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Design and implementation of a new algorithm for identifying moving objects around the car when leaving the park

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In this paper, an intelligent system based on a novel algorithm for pulling out is designed and implemented. Through processing images of the surroundings of a vehicle, this very algorithm detects the obstacles and objects which are likely to pose danger to the vehicle while pulling out. Two different methods are integrated into this system to detect obstacles and objects. The first method, which is called Support Vector Machine (SVM), detects a broad range of moving objects around the vehicle drawing on training datasets. Whereas, in the second method, types of obstacles and objects are detected using the area of the moving object within range. The system in question is implemented using both methods whose performance are compared in terms of computation and image processing speed; SVM and object area methods detected 93% and 96% of vehicles respectively. The utilization of this algorithm can contribute to the safety of vehicles while executing pullout maneuver and decreased the probability of crashing into fixed and moving obstacles in the surroundings. Results of this research will be available to be used in the design and development of parking control systems.

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1. Introduction

Finding a parking space and executing safe parking and pullout maneuver has represented a challenge in busy and congested streets. In some cases, the driver has to drive far away from a desired location and spend a lot of time only to find a parking space. Moreover, due to the lack of enough sight of the space in the front or rear of a vehicle or poor sight of the street conditions, there is a risk that the vehicle may crash into obstacles.

One of the key issues in recent studies has been to create automatic motion capability for pulling out vehicles from the parking space. This capability of intelligent vehicles involves, firstly, the backward movement in the parking space to prepare the necessary space for pulling out. Having the enough space for pulling out, the vehicle is able to exit the parking space. Systems which have been developed for intelligent vehicles operate by detecting the available space for exiting the parking space and if enough space is detected pullout maneuver is executed. [1]

A general solution to this problem may involve enhancing driving skills for parking and pulling out and increasing the number of neatly lined parking lots; however, this may not be feasible everywhere. The second solution is to use parking alarm systems known as parking assist system which could help the driver in three ways . [2]to[6]

Implementation of the system: Parking assist systems for searching parking places and robot-assisted parking; park assist systems to help detecting the parking obstacles and guiding the driver. Figure 1 shows a schematic diagram of the systems.[7]

(C) (B) (A)

Figure 1: A: Intelligent Parking B: Parking together with a robot C: Barrier detection system to help the driver

The third solution is to design such intelligent systems to execute automatic parking (parking and pulling out) without the driver`s involvement. The systems evaluate the surroundings using appropriate sensors whose data are employed in steering the vehicle into and out of the parking place in a safe and timely manner. Many systems have been designed and implemented to assist drivers in steering into and out of the parking spaces on the basis of their own methods and unique logics. [8]

It must be noted that, the distance from obstacles in the front and rear as well as moving objects on the street should also be detected while executing pull out. In order to pull out from the parking space, the system should identify dangerous moving objects on the street after having ensured the appropriate space for the maneuver. [9]to[11]

Also, other research has been done on driver behavior on highways and roads and the linear speed of cars, which can be used to design self-driving cars with image processing for highways and roads.[12][13]

For self-driving cars that use image processing, street and road signs need to be identified. By giving the algorithm images of the boards and giving the system a default, the boards can be identified and detected before seeing the driver, thus helping the driver to avoid injuries caused by accidents.[14]

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In this paper, a new algorithm is proposed for designing an intelligent system for executing pull out from the parking place. This algorithm is implemented on a real vehicle and various experiments are designed and performed. The different steps of the study are described as below.

2. The design algorithm of intelligent image processing system for pulling out

One of the issues affecting drivers in the form of traffic accidents on the streets and roads occurs when the passing vehicles may not notice the parked vehicles due to not having seen a vehicle just around the corner or a vehicle getting out of the parking space. The vehicles equipped with parking assist systems can detect objects at a maximum distance of six meters using sensors installed around them; however, the type and distance of incoming and outgoing objects over this detection range are not detected. For this purpose, accidents and injuries can be avoided by identifying and separating various parts of the images captured from the street in order to spot moving objects.

