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A GENERIC MODEL FOR CAMERA BASED INTELLIGENT ROAD CROWD CONTROL

F. K. Zaman[1], M. H. Ali[2,*] and Z. I. Rizman[3]

[1]Faculty of Electrical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

[2]School of Engineering, Nazarbayev University, Astana, Kazakhstan

[3]Faculty of Electrical Engineering, Universiti Teknologi MARA, 23000 Dungun, Terengganu, Malaysia

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ABSTRACT

Traffic flow control is often a big problem in many big cities in the world, especially during the peak and off-peak hours. Researchers are trying to find the optimal solution to solve this daily problem. Often, the problem is caused by the poor traffic signal light control system. Improper placement of the signal light and timing is the main issue. The problem can be solved by proper time management for the traffic signal through the congested and often over crowded areas. This research proposes a model for intelligent traffic flow control by implementing camera based surveillance and feedback system. A series of cameras are set minimum three signals ahead from the target junction. The complete software system is developed to help integrating the multiple camera on road as feedback to the signal light control systems.

Keywords: surveillance; traffic flow; network; vehicles.

Author Correspondence, e-mail: md.ali@nu.edu.kz

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1. INTRODUCTION

Smart video surveillance is highly demanding in a wide range of applications. Motion detection and object recognition in the area of smart surveillance system is the main element. A software system with its available features is proposed for people and object classification which suits well in solving real-world constraints such as the under the shadows, unclear image for low resolution, occlusion, partial distortions, individual camera viewpoints and groups of crowd. A suitable model of SVSS that meets the requirements of high business demands has also the implication of the software for the security purposes which made the whole system a smart video surveillance is elaborated in [1]. Smart video surveillance systems consider automatic image understanding techniques to retrieve information from the surveillance data as well as it stores the data efficiently. Some other has proposed efficient crowd control system based on the number of vehicles detected at different times and locations. Currently, one of main obstacles in the large cities in many countries is the vehicle crowd control during peak hour. Sometimes, it is noticed that crowd control green signal light is activated despite of the empty road. Likewise, it can be seen that the large queues of vehicles wait due to poor crowd management system. This is due to traffic signal light (TSL) assignment without thorough investigation on crowd flows at the junctions. A few investigation results of crowd flows are explained in [2]. Fig. 1 highlights a traffic junction's scenario if the traffic signal lights are not controlled efficiently.

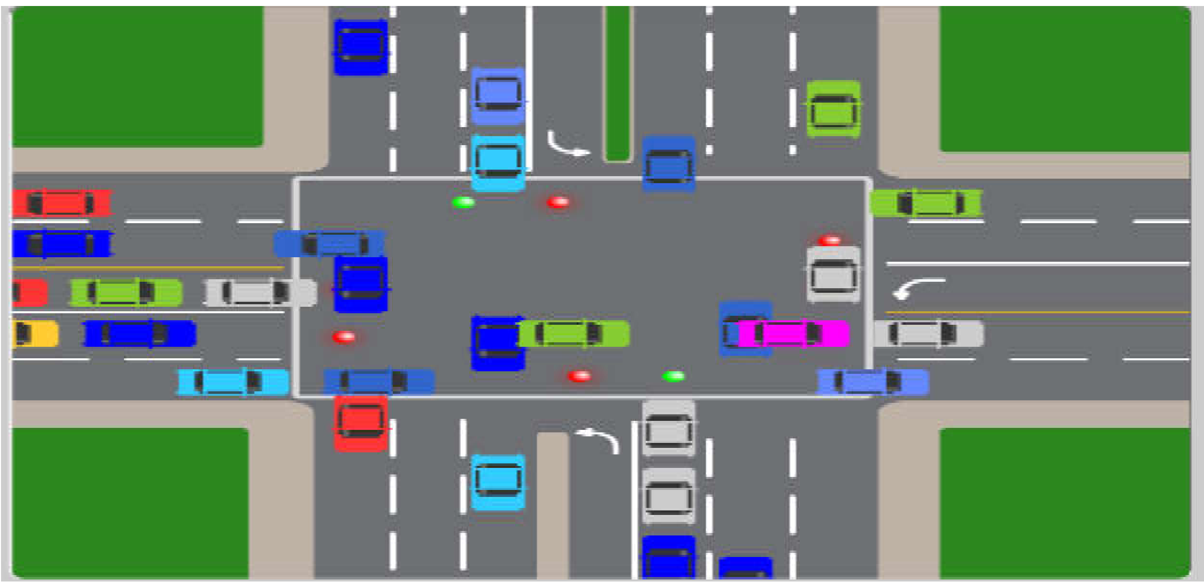

Fig.1. Traffic jam in a junction due to improper signal management

Motion detection and object classification technique is very important in video surveillance system [21]. Optical flow is one of the ways to detect motion. As only a single autonomous measurement is applicable, the optical flow cannot be calculated at that segment. The second constraint is required. The technique says that the apparent speed of the optical flow differs easily around all parts of the image. This method is applied in developing algorithm for movement detection, which is able to execute varieties of movement detection. Also, the developed algorithm can display movement region, count motion level and the total number of objects. Numerous target components such as bus, truck, car as well as human being from the stored video can be perceived by integrating optical flow technique to the algorithm [3].

TSL can be improved applying object crowd data acquired by the SVS system. The research highlights on the efficient traffic management system by distinguishing and counting the vehicle numbers at different times and areas. A few physical test results of crowd flows are highlighted besides proposing adaptive background model in SVSS [4]. Currently, video surveillance has a huge demand in security areas. This paper presents another characterization for the SVSS based on their needs and market demands [5].

An intersection controlled by the traffic signal gives a lot of important information. Starting from the vehicle counts, speeds and occupancies to driver as well as determine passenger characteristics, the applications are tremendous. A simulation and statistical analysis can explain and simplify this apparently complex procedure. A motion describes vehicle approach direction and final maneuver. Similarly, a cycle refers to the series of green and red phases that completes a full utilization of the crossing point. Using data shown in Table 1 and Table 2, a simulation result is highlighted applying proper traffic light control mechanism as in Fig. 2 [6].

