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Intelligent Parking Space Detection System using Sobel Edge Detection in Open CV

Roma Jain[1], Jijo S. Nair[2]

[1, 2]Oriental Institute of Science and Technology, Bhopal, MP, India

Abstract: ***Automatic parking space detection system is newly introduced in the modern era of intelligent congestion management. It is an emerging field and attracted computer vision researcher to contribute in this arena of technology. Here the proposed system is able to recognize free parking space as well as occupied parking. OpenCV is the latest computer vision technique or a library through which a system can be developed with high level of accuracy. Proposed system is based on Sobel Edge Detection method which is able to recognize the occupied and free space for smart parking which may reduces the human efforts. This system is also useful for alarming if a vehicle is parked in no parking area and inform about the parking space availability at real time with high level of accuracy. In the field of intelligent vehicle and parking management system, accuracy is often important as human convenience required. It is required to get accurate outcomes at real time through which an intelligent parking slot or space detection can be implemented with newly introduced technique.***

Keywords: Automatic Parking, Smart Parking, OpenCV, Sobel, Space Detection, Edge, Computer Vision

1. Introduction

Automatic parking slot occupancy detection is method of detecting particular region for confirming whether it is occupied or not. Parking is not systematically managed or it is managed by manually. The problem that always occurs is to identify the free parking space. This problem usually occurs in urban areas, where number of vehicles is higher as compared to the availability of parking spaces. Various systems are developed for providing information regarding free space for parking but these systems are either based on hardware sensors or based on Around View Monitor (AVM). Previously implemented systems are costly because they are using more than one camera for each parking slot and some are using fish cameras for recognizing free spaces.

Figure 1: AVM based System [8]

There are several issues related to the parking area took place as no any ideal technique available to resolve it. There is no automated system installed practically where parking can be managed automatically with high level of accuracy. Drivers have to manually search for the slots and park their vehicle which sometimes create blockage. The proposed system can solve the issues related to the parking management system. Proposed system is intelligent enough to identify whether the vehicle is partially parked or not. Proposed system also recognizes motion at real time which alerts controller about entering or exiting vehicles.

Figure 2: Proposed System

System works at real time with high level of accuracy that segment pedestrian and vehicles for better level of accuracy and ideal managements.

2. Problem Statements

The techniques which have been developed till now in the field of detection of parking slot doesn't provide any perfect approach to implement practically. Some systems emphasized on the method of hierarchical tree structure by using AVM image sequences to spot the parking slots and tried to display the cluster of vacant slots and avoid to display sing slot in a cluster which consumes time and wasted that available single slot. There is no case to handle the situations where adjacent vehicles obstruct the slots. Some technique employed ultrasonic sensors which are sensitive to temperature variation and result in reduced accuracy. Similarly RFID is also used in previously developed techniques which are sensitive to change in nature and may get affected due to dust, water and increase in temperature. Deployment of tags in RFID systems are not trained enough to detect the presence of obstacle that can limit the transmission of information. Latest technique which has been developed in the base paper employed four fish eye cameras in AVM system which deliberately increases the cost of

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whole setup and limits their implementation at an extended scale as the installation of system is expensive.

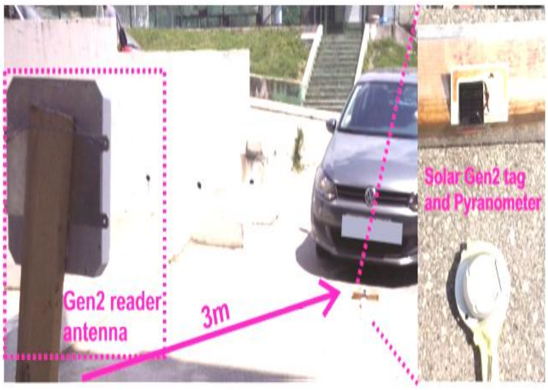

Figure 3: RFID based System [3]