The fundamental of designing an intelligent algorithm of a pullout system is similar to what really happens to a real driver, that is, it includes an evaluation of the surroundings and image processing. The first step in evaluating the vehicle surroundings through image processing is to capture images. The images taken must benefit from some certain features depending on the technology and placement of cameras on the vehicle. Then, the identification of the moving objects is carried out by applying the operator's suitable functions. Then it detects the type of objects with two different methods.

The size of an image plays a significant role. Considering the size of the image, calculations can be decreased so that the desired result is achieved quickly. The steps of the processing algorithm will be explained below.

The new proposed algorithm enables the driver to identify moving objects and their types to take appropriate timely action while pulling out of the park based on the street conditions.

2.1. Identification of moving objects and binarization of images

The video captured from cameras consists of several frames each of which has different pixels from the others. To identify moving objects, the frame of a moment must first be subtracted from its previous frame. In this case, the blocks that have changed are in white and the blocks that have remained unchanged are in black. As moving objects have different pixels in frames, the objects whose locations are changed in the image can be identified and located in their new positions.

When, after the image processing step, the desired image for certain surroundings is produced, the identification stage beings based on the parking location of the vehicle. At this stage, the system ought to distinguish the moving objects from the fixed ones. In the proposed algorithm, the condition of generating black and white image is first to be met. The condition involves displaying moving objects in white and fixed objects in black. To get a black and white image, the image firstly needs to be converted to gray scale so that a better resolution can be achieved using fewer colors.

2.1.1. Subtracting two images

Subtracting two equal-size images means that the brightness of the corresponding pixels of the two images is subtracted. When subtracting pixel values, negative values are converted to zero. Absolute value of the obtained subtraction can also be used while subtracting. The application of image subtraction can be found in the motion identification in CCTVs, for

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example. When there is a difference between the two consecutive frames taken from the camera, the movement has taken place. As stated previously, the subtraction operator is used to calculate the difference between two images. Thus, by subtracting the current frame and the previous frame taken from the camera, the difference between the two images can be identified. Among other applications of image subtraction, removing the fixed background of the image can be highlighted.

2.1.2. Enhancing the identification of moving objects

Images taken from the cameras pose problems which include the followings:

- In addition to the desired moving objects, every moving object is shown in the image which produces noises such as birds, shadows of vehicles, and moving trees.
- Due to varying body color, moving objects are shown only by the lines and sides of them for image processing and the whole body of an objects is not shown in a single color.

The first problem in image processing is to display all moving objects. In this case, the fine moving objects are removed by the Gaussian method which produces images as noiseless as possible. The second problem is the discontinuity of the image captured from the moving objects which displays the objects partially in the form of lines. At this stage, in order for the interior points of the vehicle or any other moving objects to be capture in a continuous form, the potential cavities have to be filled up. This function is called morphology method that is performed in 3 by 3, 5 by 5, 7 by 7, and 15 in 15 squares. Erosion and abrasion are also applied to improve the image. Abrasion is also used to connect the broken parts of the body displaying a better image.

2.1.3. Applying Bubble Algorithm

In the bubble algorithm, finding points that have common features is sought. These points must be similar in terms of five features. The bubble algorithm contributes to a full display of the objects in its entirety. The bubble operator can demonstrate this algorithm using five methods:

1. By color: First, the adjustment of the filter needs to be done according to color where the bubble color is set to zero, the bubble is darker and where the bubble color is set to 255, the bubble is lighter.

2. By the surroundings: The bubble can be filtered in terms of size by setting the filter parameters based on the surroundings and the appropriate values for the maximum and minimum number of pixels.

3. By being circular: The spots identified in the candidate regions are selected based on the degree of similarity to the shape of a circle.

4. By minimum to maximum ratio of inertia: This measure pivots on the width-to-length ratio of a shape. For example, this value for a circle is 1 and for an ellipse between 0 to 1.

5. By the bulge and or dent: Based on the amount of bulge and dent of the shapes, shape selection can be conducted.

At this stage, once the image has been improved, the object must be fully identified. Similar to the moving object itself, the color of the vehicle is shown as white in a binary image. For this purpose, the bubble operator is used and the entire object is displayed like a white bubble. In this case, the displayed lines of the moving object are linked together and the interior of the generated shape is shown in white.