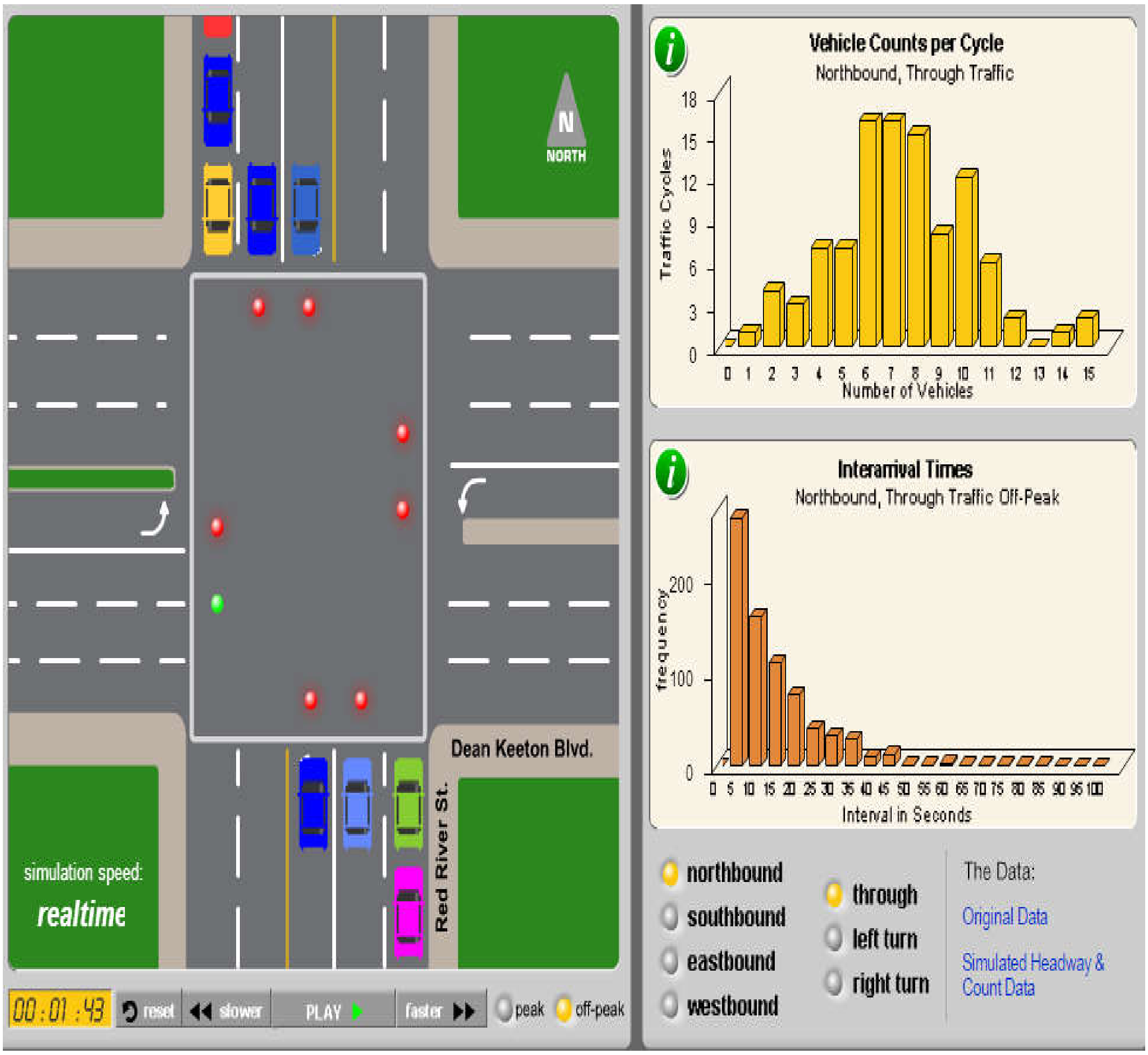

Fig.2. Proper traffic signal management in a junction [6]

Table 1. South-bound through traffic peak simulation data

Average arrival time in seconds	23.95	Average number of vehicles per cycle	5.41

Cycle	# of vehicles	Time between vehicles (secs)							
		1	2	3	4	5	6	7	8
1	8	5.93	1.36	2.33	7.24	39.82	44.27	3.51	12.60
2	6	10.41	38.23	26.14	21.09	6.25	10.27		
3	4	8.03	9.14	3.59	87.71				
4	8	11.22	37.06	3.34	29.53	21.77	1.35	22.22	2.62
5	7	4.02	34.33	22.97	20.08	5.91	2.65	28.49	
6	8	15.89	3.41	51.27	8.28	12.17	20.62	0.34	3.56
7	3	16.12	25.89	61.72					
8	8	11.74	6.31	1.13	32.98	19.85	9.81	23.62	19.89
9	1	47.05							
10	8	61.72	15.68	2.60	20.22	1.50	2.42	4.93	13.52
11	5	0.61	22.39	11.44	1.76	60.02			
12	2	47.91	28.55						
13	5	11.84	57.57	7.58	15.93	21.34			
14	3	25.98	65.79	5.57					

Another research shows that the vehicular TSC problem is formulated as a job management problem corresponding to a big number of transports. Based on the forecast, the size of all the jobs are the same and an real-time technique is formulated, considering that the first come first job algorithm, to reduce the waiting time around the crossing point [7]. Adaptive TSC is a demanding technology to avoid road traffic. Reinforcement Learning (RL) has the probability to solve the maximum TC problem for an individual agent. Nevertheless, the final target is to create an integrated TSC for multiple crossing points. Inter-connected traffic control system can be effectively obtained utilizing different controllers.

Table 2. North-bound through traffic peak simulation data

Average arrival time in seconds	13.00	Average number of vehicles per cycle	10.18

Cycle	# of vehicles	Time between vehicles (secs)							
		1	2	3	4	5	6	7	8
1	10	19.45	2.46	11.79	12.31	10.09	1.92	8.98	6.68
2	9	11.06	21.08	13.14	0.27	8.50	9.10	8.42	29.38
3	8	12.10	4.80	1.28	16.33	9.73	2.06	5.08	20.91
4	10	21.62	3.51	21.80	1.87	16.18	25.44	7.69	0.81
5	10	23.98	7.01	4.10	8.86	12.15	6.57	21.34	24.89
6	12	7.88	7.35	46.55	2.39	5.48	10.00	9.48	1.70
7	6	24.43	16.86	18.57	7.07	38.55	7.29		
8	5	19.27	74.19	2.20	23.05	3.52			
9	5	10.39	25.86	8.00	23.32	10.78			
10	10	7.66	3.72	12.75	7.24	5.99	19.37	21.35	30.70
11	10	27.18	26.60	13.67	9.93	5.07	6.72	4.65	0.07
12	9	20.54	4.85	39.29	19.66	12.16	2.43	5.57	2.72
13	9	7.67	1.09	6.57	23.47	13.19	6.90	4.70	29.88
14	7	11.58	4.66	18.65	19.64	11.30	13.47	47.87	

