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SMART VIDEO SURVEILLANCE SYSTEM FOR VEHICLE DETECTION AND TRAFFIC FLOW CONTROL

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Abstract

Traffic signal light can be optimized using vehicle flow statistics obtained by Smart Video Surveillance Software (SVSS). This research focuses on efficient traffic control system by detecting and counting the vehicle numbers at various times and locations. At present, one of the biggest problems in the main city in any country is the traffic jam during office hour and office break hour. Sometimes it can be seen that the traffic signal green light is still ON even though there is no vehicle coming. Similarly, it is also observed that long queues of vehicles are waiting even though the road is empty due to traffic signal light selection without proper investigation on vehicle flow. This can be handled by adjusting the vehicle passing time implementing by our developed SVSS. A number of experiment results of vehicle flows are discussed in this research graphically in order to test the feasibility of the developed system. Finally, adoptive background model is proposed in SVSS in order to successfully detect target objects such as motor bike, car, bus, etc.

Keywords: Vehicle detection, Motion detection, Traffic density estimation, Traffic signal control.

1. Introduction

In recent years, video processing techniques have attracted researchers for vehicle detection [1-6]. Neural networks have been widely used in traffic control system [7-9]. Traffic incident detection model using neural networks has been developed using traffic magnetic sensors [7]. Intelligent agent systems have been used in order to control the traffic [8]. Hybrid computational intelligent techniques and fuzzy neural networks have been applied in multi- agents in order to control the traffic signals. They have reduced the average waiting time in the traffic. Traffic

Abbreviations

BS	Background subtraction
ED	Event database
FAR	False acceptance rate
FRR	False rejection rate
SVSS	Smart video surveillance software
TSR	Total success rate
TV	Threshold value
VD	Video database

flow prediction is achieved using time delay based neural networks [9]. In this paper, we will use image processing technique for identification of vehicles and traffic density by processing the traffic videos.

The pre-processing algorithm determines the contour of an object depending on the application. Once the object is detected and located, its boundary can be found by using edge detection and boundary following algorithms [10]. For object detection and recognition in video surveillance, various approaches have been proposed in the past years by many experts on this topic [11, 12].

Viitaniemi and Laaksonen [13] proposed a technique of moving object detection in video analysis. They considered all the test image segments given by a certain segmentation method. The segments have been ranked using the PicSOM framework according to their similarity of target object segments in the training images. They showed the average precision measurement for the test set object detection. Hampapur et al. [14] proposed the different approach, called salient motion detection, assumes that a scene will have many different types of motion, of which some types are of interest from a surveillance perspective.

2. System architecture of SVSS

Figure 1 shows the detail software design and system architecture of Smart Video Surveillance Software (SVSS). It highlights the relationship unit among different hardware and software components.

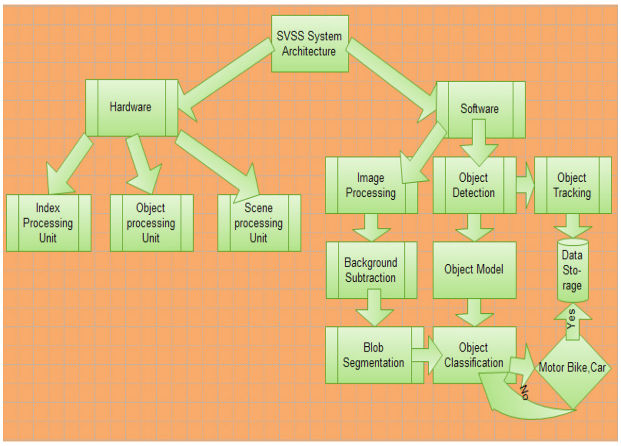


Fig. 1. SVSS Software Architecture.

2.1. Hardware selection

The hardware components required for the SVSS is shown in Table 1.

Table 1. Hardware Components of the SVSS.

	Components	Description	Quantity
1.	Outdoor Box Camera	1/3" Sony Super HAD, 380TVL / 0lx / 3.6 mm / 22IR LEDs / 12VDC	3
2.	Dome Camera	1/3" Sony Super HAD	1
3.	DVR Card	4 Channel 3rd Party DVR Card	1
4.	Cable	Lay coaxial cable	50 ft
5.	DVR	DVR card	1
6.	Main Server	High Speed CPU	1

2.2. Software selection

The minimum software requirements for this project are:

- Windows XP
- Task Manager (Testing Tool Server)
- C # Programming Language

2.3. Camera positioning

The test camera view angles are shown details in Fig. 2. The test parameters are selected based on our software optimization requirements. Selecting appropriate camera parameter is one of most important factors for successfully implementing the developed system.

