

## Implementation of Smart Parking System Using Image Processing

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### Abstract

Today, most of Sri Lanka's operational parking areas are controlled manually and inefficient. For this reason, drivers can take extra time to drive around the parking area in busy days to find a free parking spot. The proposed system can identify the vehicle type and free parking slots. Also, the system contains the shortest path algorithm to help drivers in finding the nearest vacant parking space. In this project, the camera is acting as a sensor. The reason behind using a camera is with an image it can detect the presence of many vehicles at once. Depending on the area to be covered, one or more cameras are used to process video clips. Since there are no sensors employed, the mechanical and electronic functionality of the system is reduced to a great extent. In previous research, Canny Edge detection method was used to identify the vehicles. In this research, Yolo algorithm is used to detect the presence and the type of vehicles in the parking area because Yolo algorithm is more accurate compared to Canny Edge detection method. After detecting the vehicles, the mean pixel value of each vehicle is taken. The coordinates of the parking slots are taken to an XML file when the parking area is empty and mark the polygon area of each parking slot. Ultimately, each parking slot is uniquely numbered, and status of the parking slot is decided according to the mean value of the vehicle. If the mean pixel value of the vehicle is inside the given bounding box then, that parking slot is not empty. Otherwise, it is empty. The updated status of each parking slot is displayed at the entrance of the parking area. The accuracy of system was approximately 95% in different weather conditions and various angles of images. The smart parking system reduces the stress, waste of time associated with the parking vehicles and makes managing such parking areas more economical.

**Keywords:** *Smart parking system, Image processing, Parking space detection, Shortest path algorithm, Convolutional Neural Network*

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## Introduction

With the ever-increasing urban population and the improvement in living standards, usage of the vehicles has increased. Because of this reason, occurrences of traffic congestion is high in metropolitan areas. Therefore, it is difficult to find a free parking slot. Hence the need for parking areas is increasing. Even the number of parking areas is high, drivers cannot find an available parking space due to the unavailability of the proper status of the parking area. The figure No.01 shows the increasing usage of vehicles from 2008 to 2106 according to the department of motor traffic in Sri Lanka (Department of motor traffic Srilanka, 2015).

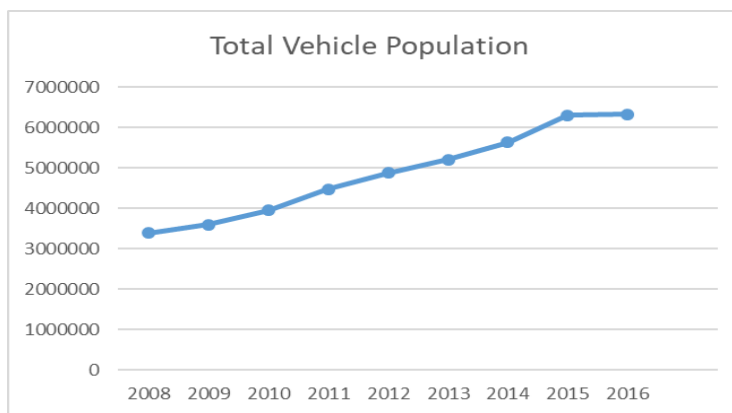


Figure No.01: Total vehicle population in Sri Lanka

Nowadays most car parking areas are not running efficiently. In Sri Lanka, the existing parking areas are not efficient and are not meeting the driver's expectations. Because of that drivers may take extra time driving around the parking area on busy days to find a free parking space. Failure to find a free parking slot can cause congestion on the roads, CO<sub>2</sub> emission, waste of energy, road accidents and an increase in the stress level of drivers. Also vehicle owners, often undergo an extremely frustrating process of driving. The key issue that often happens at the car park is waste of time when looking for the parking spaces open. These problems are seriously affecting public health and the effective use of resources. In most urban cities, the average searching time for an available parking place is up to 10 minutes (Edirisinghe, 2014).