Multi-Agent Reinforcement Learning (MARL) can be used to separate multiple agents in a dynamic surrounding and situation. The shortcomings of the fixed surveillance system are discussed in this research [8]. In another work, a model of a self-learning TSC technique relates to fuzzy logic and genetic algorithm is discussed. The experiment was carried out based on simulation. After simulating the results were compared with the existing one. The result of simulation shows that the proposed algorithm has more advantage than the conventional method [9]. The pioneer multi agent system is created applying integrated numerical smart method. Every agent generates a multistage real time training method to enhance and accepts its cognition and right procedures [10]. An advance adaptive rural TSC system is discussed in [11].

Another paper explains the TSC system software development method developed at TRL, in which traffic management is combined to create, test and compare the performance of the TSC system software. In addition, TSS and the interface between TSC and TSC devices are explained [12]. An investigation on the vision based surveillance is discussed here [13]. The key methodologies are object segmentation, recognize and tracking to have proper information about the real time surveillance in rural roads. Similar research was carried out to build a smart system to control and monitor traffic light system in a Nigerian city. An integrated technique achieved by the junction of the Structured Systems Analysis and Design Methodology (SSADM) and the Fuzzy-Logic based design technique was used to create and implement the system [14]. An intelligent auto TSC system is discussed in [15]. Traffic jam is one of the main problems to be solved. Generally traffic lights intersect at the junctions of the road and are controlled by the traffic signals. Traffic signals require a good coordination and control to ensure the proper and fast flow of the road traffic. The findings of an area verification [22] algorithm show that the static actuated-coordinated system timings are better than the dynamic one. The impact of this mechanism on reducing fuel burnt and minimizing air pollution is elaborated in detail. The positive influence of the adaptive TSC on fuel burnt and environment pollution are also elaborated in [16].

A simplified and effective technique to count the vehicle numbers at various junctions to efficiently control the crowd by managing traffic signal lights to eliminate traffic jam is proposed in [17]. The developed model works by the detecting the target objects in stored videos acquired by the cameras installed on roads and by counting the number of bus, truck and car simultaneously. Moving background elimination method and morphological operations were integrated to detect vehicle as well as to acquire excellent detection efficiency.

Fig.3. Manual traffic control (1)

Fig.4. Manual traffic control (2)

Fig. 3 and 4 show manual traffic management during peak hours in Astana, Kazakhstan. Improper signal management often causes traffic jam during peak hours. Normally, busy traffic junctions are manually managed during rush hours. A research has been accomplished based on traffic signal ON/OFF conditions. This signal alternation sequences based on colors are shown in Fig. 5. The proposed sequences which are illustrated in Fig. 5 can be explained as follows:

1. The system simulates a traffic light (in one direction only). A "Traffic Light Manager (TLM)," can send request either to activate (turned on) the light that will change the color or to deactivate (turned off).
2. When user activates the light, the system will try to turn it on. If the light is still deactivated when this attempt is made, then the light will be activated. However, if the light is activated, this will deactivate.
3. Likewise, a request to turn off the light will cause the light to deactivate if it is currently activated, and to turn it on if it is currently deactivated.
4. In either of these cases, the system will return a short "status message" to the TLM, informing the status of the traffic light acquired from the attempt to turn on or to turn off the light.
5. The user can also send request to change the light color. On such case, this should cause the light to change from green to red, from red to green or from red to yellow. In case the light is deactivated, then a trial to "change its color" will have no impact.
6. The system will report the selection of new color to the TLM after a trial to change its color.
7. When the system is turned on, the light will be turned off. Whenever the light is turned on, the initial display color will be red [18].

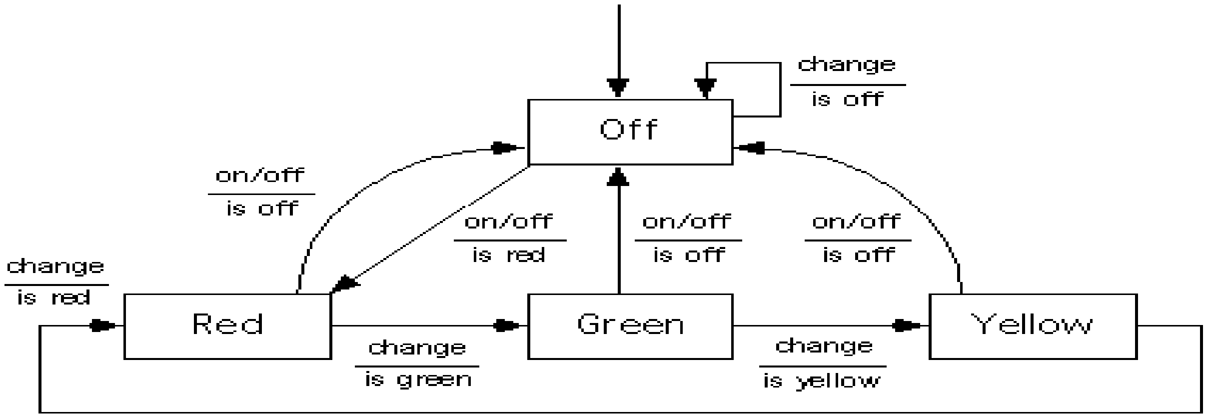

Fig.5. State transition diagram for traffic signal light control [18]

2. METHODOLOGY

2.1. System Components

A fundamental video surveillance consists of a camera, object detection algorithm, image saving hard disk, shadow removal technique [19], background elimination in, object classification method, blob analysis and integrated algorithm. An image storage device is used in order to store the image during the recording by capturing the segmented snap of an object. Finally, it stored the moving object's video during the surveillance hour. The surveillance system designed here will be combined together into the traditional monitoring system as an improvement to enhance the system better than the existing security system, in order to execute various security related tasks which will simplify the user's complexities. The proposed traffic management system includes the aforementioned components as highlighted in Fig. 6.