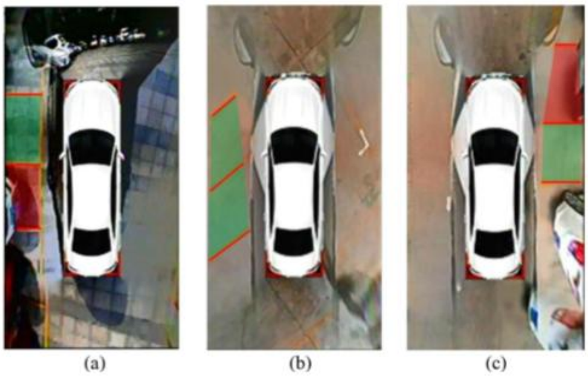

Figure 4: Experiments Results of Typical Parking Slot. (A) Rectangular Type. (B) Slated Rectangular Type. (C) Open Rectangular Types [8]

The proposed system may replace the earlier systems which do not possess with intelligent approach to recognize fully parked vehicles as well as partially parked. Let it be more precise in next section.

3. Proposed Work

The system proposes real time parking slot detection using Sobel Edge Detection. Proposed system is able to recognize free space as well as occupied one at real time and also able to inform about the visits of vehicles. No pedestrians can occupied the parking slots, only vehicles over the spaces considered for occupied parking. The platform uses OpenCV library which is most popular library for advanced image processing.

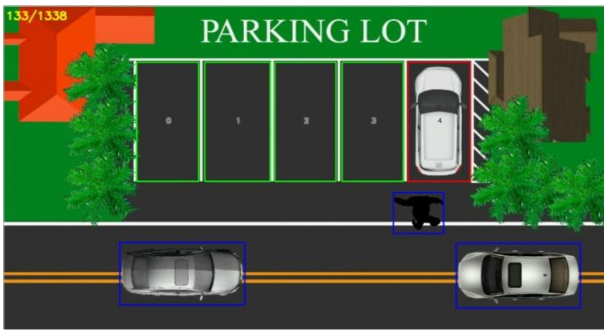

Figure 5: Parking Slots

Proposed system can recognize motion at real time for transition alert and classify pedestrian among vehicles.

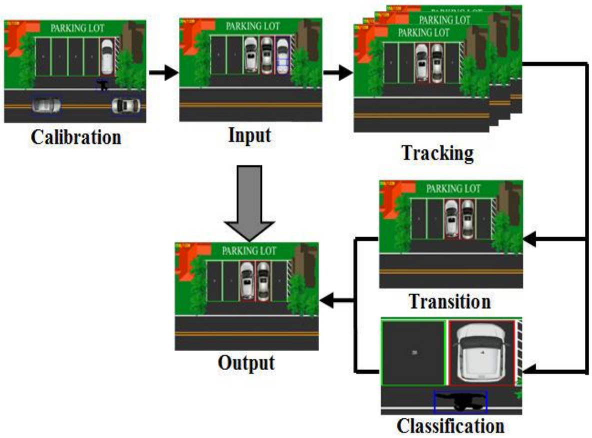

Figure 6: Overview of Proposed System

Calibration: Calibration primarily consists of drawing lines to identify the parking slots that identifies whether slot is occupied or not. The calibration process allows the system to increment (when a car arrives) or decrement (when a car leaves) a counter in order to keep track of the parking lot occupancy.

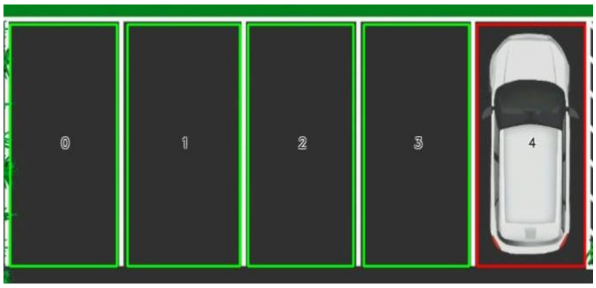

Figure 7: Calibration

Input: Test the system by passing or parking some vehicles along with pedestrian.

Tracking: After calibrating all x and y coordinates for parking slots assignment, it tracks vehicles along with pedestrians at real time using Sobel edge detection and blobs marking shows real time motion that alerts arrival and departure of vehicles.

Transition: The transition process establishes the criteria used to detect when cars enter or leave the parking area.

