manoeuvres,
- No information about available free spots,
- Vehicle blocked due to parking in unauthorized parking areas,
- Traffic jam due to search of free parking spots,
- In the case of massive parking garages, it's common for people to forget where they have parked their vehicles.

In this paper, a low cost fully automated self-parking management solution is presented. This solution is composed of two main parts, an indoor navigation system for vehicle localization and an auto-parking kit intended to be integrated into the vehicle's electronic system thanks to a CAN (control area network) interface, in addition to a Wi-Fi interface used to connect the vehicle to the parking management system. The auto-parking kit will control the vehicle during all the parking operations. At the parking entrance the driver will be informed about the number of available free places, this way all of unsuccessful free parking research operations inside full parking garages will be eliminated. Then the driver will activate the self-parking system and leaves the vehicle. The vehicle will connect to the WI-FI based network of the parking garage, at this moment the parking management system and the vehicle will collaborate to guide the vehicle to its position. Where it will wait until the reception of exit command so it will be guided towards the parking exit. At this moment the driver can take control of the vehicle. This way the traffic jam created, the amount of fuel consumed, air and noise pollution, time spent and stress occurred during looking for free place are all expected to be decreased. And as a result the quality of life will be improved.

The remainder of this work is organized as follows; section 2 presents the related works, where the indoor navigation system, the auto-parking kit architecture. In addition to the parking server to vehicle communication are detailed in section 3. The test environment, as well as the discussion of experimental results are covered in section 4. And finally section 5 draws the conclusion.

2. Literatures review

The During the last decade several works have been conducted to provide reliable solutions for the parking challenge using different approaches.

In [Ulrich & al, 2016] & [Kyoung-Wook Min & Jeong-Dan Choi, 2015] an intelligent system of self-parking vehicle is proposed for low speed limited parking area. Each vehicle in this approach need to be equipped with several cameras for localization, two LIDAR sensors for forward obstacle detection and several sonar sensors for detecting near obstacles.

In [Harmeet Singh & al, 2014] an automated parking system is described, the system makes use of a mechanical mechanism that transports vehicles to and from parking lots without any intervention from the driver, as a result effort and time generally spent during the traditional parking operation are optimized.

In [Trupti Y. Nirwan & al, 2016] a detailed description of multi-stage car-parking characteristics in order to develop a reduced working model of a car parking system for parking 6 to 24 cars

Copyright © 2018 Hicham Lahdili, Zine El Abidine Alaoui Ismaili. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

within a parking area of 32.17 m². Mechanical structures are used for vehicle transportation.
In [Xinxin Du & Kok Kiong Tan, 2014] a fully self-reverse parking approach was proposed with an arc-line based as a novel path-planning algorithm that guarantees to find a feasible path under any initial pose, in addition to a revised sliding mode control.
In [6] and [7] two type of parking assisting system respectively proposed by Toyota and BWM, those systems assist the driver during parking manoeuvres, which help making different parking situations easier, safer and effortless.
In [S. M. Bhadkumbhe & al, 2017] an automatic car parking application is proposed, it regulates the number of cars to be placed on a selected park. The proposed application keeps tracks of free and occupied parking spots.
In [Dusan Nemec & al, 2017] a visual localization and identification system of vehicles inside a parking lot was proposed. The system is based on active visual ID tags - small LED arrays. The main idea is the usage of 2D color codes mounted on top of each vehicle. These code tags can be captured by external static cameras as placed above the parking area, from this the distance to the camera will be computed.
In [Ruipeng Gao & al, 2017] a smart phone based real time vehicle tracking system is presented. The application tracks the vehicle movements, estimates and displays its location in a garage map in real time, and also record the final parking location, which can be used by the driver later to find the vehicle. The current vehicle position is computed only based on the inertial sensors of the smart-phone and all the sensing/computing happen locally on the phone. It uses a novel shadow trajectory tracing method to convert the smart-phone movements to vehicle ones.
In [Junhuai Li & al, 2016] a Smart-phone Based Car Searching System for Large Parking Lots. This method has interest of optimizing the time spent for parkers to find their cars in a large parking lot, for this purpose information of each parking spot, including the parking lot, floor and parking location are encoded into QR codes. The driver parks its car arbitrarily in the parking, after that the driver scans the nearest QR code to record the parking location. At the moment when driver come back to take its car he just needs to look for the nearest QR code which will guide him to the QR code near his car.
In [B. Yeniguna & al, 2016] a real-time navigation system for multi-story car park was implemented based on RFID and Ultrasonic Sensor technologies to localize vehicles inside a parking.
In [Zuwei Yin & al, 2017] a Peer-to-Peer Indoor Navigation application was presented, based on Smartphone Wi-Fi trace measurements and inertial sensory readings, the experimental result for this system show that its achieves an average relative error of 0.9m in trace tracking and a maximum delay of 9 samples (about 4.5s) in deviation detection.
In [Cheng Yuan & al, 2016] a Smart Parking System was presented, it is based on Wi-Fi and Wireless Sensor Network. Geomagnetic sensors are used to detect the occupation of parking spaces, while the trace signal strength of Wi-Fi is used for navigation in a so called Radio Map.
In [Pei-Chun Lee & Sheng-Shih Wang, 2016] a route guidance system for Car Finding in Indoor Parking Garages based on the IBeacon technology that operates over BLEUTOOTH and power saving.
All previous work can be classified into 4 categories:

- Fully automated parking (mechanical) [3], [4]: the whole parking operation is performed by the parking system; their major inconvenient is the implementation cost.
- Self-parking car [1-2, 5]: Cars are equipped with sophisticated systems that can perform the full parking operation autonomously. The use of such car is very limited due to their high cost.
- Driver assistance [6-7]: the parking operation is performed by the driver, but with assistance from the assistance parking system. This type of solution can't resolve problems like traffic jams and loss of time during the parking operation.
- Parking management system [8-15]: provide different types of services such as information about available free parking spots, indoor parking navigation solution. These solutions can reduce the time spent during the parking operation but the driver presence can't be avoided.