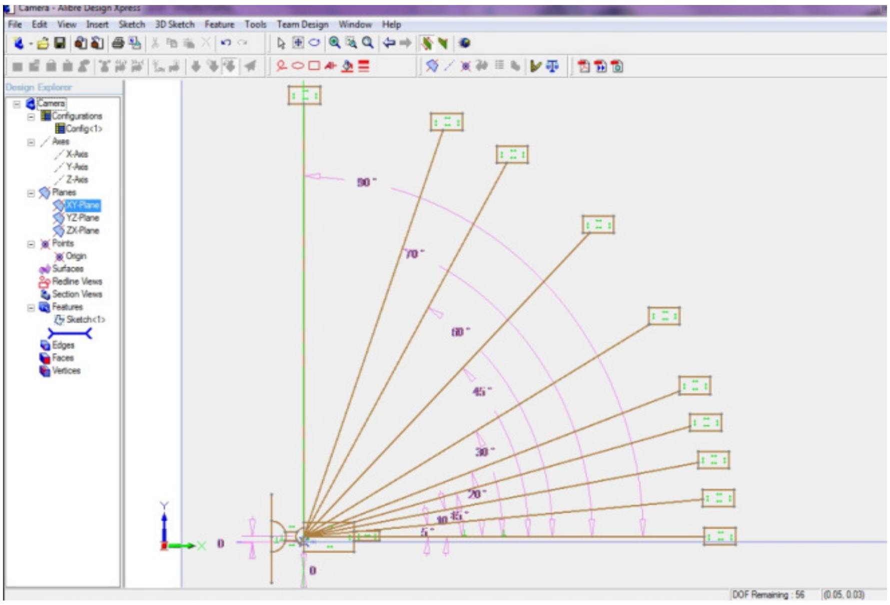


Fig. 2. Camera View Angles are shown in Details from Different Positions.

2.4. SVSS Database

SVSS requires huge database storage in order to run the system smoothly. It is a collection of data for the surveillance system. SVSS classifies databases as a type of content, for example: bibliographic, full-text, numeric, and image. SVSS has two main types of database which are: (a) Event Database, (b) Video Database.

As both of the databases are important for the system, we have discussed more about these database systems and its relationship with the other functional components.

2.5. Event database

Figure 3 elaborates the Event Database (ED) and its attributes of SVSS while showing the inter-relationships with other functional components. ED shows that the Event is linked directly to the attributes and logical data type while describing the functional blocks.

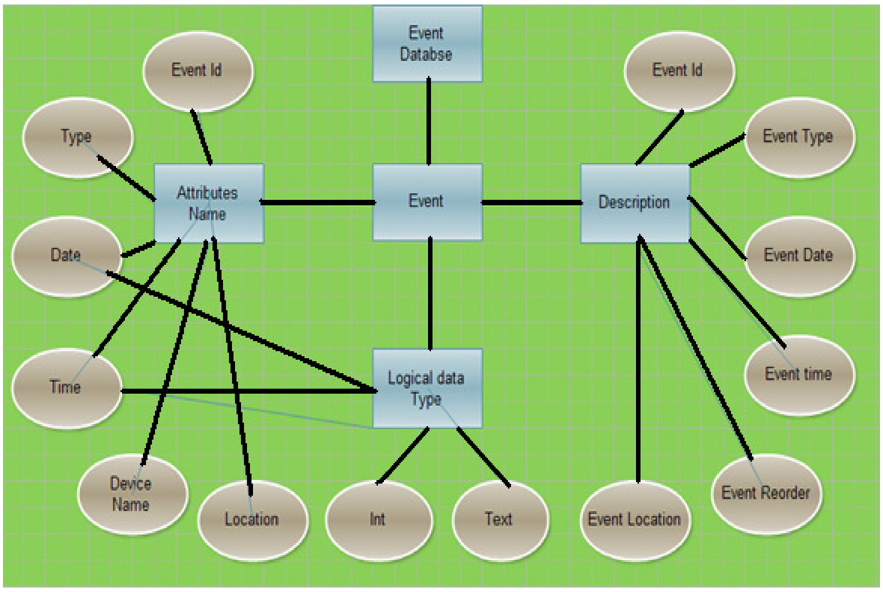


Fig. 3. Description of an Event Database System of SVSS.