To tackle these problems, the smart parking system has been implemented. Implementing this system will help to solve the growing problems of traffic congestion, wasting money, wasting time, increasing vehicle emissions and pollution. Also, the system helps in providing a better public service, improving the city visitor experience, increasing

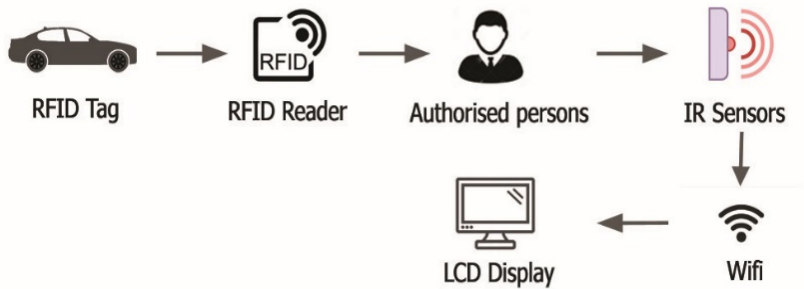
parking utilization and preventing unnecessary capital investments. By using this system status of the parking area (availability of parking slots) is displayed at the entrances. Because of that, the drivers can easily know the availability of the parking lots and can park their vehicles accordingly. Also, this system helps the drivers to park the vehicles efficiently in a specified location. Nowadays, there are many methods used in detecting free parking lots in a vehicle park. A camera is used in the project as a sensor for detection of video images. One or more cameras are used for video image processing, depending on the area to be covered. The existing automated parking system relies heavily on various sensors. Therefore, the proposed system just uses the image processing algorithms to automate the parking with footage obtained from the parking lot's surveillance cameras. These algorithms detect empty parking spaces and convey the information to the drivers.

There are various methods to detect vehicles in a parking area. One method is using the Radio-Frequency Identification (RFID) and the Internet of Things (IOT) which can detect the available parking lot (Aekarat Saeliw, 2019). This IOT based parking system is created by using controllers, sensors, servers, and cloud. Sensors are placed in each parking slot to detect the presence of a car. The sensor will read the number of vacant parking lots and send the data to the microcontroller. Then the microcontroller will display the number of vacant parking spots and display it in the LED display. Therefore, drivers can know the availability of free parking slots before entering the parking area. Figure No.02 shows the process of the above-mentioned system.

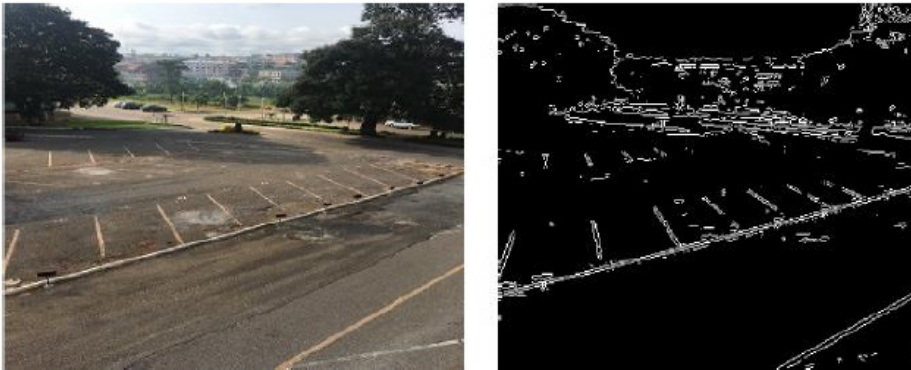
The problem of this system is the inability of sensors to detect the presence of a vehicle in the bad weather condition. Each slot must have a sensor and having sensors in every parking slot is not cost-effective. Also, it is difficult to maintain a sensor-based parking system. There is another method to determine the vacancy status of parking space, through magnetic sensors by using the effect of Earth's magnetic field (J. Wolff, 2006).

Another way is to identify the parking slot using image processing technology (Benjamin Kommey, 2018). This system consists of some operations such as system initialization, image acquisition, and image processing, data interpretation, and display updates. Cameras take snapshots and pass them to the microcontroller unit (MCU) for communication at regular time intervals. The controller forwards the collected data to the base station over the setup local area network. At the base station, the received images undergo a preprocessing stage. The system can display the result using the method of Luminosity, Canny edge detection, and other techniques. The accuracy of this system depends on information captured from images of the parking space. Most of research used canny edge detection algorithm for identify the free parking slots.

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing (Abid, 2013). Parking spots with cars in the designated regions would have extra edges which would increase the mean density within the regions. A significant increase in an area's pixel count enables filling of the corresponding spot.



**Figure No.02 : The architecture of Detecting Empty Parking Slot**



**Figure No.03 : Strong edges identified using the canny detection algorithm**

But there are some disadvantages of this algorithm. The primary disadvantage of using Canny edge detector is that it consumes a lot of time due to its complex computation. Also, reaching the real-time response is difficult to implement. If the amount of smoothing needed is significant in the spatial domain, computing can be slow. It gives a bias towards vertical and horizontal edges and does not provide a reasonable approximation of the rotational symmetry. Because of these reasons, this system used yolov3 object detecting algorithm for identify the vehicles in the parking area. Also, Yolo algorithm is more accurate compared to Canny Edge detection method.