3. Self-parking management system

The self-parking management system is composed of two main parts: the indoor navigation system and the auto parking kit. This implementation was performed under the following conditions:

- The parking area is already equipped with a network of surveillance cameras.
- Only one vehicle can park at a time.

3.1. Indoor navigation system

3.1.1. Indoor visual localization system

3.1.1.1. Vehicle to camera relative distance

In a vision of building a low cost, real time and accurate indoor localization system, the surveillance camera network that can be found almost in all parking areas, is adapted to build a real time visual localization system. The main idea is to develop a software script based on the image processing theory. The solution can identify objects in movement, and compute their relative distance to the nearest camera. And based on the computed distance and the camera position, absolute position is computed.
In Optic it's proved that object projection on the camera lens is a function of the object real size, camera focal length and distance between the object and the camera as presented in Figure 1.

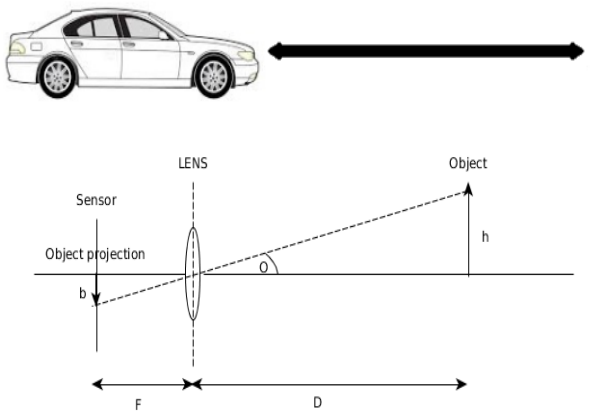


Fig. 1: Vehicle Projection on Camera Sensor.

With mathematically this relation is presented as:

$$\tan(\theta) = \frac{b}{F} = \frac{h}{D} => D = \frac{h * F}{b} \quad (1)$$

Where:
H is the object size in real life,
F is the focal length (technical characteristic of the used camera),
D is the distance between the object and the camera,
And b, which is the object size on the sensor:

$$b = \frac{S * O}{I} \quad (2)$$

Where:
O is the object size in pixels;

I is the image size in pixels;
S is the size of the sensor.
So, the whole equation can be rewritten as:

$$D = \frac{F * h * I}{S * O} \quad (3)$$

As that the focal length, the object size, the image size in pixels and the size of the sensor are constant, so the distance between the camera and the vehicle can be rewritten as:

$$D = \frac{Constant}{O} \quad (4)$$

3.1.1.2. Object segmentation

Dynamic thresholding block
As we will see later in the background subtraction method description, the resulting image from the background subtraction method will contain two groups of information, and in order to select one of the two groups we will apply a segmentation filter: the resulting image will be compared pixel by pixel to a one global threshold as presented in equation 5.

$$O(x,y,t) \leq T \quad (5)$$

Where:
O(x, y, t) a pixel of the image in instant t,
T is the threshold value.
If the pixel O(x, y, t) verifies equation (5), then it is considered as a foreground pixel, else it is a background pixel. The T threshold need to be a time function, otherwise our solution will lose the accuracy with any environment change. The Otsu algorithm [Miss Hetal J. Vala & Prof. Astha Baxi, 2013] was developed based on the idea that for images with two components, in others words that has a two class histogram, which mean a histogram that can be divided into two classes, the Otsu script will look for a threshold that minimizes the variance for both classes. This way, each class will be as compact as possible. Spatial relationship between pixels has no effect on the algorithm result, only pixel value is taken into account, different regions with similar pixel value are treated as one region.
In Otsu method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_w^2(t) = \omega(t) * \sigma^2 + \omega'(t) * \sigma'^2(t) \quad (6)$$

Where:
σw² (t) is the intra-class variance,
w and w' are the probabilities of the two classes separated by a threshold t,
σ² (t) and σ'² (t) are variances of these two classes,
According to equation (7), Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance:

$$\sigma^2 = \sigma_w^2(t) + \sigma_b^2(t) \quad (7)$$

Where:

$$\sigma_b^2(t) = \omega(t) * \omega'(t)[\mu(t) - \mu'(t)]^2 \quad (8)$$

An implementation of the Otsu method was performed based on equation (8), the algorithm will step through all possible thresholds and keep the threshold value that maximizes the inter-class variance σb2.
Moving Object detection
Moving object detection can be achieved using different approaches, the most used nowadays are based on feature descriptor[Navneet Dalal & Bill Triggs, 2005], classification algorithms like the Support Vector Machine are trained by large image datasets composed of negative (images don't contain the object to be detected) and positive(images contain the object to be detected) classes, at the end of the training process a features vector descriptor is computed, then for any new image the vector descriptor will compute and compare the one resulting from the training process to confirm or not the presence of the searched object in the image. Although the use of such approach as we are targeting indoor area in which environment condition are almost the same. In those conditions the background subtraction method presents another alternative, especially by taking into account their minimal implementation cost and their sufficient accuracy.
The background subtraction consists of subtracting the current image (in which the moving object can be present) pixel-by-pixel from a reference background image (don't contain any moving object) as described in equation (9).

