International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

Vehicle Speed Estimation in Accident Prone Areas using Image Processing

Siddharth Jhumat

M.Tech (CSE), Department of Computer Science & Engineering, University School of Information & Communication Technology, Guru Gobind Singh Indraprastha University, Delhi, India

Abstract: In this paper, I present a method to determine the vehicle speed in accident prone areas using the video frames captured from the camera fixed on the road. One frame is taken as the reference frame and then two different frames are taken to calculate the absolute difference between those two frames with the reference frame. The absolute difference gives us the motion in the frame. Then we perform the thresholding and morphological operations to calculate the vehicle mask. The mask is used as a basis to calculate the centroid in the two images. The difference between the centroid of the two images gives us the displacement of the vehicle with respect to the two frames through which we calculate the velocity. Experimental results show that the proposed method exhibits good and consistent performance.

Keywords: Frame Differencing, Thresholding Operation, Morphological Operation, Centroid, Radar.

I. INTRODUCTION

Traffic management is one of the critical issues of modern society and economy. With growth in traffic there is occurrence of bundle of problems too like traffic jams, accidents and traffic rule violations. Road is one of the mode of transportation and if we do not follow the rules of driving than it can lead to fatal accidents. The expected increase of cars and SUVs from 2005 to 2035 is 13 times i.e. 35.8 million to 236.4 million vehicles and with two wheelers the increase is 6.6 times i.e. 35.8 million to 236.4 million vehicles [1]. Finance minister P. Chidambaram in budget 2014-15 has given relief to the automobile industry by reducing the excise duty on SUVs from 30% to 24% and for small cars, motorcycles, scooters and commercial vehicles from 12% to 8% [2]. This decrease in excise duty will also increase the number of vehicles on road by a huge numbers in the current fiscal year. There are certain areas that are highly prone to accidents and those areas are converted into speed restricted areas, where one is allowed to drive within a certain speed limit.

National Highways in India accounted for 30.1% of the total road accidents and 37.1% of the total number of persons killed in 2011 [3]. The major human factors that contribute to the potency of road accident causation include drunken drivers, indecisiveness, fatigue, distraction, and confusion. In addition, in most of the cases the drivers are found to be inexperienced, risk takers, impulsive, aggressive, casual and unaware of the road signals.

Intelligent transportation systems are becoming more important due to their advantages of saving lives, money and time. Acquiring traffic information, such as lane width traffic volume (the number of travelling vehicles per time period through a position in a lane), traffic density (the number of total vehicles in a given area at a given time) and vehicle speed, these are the key part of intelligent transportation systems, and such information is used to manage and control traffic. It focuses on vehicle speed since reducing speed can help to reduce accidents.

II. EXISTING SPEED DETECTION TECHNIQUES

A. *Radar Detectors*

One of the technologies that law enforcement agencies can use to measure the speed of a moving vehicle uses Doppler radar to beam a radio wave at the vehicle, and then infer the vehicle's speed by measuring the Doppler effect-moderated change in the reflected wave's frequency. Radar guns can be hand-held, vehicle mounted or mounted on a fixed object, such as a traffic signal [4].

Disadvantages:

- High Cost: Cost of Escort - PASSPORT Max Radar Detector – Black is $ 549.99 [5].
- Radio Interference
- Less Accuracy

Fig 1: Escort - Passport Max Radar Detector – Black [5]

B. *Lidar Detector*

A lidar detector or a laser detector is a passive device designed to detect (observe) the infrared emissions of law

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

enforcement agencies lidar speed detection devices and warn motorists that their speed is being measured [6]. Its advantage is its low cost. The cost of Cobra detector is $ 69.65. When measuring the speed with Lider, the delay is measured between individual infrared pulses from the transmitter to the vehicle and back to the receiver.
Disadvantages:

- A limitation of lidar is that it cannot be used while a police car is in motion, because it requires the operator to actively target each vehicle. So it has to be held or placed at a static point.
- Other restrictions in lidar include a precipitation free environment.

Fig 2: Cobra XRS9370 High-Performance Laser Detector [7]

C. Vision Based System

Vision based vehicle speed measurement is one of the most convenient methods available in speed detection. A novel algorithm is given for estimating vehicle speed from two consecutive images in [8]. Its principles are both images are transformed from the image plane to the 3D world coordinates based on thee calibrated camera parameters. Second, the difference of the two transformed images is calculated, resulting in the background being eliminated and vehicles in the two images are mapped onto one image. Finally, a block feature of the vehicle closest to the ground is matched to estimate vehicle distance and speed. Vehicle speed measurement for accident scene investigation in [9] shows the characteristics of accident scene by including the information of lane marks and background model is estimated and used for motion detection.

