Traffic Signal Violation Detection System

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Abstract

The increasing number of transports in cities can cause high volume of traffic, and implies that traffic signal violations become more critical nowadays in Bangladesh and also around the world. This causes severe destruction of property and more accidents that may endanger the lives of the people. To solve and well-manage this alarming problem and prevent such unfathomable consequences, traffic violation detection systems are needed. For which the system enforces proper traffic regulations at all times, and apprehend those who does not comply. This project is implemented using a self-developed approach. Conventionally vehicle detection is referred as an object detection problem. To detect moving vehicle objects from the road, YOLOv3 model is used which uses Darknet-53. After detecting vehicles, violation conditions are checked. A traffic violation detection system must be realized in real-time as the authorities track the roads all the time. Hence, traffic enforcers will not only be at ease in implementing safe roads accurately, but also efficiently; as the traffic detection system detects violations faster than humans. This system can detect traffic light violation in real-time and an audible alarm will be rang whenever a vehicle violates the signal. A user friendly graphical interface is associated with the system to make it simple for the user to operate the system, monitor traffic and take action against the violations of traffic rules. The use of this system in POLICE control room will reduce accident and manage transports efficiently.

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1 Introduction

Background

In almost all countries in the world, there are traffic lighting signal system used to serve transportantion safety in the road. But nowadays with huge numbers of traffics on road, it is almost impossible to check whether traffic signal is obeyed or not as the drivers have become so rough.The increasing number of cars in cities can cause high volume of traffic, and implies that traffic violations become more critical nowadays in Bangladesh and also around the world. This causes severe destruction of property and more accidents that may endanger the lives of the people. But in this era of digitilization, it is not expected to let such problem to go unsolved. This problem of traffic signal violation can be easily monitored via the CCTV footage and a pre-trained signal violation detection model from live video footage. Thus the traffic that violates the signal can be detected and take under control to minimize road accident.

Problem Statement

In modern transportation systems, ensuring road safety is a big issue as the lion's share of the population travels by roads for earning their livelihood in day to day life. The pre-existing traffic safety system i.g. the use of signal light is not efficient nowadays as the drivers are less concerned to abide by the signals. If the RED light is ON, it means the traffics should be stopped as long as the GREEN light is not ON. But it is very much shocking that the drivers often don't care about the signals and drive during the RED light is ON. Consequently the passengers crossing the road are becoming the sufferer of terrible road accident. If there was a system to detect the vehicle whenever it crosses the signal during RED light is ON, it can be stopped and as a result the accident rate might be decreased to a satisfactory level. Our project is to design such a system to detect the violated traffic at once and take immediate step to minimize road accident.

Motivation

There has been an alarming rise in the number of road accidents in Bangladesh over the last few years. The number of accidents and fatalities has continued to increase from 2020 to 2021. According to the Bangladesh Road Safety Foundation’s (RSF) annual report, at least 6,284 people died, and 7,468 others were injured in road accidents between January and

December 2021, compared to 5,431 people dead and 7,379 injured in road collisions in 2020. The RSF data elaborates that motorbikes were involved in 38.68 percent of all accidents in 2021. At least 2,214 individuals were killed, and 1,309 were injured. RSF also published survey data that shows students accounting for 11% of all fatal road accident victims in April 2022. Every day, an average of 18 people are killed in car accidents. Some of the many reasons behind the increasing number of traffic accidents include: Reckless driving, overspeeding, forced overtaking, an ineffective traffic management system, and a lack of public awareness. Our project is inspired to step forward to the solution of this huge traffic problem using image processing and machine learning tecniques.

Specific Objective

The goals of the project are presented below:

1) To automate the traffic signal violation detection system.

2) Make it easy for the traffic police department to monitor the traffic and take action against the

violated vehicle owner in a fast and efficient way.

3)Detecting and tracking the vehicle and their

activities accurately is the main priority of the system.

Contribution

1) Detecting the signal violated traffic by changing color of bounding box and ringing an alarming sound.

2) Selecting the region of signal violation dynamically on the video.

3) Properly using the YOLOv3 model to detect almost all types of vehicles and pedestrians for maintaining safety.

4) Designing a user-friendly graphical interface to use the system.

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Conclusion

In this section, the previously discussed topics are summed as the introductory part of this hole project including the background, problem statement, motivation for this project, our contribution etc.