$$O(x,y,t) = [I(x,y,t) - R(x,y)] \quad (9)$$

Where:
O(x, y, t) is the resulting image,
I (x, y, t) is the input image at the t instant,
R(x, y) is the reference image.
Then a process of segmentation will be applied on the resulting image O(x, y, t) using the Otsu method as explained in the last part, the result will be a binary image that contains the object in movement and that way the object dimension (in pixel) can be computed.

3.1.2. Path computing

Thanks to the adaptation performed on the surveillance camera network, vehicles inside the parking area can be localized. So based on the vehicle position in real time and the vehicle destination (the reserved place for the vehicle) we will generate a turn by turn navigation instructions for the auto parking kit. Let's take the parking lot in Figure 2. Mathematically this parking area can be modelled with the graph in the same Figure, where the parking lots are represented with 8 nodes in addition to the parking entrance and exit: 10 nodes in total.
For the path computing we have performed an implementation based on the work in [Tan, G. & al, 2006] which consists of an adaptation of Dijkstra's algorithm, it was used to compute the shortest path between two nodes (in our case: the parking entrance and the reserved parking place). An execution of our parking simulator was given in Figure 3.

3.1.3. Navigation server

At the entrance of the parking area, the vehicle is connected to the parking network. The first operation performed by the parking server is looking for a free place for the vehicle by going through all the parking places starting by the first one, until its reach a free one. Now that we have defined the vehicle to the camera's relative distance, we will move to explain our block model of the vehicle segmentation system.

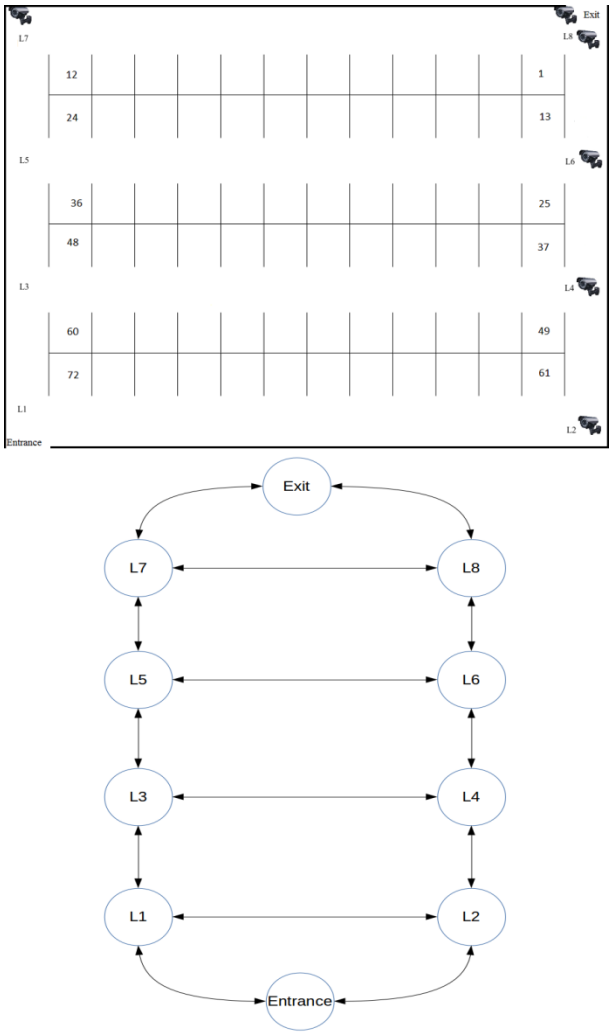
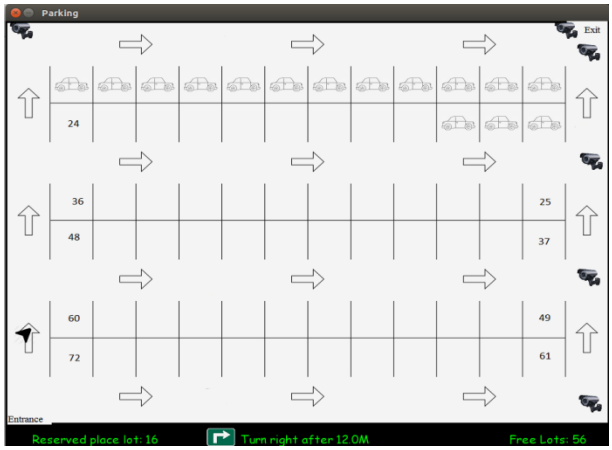


Fig. 2: Parking Lot of 72 Parking Place & Its Mathematical Representation as Graph.