3. Identification of moving object types

In the proposed algorithm, the image processed in the previous step is the image that is suitable for detecting the type of moving objects inside the image.

In this case, there are various ways to detect the type of moving objects. This algorithm relies on the idea of identifying the area of objects in the image. To evaluate the performance of this idea, the results are compared to the conventional method of Support Vector Machine.

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3.1. Object type detection by Support Vector Machine

This method works in a manner that, at first, 400 images of widely used vehicles are taken nationwide being referred to as positive or target images. The more the number of the images, the better the performance will be. These images need to be identical in size and taken from the same angle. Generally, they ought to be the same in every respect. On the other hand, more 300 images must also be taken from other apparently unneeded angles and from angles that may not be shown. In this case, these images are called negative images having to have characteristics similar to positive images; all these photos must be exactly the same in size and taken from the same angle. [15]

After collecting positive and negative images, positive and negative images are stored in separate files. Using the support vector machine algorithm, the trained information is produced in a file. In this file, all photos are placed within their own profiles. By using this file in the original algorithm, it has become possible to detect vehicles whose images are captured; their locations are indicated using a color box drawn around them. It should be noted that a separate trained data file must be prepared for every moving object, for example a man, motor, and or a heavy vehicle. Finally, all files are fed into the original algorithm generating a display of every object which can pose a danger to the vehicle existing the parking space.

In this operation, when a moving object is detected, it is indicated by a red box until it get past the parked vehicle; the location of the object is announced as well. Because the trained data file is fed into the original algorithm, when the moving object stops at any point in the image, the very box disappears because the object is no longer moving; therefore, it is no longer the objective of the program as it poses no danger of collision to the parked vehicle. If the object starts to move once again, the box appears around it indicating the movement.

3.2. Object type detection by detecting the area of objects in the image

The method of object detection by area or dimensions in the image involves displaying the objects at different distances using different boxes.

Every moving object, such as human, automobile, motor, and heavy vehicle, has a characteristic length and width in the image, which is determined by the distance of the object from the camera. For this system, at first, one object such as a car is placed at a distance of 15 meters (the distance that is enough to start moving or stop); then, a camera which is installed in the mirror inspects the street. Generally, sedan cars share almost the same length and width and this holds true for SUV cars as well. A significant percentage of mid-size cars can be detected by introducing a mid-size car to the system. The length and width of the car inside the image is measured; the area of the rectangle in which the car is located can be used for measurement. Then, an approximation of this size is recorded based on the popular cars in the country. These values are fed into the original code of the algorithm which has been used for the identification of the moving object so far; the vehicle data is provided to the program for detection by plotting the length, width, and or the area of the object in the image. Afterwards, the program is provided with the extent to which a moving vehicle (a sedan car) can enlarge to drive past a parked vehicle. By using color boxes, various moving objects can be distinguished achieving better detection.[16][17]

Afterwards, the size of the intended moving vehicle can be enlarged to pass through a parked car, which is a certain range of sizes, would be given to the program.

In this program, every moving object must be coded separately because of the difference in width and length in the image. By accurately measuring objects in the image, objects can be

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more precisely identified with more precise boxes.

4. Identifying the right moment for pulling out

After identifying the moving objects, their types, and locations, the parked vehicle remains in the parking as long as the potentially dangerous objects keep moving on the street. To avoid collisions when leaving the parking, the best time to get out of the park has to be determined. For this reason, the system can be programmed in terms of software and hardware so that when there is a moving object within range of the camera, the vehicle remains motionless and if there is no moving object in 5 seconds the best time for leaving the parking is notified. Considering this matter, if a moving vehicle stops for 5 seconds next to the parked vehicle which is about to exiting the parking, it is the right moment to depart. However, if the vehicle stops on the street and moves again, the system reverts to the first stage and starts processing the surroundings again.