2.6. Video database

The Video Database (VD) is shown in Fig. 4. It highlights the video format, video start time and end time, date, video recording location, etc. The VD is stored in the video storage until a specified period selected by the user.

The SVSS video storage normally can store 4 month's continuous videos for one terabyte hard disk consist of 4 cameras. It is also user friendly and user can delete unnecessary video data and store necessary video data according to the user's needs. User has an easy access to the SVSS for these purposes.

2.7. Video database

In this section, moving vehicle detection was carried out applying the existing Background Subtraction (BS) technique as well as our proposed and implemented Threshold Value (TV) adjusting technique. Thus, selected threshold values minimize noise effects. From various experiments carried out, the optimal threshold value is 25 as shown in Fig. 5. It can be observed that the image with Threshold Value (TV) 128 and 255 are darker than the previous image. Finally, image with TV 255 is completely dark due to increasing the TV up to the peak value. In case of camera pixel noise due to illumination changes, it was removed using opening filter. Small white pixels also have been removed in this process to smoothen the image. Finally motion boundary or blob indicator is used to detect the target objects.

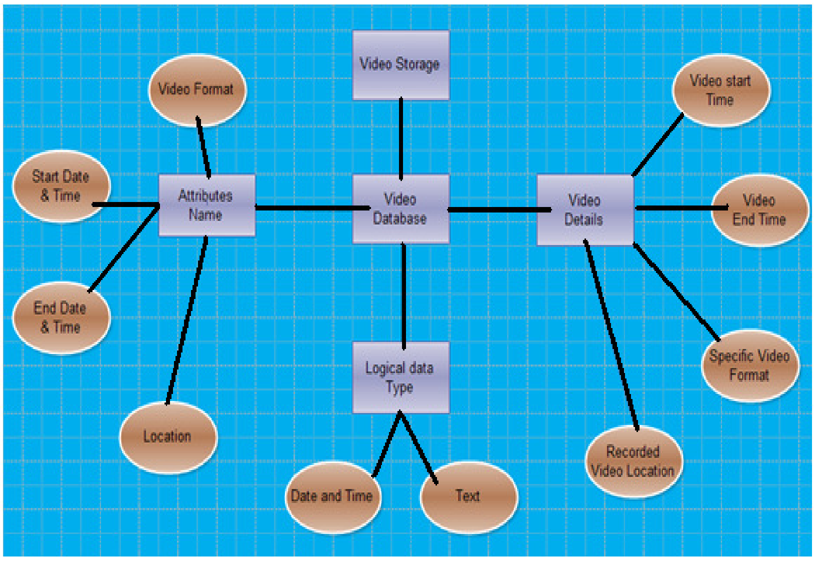


Fig. 4. Video Database of SVSS.

2.8. Motorbike detection using blob segmentation technique

The image from edge filter is merged with the original image, producing image with edge around motion area. Then this edge will be changed to color channel. This is solely to emphasize the region where the motion actually occurs. Subsequently this will produce final image with colored blobs. Figure 6 shows the blob detected motor bike using our SVSS. The blob is marked by green color. Similarly if another object either motor bike or any other vehicle appears at under the camera surveillance it will be detected by another color indicating blob.

Table 2 explains blob ratios for different types of vehicles. Our selected range for the blob ratio algorithm is $0.3<R<1.2$. Blob ratio has been calculated by counting the pixel of Height/Width of the image. We observed above that the blob ratios for different vehicles are between 0.3 and 1.2. On the other hand, in the top right hand corner of Table 2 is shown the blob ratio of a human being. The blob ratio is 2.1. For this reason, human being will not be detected by SVSS. Only the moving object which falls under the selected range will be considered as target object. It is also noticeable that if the ratio falls under the range of $0.9<R<1.2$ then it will be saved as motor bike. Similarly, if the ratio is between 0.3 and 0.6 then the detected object will be saved as car and if greater than 0.6 then it will be saved as bus.

Fig. 5. Impact of Threshold Values (TV), (a) Reference Image, (b) Gray Scale Image, (c) Image with TV=25. (d) Image with TV=128, (e) Image with TV=250 and (f) Image with TV=255.