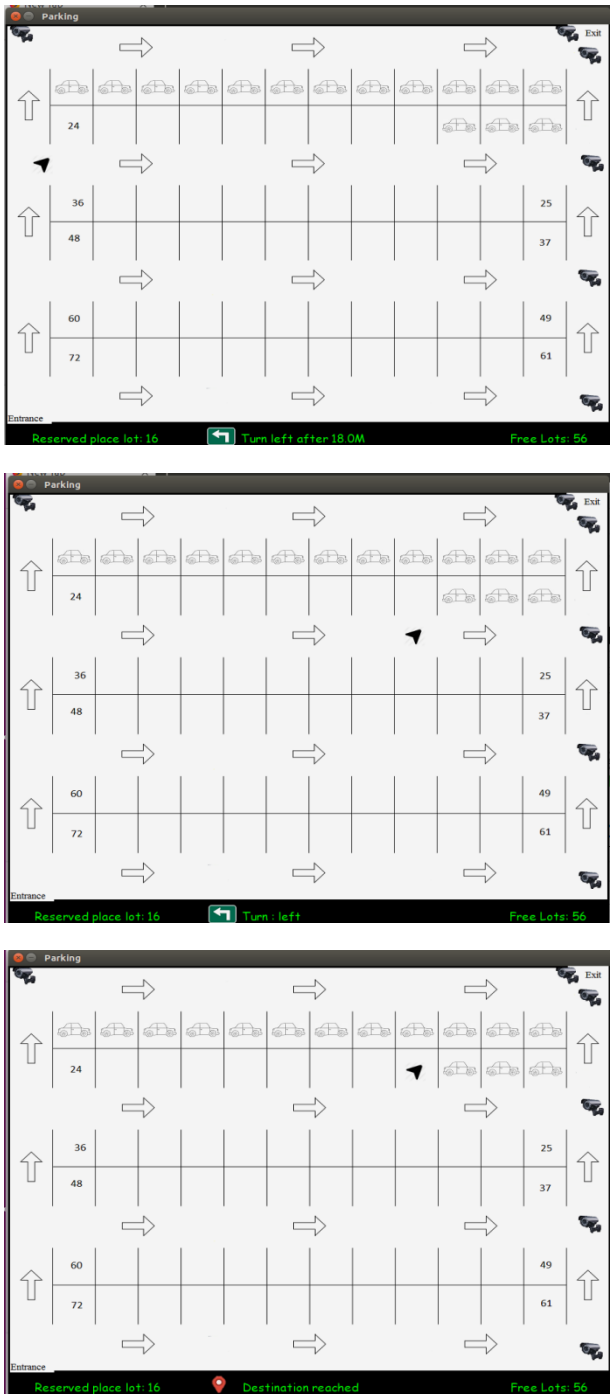


Fig. 3: Some Screen Shot during the Execution of the Parking Simulator for Path Planning.

After reserving a free place, the path computing algorithm will be executed. At this moment the server will control the vehicle by providing the auto-parking kit by the necessary consigns and both of them will collaborate to guide the vehicle to its reserved place. With each new vehicle position evaluation, the server adjusts its consigns according to the new position and the navigation path. The implementation was performed using the pynq board, which

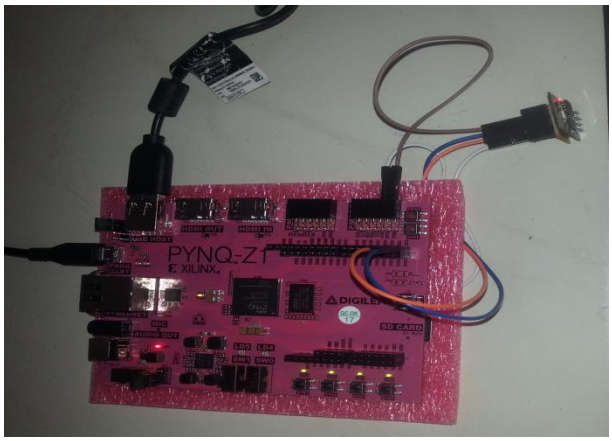


Fig. 3: Parking Server Implementation Using the PYNQ Board.

Is a system on ship? The server is running on a 650MHz ARM Cortex-A9 dual core processor running Linux and was implemented using python. A Wi-Fi module is added to the board for Wi-Fi access, Figure 4 shows the whole system during its run time.

3.2. Auto-parking kit

3.2.1. Vehicle electronic architecture

In the last vehicles generation (vehicles produced by 2010 and later) more than 80% of vehicle functionalities are managed by electronic control units (ECU), those computers can control steering, acceleration and brakes, and basically everything in the vehicle from the fuel injecting system to the infotainment system. ECU's in addition to intelligent sensors such as the wheel angle sensor present the vehicle's brain. Where in a modern vehicle may have up to 100 ECU's they are related to each other thanks to deterministic and real time Networks, the most used is the CAN bus.
The use of a CAN bus system in a vehicle makes it possible to share very critical information in a safe and reliable way. Exchanged information is referred to as messages. And any control unit can send or receive messages. Which contains physical values such as the engine speed (RPM), vehicle speed (KM/h), engine temperature.
In the CAN bus, messages are broadcasted to all ECUs and identified by a bus identifier (11 bits for standard CAN bus). Each vehicle manufacturer has its own databases that relay CAN identifier to specific information for example vehicle speed. This database is shared between all ECUs, as a result, if an ECU is looking for a specific information, it just needs to look for the message with the related identifier.
The CAN is a message-based protocol, in which the message is presented in a form of Frames. A frame presents the message structure, where message identifier and data present the most important parts:
Message Identifier (ID): The ID can be one of two formats: standard composed of 11 bits or extended with 29 bits. The ID is used to set the message priority if two ECUs or more are sending messages (different ID's) simultaneously, it's the lower ID which corresponding to the highest priority who takes control and get to send its message.
Data: presents the message data (from 1 to 8 bytes maximum) that will be consumed by other ECUs.