5. Implementing an intelligent parking pullout system and the empirical results

To begin with, the position of the camera must be determined to process the surroundings of the parking. The following conditions must be considered to find the right position:

1. Posing no obstruction to the driver`s view;

2. Being capable of identifying the best space around the vehicle;

3. Being small enough to operate optimally;

4. Being placed away from the vehicle`s surface and to be environmentally resistant.

Considering the above conditions, side view mirrors of a vehicle are the best place to install the cameras. Owing to the fact that the mirrors protrude from the vehicle, the best view can be obtained fulfilling the second condition. Despite being small enough to fit into mirrors through a hole, cameras must be selected in a way to bring about high quality as well to produce better images of the surroundings meeting conditions 1 and 3 as proposed above. The camera, which is installed into a mirror, can be water resistant or made into a case for more protection against water meeting condition 4 as proposed above. In Figure 2, the position of a camera, which is a cellphone camera in this case, can be seen on a mirror.

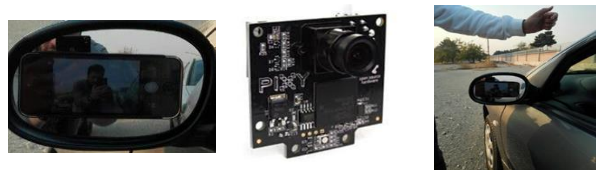

Figure 2: The location of camera position for image processing

The camera needs to benefit from some certain features to deliver the best efficiency. It must be small enough to be installed into a vehicle`s mirror. Because a vehicle`s mirror provide the best view to the driver which makes it possible to capture images from the surroundings. It must deliver the quality images to the system: the more the quality of the images, the better the detection of objects in the distance. Given that the camera is installed in the mirror, the camera is exposed to rain and shock, hence, the camera needs to be water- and shock-resistant. Figure 3 shows an image processed from cars and motorcycles on the street.

Figure 3: The right image is the initial image of the camera and the left image is the detection image of the moving objects

Using the camera located in the mirror, an image of the street is processed and the moving objects

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are identified through binarization and subtraction of two images. Due to the sunlight, shadows of vehicles and movements of trees on the street impact the quality of the image that is known as noise. Figure 4 illustrates such problems as showing all moving objects or not showing the entire vehicle.

Figure 4: Image processing problems and identification of all moving objects

Applying Gaussian operators, the morphology and bubble of the images obtained from the camera are enhanced and the moving objects are displayed fully and in one single color. In Figure 5, the process of image enhancement is shown in the implementation process of the proposed algorithm.

(a) (b)

Figure 5: Image (a) without applying the operators and the image (b) by applying the operators

Better images can be displayed benefiting from the quality and capability of the camera to detect moving objects in the distances. Using a 2 megapixel cellphone camera, vehicles and humans have been detected from a long distance.

In the first part of this project, all moving objects in the image can be identified and located regardless of the types of an object and the size by inspecting only 50 objects (individuals, motorcycles, cars, and heavy vehicles), Figure 6 shows the percentage of identification of the moving objects.

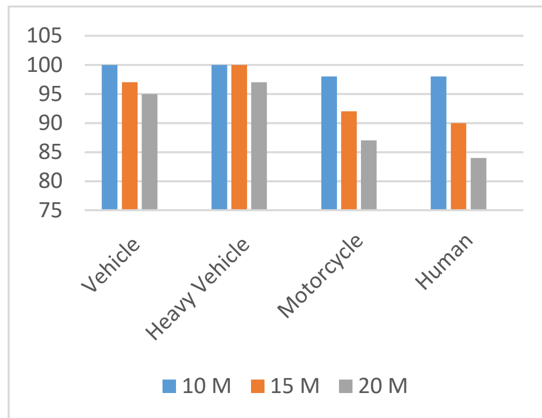

Figure 6: Displays the percentage of detecting moving objects at different distances

Due to their considerable size and relatively low speeds, heavy duty vehicles have a higher percentage of identification than other moving objects. Motorcycles and individuals have the same detection percentage due to their relatively similar size. Now, after obtaining the appropriate image of the moving object, the type of the moving object is detected by using the Support Vector Machine and its implementation in the algorithm. In Figure 7, the whole process of this method is shown.

