SMART CONTROL OF TRAFFIC LIGHT USING DEEP LEARNING

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Abstract
Traffic congestion is becoming one of the critical issues with increasing population and automobiles in cities. Traffic jams not only cause extra delay and stress for the drivers, but also increase fuel consumption and air pollution. Although it seems to pervade everywhere, megacities are the ones most affected by it. And its ever-increasing nature makes it necessary to calculate the road traffic density in real-time for better signal control and effective traffic management. The traffic controller is one of the critical factors affecting traffic flow. Therefore, the need for optimizing traffic control to better accommodate this increasing demand arises. This paper is utilizing traffic cameras and YOLO object detection algorithms to estimate traffic density at all lanes and then adjust red and green signal time. Cameras will take snapshot of all lanes every five seconds and then estimate traffic at lanes and based on density green and red signal time will be adjusted.

Keywords – Traffic control, Traffic light system, Traffic management, Intelligent transport systems, Smart surveillance, Computer Vision, Machine Learning, Object detection, YOLO.

1. INTRODUCTION

In recent years, video monitoring and surveillance systems have been extensively used in traffic management for security, ramp metering, and providing information and updates to travellers in real-time. The traffic density estimation and vehicle classification can also be achieved using video monitoring systems, which can then be used to control the timers of the traffic signals so as to optimize traffic flow and minimize congestion. Our proposed system aims to design a traffic light controller based on Computer Vision that can adapt to the current traffic situation. It uses live images from the CCTV cameras at traffic junctions for real-time traffic density calculation by detecting the number of vehicles at the signal and setting the green signal time accordingly.

2. RELATED WORK

An intelligent video-based drowsy driver detection system, which is unaffected by various illuminations, is developed in this study. Even if a driver wears glasses, the proposed system detects the drowsy conditions effectively. By a near-infrared-ray (NIR) camera, the proposed system is divided into two cascaded computational procedures: the driver eyes detection and the drowsy driver detection. The average open/closed eyes detection rates without/with glasses are 94% and 78%, respectively, and the accuracy of the drowsy status detection is up to 91%. By implementing on the FPGA-based embedded platform, the processing speed with the 640×480 format video is up to 16 frames per second (fps) after software optimizations.

A vision-based real-time driver fatigue detection system is proposed for driving safely. The driver's face is located, from colour images captured in a car, by using the characteristic of skin colours. Then, edge detection is used to locate the regions of eyes. In addition to being used as the dynamic templates for eye tracking in the next frame, the obtained eyes' images are also used for fatigue detection in order to generate some warning alarms for driving safety. The system is tested on a Pentium III 550 CPU with 128 MB RAM. The experiment results seem quite encouraging and promising. The system can reach 20 frames per second for eye tracking, and the average correct rate for eye location and tracking can achieve 99.1% on four test videos. The correct rate for fatigue detection is l00%, but the average precision rate is 88.9% on the test videos.

3. PROPOSED FRAMEWORK

In this paper, we describe a non-intrusive vision-based system for the detection of driver fatigue. The system uses a colour video camera that points directly towards the driver's face and monitors the driver's eyes in order to detect micro-sleeps (short periods of sleep). The system deals with skin-colour information in order to search for the face in the input space. After segmenting the pixels with skin like colour, we perform blob processing in order to determine the exact position of the face. We reduce the search space by analyzing the horizontal gradient map of the face, taking into account the knowledge that eye regions in the face present a great change in the horizontal intensity gradient. In order to find and track the location of the pupil, we use gray scale model matching. We also use the same pattern recognition technique to determine whether the eye is open or closed. If the eyes remain closed for an abnormal period of time (5-6 sec), the system draws the conclusion that the person is falling asleep and issues a warning signal.

4. EXPERIMENTAL RESULTS

To measure how the proposed adaptive system compares to the existing static system, 15 simulations of both the systems were run for a period of 5 minutes each, with varying traffic distributions across the 4 directions. Performance was measured in terms of the number of vehicles that were able to pass the intersection per unit of time. In other words, the idle time of the signal i.e. the time when the signal is green but no car passes the intersection is compared. This has an impact on the waiting time of vehicles and queue lengths of the other signals.

The distribution [a,b,c,d] means that the probability of a vehicle being in lane 1, lane 2, lane 3, and lane 4 is a/d, (b-a)/d, (c-b)/d, and (d-c)/d, respectively. For example, in simulation 1, the distribution is [300,600,800,1000] which means probabilities of 0.3, 0.3, 0.2, and 0.2. The results obtained were tabulated in the form of number of vehicles passed lane-wise and the total number of vehicles passed.