Table 1: The Remote Control Frame Characteristics

Frame_Remote_Control (ID = 0xA00)			
ID	Data length	Type	Transmission
0xA00	3 octets	Produced	Periodic each 50 ms

Table 2: The Remote Control Frame Implementation

Frame_Remote_Control (ID = 0xA00)		
Signal	Description	Position
Acceleration	Vehicle acceleration	1.0 – 1.7
Brake	Brake the vehicle	2.0
Direction	Front or Rear	2.1
Angle_of_Rotation	Wheel's angle of rotation	3.0 – 3.7

One of the most interesting concepts of the new generation vehicle is Drive-by-wire technology (Figure 5). In this approach the traditional mechanical controls are completely replaced. Instead of providing the driver with physical control over the speed and direction of a vehicle by using mechanical and hydraulic pressure. The drive-by-wire technology retrieve the driver consigns thanks to sensors and uses electronic controls to activate the brakes, control the steering and operate other systems. Four main components are impacted by this change and they are the steering, the brakes, gear shifting and the throttle systems.
Throttle-By-Wire Technology: unlike the traditional throttle controls that couple the gas pedal to the throttle with a mechanical liaison, the newer systems use a series of electronic sensors and actuators. The gas pedal sensor essentially just informs the electronic throttle control of the position needed, then this later activate an electromechanical actuator that opens the throttle. These systems are generally designed in a way that the throttle will be closed automatically in the case of communication failure with the pedal sensor.
Brake-By-Wire Technology: in the same philosophy the Brake-by-wire technology is based on removing any mechanical connection between the driver and the brakes. Based on the brake pedal sensor state, the electronic brake controls an electromechanical actuator that are used to activate the brakes located in each wheel.
Steer-By-Wire Technology: in this configuration the rack and gear unit that is physically connected to the steering wheel is removed. So the control of the steering is performed by a steering actuator based on the angle sensor consigns.
Shift-by-wire Technology: in the shift by wire mode the vehicle transmission is controlled through an electronic control without any mechanical linkage between the transmission and the gear shifter.

3.2.2. Auto-parking kit

In the drive-by-wire configuration there is no mechanical contact between the driver and the vehicle. The different vehicle components are controlled thanks to specific ECU (Electronic Control Unite) based on the drivers consigns. Thanks to this configuration the vehicle can even be controlled remotely. So for this purpose we have designed a specific kite with two communication capabilities. A CAN base (in order to be integrated in the vehicle CAN network) and a Wi-Fi interface. The kit will receive the driver consigns (Brake pedal position, Throttle pedal position and the steering rotation angle) remotely, and then it will translate those consigns to a CAN frame consumed by different ECUs. The auto-parking kit is intended to be developed as an ECU that will assure an autonomous, fully automated parking without any human intervention. The vehicle will not make any decision by itself, but just executes the auto-parking commands. In other words, the auto-parking kits will provide the vehicle with information that is usually provided by the driver: the acceleration, angle of rotation, direction and finally when to brake. That information will be interpreted by the auto-parking kit to CAN frames as described in table 1 and 2.
The remote control frame will be sent periodically each 50ms, and the value of each signal will be updated according to the received parking server consigns. The Figure 6 shows the first prototype of the auto-parking kit. it is equipped with CAN and Wi-Fi connection.

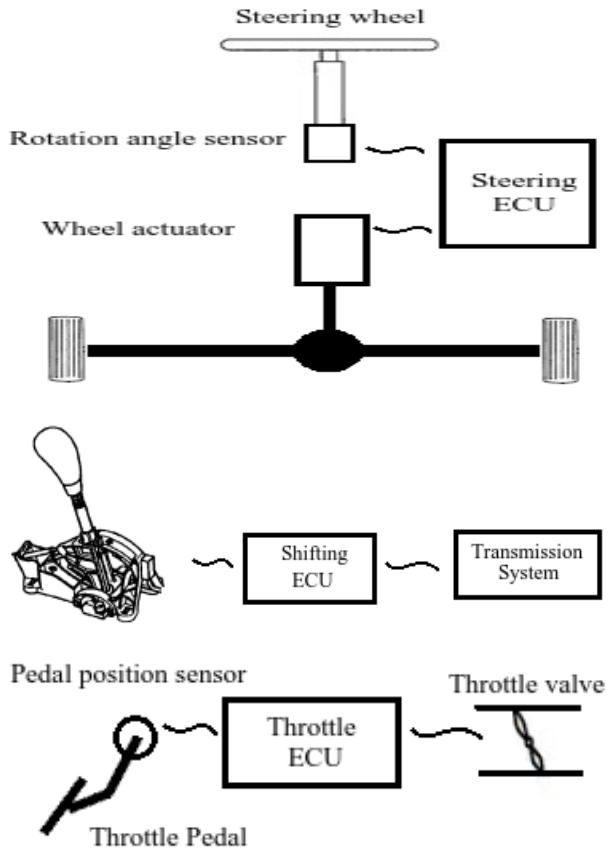


Fig. 5: Some Examples of Drive by Wire Technology.