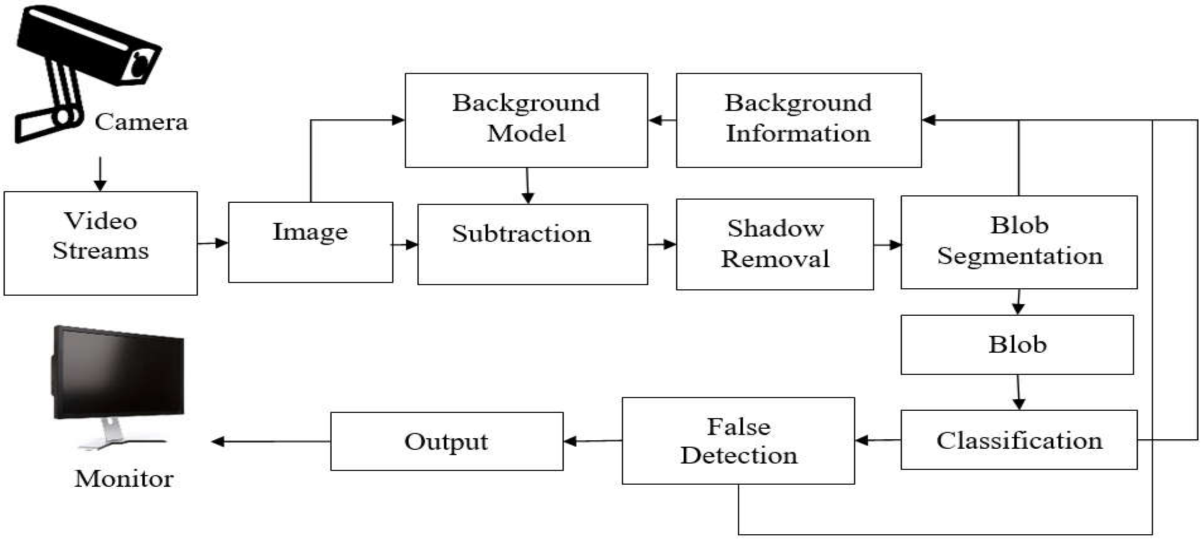

Fig.6. Proposed vehicle detection and tracking system's block diagram

2.2. Junction Control Algorithm

Fig. 7 shows the flow chart of the lane management systems to avoid traffic jam.

2.2.1. Junction 1: East

Lane 1: If the number of vehicle exceeds in lane1, the information is sent to the server

Lane 2: If the number of vehicle exceeds in lane2, the information is sent to the server

Lane 3: If the number of vehicle exceeds in lane3, the information is sent to the server

All vehicle information such as number of vehicles per lane is sent to the central server.

2.2.2. Junction 1: West

Lane 1: If the number of vehicle exceeds in lane1, the information is sent to the server

Lane 2: If the number of vehicle exceeds in lane2, the information is sent to the server

Lane 3: If the number of vehicle exceeds in lane3, the information is sent to the server

All vehicle information such as number of vehicles per lane is sent to the central server.

2.2.3. Junction 1: North

Lane 1: If the number of vehicle exceeds in lane1, the information is sent to the server

Lane 2: If the number of vehicle exceeds in lane2, the information is sent to the server

Lane 3: If the number of vehicle exceeds in lane3, the information is sent to the server

All vehicle information such as number of vehicles per lane is sent to the central server.

2.2.4. Junction 1: South

Lane 1: If the number of vehicle exceeds in lane1, the information is sent to the server

Lane 2: If the number of vehicle exceeds in lane2, the information is sent to the server

Lane 3: If the number of vehicle exceeds in lane3, the information is sent to the server

All vehicle information such as number of vehicles per lane is sent to the central server.