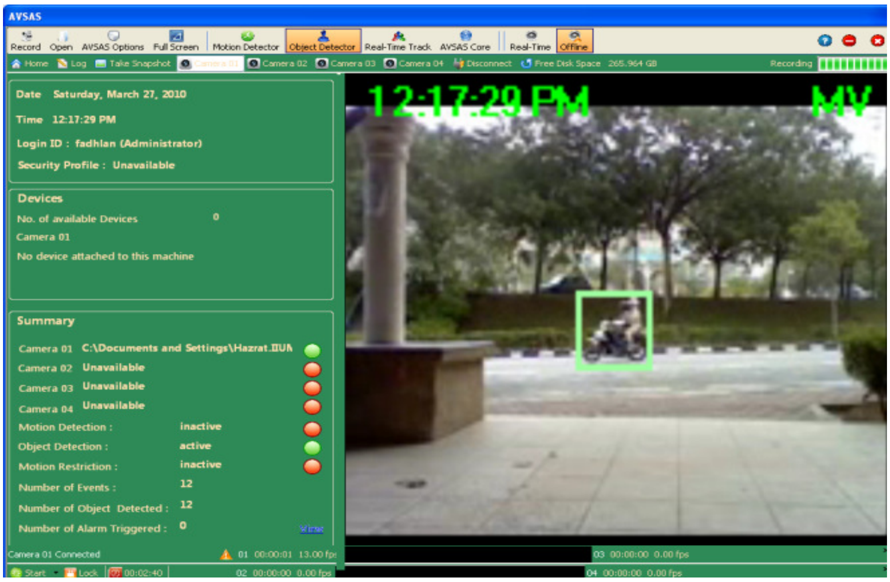
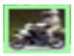
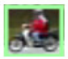


Fig. 6. Motor Bike Detection using Blob Segmentation using SVSS.

Table 2. Blob Analysis for Different Vehicles.

 W=56 H=55 Ratio = 0.98	 W=57 H=67 Ratio = 1.17	 W=60 H=126 Ratio=2.1
 W=46 H=24 Ratio = 0.52	 W=67 H=33 Ratio = 0.49	 W=100 H=36 Ratio=0.36
 W=87 H=37 Ratio=0.43	 W=78 H=42 Ratio=0.54	 W=384 H=269 Ratio=0.70

3. Results and Discussion

3.1. Vehicle detection in cloudy evening

Figure 7 shows the detected vehicle in the evening at about 6.42pm while it was cloudy environment. Table 3 gives detail results of the experiment. The testing videos were recorded at an angle of 10 degree while the position of the camera was 1.25 m from the ground. The targeted distance for the experiment was 2-30 m. We found the rate of false detection or false acceptance is 5.81% which shows the satisfactory result of the test case.

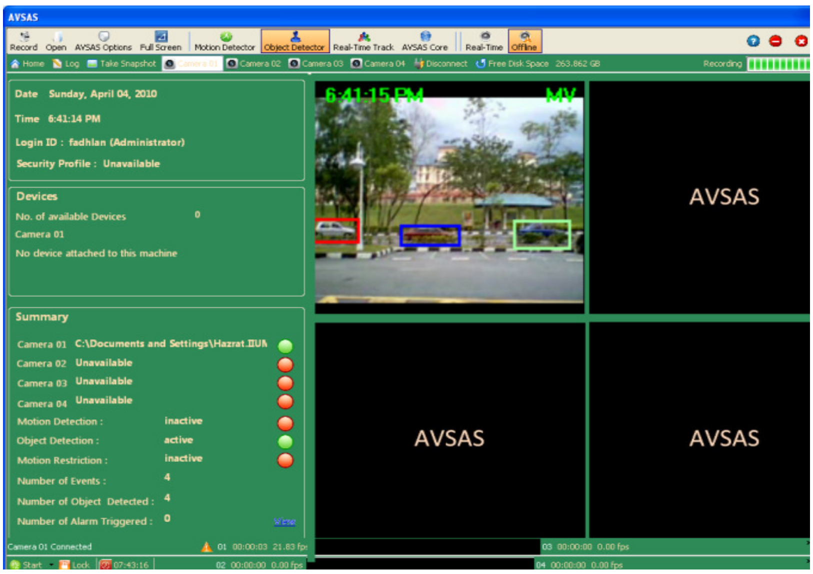


Fig. 7. Detected Multiple Vehicles at 06.41.15pm in a Cloudy Evening.

Table 3. Detection and Tracking Result at an Angle of 10 Degree.