In upcoming sections, the Literature Review (i.e. related publications or articles that are studied during the project development), methodology, conclusion and recomendation etc will be discussed.

Literature Review

Introduction

To make the project in complete shape, several publications and articles were studied which will be later presented in the References section. To to detect almost all types of vehicles we used here YOLOv3 model in our own style to detect the signal violated vehicle as per our need.

We also used Tkinter, the standard GUI library for Python, to select the region of interest, to select the input video for system and to observe the output video also.

About YOLOv3:

You only look once (YOLO) is a state-of-the-art, real-time object detection system. On a Pascal Titan X it processes images at 30 FPS and has a mAP of 57.9% on COCO test-dev.

YOLOv3 is extremely fast and accurate. In mAP measured at .5 IOU YOLOv3 is on par with Focal Loss but about 4x faster. Moreover, you can easily tradeoff between speed and accuracy simply by changing the size of the model, no retraining required!

How It Works

Prior detection systems repurpose classifiers or localizers to perform detection. They apply the model to an image at multiple locations and scales. High scoring regions of the image are considered detections.

We use a totally different approach. We apply a single neural network to the full image. This network divides the image into regions and predicts bounding boxes and probabilities for each region. These bounding boxes are weighted by the predicted probabilities.

Our model has several advantages over classifier-based systems. It looks at the whole image at test time so its predictions are informed by global context in the image. It also makes predictions with a single network evaluation unlike systems like R-CNN which require thousands for a single image. This makes it extremely fast, more than 1000x faster than R-CNN and 100x faster than Fast R-CNN. See our paper for more details on the full system.

What's New in Version 3?

YOLOv3 uses a few tricks to improve training and increase performance, including: multi-scale predictions, a better backbone classifier, and more.

Tkinter Library:

Tkinter is the standard GUI library for Python. Python when combined with Tkinter provides a fast and easy way to create GUI applications. Tkinter provides a powerful object-oriented interface to the Tk GUI toolkit.

Creating a GUI application using Tkinter is an easy task. All you need to do is perform the following steps −

Import the Tkinter module.

Create the GUI application main window.

Add one or more of the above-mentioned widgets to the GUI application.

Enter the main event loop to take action against each event triggered by the user.

Conclusion

In this section, we discussed about the articles that helped us during the project development.In the further sections, we will discuss the working methodology, system architecture of this project, the conclusion of this project and the recomendation of future work on this project.

4 System Overview

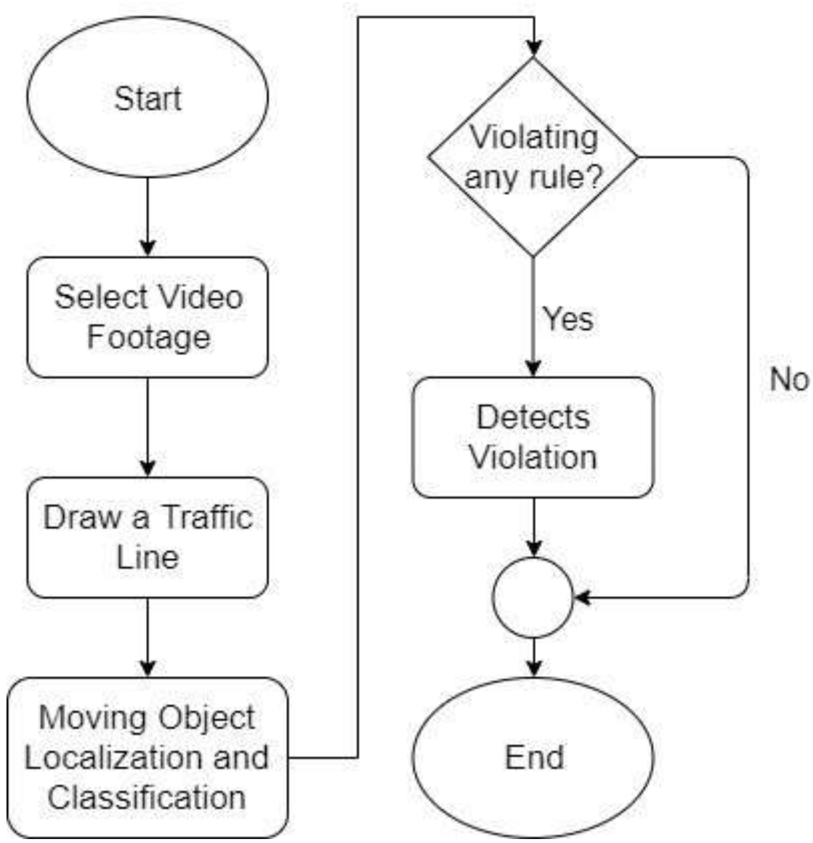

Figure-1: Flow diagram of traffic signal violation detection system.