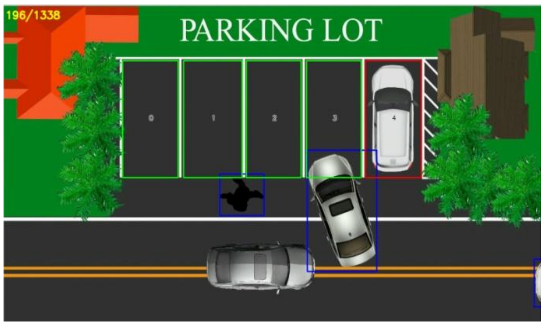

Figure 8: Transition

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Classification: Following to blob detection and tracking, a bounding box of the blob was determined. The approximate area of the blob, measured using the bounding box, was used to filter the noise in the image. Blobs that are extremely small are considered noise while those with an area greater than a certain threshold are considered objects of interest to the parking problem.

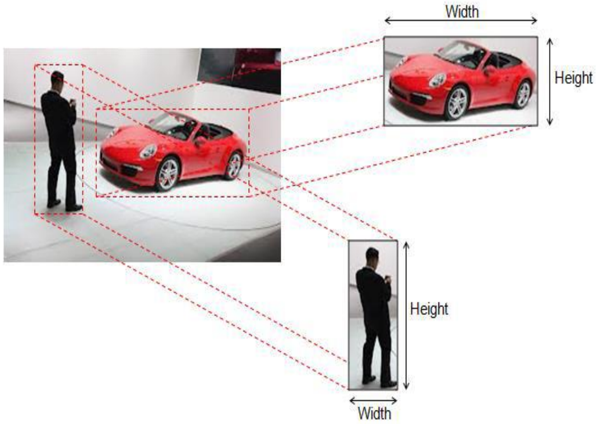


Figure 9: Classification

Proposed system is also able to recognize partial parked vehicles and fully parked. If partially parked vehicle consumes more than half of the slot then it should be considered as consumed parking otherwise it will be considered as free space.

Figure 10: Partially Parked Vehicles

4. Proposed Methodology

Proposed system classifying vehicles and pedestrian by identifying through edge using Sobel edge detection algorithm. Sobel edge detection is a filter used in image processing or computer vision for detecting edges. A large change in image brightness of a short spatial distance is known as edge. The operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives – one for horizontal changes, and one for vertical. If we define A as the source image, and Gx and Gy are two images which at each point contain the horizontal and vertical derivative approximations respectively, the computations are as follows:

$$\mathbf{G}_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * \mathbf{A}$$

$$\mathbf{G}_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * \mathbf{A}$$

where * here denotes the 2-dimensional signal processing convolution operation. The x-coordinate is defined here as increasing in the "right"-direction, and the y-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$\mathbf{G} = \sqrt{{\mathbf{G}_x}^2 + {\mathbf{G}_y}^2}$$

is the gradient magnitude.

$$\mathbf{\Theta} = \operatorname{atan}\left(\frac{\mathbf{G}_y}{\mathbf{G}_x}\right)$$

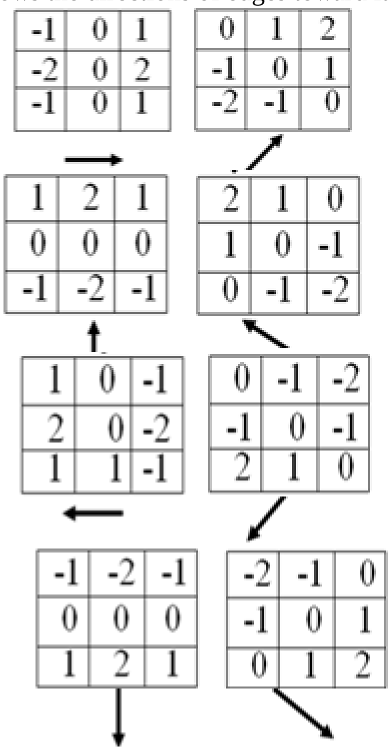
is the gradient direction.

$$S_1 = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \qquad S_2 = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$\text{Edge Magnitude} = \sqrt{S_1^2 + S_2^2}$$

$$\text{Edge Direction} = \tan^{-1}\left[\frac{S_1}{S_2}\right]$$

Array shows the directions of edges toward it filtered.



The arrow shows the direction of edges or gradients. There are eight directions for gradients such as – (a) East, (b) North East, (c) North, (d) North West, (e) West, (f) South West, (g) South, (h) South East, respectively.