## Methodology

The vision-based method makes it possible to manage a large area by just using several cameras. This project aims to detect the existence of any vehicle in each parking slot. The system initialization is a major part of this process. One or more cameras are used for video image processing it is depending on the parking area. Here, one camera situation is considered. The process of this system shown in the figure No.04.

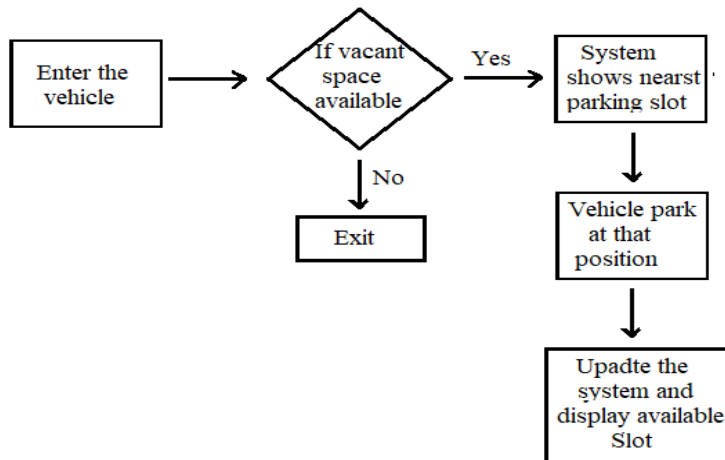


Figure No.04 : Block Diagram of system

To show the available free parking slots and the nearest parking slot used following the algorithm. If there are no free parking slots, the system displays the message parking area is full. Otherwise, the system shows free available parking slots. After the driver parking, the vehicle in the nearest or any free parking slot the system updates the status of each parking slot and displays the result at the vehicle park entrance.

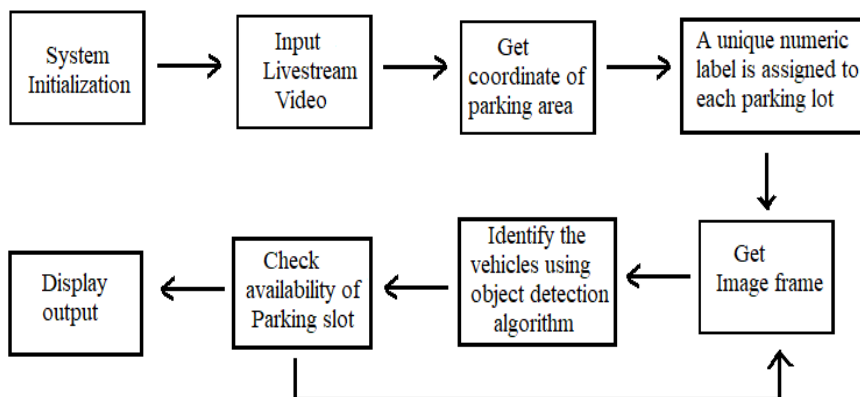


Figure No.05 : System algorithm

Firstly, placing a camera in a fixed position above the vehicles, to acquire the video which used to get the vacancy of the car park. This camera should be in a position where can see all parking lots and camera should be fixed more than ten feet above the ground level because the mean pixel value of each vehicle in the parking area must be captured at any time. There are few steps to identify the free and busy parking slots.

- Input the Livestream video

CCTV system was used to get a real-time video of the parking lot. This device uses a camera which is set. Fixed cameras are mounted in a stationary location, focusing on a single field of view which is typically a defined area of interest.

- Identify the parking area

The individual parking slots must be identified after receiving the CCTV footage. For this step, the fist gets a video frame without any vehicles in the parking area. The figure No. 06 is shown in the parking area without any vehicles. Using the online image map creator identify the coordinates of each parking. Using online tool get the coordinates of each parking slot. The figure No.06 is shown marked polygon of some parking slots and gets the coordinates of that parking slots.