The System consists of two main components -

- Vehicle detection model
- A graphical user interface (GUI)

First the video footage from the road side is sent to the system. Vehicles are detected from the footage. Tracking the activity of vehicles, system determines if there is any violation or not. Figure 1 shows how the system works.

The Graphical User Interface (GUI) makes the system interactive for the user to use. User can monitor the traffic footage and get the alert of violation with the detected bounding box of vehicle. User can take further action using the GUI.

5 Methodology

1. Vehicle Classification

From the given video footage, moving objects are detected. An object detection model YOLOv3 is used to classify those moving objects into respective classes. YOLOv3 is the third object detection algorithm in YOLO (You Only Look Once) family. It improved the accuracy with many tricks and is more capable of detecting objects. The classifier model is built with *Darknet-53* architecture. Table-1 shows how the neural network architecture is designed.

Features:

1. Bounding Box Predictions:

YOLOv3 is a single network the loss for objectiveness and classification needs to be calculated separately but from the same network. YOLOv3 predicts the objectiveness score using logistic regression where 1 means complete overlap of bounding box prior over the ground truth object. It will predict only 1 bonding box prior for one ground truth object and any error in this would incur for both classification as well as detection loss. There would also be other bounding box priors which would have objectiveness score more than the threshold but less than the best one. These errors will only incur for the detection loss and not for the classification loss.

2. Class Prediction:

YOLOv3 uses independent logistic classifiers for each class instead of a regular softmax layer. This is done to make the classification multi-label classification. Each box predicts the classes the bounding box may contain using multilabel classification.

3. Predictions across scales:

To support detection a varying scales YOLOv3 predicts boxes at 3 different scales. Then features are extracted from each scale by using a method similar to that of feature pyramid networks. YOLOv3 gains the ability to better predict at varying scales using the above method. The bounding box priors generated using dimension clusters are divided into 3 scales, so that there are 3 bounding box priors per scale and thus total 9 bounding box priors.

4. Feature Extractor:

YOLOv3 uses a new network- **Darknet-53.** Darknet-53 has 53 convolutional layers, its deeper than YOLOv2 and it also has residuals or shortcut connections. Its powerful than Darknet -19 and more efficient than ResNet-101 or ResNet-152.

	Type	Filters	Size	Output
	Convolutional	32	3 × 3	256 × 256
	Convolutional	64	3 × 3 / 2	128 × 128
	Convolutional	32	1 × 1	
1×	Convolutional	64	3 × 3	
	Residual			128 × 128
	Convolutional	128	3 × 3 / 2	64 × 64
	Convolutional	64	1 × 1	
2×	Convolutional	128	3 × 3	
	Residual			64 × 64
	Convolutional	256	3 × 3 / 2	32 × 32
	Convolutional	128	1 × 1	
8×	Convolutional	256	3 × 3	
	Residual			32 × 32
	Convolutional	512	3 × 3 / 2	16 × 16
	Convolutional	256	1 × 1	
8×	Convolutional	512	3 × 3	
	Residual			16 × 16
	Convolutional	1024	3 × 3 / 2	8 × 8
	Convolutional	512	1 × 1	
4×	Convolutional	1024	3 × 3	
	Residual			8 × 8
	Avgpool		Global	
	Connected		1000	
	Softmax			

Table 1. **Darknet-53.**

5.2 Violation Detection

The vehicles are detected using YOLOv3 model. After detecting the vehicles, violation cases are checked. A traffic line is drawn over the road in the preview of the given video footage by the user. The line specifies that the traffic light is red. Violation happens if any vehicle crosses the traffic line in red state.

The detected objects have a green bounding box. If any vehicle passes the traffic light in red state, violation happens. After detecting violation, the bounding box around the vehicle becomes red.