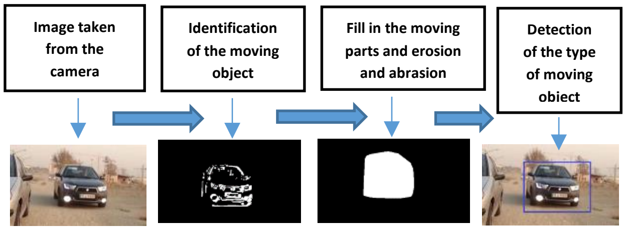

Figure 8: Procedures for detecting the type of moving object through detecting the area of the objects

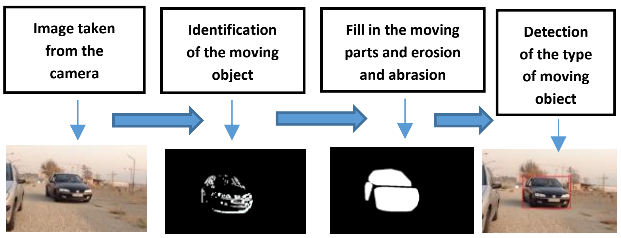

Figure 7: Identification and detection steps of moving object in the Support Vector Machine Method

In the implementation of the algorithm, the method of object area detection is used to obtain results. In Figure 8, the stages of the implementation of the method of object area detection are shown in the intelligent system.

By accurate measurement of the objects in the image, objects can be detected with more precise boxes. In the proposed algorithm, moving objects can be shown with different color boxes enabling a better distinction of objects. In Figure 9, two different moving objects (individuals and vehicles) are identified with boxes of different colors.

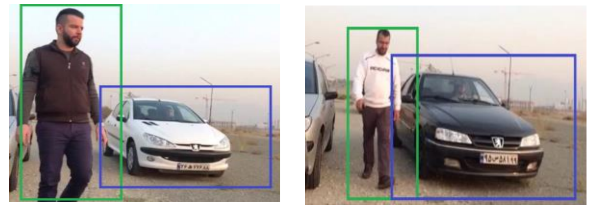

Figure 9: The human moving object with a green box and a vehicle moving object with a blue box are shown

In the method of object area detection, the color of the box for an object can be changed by entering the distance of the moving object from the vehicle. That is, if the moving object is detected in a distance more than 15 meters from the vehicle, the box is shown in green; where the object is closer than 15 meters, the box is shown in red. Now, Table 1 compares the two methods and shows which method achieves better results considering the detection percentage of moving objects from different distances using Support Vector Machine and object area detection that identify the type of objects.

Table 1: Comparison of two methods in different situations

Measurement items	Support Vector Machine Method	Area detection method
Number of vehicle detection	93%	96%
Number of Motorcycle Detection	86%	90%
Detection and identification time	200 Millisecond	50 Millisecond
Volume of calculations	50 MB	2 MB

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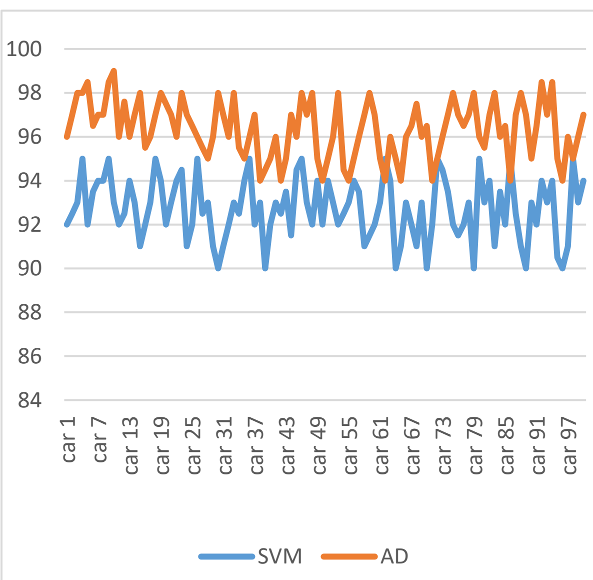
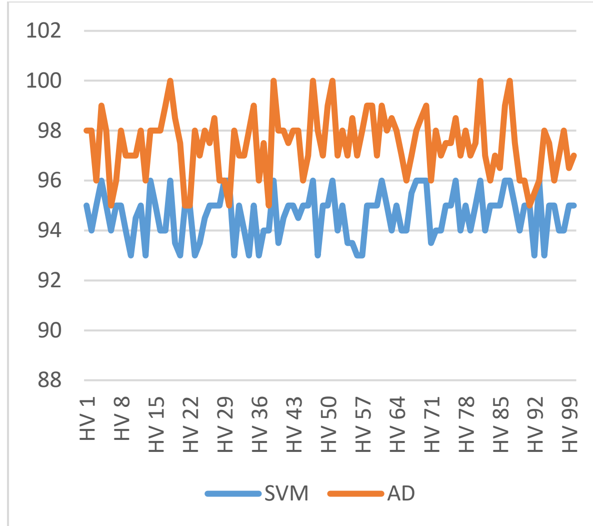
Now, using the chart, percentages of Super Vector Machine Method and Area detection Method will be compared. In this comparison, three types of important moving objects, including cars, heavy vehicles and humans, are identified and detected at various intervals, of which 100 are measured. Each of the objects is different in their own terms with other homosexuals, and they are not all shapes. The distance between the camera and the objects at first is 20 meters and decreases over time. Every 20 cm, 1% of 100% of the body's detection decreases.