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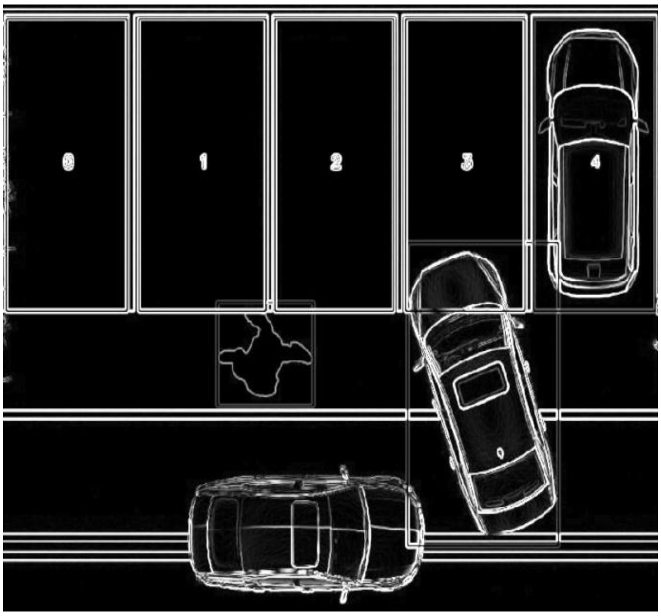

Figure 11: Sobel Edge Detection in West (x) and North (y) Direction

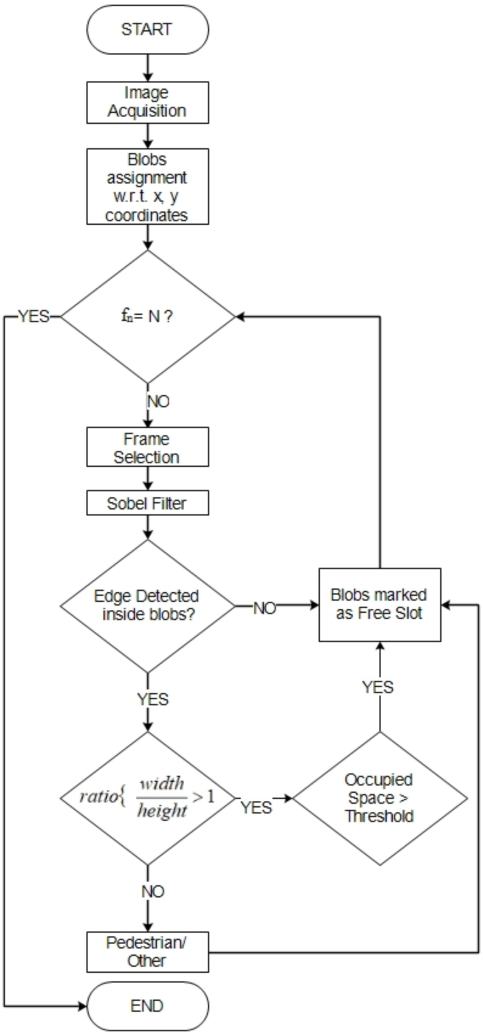

Figure 12: Flow Chart

In flow chart, first of all blobs will be assigned w.r.t. x and y axis while first frame is acquired. Then it will rectify whether frame is about to end or not, if it becomes end then the process will get expired otherwise process get accessed till frames acquisition. Then Sobel filter has been applied once the frame is acquired. If edge has been detected inside the blobs then it will confirm whether its aspect ratio is greater than 1 or not, if it is greater than 1, it means that it is a vehicle otherwise it is considered as pedestrian. It will further check whether it is greater than the threshold value, and if it is greater than the threshold value it means that it should be considered as occupied slot otherwise it will be free parking slot.