6 Implementation

1. Computer Vision

OpenCV is an open source computer vision and machine learning software library which is used in this project for image processing purpose. Tensorflow is used for implementing the vehicle classifier with darknet-*53*.

2. Graphical User Interface (GUI)

The graphical user interface has all the options needed for the software. The software serves administration and other debugging purposes. We don't need to edit code for any management. For example, if we need to open any video footage, we can do it with the Open item (Figure-2).

Figure-2: Initial user interface view.

Primarily, for the start of the project usage, the administrator needs to open a video footage using ‘Open’ item that can be found under ‘File’ (Figure-2). The administrator can open any video footage from the storage files (Figure-3).

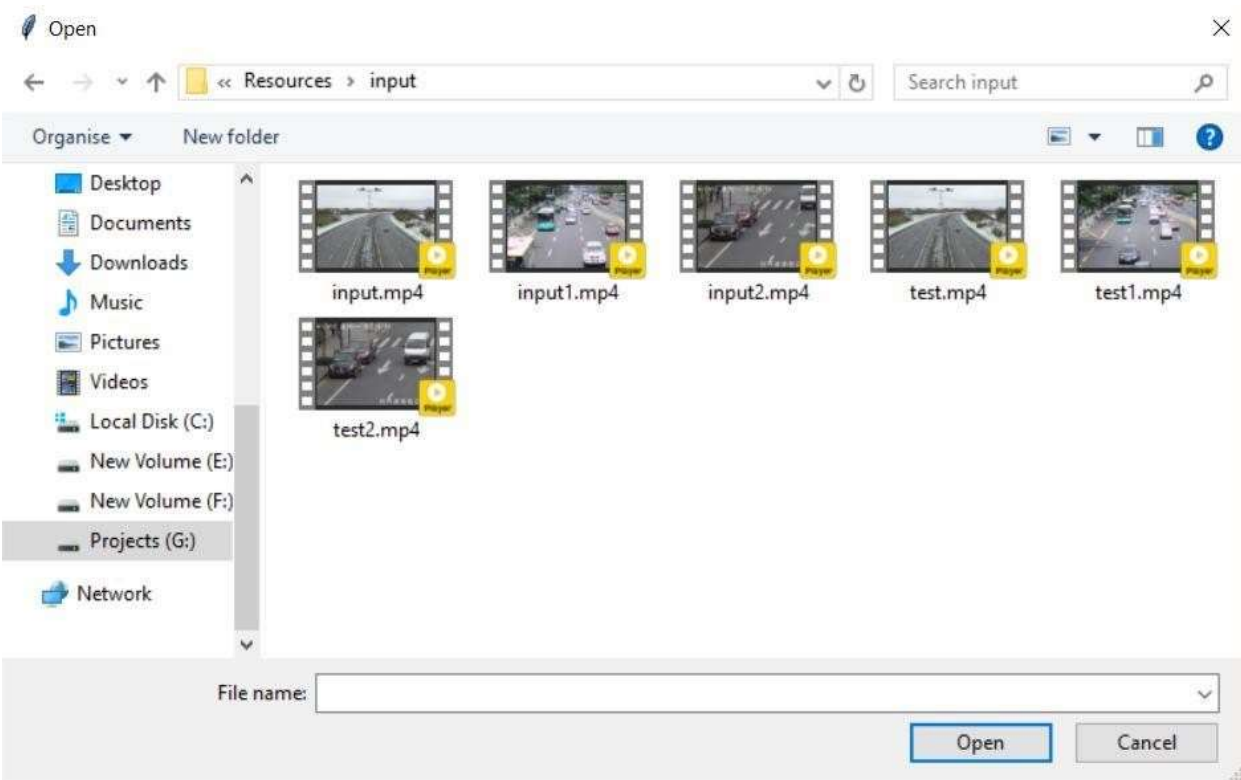

Figure-3: Opening a video footage from storage.

After opening a video footage from storage, the system will get a preview of the footage. The preview contains a frame from the given video footage. The preview is used to identify roads and draw a traffic line over the road. The traffic line drawn by administrator will act as a traffic signal line. To enable the line drawing feature, we need to select ‘Region of interest’ item from the ‘Analyze’ option (Figure-4). After that administrator will need to select two points to draw a line that specifies traffic signal.