Place	Time	Number of Vehicles (Total=162)	Number of Vehicles detected by SVSS	Camera Angle (degree)	Light Intensity (Lux)	False Detection (%)	Target Distance (m)	Camera Position (Height) (m)
E4	6.42-6.47pm	53	Total=172	10	36	5.81	2-30	1.25
E4	6.48-6.53pm	38		10	36			
E4	6.54-7.00pm	37		10	36			
E4	7.01-7.05pm	34		10	36			

Figure 8 highlights that the numbers of vehicles are decreasing with the increment of time. Using this data traffic signal light can be control efficiently at that place. The significant of the cloudy environment is to justify the accurate vehicle detection rate under this condition in order to implement practically. The special feature used in this case is the moving vehicle's blob segmentation. The image from edge filter is merged with the original image, producing image with edge around motion area. Then this edge will be changed to color channel. This is solely to emphasize the region where the motion actually occurs. Subsequently this produces final image with colored blobs. The blob ratio has been calculated by counting the pixel of Height/Width of the image.

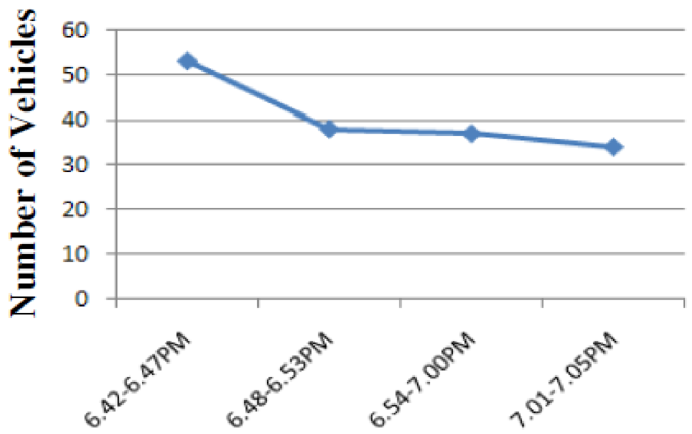


Fig. 8. Vehicle Flow at 06.41.15pm in a Cloudy Evening.

3.2. Vehicle detection in early morning

Figure 9 presents the surveillance test results that have been conducted in the early morning of the day. This experiment was done to check the reliability of accurate detection in the morning environment. Camera was positioning at a height of 3.5 m from the ground and at an angle of 20 degree. The light intensity was 45 lux. The targeted distance was 6-30 m. The rate of false detection was 12.31%. The accuracy is satisfactory even though there were some false detection due to occlusion. Figure 10 and Table 4 below demonstrate that the numbers of vehicles are increasing with the increment of time.

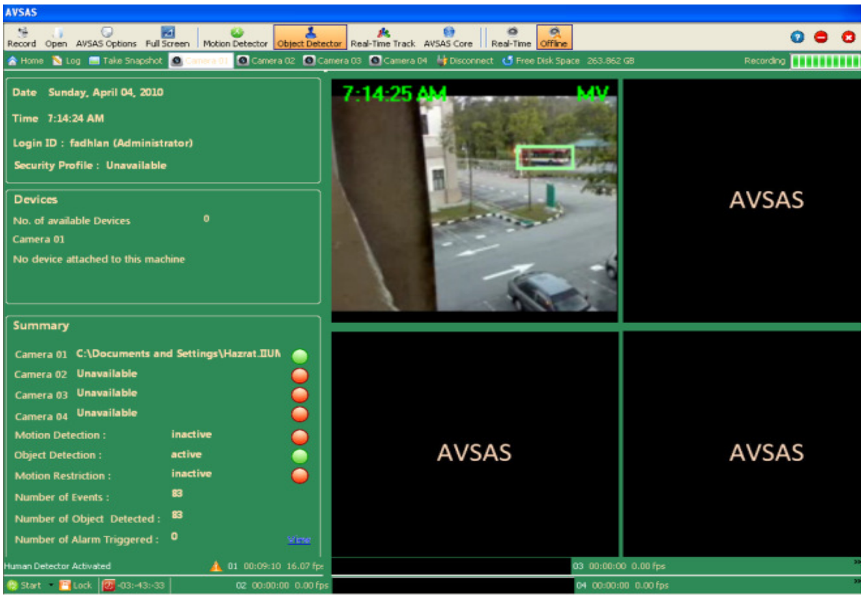


Fig. 9. Detected Bus at 07.14.25am in the Morning.