4.1 Edge Magnitude Sobel Algorithm

Require: Horizontal gradient mask G_x, Vertical gradient mask G_y, free slot S, Occupied slot S_d, Pedestrian P, Vehicle V, threshold T, Absolute magnitude G, Unknown Object O_b.
Input: A as 2 dimensional image arrays.
Output: Gradient ratio w.r.t. width and height.
Step 1: Acquire the input image.
Step 2: Function Sobel (A)

$$G_x = [-1\ 0\ 1; -2\ 0\ 2; -1\ 0\ 1]$$
$$G_y = [-1\ -2\ -1; 0\ 0\ 0; 1\ 2\ 1]$$

Step 3: Apply gradient mask G_x and G_y to input image

$$S_1 = G_x * A$$
$$S_2 = G_y * A$$

Step 4: Separate mask manipulation for G_x and G_y as S_1 and S_2 resp.
Step 5: Combine the results to find out the absolute magnitude of the gradient.

$$|G| = \sqrt{S_1{}^2 + S_2{}^2}$$

Step 6: Create blobs for absolute magnitude as V.
Step 7: **if** ratio $\left\{\frac{width}{height} > 1\right.$ **then**
O_b declared as vehicle O_v
else
O_b is pedestrian
end if
Step 8: **if** O_b > T **then**
S declared as occupied slot S_d
else
S declared as free slot
end if
Step 9: End

5. Result Analysis

Table 1: Result Analysis

V_n	PP>T	PP<T	TP	TN	FP	FN	MD
V_1	1	0	1	0	0	0	1
V_2	1	0	1	0	0	0	1
V_3	1	0	1	0	0	0	1
V_4	0	1	1	0	0	0	1
V_5	1	0	1	0	0	0	1
V_6	1	0	1	0	0	0	1
V_7	1	0	1	0	0	0	1
V_8	1	0	1	0	0	0	1
V_9	1	0	1	0	0	0	1
V_{10}	0	1	1	0	0	0	1
V_{11}	1	0	1	0	0	0	1
V_{12}	1	0	1	0	0	0	1
V_{13}	0	1	0	0	1	0	1
V_{14}	1	0	1	0	0	0	1

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V_{15}	1	0	1	0	0	0	1
V_{16}	1	0	1	0	0	0	1
V_{17}	0	1	1	0	0	0	1
V_{18}	1	0	1	0	0	0	1
V_{19}	1	0	1	0	0	0	1
V_{20}	1	0	0	1	0	0	1
V_{21}	1	0	1	0	0	0	1
V_{22}	1	0	1	0	0	0	1
V_{23}	0	1	1	0	0	0	1
V_{24}	1	0	1	0	0	0	1
V_{25}	0	1	1	0	0	0	1
T_n	19	6	23	1	1	0	25

PP- Partial Parking, TP – True Position, TN- True Negative, FP – False Positive, FN – False Negative, MD – Motion Detection.

Table 2: Result Comparison

X	*Present*	*Proposed*
Total no. of Vehicles Tested (N)	Not Mentioned	25
Total no. Correct Partial Parking Recognized	Not Mentioned	19
Total no. Incorrect Partial Parking Recognized	Not Mentioned	2
Total no. of Correct Partial Parking that not Recognized	Not Mentioned	0
Total no. Correct Parking Recognized	Not Mentioned	23
Total no. of Correct Parking that Not Recognized	Not Mentioned	2
Total no. of Incorrect Recognition (FP)	Not Mentioned	1
Total no. of parking vehicle motion detection	Not Mentioned	25
Recall *(R)*	0.921	1.0
Precision *(P)*	0.933	0.958
Overall Accuracy	92.7	97.9

$$P = \frac{True\ Positive(TP)}{True\ Positive(TP) + False Positive\ (FP)}$$

$$R = \frac{True\ Positive(TP)}{True\ Positive(TP) + False\ Negative\ (FN)}$$

R – Recall, P – Precision

Precision is defined as the number of true positives over the number of true positives plus the number of false positives. Recall is defined as the number of true positives over the number of true positives plus the number of false negatives.

6. Conclusion & Future Scope

The systems which have been proposed till now are costly because most of the systems are using sensors like ultra sonic, proximity and fish cameras which increase the cost of the system since these components needs to install in every vehicle to execute the system. There is more than one camera or sensors have been used for each vehicle which increases the cost of the system. The proposed system is capable enough to efficiently identify vacant and occupied parking slots by using OpenCV which enhances the accuracy and proficiency of the system up to a great extent. The real time parking slot detection can be used for automatic parking management. But accuracy is often important which requires enhancing for developing an ideal system that can be implemented practically. Edge detection technique can be enhanced in future where accuracy depends.

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