Figure-4: Region of Interest (Drawing signal line)

Selecting the region of interest will start violation detection system. The coordinates of the line drawn will be shown on console (Figure-5). The violation detection system will start immediately after the line is drawn. At first the weights will be loaded. Then the system will detect objects and check for violations. The output will be shown frame by frame from the GUI (Figure-6).

```
car: 85.616534948349%
line: (260, 350) (1021, 335)
Box: (724, 188) (789, 239)
```

Figure-5: Line Coordinates (from console)

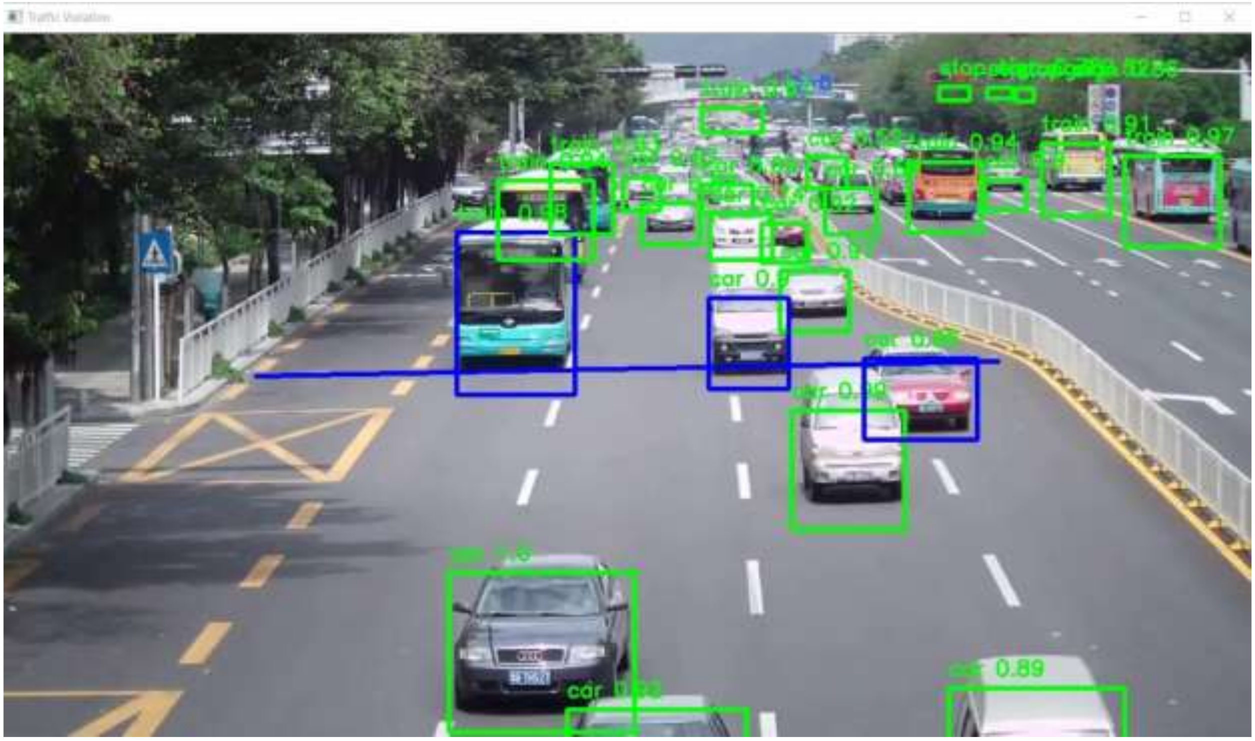

Figure-6: Final Output (on each frame)

The system will show output until the last frame of the footage. In background a ‘output.mp4’ will be generated. The file will be in ‘output’ folder of ‘Resources’. The process will be immediately terminated by clicking ‘q’.

After processing a video footage, the administrator can add another video footage from the initial file manager (Figure-2). If the work is complete the administrator can quit using ‘Exit’ item from File option.