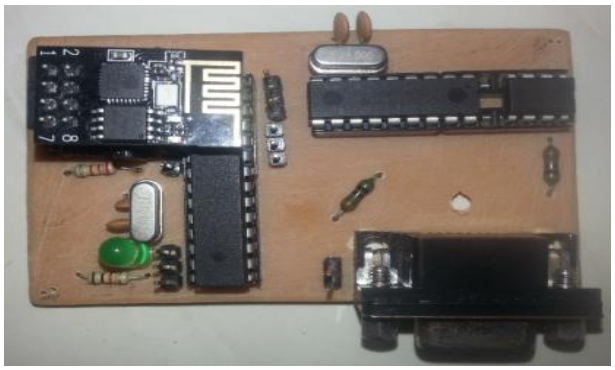


Fig. 6: Auto-Parking Kit Prototype.

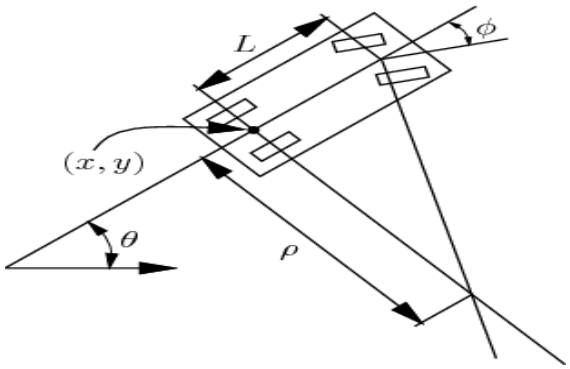


Fig. 7: A Mathematical Movement Model of A Four-Wheel Vehicle.

3.2.3. Adaptation of the server consigns to the vehicle

The auto-parking kit will receive different consigns from the parking server, such as go straight for x meter, turn left, turn right, park left, park right. The adaptation of these consigns to the vehicle is the main feature of the auto-parking kit. This adaptation depends on the vehicle characteristics such as its dimensions, the CAN characteristic. So for each vehicle the auto-parking kit will have a specific calibration. For better comprehension Lets take the example of a perpendicular parking for a driver that wants to park in a perpendicular configuration, it can follow the instructions below:

- Line up the front of your vehicle with the first line of the free parking spot,
- Stop,
- Signal & Turn your wheel 2.5 times to the right,
- Moving forward,
- When the vehicle is in the parking spot, turn your wheel 1.5 times to the left.

Based on the elementary mathematical movement model of a four-wheel vehicle (Figure 7) presented in [Viktor Zadachyn & Oleksandr Dorokhov, 2012].

$$\frac{\partial x}{\partial t} = v * \cos(\theta), \frac{\partial y}{\partial t} = v * \sin(\theta), \frac{\partial \theta}{\partial t} = v * \tan(\varphi) \quad (10)$$

The movement equation is explained as function of four elements:

- The rotation angle of the steering wheel,
- The gear selected,
- The acceleration,
- The braking.

And all driver consigns or the previous parking instructions can be seen as the output of this function.

3.3. Parking server to vehicle communication

The parking area is equipped with Wi-Fi network, and a standard IP address is affected to the parking server. At the time of writing this paper, the parking server can only control one vehicle at a time. The server at its initial state will wait for a vehicle to request the server control, and at this step the parking operation will be started by reserving a free place for the vehicle behind the request. From this point the server will send consigns to the vehicle and at the same time supervise its position in real time. and based on the vehicle position the server consigns will be updated, when the vehicle reaches its final position the server closes the connection and starts waiting for a new GET request. The TCP/IP protocol and sockets are used for the communication between the vehicle and the server. The algorithm used in the implementation of the parking server is presented in Figure 8.

4. Results and evaluation

To measure the performance and the accuracy of the proposed system, we prepared some test scenarios. We have prepared a small parking area with 18 parking slots, and we have equipped this area with our proposal of visual localization system, for the parking vehicle we made the choice of using a robot instead of a real vehicle and this is due to safety constraints in order to avoid human or material damage. The choice of using a robot instead of real vehicle will imply some limitations [Bessas, Aicha & al 2016] to our algorithm, especially for vehicle control.

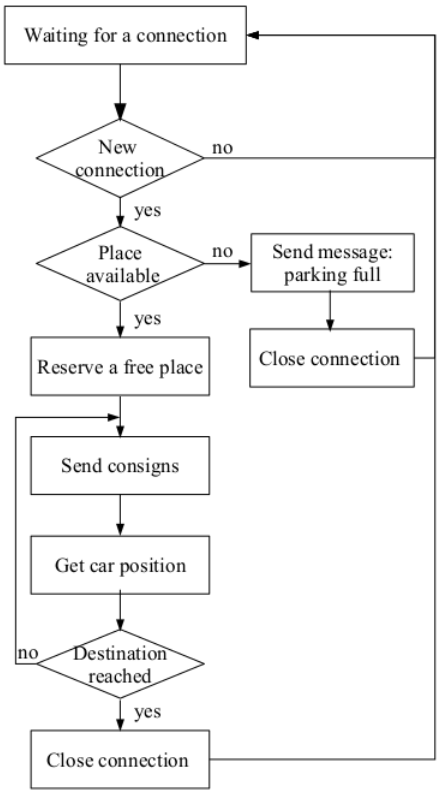


Fig. 8: A Mathematical Movement Model of A Four-Wheel Vehicle Parking Server Algorithm.