Table 4. Detection and Tracking Result at an Angle of 20 Degree at Various Times.

Place	Time	Number of Vehicles (Total=162)	Number of Vehicles detected by SVSS	Camera Angle (degree)	Light Intensity (Lux)	False Detection (%)	Target Distance (m)	Camera Position (Height) (m)
E5	7.05-7.15am	38	Total=268	20	45	12.31	6-30	3.5
E5	7.15- 7.25am	48		20	45			
E5	7.25-7.35am	48		20	45			
E5	7.35-7.45am	101		20	45			

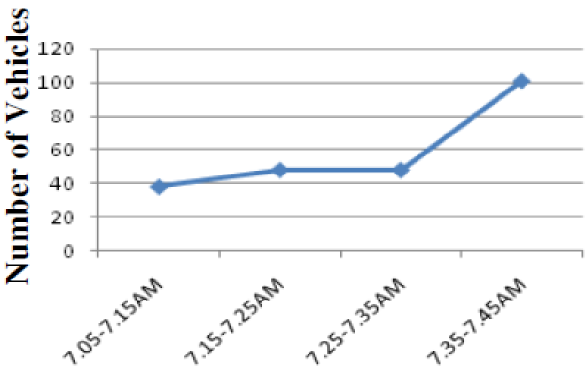


Fig. 10. Flow of Vehicles at Different Times in early Morning.

4. Performance Analysis of SVSS for Adaptive Background

In the developed SVSS adaptive background technique is used in vehicle detection purpose. In this technique we have moved the background frame slightly in the direction of the current frame. We have changed the colors of pixels in the background frame by one level per frame. In this process, the background is changed to the current image, pixels by pixels (1 level per frame). This process ensures that even smallest change with respect to the background in the image is detected successfully. To evaluate the system performance, three well-known measurements are used, False Rejection Rate (FRR), False Acceptance Rate (FAR), and Total Success Rate (TSR). The comparison of this method is illustrated in Table 5 which includes the performance evaluation based on computational efficiency measured from Average CPU Usage.

Table 5. Performance Analysis of Adoptive Background Model.

Motion Detection Methods	Total Success Rate (%)	False Acceptance Rate (%)	False Rejection Rate (%)	Average CPU Usage
Background Subtraction	**92**	**2**	**6**	**9**
Low Precision Background Modeling	**95**	**5**	**0**	**10**
Proposed Technique (Adoptive Background Modeling)	**99.1**	**0.9**	**0**	**11**

The above discussion and results can be summarized as follows. The most accurate result was found at an angle of 0 degree and 45 degree while camera height was 0.5 m and 6 m respectively. The nearest result was at 15 degree angle and 4 m height followed by 5 degree angle and 0.5 m height. On the other hand, majority of the false detections occurred at 70 degree and 60 degree angles and a height of 6 m from the ground. Besides this, there were false detections that occurred at night and in cloudy environment due to occlusion.

5. Traffic Control by Implementing SVSS

From the above results, we can easily find which road needs the efficient traffic system indicating the time period. Vehicle flow is also clearly viewed from the experimental results. Based on the results for the above test areas we can reset the traffic signal timing in order to achieve less waiting period in each junction. Thus, the developed SVSS is capable to optimize the traffic signal light successfully in any application environment.

6. Conclusion and Future Work

The developed Smart Video Surveillance System for the purpose of vehicle detection and traffic flow control was successfully tested in the real environment. Inspiring result was found in the field of security application. Effective performance evaluation is deemed important towards achieving successful Smart Video Surveillance Systems with higher accuracy and less false detection. From the point of practical implementation, several experiments have been conducted in order to verify the performance of the system and the results showed that the developed system is more efficient than the existing traditional surveillance system because it can detect the vehicle almost perfectly with a small rate of false acceptance and thus from the achieved result, traffic flow can be easily controlled.

Traffic flow control by SVSS in machine vision is the main contribution to the existing system. The following future works will enhance the system to solve the sophisticated security problems extensively:

- Night vision camera or infrared camera will help in recording the videos even at night or at dark place. Collision and damage detections are important areas that can benefit from such advance system.
- IP camera should be used to notify any danger or suspect acts to the user in real-time alert system.
- High camera resolution should be selected where very clear images are necessary.
- Wireless camera should use in order to reduce wiring and maintenance cost.

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