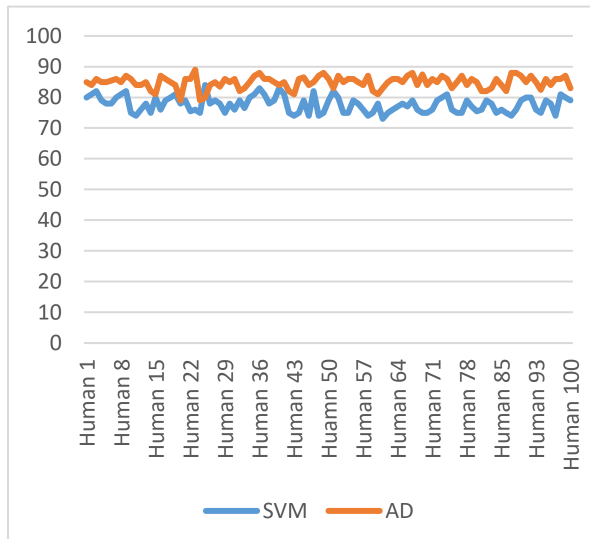


Figure 10: compares two methods of SVM and AD to identify and detect three different types of objects, each of which is 100 times at different intervals

Both methods significantly assist the driver to identify the type of objects while pulling out of the parking. This program can be used for exiting the parking as well as other applications. Support Vector Machine has three disadvantages. The first disadvantage is that lots of images must be taken from different locations and objects. More importantly, all the images must be of the same size and angle, which is problematic and time consuming. The second disadvantage is that as the program is bulky, the calculations are slow resulting in delayed processing.

In the method of object area detection, the advantages outweigh the disadvantages. Moreover, disadvantages can be minimized as well. The advantage of the method is tripartite.

1. Considering different dimensions of objects, a better distinction can be achieved using colored boxes.

2. It is less time consuming than the other method and only needs to measure objects in the image.

3. It involves fewer computations and the size is much lower because there is no image in the program itself, which results in higher computational speeds than Support Vector Machine.

Owing to the outperformance of the method and considering the calculation and processing speed, it can be concluded that the method of object area detection is suitable for image processing of the vehicle surroundings.

According to the research done by different people in the world for the identification and identification of moving objects in the street, it can be concluded that the method used in this paper with a 96% detection rate is a better way to detect moving objects.

Table 2: Comparison of three methods in the world with Area detection method

	Vehicle	Heavy vehicle	Human
Area detection method(ADM)	96%	99%	90% to 93%
Source [13]	85% to 90%	94%	-
Source [14]	91%	95%	-
Source [15]	99%	99%	-

As you can see in the table 2, each method has a different detection percentage, with the method presented in this article having a higher percentage of detection than other methods. It is true that Source [18] method is higher in terms of detection rate, but ADM's superiority is that it can detect and identify the type of moving object at different intervals. That is, identification in the ADM is measured at three distances, and it recognizes the type of object, such as man, vehicle, and motor. In the other way, ADM's speed is faster to detect and identify than the Source [18], which prevents traffic accidents on the road and on the streets.