Although the test result will stay representative for two reasons:

- Firstly, vehicles are already controlled nowadays using software such as smart-phone to perform the parking operation, so the behaviour of the vehicle will only depend on the generated commands.
- Secondly the robot used will be controlled as much as possible as a vehicle, for this purpose, we have equipped it with a CAN network, to which the auto-parking kit will be connected and based on CAN frames generated by the auto-parking kit, the robot will control its mechanical parts. Figure 10 shows the robot used in test with the auto-parking kit already connected. The visual localization accuracy was already tested in a parking environment (Figure 9); The test case consists of driving (speed less than 10 km/h) a car in free parking area. The real and computed distances are given in table 3.

Figure 11 show the test environment in which we have a robot equipped with the auto-parking kit, and the only connection between them is over the CAN network. In the parking entrance, when we switch on the robot the auto-parking kit is connected automatically to the parking Wi-Fi network, then parking operation is performed as described in the previous sections. The experimental results prove the system performance and accuracy. Further tests are performed under different robot speeds show that the system under-perform in high speeds, but this doesn't present a limitation if take into consideration that speed is generally limited in parking area.

Table 1: Real and Computed Distances

Real Distance	Computed Distance	Real Distance	Computed Distance
0.9 M	0.89 M	10 M	9.97 M
2 M	1.99 M	15M	14.95 M
5 M	4.98 M	20 M	19.9M



Fig. 9: System during Real Test Scenario.

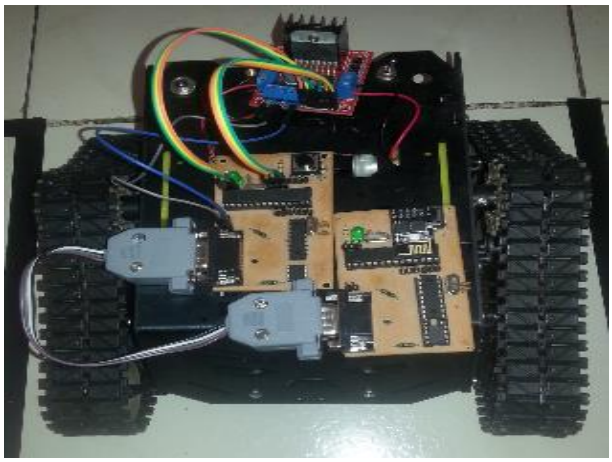
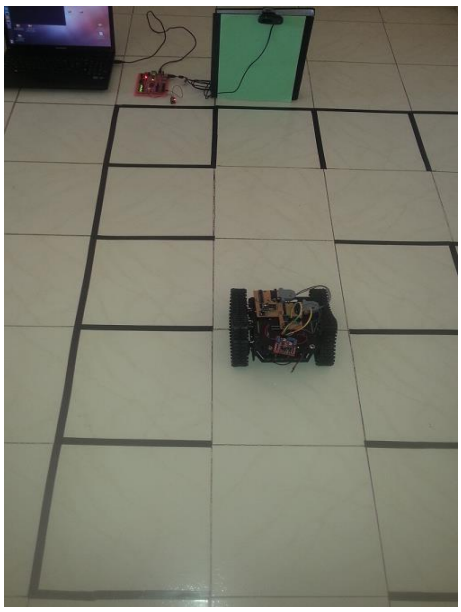


Fig. 10: The Auto-Parking Kit Connected to the Robot Used in Tests.



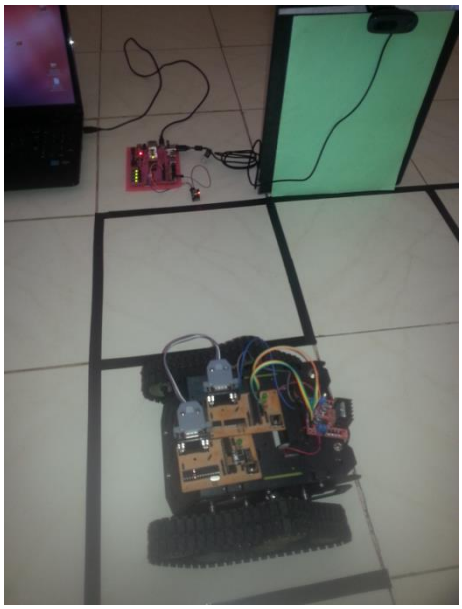


Fig. 11: Self-Parking Robot During and at the End of the Fully Automated Parking Operation

5. Conclusion

This paper highlights a new approach of a self-parking management system. At the entrance of the parking area, the driver will connect the vehicle to the parking Wi-Fi network via the auto-parking kit, then a free place will be reserved for the vehicle, so the parking server will periodically send consigns to the auto-parking kit which will translate them to CAN frames, the vehicle read the frames and execute the commands, when the vehicle reaches its final destination the server will close the connection. This way the traffic jams created, the amount of fuel consumed, air and noise pollution, time spent and stress occurred during looking for free place are all expected to be decreased. And as a result the quality of life will be improved. And as this solution is designed to be low cost, it can be integrated easily in any parking area, and this can present a better alternative especially for the developing countries.

In the next step, we will work on the adaptation of the control algorithms, the execution time improvement, in addition to integration of more functionalities to our system for indoor parking management.

References

[1] Ulrich Schwesinger, Mathias B¨urki1, Julian Timpner "Automated Valet Parking and Charging for e-Mobility", 2016 IEEE Intelligent Vehicles Symposium (IV) Gothenburg, Sweden, June 19-22, 2016.