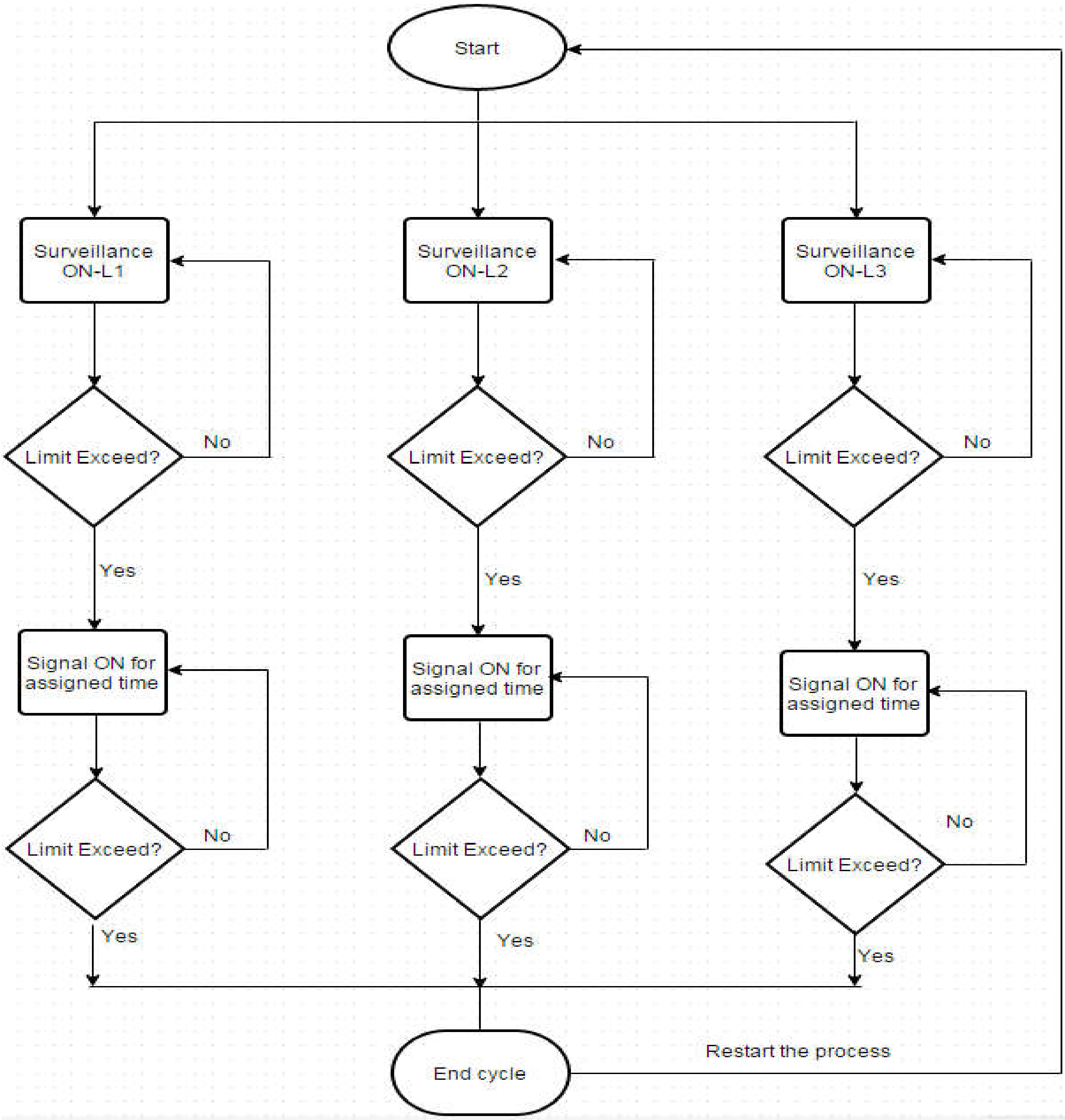

Fig.7. Flow chart for traffic signal light ON/OFF based on lane data

Fig. 8 shows the peak hour situation in certain road applying simulation data. This causes due to lack of traffic signal optimization without having proper vehicle flow investigation at an earlier stage.

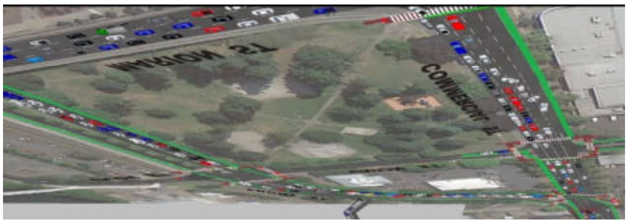

Fig.8. Traffic jam simulation in peak hour

2.3. Traffic Signal Control

Based on the information acquired through camera and central server, the controller will ON the signal of the junction which is filled fast. Then, it will check three other junction and OFF and turn the next filled junction until it finishes all four junction in similar fashion. Again, based on the vehicle flow in all junctions, the ON duration can be adjusted by the controller. This algorithm can be applied for a junction where vehicle moves on eight different directions. Fig. 9 shows the proposed traffic junction management system, while Fig. 10 highlights the camera network system for road surveillance.

3. RESULTS AND DISCUSSION

The developed smart video surveillance storage system is different than the traditional system in the way that it saves the videos in the storage device. Figure 11 shows the surveillance system's storage device. This device does not require external hard disk to save the videos. If a computer monitor is used, then it will save the videos in CPU memory itself. It saves the image first then the images are converted to video by compressing the original size. JPEG player has been implemented to play the videos in this SVSS.