Vehicle speed detection based on video at urban intersection in [10] calculates the vehicle velocity by the width of the detection zone and the time it takes for the target vehicles to drive into and depart from the detection zone. Vehicle velocity estimation for traffic surveillance system in [11] calculated the speed of the vehicle based on the displacement of the vehicle's centroid.

Most vision-based speed estimation methods estimate average traffic speed over a period of time with error rate of over 10% compare with the reference value. Such error rate is considered large for any practical use. The errors due to day-night transition or general weather changes could be large unless updating is frequent enough, which needs to trade-off with computational complexity.

III. PROPOSED WORK

A. Algorithm

i. Read and access the video and find information like number of frames, width and height of the video captured.
ii. Create a structure to capture all the frames from the video.
iii. From the list of frames, select two frames and a background frame.
iv. Perform frame differencing of the two frames with the background frame and a grayscale image is created.
v. Convert the grayscale image into binary image using thresholding operation.
vi. Remove lane marking and others non-disk shaped structures using morphological processing.
vii. Perform morphological closing to join the vehicle disconnected components together.
viii. Get the centroid of the maximum area in both the images.
ix. Calculate the change in horizontal distance by subtracting the x value of both the centroid.
Delta_x = abs(x2-x1) (1)
x. Convert the distance in pixels to metres using white lane distance measured using tape. Here 1.57 metre is the measured distance of the white lane and 160 is the pixel distance of white lane.
Pixel_metre = 1.57 / 160 (2)
distance_travel = Delta_x*Pixel_metre (3)
xi. Calculate the velocity by dividing the distance to the time elapsed calculated using the frame rate.
time_elapsed = frame_difference *1/frame_rate (4)
xii. Velocity = distance_travel/time_elapsed -- -- (5)

B. Frame Differencing Operations

In the frame differencing operation we first select a reference background frame. We then select two different frames of the video and calculate the absolute difference between those two frames with the reference background frame. The result of this operation shows the actual movement in the frame as seen in Fig 3.

(a) Frame X

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

(b) Frame Y

Fig 3: Result of Frame differencing being performed on (a) Frame X and (b) Frame Y with background frame.

C. Thresholding Operations

Image Thresholding is a simple, yet, effective way of partitioning an image into a foreground and background. [12] This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images. Image thresholding is most effective in images with high level of contrast. After performing the frame differencing operation we perform the thresholding operation to convert the image into the binary image as seen in Fig 4. It is easy to perform the motion operations on the binary image than the grayscale image. Threshold follows the same concept as in basic electronics, here it is used to convert the grayscale image to black and white (binary image, consisting of 0's and 1's as pixel values.) We select the same frame X and frame Y from the last operation and perform thresholding on it.

(a) Frame X

(b) Frame Y

Fig 4: Thresholding is performed on (a) Frame X and (b) Frame Y to convert it into binary images.

D. Morphological Operations

After thresholding operation we observed that we are left with lots of isolated points which add to the complexity. Morphological operations are performed to remove all the isolated points that are observed in the thresholding operations as seen in Fig 5. We are removing the isolated points so that we are left with clear points that belong to the vehicle.

Now after removing the isolated points we are left with some disconnected components. If we calculate the centroid of all these disconnected components than it will become difficult for us to calculate the displacement of the vehicle because of large number of centroid. We will not able to judge that which centroid we need to pick to calculate displacement. Therefore we will connect all these disconnected components together. So we will now perform morphological closing to connect the vehicle disconnected components together as shown in Fig 6 for Frame X and Frame Y.

(a) Frame X

(b) Frame Y

Fig 5: Morphological operations are performed on (a) Frame X and (b) Frame Y to clean up all the isolated points.

(a) Frame X

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

(b) Frame Y

Fig 6: Morphological closing is performed on (a) Frame X and (b) Frame Y to join the disconnected vehicle components together.

The centroid of the maximum area in both the frames is calculated. Then the displacement is calculated by the difference in the x position of their respective centroid.

IV. EXPERIMENTAL RESULTS

S. No	Original Velocity	Velocity Calculated	Percentage Error
1	38	37.12	2.31 %
2	34	32.90	3.23 %
3	30	29.04	3.20 %
4	26	25.28	2.76 %

Table I: Velocity calculated of a vehicle moving at constant speed using the proposed work and its percentage error.