[2] Kyoung-Wook Min and Jeong-Dan Choi, "Design and Implementation of an Intelligent Vehicle System for Autonomous Valet Parking Service".

[3] Harmeet Singh, Chetan Anand, Vinay Kumar and Ankit Sharma "AUTOMATED PARKING SYSTEM WITH BLUETOOTH ACCESS", International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume 3 Issue 5, May 2014, Page No. 5773-5775, http://ijecs.in/issue/v3-i5/28%20ijecs.pdf.

[4] Trupti Y. Nirwan, Akash S. Waghmare, Gaurav R. Rahate, Kartik Bhujade, Asaraf Ali Saiyyad, Adarsh Shahu and A.D. Anjikar "INTRODUCTION TO VERTICAL MULTISTAGE CAR PARKING SYSTEM", International Research Journal of Engineering and Technology Volume: 03 Issue: 04 | Apr-2016, https://www.irjet.net/archives/V3/i4/IRJET-V3I4296.pdf.

[5] Xinxin Du and Kok Kiong Tan "Autonomous Reverse Parking System Based on Robust Path Generation and Improved Sliding Mode Control", IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS.

[6] Toyota: Intelligent Park Assist System [online] http://www.whiterivertoyota.com/blog/learn-to-use-the-toyota-intelligent-park-assist-system/.

[7] BWM: Park Assistant [online] https://secure.bmw.com/com/en/newvehicles/5series/sedan/2013/showroom/driver_assistance/park_assistant.html.

[8] S. M. Bhadkumbhe, Anuj Narayan, Dnyaneshwar Narayan, Sarfraj Shaikh and Yogesh Kunjir "Efficient Automated Smart Parking System using IOT Technologies", Imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue-4, 2017, DOI = http://www.imperialjournals.com/index.php/IJIR/article/view/4584/4400.

[9] Dusan Nemec, Marian Hrubos, Michal Gregor and Emilia Bubenikova "Visual localization and identification of vehicles inside a parking house",TRANSCOM 2017: International scientific conference on sustainable, modern and safe transport, DOI = https://doi.org/10.1016/j.proeng.2017.06.109.

[10] Ruipeng Gao, Mingmin Zhao, Tao Ye, Fan Ye, Yizhou Wang and Guojie Luo "Smartphone-based Real Time Vehicle Tracking in Indoor Parking Structures", IEEE Transactions on Mobile Computing (Volume: 16, Issue: 7, July 1 2017), DOI = 10.1109/TMC.2017.2684167.

[11] Junhuai Li, Yang An, Rong Fei and Huaijun Wang "Smartphone Based Car-Searching System for Large Parking Lot", 2016 IEEE 11th Conference on Industrial Electronics and Applications (ICIEA), https://doi.org/10.1109/ICIEA.2016.7603916.

[12] B. Yeniguna, I. R. Karasb and E. Demiralc "REAL-TIME NAVIGATION SYSTEM IMPLEMENTATION WITHIN THE SCOPE OF 3D GEOGRAPHIC INFORMATION SYSTEMS FOR MULTI STOREY CAR PARK", 3rd International GeoAdvances Workshop, 16–17 October 2016 DOI = https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W1/115/2016/isprs-archives-XLII-2-W1-115-2016.pdf.

[13] Zuwei Yin, Chenshu Wu, Zheng Yang and Yunhao Liu "Peer-to-Peer Indoor Navigation using Smartphones", IEEE Journal on Selected Areas in Communications (Volume: 35, Issue: 5, May 2017).

[14] Cheng Yuan, Li Fei, Chen Jianxin and Ji Wei "A Smart Parking System using WiFi and Wireless Sensor Network", 2016 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), https://doi.org/10.1109/ICCE-TW.2016.7520924.

[15] Pei-Chun Lee and Sheng-Shih Wang "A Route Guidance System for Car Finding in Indoor Parking Garages", International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol: 10, No: 10, 2016, DOI = http://www.waset.org/publications/10005443.

[16] Miss Hetal J. Vala and Prof. Astha Baxi "A Review on Otsu Image Segmentation Algorithm" International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 2, Issue 2, February 2013, http://ijarcet.org/wp-content/uploads/IJARCET-VOL-2-ISSUE-2-387-389.pdf.

[17] Navneet Dalal and Bill Triggs, "Histograms of Oriented Gradients for Human Detection". 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05). https://doi.org/10.1109/CVPR.2005.177.

[18] International Parking Institute (IPI) 2012 Emerging Trends in Parking Study, http://www.parking.org/2016/01/02/2012-06-11-new-survey-of-emerging-trends-in-parking/

[19] Tan, G., He, H. & Aaron, S. J Cent. South Univ. Technol. (2006) 13: 80. https://doi.org/10.1007/s11771-006-0111-8.

[20] Viktor Zadachyn and Oleksandr Dorokhov "Calculation of Optimal Path for Parallel Car Parking" Transport and Telecommunication, Volume 13, Issue 4, Pages 303–309, ISSN (Online) 1407-6179, ISSN (Print) 1407-6160, https://doi.org/10.2478/v10244-012-0026-4.

[21] Bessas, Aicha; Benalia, Atallah; Boudjema, Farès "Robust Output Trajectory Tracking of Car-Like Robot Mobile", Journal of Electrical Systems. 2016, Vol. 12 Issue 3, p541-555. 15p.