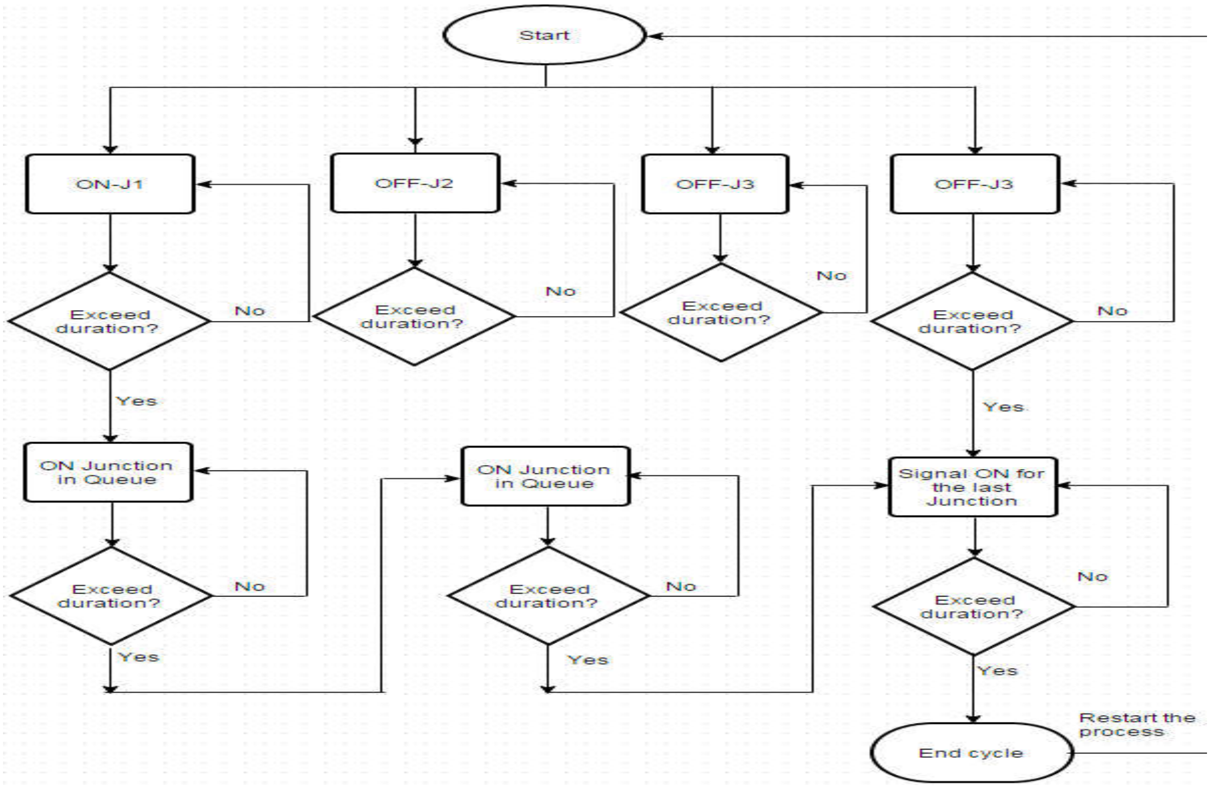

Fig.9. Flow chart for traffic signal light ON/OFF based on junction data

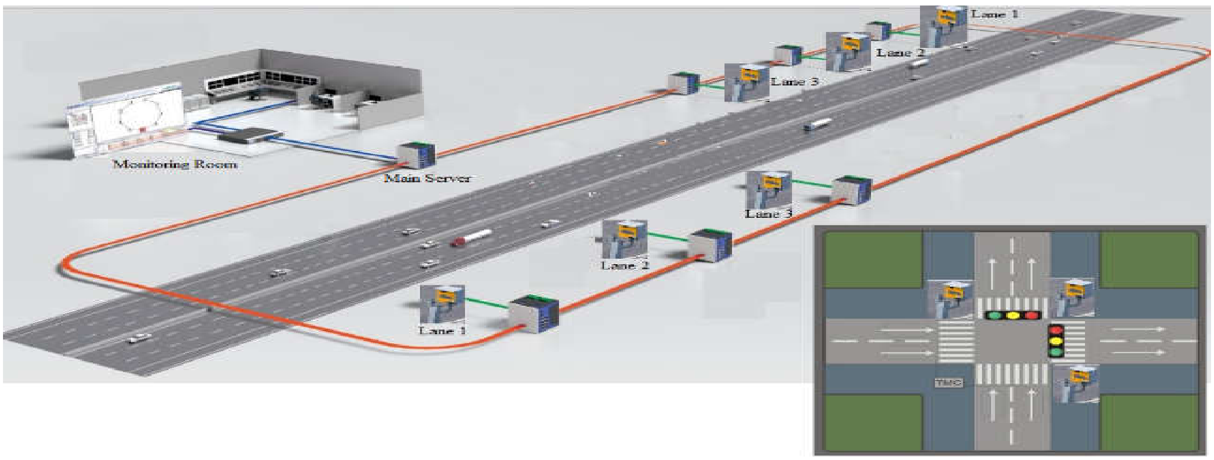

Fig.10. Camera based proposed road surveillance system

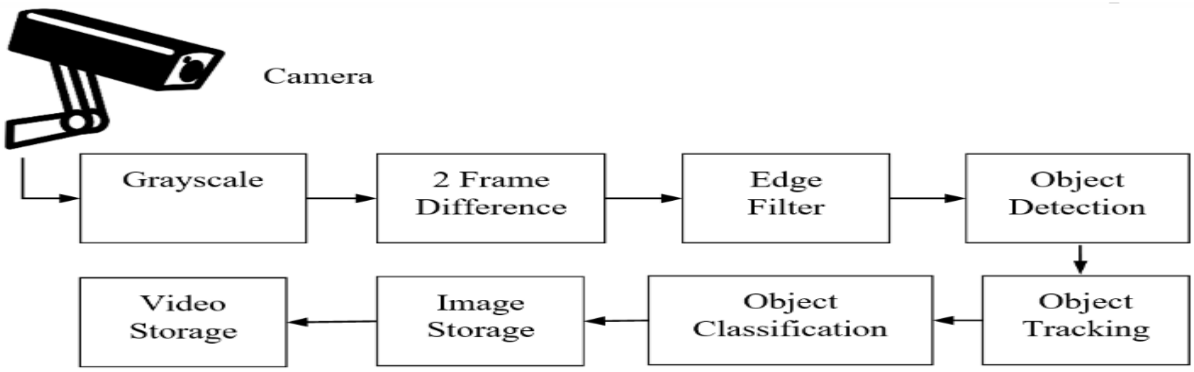

Fig.11. SVSS storage system

Fig. 12 and 13 show the real time data processing sequences through camera and network systems. First camera will be placed about 1 KM far from the target junction. Second camera will be placed 500 M far from the target junction and third camera designed to place 200 M far from the junction. First camera will update the recorded data in every 3 seconds to the server. Normal arriving time to second camera from the first one is 30 seconds. After 15 seconds the second camera updates its recorded data in the server. The arriving time between camera two and three is 18 seconds. The third camera updates its surveillance data after every 9 seconds. Based on the 3 cameras, the server will determine duration for ON and OFF states.