6. Conclusion

In this paper, a new algorithm is proposed for designing an intelligent system for executing pullout maneuver from the parking place. As the pullout issues not having been addressed in other systems, an intelligent system can bring about a solution in preparation for a safe pullout space.

A mirror camera enables detecting the moving objects on the street drawing on the two key detection methods: object area detection and Support Vector Machine. In view of the results of this study, it could be concluded that the object area detection performs better by minimizing risks of accidents while pulling out through moving object detection. The driver is informed of the safety for pulling out which contribute to a decrease in traffic congestion.

References

[1] M. Roca-Riu, E. Fernández, and M. Estrada, “Parking slot assignment for urban distribution: models and formulations,” Omega—International Journal of Management Science, 2015, vol. 57, pp. 157–175.

[2] H. Shani, “Shuttle cars for use in automated parking”, Unitronics parking Solutions Ltd, September 13, 2016.

[3] C. Pypno, “Automated large capacity multi-story garage—Concept and modeling of client service processes” September 2017, Vol. 81, Pages 422-433.

[4] B. Schäufele, O. Sawade, D. Becker, Ilja Radusch, “A transmission protocol for fully automated valet parking using DSRC”, IEEE, Jan 11, 2017.

[DOI: 10.22068/ase.2020.513]

[5] S. Klaudt, A. Zlocki, L. Eckstein, “A-priori map information and path planning for automated valet-parking”, IEEE , June 14, 2017.

[6] Y. Han, J. Shan, M. Wang, “Optimization design and evaluation of parking route based on automatic assignment mechanism of parking lot”, Sage Journals, July 21, 2017.

[7] W.Wang, Y.Song, J.Zhang, H.Deng “Automatic parking of vehicles: A review of literatures”, International Journal of Automotive Technology, October 2014, Vol. 15, Issue 6, pp 967–978.

[8] S. Yasunobu and Y. Murai, “Parking control based on predictive fuzzy control,” in Proceedings of the 3rd IEEE Conference on Fuzzy Systems, June 1994, pp. 1338–1341.

[9] Y. Hua, H. Jiang, Y. Cai, X. Zhang, S. Ma, and D. Wu “Path Tracking Control of Automatic Parking Cloud Model considering the Influence of Time Delay” , Mathematical Problems in Engineering, Vol. 2017, 2017, 14 pages.

[10] B. Wang, C. Shao, J. Li, D. Zhao, and M. Meng, “Investigating the interaction between the parking choice and holiday travel behavior,” Advances in Mechanical Engineering, 2015, vol. 7, no. 6, pp. 1–11.

[11] L. Dean Elie, D. Scott Rhode, “System and method for autonomous valet parking using plenoptic cameras”, Ford Global Technologies Llc, Jan 31, 2017.

[12] M Durali, M Sadedel. “Multi Purpose Drive Train Road Test Simulation System” IJAE. 2011; 1 (4) :280-287

[13] A. Maghsoudi, E. Khanmirza. F. Gholami, “Longitudinal Speed Control Using Model Reference Adaptive Control for Intelligent HighwayPlatform” IJAE, Vol. 10, Issue 2 (6-2020)

[14] A. Khodayari, A. Ghaffari, F. Fanni. “A Real Time Traffic Sign Detection and Recognition Algorithm based on Super Fuzzy Set”. IJAE. 2017; 7 (1) :2346-2355

[15] D. Meyer, FH Technikum Wiengnn, Austria, “Support Vector Machines” The Interface to Libsvm in package, February 2017, pp 1071.

[16] X. Xiang, M. Zhai, N. Lv and A. El Saddik, “Vehicle Counting Based on Vehicle Detection and Tracking from Aerial Videos” 2 August 2018.

[17] P. Kumar Bhaskar, S. Yong, “Image processing based vehicle detection and tracking method” Date Added to IEEE Xplore: 31 July 2014. DOI: 10.1109/ICCOINS.2014.6868357

[18] F. Liu, Zh. Zeng, R. Jiang, “A video-based real-time adaptive vehicle-counting system for urban roads” November 14, 2017