**Figure No.06 : Marked area of parking slots**

Below are the co-ordinates of this parking spaces.

```
<map name="map">
```

```
<area shape="poly" coords="720, 549, 805, 665, 715, 698, 644,582" />
```

```
<area shape="poly" coords="769, 451, 849, 534, 789, 586, 701, 489" />
```

```
</map>
```

Using this coordinate create an XML to identify each slot. The XML file is shown below.

```
<? Xml version="1.0"?>
<parking id="ufpr04">
<space id="0" >
<point x="720" y="549" />
<point x="805" y="665" />
<point x="715" y="698" />
<point x="644" y="582" />
</space>
<space id="1" >
<point x="769" y="451" />
<point x="849" y="534" />
<point x="789" y="586" />
<point x="701" y="489" />
</space>
</parking>
```

- Labeling parking slots

The XML file has coordinates of each polygon. Used these polygon coordinates to find the middle of each polygon. After that, each car parking slot has been given a unique number. The figure No.07 is shown parking slots with a unique id.



Figure No.07 : Park slots with unique ID

The maximum number of slots that could be labeled depends on the capture area of the camera and the training model.

To find the mean pixel value of each vehicle takes the fix numbers of pixel values inside the vehicle bounding box. Here  $n$  is the fix numbers of points.

- Identify Vehicles

To identify the vehicles in the parking area, used the YoloV3 object detecting algorithm. After detecting the vehicles in the parking area get the mean pixel value of each vehicle in the parking area.



Figure No.08 : Identify the vehicle

Use the following equations to find the mean pixel values.

*Mean pixel value of  $x = \Sigma x/4$*

*Mean pixel value of  $y = \Sigma y/4$*

- Yolo Object Detection Algorithm

The use of algorithms for object detection is becoming increasingly important when detecting objects with high precision. Object detection is an operation of computer vision that requires the recognition of the existence position and form of one or more objects in each image. Deep learning techniques have been obtaining state-of-the-art results for object detection in recent years, for example on regular comparison datasets and in computer vision competitions. The YOLO Convolutionary Neural Networks family is known for generating virtually state-of-the-art outcomes with a single end-to-end model capable of real-time object detection.

- Identify the busy parking slots and free parking slots

The status of each parking slot can be determined by comparing the mean pixel value of each vehicle and the coordinates of bounding boxes. If the mean pixel value of the vehicle is inside the given bounding box then that parking slot is not empty. Otherwise, it is empty. Sequentially update the status of each parking slot and display it. The following figure is shown by busy parking slots. The mean pixel value of the vehicle is inside the boundary area because of that parking is busy.



**Figure No.09 : Busy Parking slot**

The figure No.10 shows the free parking slot. There are no mean pixel values of a vehicle inside the boundary area.



**Figure No.10 : Free Parking slot**

- Identify the nearest parking slot

Numbering each parking slot is done by considering the distance from the entrance to the parking slot. Then XML file is created according to these numbering. The number zero is given the nearest parking slot. Finally, the system is displayed nearest parking firstly.

- Identify the vehicles types

The system can identify different types of vehicles such as car, van, bus, and truck, etc. To identify the vehicle's type used YOLOV3 object detection algorithm. After identifying the vehicles in the parking area, display the vehicle types in each parking slot.

## **Results and Discussion**

Various images of the PKLot dataset were used to find the system's accuracy.

The PKLot dataset

The PKLot dataset includes 12,417 images of parking lots and 695,899 images of segmented parking spaces, checked and numbered manually. Both photographs were bought at the Federal University of Parana and the Pontifical Catholic University of Parana parking lots in Curitiba, Brazil. The dataset for parking slots is acquired by following the image acquisition process. This process was executed with a 5-min time-lapse interval for more than 30 days by means of a low cost full high definition camera (Microsoft LifeCam, HD-5000) positioned at the top of a building to minimize the possible occlusion between adjacent vehicles. Here is a short summary of this dataset.

- Photos are taken under unregulated lighting that depicted various climatic conditions (sunny, rainy and overcast periods).

- Images were taken from different parking lots presenting distinct features.
- Images show a variety of issues, such as shadow effect, over-exposure to sunlight, low light in rainy days, the disparity in perspective, etc.

Also, an Extensible Markup Language (XML) file containing the position and location (vacant or occupied) of each parking space was created for each parking lot image.

The output of the proposed system is calculated using the equation which follows (Almeida, n.d.).