Table i. simulation results of current static system

No.	Distribution	Lane1	Lane 2	Lane 3	Lane 4	Total
1	[300,600,800,1000]	70	52	52	65	239
2	[500,700,900,1000]	112	49	48	31	240
3	[250,500,750,1000]	73	53	63	62	251
4	[300,500,800,1000]	74	44	65	71	254
5	[700,800,900,1000]	90	32	25	41	188
6	[500,900,950,1000]	95	71	15	14	195
7	[300,600,900,1000]	73	63	69	24	229
8	[200,700,750,1000]	54	89	10	67	220

9	[940,960,980,1000]	100	10	8	4	122
10	[400,500,900,1000]	81	29	88	37	235
11	[200,400,600,1000]	42	47	54	86	229
12	[250,500,950,1000]	39	52	93	22	206
13	[850,900,950,1000]	74	10	13	17	114
14	[350,500,850,1000]	49	46	69	50	214
15	[350,700,850,1000]	51	64	37	43	195

Table ii. simulation results of proposed adaptive system

No.	Distribution	Lane1	Lane 2	Lane 3	Lane 4	Total
1	[300,600,800,1000]	87	109	41	50	287
2	[500,700,900,1000]	128	55	49	25	257
3	[250,500,750,1000]	94	50	60	58	262
4	[300,500,800,1000]	89	46	69	59	263
5	[700,800,900,1000]	185	25	23	28	261
6	[500,900,950,1000]	94	118	11	16	239
7	[300,600,900,1000]	87	68	70	33	258
8	[200,700,750,1000]	56	108	19	78	261
9	[940,960,980,1000]	193	6	5	7	211
10	[400,500,900,1000]	97	29	100	34	260
11	[200,400,600,1000]	26	52	67	99	244
12	[250,500,950,1000]	52	75	101	7	235
13	[850,900,950,1000]	154	17	12	18	201
14	[350,500,850,1000]	64	53	80	47	244
15	[350,700,850,1000]	66	82	40	48	236

As it can be seen in fig. 4, the proposed adaptive system always performs better than the current static system, regardless of the distribution. The improvement in performance depends on how skewed the distribution of traffic is across the lanes. More the skewness of the distribution of traffic, more improved is the performance.

- When the distribution of traffic among the 4 lanes is equal or almost equal, then the proposed system performs only slightly better than the current system. This is the case in simulation numbers 1, 2, 3, and 4. The performance improvement is about 9% here.
- When the distribution of traffic is moderately skewed, then the proposed system performs significantly better than the current system. This is the case in simulation numbers 5, 6, 7,8, 14, and 15. The performance improvement is about 22% here. Usually, this is the kind of traffic distribution seen in real life scenarios.
- When the distribution of traffic is sharply skewed, then the proposed system has a huge performance improvement as compared to the current system. This is the case in simulation numbers 9 and 13, where the red line drops sharply and there is a large gap between the red and green line. The performance improvement is about 36% here.

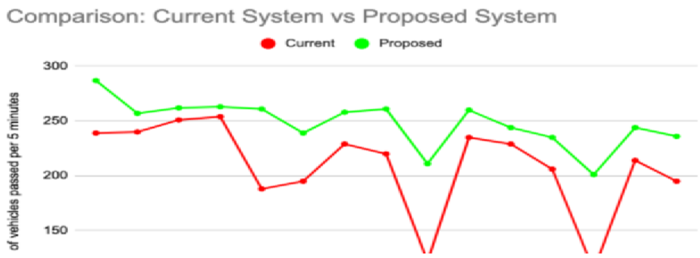

Fig. 4. Comparison of current static system and proposed adaptive system

With all simulation conditions same i.e distribution of traffic, speeds of vehicles, probability of vehicles turning, the gap between vehicles, and so on, the simulations were run for a total period of 1 hour 15 minutes, with 300 seconds i.e. 5 minutes for each distribution and it was found out that the proposed system, on an average, increased the performance by about 23% as compared to the current system with fixed times. This implies a reduction in idle green signal time as well as the waiting time of the vehicles.

On comparing these results with some alternative adaptive system, it was found that the proposed system performs better than some of those. For example, [2] gives an accuracy of 70% as compared to 80% of the proposed system. Reference [3] achieves an average performance improvement of 12% as compared to static systems while the proposed system achieves 23% improvement.

5. CONCLUSION AND FUTURE WORK

In conclusion, the proposed system sets the green signal time adaptively according to the traffic density at the signal and ensures that the direction with more traffic is allotted a green signal for a longer duration of time as compared to the direction with lesser traffic. This will lower the unwanted delays and reduce congestion and waiting time, which in turn will reduce fuel consumption and pollution. According to simulation results, the system shows about 23% improvement over the current system in terms of the number of vehicles crossing the intersection, which is a significant improvement. With further calibration using reallife CCTV data for training the model, this system can be improved to perform even better.

6.FUTURE SCOPE

The project can be further expanded to include the following functionalities to enhance traffic management and bring down congestion:

1) Identification of vehicles violating traffic rules: The vehicles running red lights can be identified in an image or a video stream by defining a violation line and capturing the number plate of the image if that line is crossed when the signal is red.

Lane changing can also be identified similarly. These can be achieved by background subtraction or image processing techniques.

2) Accident or breakdown detection: Intersections also tend to experience severe crashes due to the fact that several types of injurious crashes, such as angle and left-turn collisions, commonly occur there. Therefore, accurate and prompt detection of accidents at intersections offers tremendous benefits of saving properties and lives and minimizing congestion and delay. This can be achieved by identifying the vehicles that remain stationary for a long time in an inappropriate position such as in the middle of the road, so that parked vehicles are not included in this.

3) Synchronization of traffic signals across multiple intersections:

Synchronizing signals along a street can benefit the commuters as once a vehicle enters the street, it may continue with minimal stopping.

4) Adapting to emergency vehicles: Emergency vehicles such as an ambulance need to be given quicker passage through the traffic signals. The model can be trained to detect not just vehicles but also be able to recognize that it is an emergency vehicle and accordingly adapt the timers such that the emergency vehicle is given priority and is able to cross the signal at the earliest.

7. REFERENCES

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