Libraries used for Graphical User Interface:

- Tkinter

The overall flow of the software:

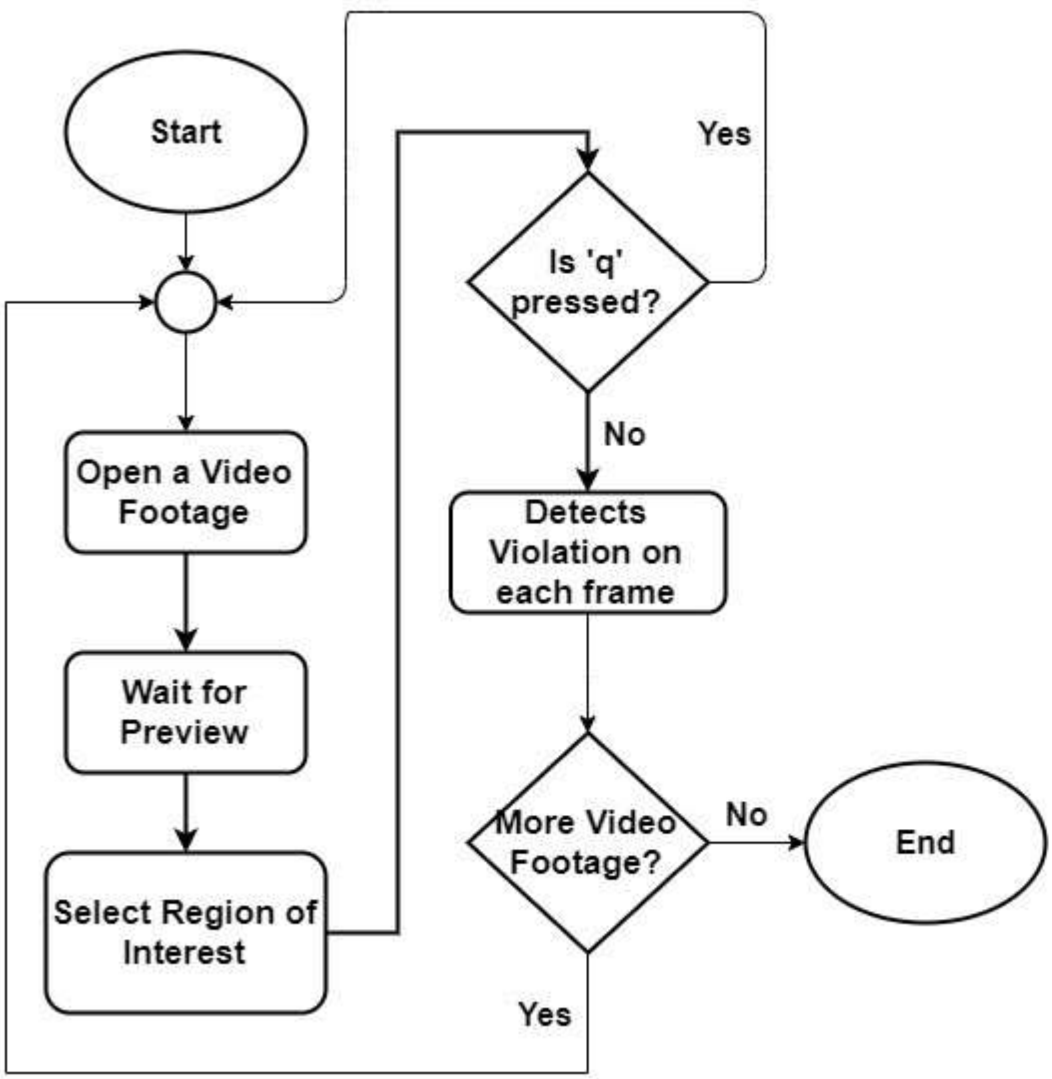

Figure-7: Overall flow of the software.

7 Conclusion & Recommendation

The designed algorithm was effectively able to detect the type of violation specified on this project which are denying traffic signal. The convergence of detection for the traffic violation mentioned is dissimilar, since it has a different threshold condition. The system provides detection for traffic signal violation. Further, the system is able to process one data at a time. Also, the program runtime is somewhat slow, and can be improved by using a computer with high speed processor specifications or GPU.

Future research about the application of the designed algorithm for other advanced image processing techniques. Since, this may improve the program runtime of the system by neglecting other unnecessary steps done in a background difference method. A computer vision algorithm may be done instead to provide more intelligence in the system. Our future plan is to implement the number plate detection with OCR support to make this system more robust.

8 References

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3. Joseph Redmon and Ali Farhadi, "YOLOv3: An Incremental Improvement".