PSP = Perfect Slots for Parking

PNC = Present Number of Vehicles

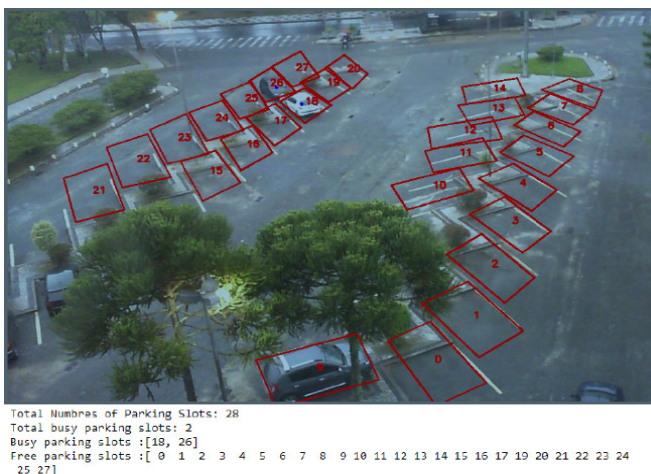
ENC = Expected Number of vehicles (detected vehicles)

Accuracy =  $1 - ((|PNC - ENC|) / PSP) * 100$

In the proposed method, the percentage of error may be Using this equation to locate it.

Percentage Error =  $((|PNC - ENC|) / PSP) * 100$

For getting the accuracy of the algorithm, used different images in different weather conditions. The following figure No.11 and figure No.12 show few test cases of the result.



**Figure No.11. UFPR04 Area in rainy weather condition**

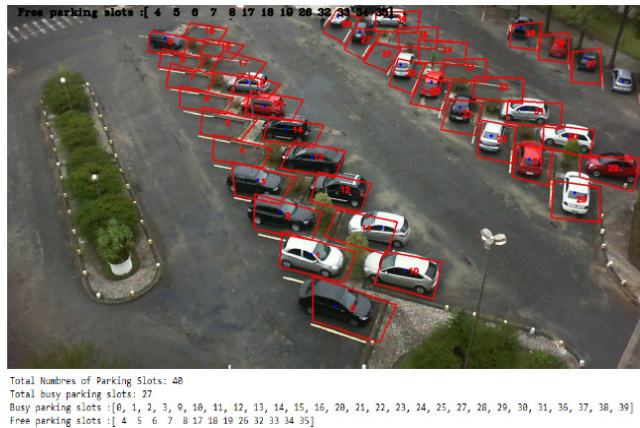
Total Numbers of Parking slots = 28

Actual Number of vehicles inside the parking slots=3

Detected Number of vehicles inside the parking slots=2

Undetected number of vehicles inside the parking slots=2

Percentage Error = 6.571%



**Figure No.12. UFPR05 Area in cloudy weather condition**

Total Numbers of Parking slots=40

Actual Number of vehicles inside the parking slots=27

Detected Number of vehicles inside the parking slots=27

Undetected number of vehicles inside the parking slots= 2

Percentage Error= 7.8%

The table No. 01 shows the accuracy of the algorithm in different weather conditions.

Weather condition	Accuracy
Sunny Day	91.25%
Cloudy Day	88.5 %
Rainy Day	84.28%

Table No. 01: Accuracy of Algorithm

Overall accuracy of this system is 90% approximately. When the parking area is large it is difficult to identify the vehicles in the parking area. These methods generally show a high accuracy but have a disadvantage of slow detection speed and lower efficiency. Because of that, it needs more hardware performances to capture the large parking area at once. During the data selection phase, it was difficult to find images and videos of the parking area. But enough images were gathered from PKLots dataset and videos were gathered from Google search engines. Also, it must be required more computational power for the implementation of this project because video processing has complex algorithms. The accuracy of this system depends on the object detection algorithm. If the parking area is large, it is difficult to detect the vehicles. The camera should be in a position where can see all parking lots and camera should be fixed more than ten feet above the ground level. To capture the vehicles by the camera, there should not have obstacles between cameras and parking areas. If the camera position is changed, coordinates should be taken again to create the new XML file.

## **Conclusion**

The key contribution of this study is to refine the detection of parking slots available to potentially minimize congestion in the parking sector. As a result of advances in machine learning and vision-based technology, cost-effective automatic parking systems make it easier for drivers to locate available parking spaces. This method is capable of managing large areas by just using several cameras. This system is developed by using an integrated image processing approach to reduce the cost of sensors and the wiring hassle. Because of its basic equipment it is inexpensive and easy to mount. The camera position could be adjusted to improve performance. Always a camera must capture the whole area of every parking slot for the highest accuracy. Drivers can get useful real-time parking lot information from this system by the guidance information display. Future researchers can focus on the allocation of specific locations and security parking system using an online parking management system by registered customers.

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