S. No	Frame X	Frame Y	Velocity(km/h)
1	14	19	31.691643
2	15	20	28.148771
3	16	21	41.890835
4	17	22	50.650307
5	18	23	44.283490
6	19	24	30.801525
7	20	25	34.668778

Table II: Velocity of the vehicle moving at variable speed when pair of different frames are taken.

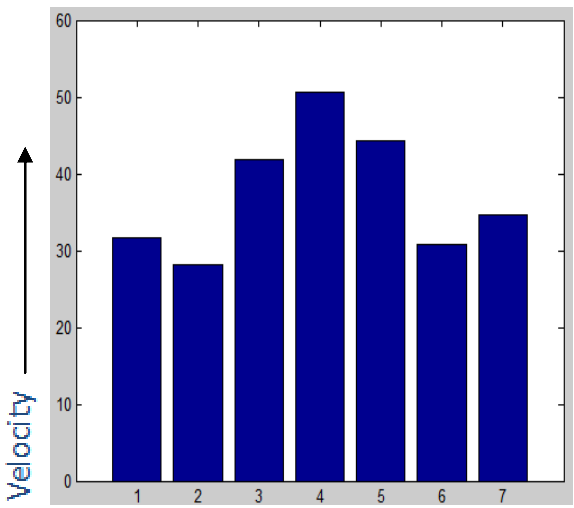

Fig 7: Bar Graph of the velocity of the vehicle that is moving at variable speed.

V. CONCLUSION

In this paper, I have implemented a method to calculate the velocity of the vehicle. First of all frame differencing is performed to get the motion in the image. Then thresholding is performed to convert the grayscale image into binary image. Isolated points are removed using the morphological operations. Morphological closing is performed to join the disconnected vehicle components together. Then the centroid is calculated and the difference in horizontal distance is the displacement of the vehicle. Through this method we calculate the velocity with percentage error less than 4 %. Future work will be focused on reducing the percentage error and developing the method that work in night time also.

REFERENCES

[1] Sukdev Singh, Rishma Chawla, Harpal Singh "Speed Violation Detection System : A review" International Journal of Engineering Sciences & Research Technology, January 2014.

[2] P. Chidambaram, Minister of Finance "Key Features of Budget 2014-2015", http://indiabudget.nic.in/ub2014-15/bh/bh1.pdf, Union Budget of India 2014-2015.

[3] Manisha Ruikar "National Statistics of road traffic accidents in India" Department of Community and Family Medicine, All India Institute of Medical Sciences (AIIMS), Raipur, Chhattisgarh, India, Jan-April 2013.

[4] Radar Detector, From Wikipedia, the free encyclopedia, http:// en. wikipedia.org / wiki/ Radar detector , November 2007.

[5] Escort - PASSPORT Max Radar and Laser Detector – Black, cost: $ 549.99, http://www.bestbuy.com/ site/ passport-max-radar-and-laser-detector/1587237.p? id = 1219056361453& skuId= 1587 237&st=categoryid$abcat0305000&cp=1&lp=1

[6] Lider Detector, From Wikipedia, the free encyclopedia, http://en. Wikipedia .org/wiki/Laser_detector, November 2007.

[7] Cobra XRS9370 High-Performance Radar/Laser Detector with 360-Degree Protection, http:// www.amazon.com/Cobra-XRS9370-High-Performance-360-Degree Protection/dp/B004RO3QOM

[8] Xiao Chen He and Nelson H. C. Yung "A novel Algorithm for estimating vehicle speed from two consecutive images" IEEE workshop on applications of computer vision 2007.

[9] Huachun Tan, Jie Zhang, Jianshuai Feng, Feng Li, " Vehicle speed measurement for accident scene investigation" IEEE International Conference on E-business Engineering 2010.[10]

[10] Zhenqian Shen, Shifu Zhou, Changyun Miao, "Vehicle speed detection on video at urban intersection", Research journal of applied sciences, engineering and technology, 2013.

[11] H.A.Rahin, U.U.Sheik, R.B.Ahmad, "Vehicle velocity estimation for traffic surveillance system" World Academy of Science, engineering and technology, 2010.

[12] Rafael C. Gonzalez, Richard E. Woods, Stecen L. Eddins, "Digital image processing using matlab" second edition, ninth reprint, 2013.