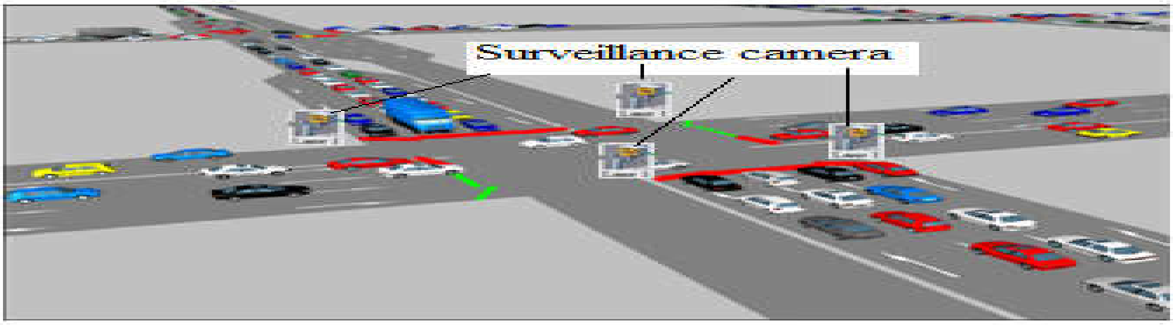

Fig.12. Camera based proposed road surveillance system

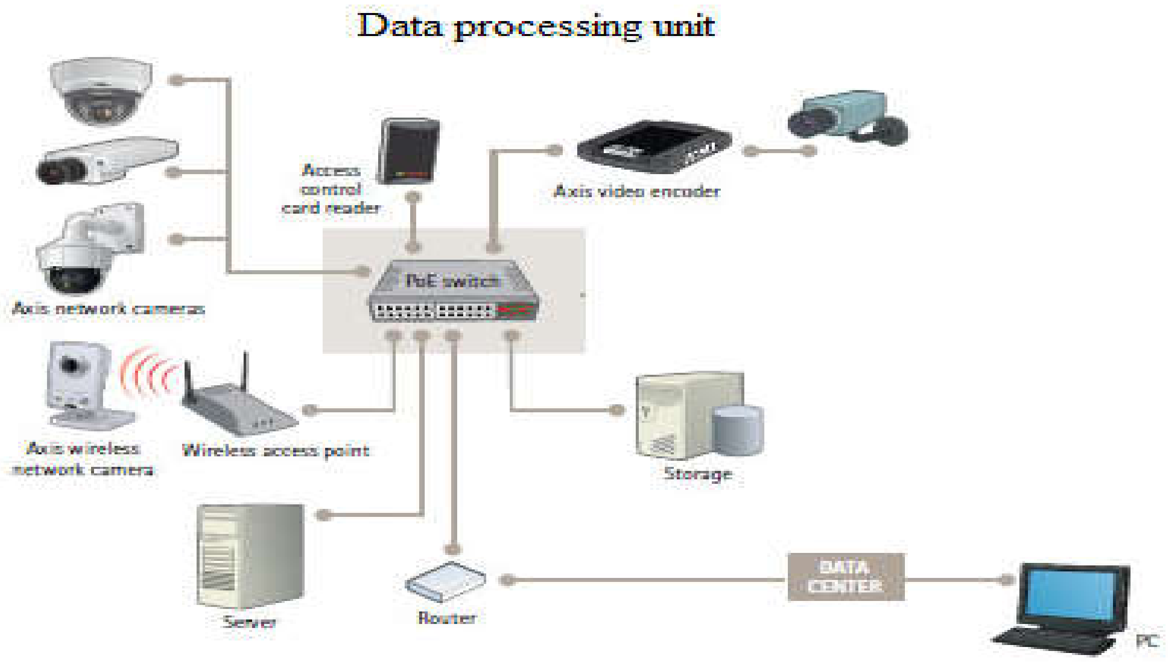

Fig.13. Camera based proposed road surveillance system

Fig. 14 and 15 explain the electrical configuration for the vehicle flow management systems. The number of maximum vehicle count will be around 50 to 60 vehicles. Based on the counted number of vehicles from the third camera from all four directions, the traffic signal light will be controlled between ON and OFF.

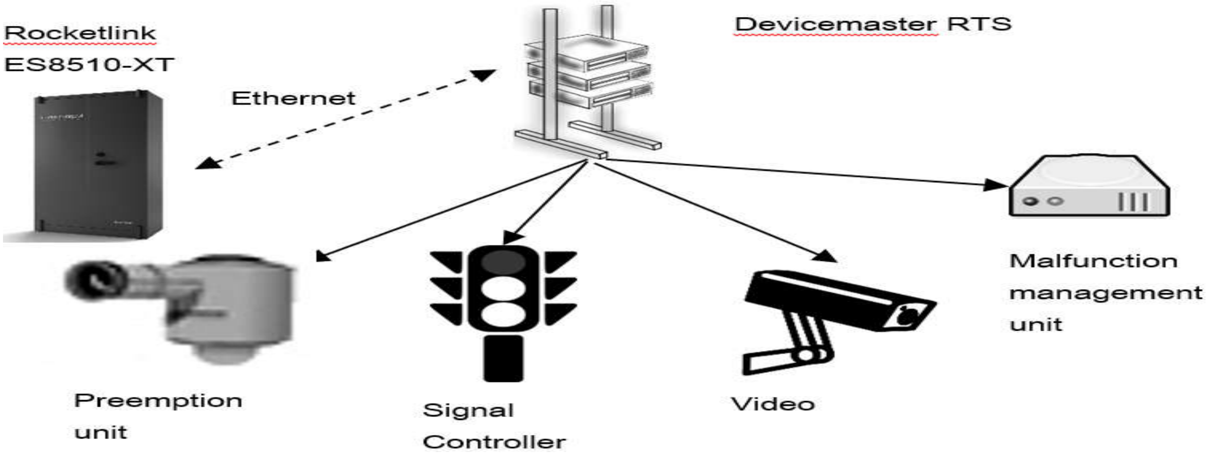

Fig.14. Proposed camera-based road surveillance system

Fig.15. Camera based proposed road surveillance system

The following data are applicable for the junctions, where each direction needs to be controlled separately. As in Fig. 12, vehicle flow can be control in the following way shown in Tables 3-6.

Table 3. Three cameras are set for one lane

Camera	D.1 (Vehicle)	D.2 (Vehicle)	D.3 (Vehicle)	D.4 (Vehicle)
# 1(L1-3)	50-60	50-60	50-60	50-60
# 2(L1-3)	25-49	30-49	30-49	30-49
# 3(L1-3)	1-24	1-24	1-24	1-24

Table 4. Signal light ON/OFF sequences

Parameters	Green ON	Yellow ON	Red ON
D1(L1-3)	40-60	20-39	1-19
D1(L1-3)	40-60	20-39	1-19
D1(L1-3)	40-60	20-39	1-19
D1(L1-3)	40-60	20-39	1-19

Table 5. Signal light duration

Parameters	Green 30 Sec	Yellow 30 Sec	Red 30 Sec
ON	40-60	20-39	1-19
ON	40-60	20-39	1-19
ON	40-60	20-39	1-19

Table 6. Signal light ON/OFF in all directions

Colors	D.1 (Vehicle)	D.2 (Vehicle)	D.3 (Vehicle)	D.4 (Vehicle)
Green	ON	OFF	OFF	OFF
Yellow	OFF	OFF	OFF	OFF
Red	OFF	ON	ON	ON
Green	OFF	ON	OFF	OFF
Yellow	OFF	OFF	OFF	OFF
Red	ON	OFF	ON	ON
Green	OFF	OFF	ON	OFF
Yellow	OFF	OFF	OFF	OFF
Red	ON	ON	OFF	ON
Green	OFF	OFF	OFF	ON
Yellow	OFF	OFF	OFF	OFF
Red	ON	ON	ON	OFF

The following data in Table 7 is applicable for the junctions where two opposite direction's vehicle flow can be controlled together. Repetition depends on the number of counted vehicles from both directions such as north-south and east-west. Signal ON/OFF follows the programmed and assigned initial sequences by the system.

Table 7. Signal light ON/OFF in opposite direction

Colors	Dir.1 (North-South)	Dir.2 (East-West)
Green	ON	OFF
Yellow	ON	ON
Red	ON	ON
Green	OFF	ON
Yellow	ON	ON
Red	ON	ON

3.1. Wireless Real-Time Data Processing

3.1.1. Blob Segmentation and Vehicle Classification

The edge filter image is combined with the initial one, forming image with the corner surrounding moving areas. Next, the corner is transferred to color channel. This is only to highlight the area where the real movement detected. As a result, this creates latest image with the colored segmentations. Fig. 16 highlights the detection and tracking of several cars using SVSS. Tables 8 and 9 explain the blob ratios for a number of different vehicles. This method has been implemented earlier in [20], specifically for human detection. The applied range for the blob segmentation algorithm in the proposed system is in between 0.3 and 1.9. Blob ratio is chosen by considering the pixel value of H/W of the image. A suitable blob proportion for a man/woman is generally more than 1.9. Due to this, people are neglected by the proposed algorithm. Only, the dynamic vehicles that fall within the defined area is regarded as the final object. In addition, it is found that if the ratio is in between 0.9 and 1.2. Then, the detected object is stored as a motorcycle. Likewise, when the blob ratio is in between 0.3 and 0.9 as well as 1.2 and 1.9, the captured object is stored as a car, a mini truck or bus depending on angle of the surveillance cameras.

Fig.16 Camera based vehicle surveillance system

Table 8. Blob ratio for different object

Vehicle Types	Blob Ratio	Camera Positions (Angle)
Motorbike	0.98 to 1.17	0
Car, Van	0.36 to 0.52, 0.56, 0.74	0-20 (downwards), 15 (downwards), 60 (downwards)
Mini Truck	0.54	0
Big Bus	> 0.60	3 (downwards)
Human	> 1.80	2 (upwards), 15 (downwards), 30 (downwards)

Table 9. Actual result of blob analysis for different objects

Types of Vehicle	Height (in Pixels)	Width (in pixels)	Camera Angles (Degree)	Ratio
Motorbike	67	56	0	1.19
Car	14	25	15 (downwards)	0.56
Car	24	46	20 (downwards)	0.52
Car	33	67	0	0.49
Car	61	42	60 (downwards)	1.45
Car	36	100	0	0.36
Motorbike	72	68	15 (downwards)	1.06
Motorbike	49	43	0	1.14

3.1.2. Event Based Video Search System

Video analysis is linked to advanced search and it handles the playback of the video containing the event searched in SVSS. Any video opened in this mode will list all the events contained in the video as indexed by the system beforehand. User can click any event listed to go directly to the video at the time it happens. The video controls of this mode are much less the same with Playback Mode. Similarly, tracking analysis enables user to view previously recorded tracking data of moving objects that appears under the surveillance area. Few key points are given below about the Event Based Video Data:

1. Event: It is considered as time interval.
2. Start Time: At this time, the event begins.
3. Event ID: A number to identify a specific event.
4. Video ID: By this ID, an object can be retrieved.
5. Date/Time: By this option, the date of an event and the exact time for that event helps to find the target object in the stored database.

3.1.3. Object Search in the Proposed System Using Recorded Image

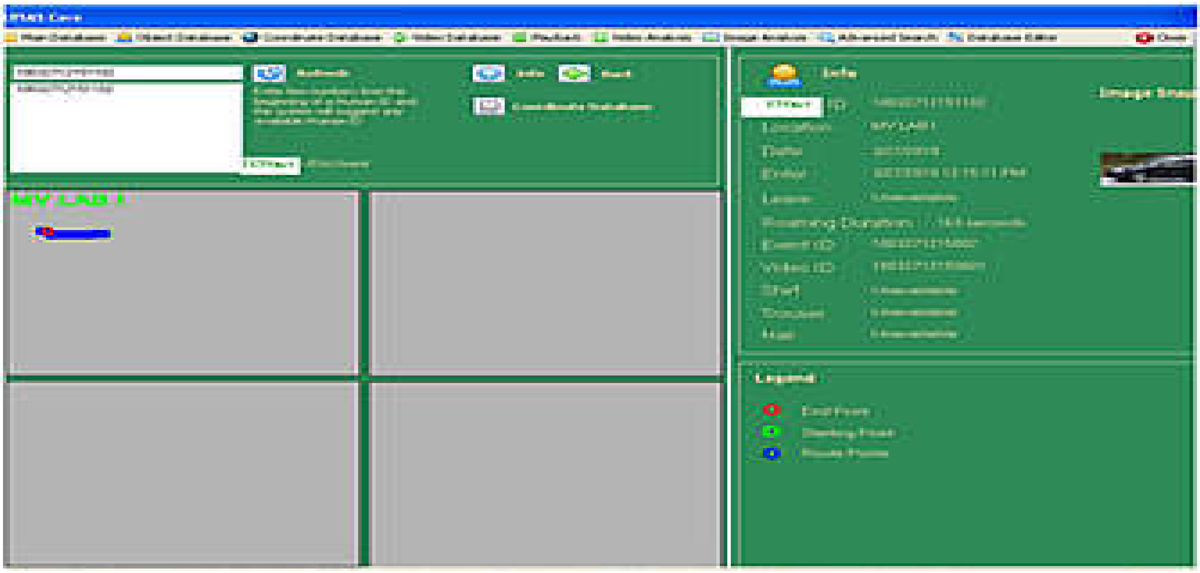

Fig.17. Object search and image display while showing tracking path

In Fig. 17, it can be seen that if any moving object is found under the secured area where the cameras are placed. Instantly, it stores the object by denoting an identical ID number to that moving object. It also shows the tracking paths by indicating different colors. In this tracking system, green color refers to the starting point while the blue and the red colors indicate the route and the end point, respectively. From the path shown below, the motion of moving object can be tracked successfully. The right hand side of the window gives necessary information of the object which was found by the search engine.

3.2. Performance Evaluation of the System

The system's performance can be compared with the existing system as shown in Table 10.

Table 10. Performance evaluation of the proposed system

Parameters	Existing Systems	Proposed System
Image	Normally is not able	Record and save
Video	Normally is not able	Record and save
Event	Do not have this feature	Based on various event data are saved
Date and Time	May exists	Can record
Multi-camera network	Do not have	This system is based on multi-camera
Real time surveillance	Lack of real time surveillance features	Able to performance real time surveillance
Junction's flow control	Real time vehicle flow control is unable	Able to perform real time traffic flow control

4. CONCLUSION

The proposed model is suitable to apply in the cities where traffic jam is often a critical problem. Traffic jam takes a lot of times from our everyday life. Proper implementation of network type of surveillance and traffic flow control is crucial to solve this problem in many big cities in the world. Developed software system has many important features to be applied for surveillance management purpose. The software system helps to monitor the real time and offline traffic flow with its detail information such as location, time and number of each type of vehicles, tracking path, event, image and video IDs. Wi-Fi network should be strong enough to send the data over the network server for immediate action.

5. ACKNOWLEDGEMENTS

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