RESEARCH ARTICLE

SAMRIDDHI Volume 12, Special Issue 3, 2020 Print ISSN : 2229-7111 Online ISSN : 2454-5767

Speed Estimation using Camera Modeling from Video Sequences for Visual Tracking Application

N.G.Chitaliya

Electronics & Communication Engineering Department, Sardar Vallabhbhai Patel Instititue of Technology, Vasad, Gujarat, India; e-mail: nehalchitaliya.ec@svitvvasad.ac.in

ABSTRACT

Object motion analysis is widely used in real time application. Motion Parameters like location, directions and speeds are derived for the learning of Machine Intelligence System. In the Visual Tracking and machine intelligence system, the motion analysis of an object and interpretation of the object behavior are performed from image sequences or consecutive video frames. In this paper, the motion parameters of the objects have been calculated using camera model parameters and implemented with best location of camera for object tracking. Practical results are performed with different Image sensor size of CCD Camera with different mounting of location having different distance angle of on traffic road to measure the speed and direction of vehicles using 2-D image video.

Keywords: Motion Estimation, 2-D Video, Camera Modelling , Motion Parameter.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, (2020); DOI : 10.18090/samriddhi.v12iS3.31

INTRODUCTION

Motion estimation is the process of determining motion vectors having displacement from one 2D image to another, normally from adjacent frames in a video sequence[1]. The main objective of modeling the parameters of camera is, to estimate the motion vectors from two time sequential or adjacent frames of the video [1,6,7,8]. The object having a motion in the 3D object space is translated into two successive frames in the image space at different time instances. Translational and rotational motion of the objects is defined in temporal frames using this model. The output of the motion-estimation algorithm consists of the motion vector for each block, and also the pixel value differences between the adjacent frames.

Camera Modeling Parameters

For Motion Estimation , different technical parameters of the camera [1] used are: Focal Length, Angle of View, F-Number, Field of View and Depth of the field.

Corresponding Author : N.G.Chitaliya, Electronics & Communication Engineering Department, Sardar Vallabhbhai Patel Instititue of Technology, Vasad, Gujarat, India; e-mail: nehalchitaliya.ec @svitvvasad.ac.in

How to cite this article : Chitaliya, N.G., (2020). Speed Estimation using Camera Modeling from Video Sequences for Visual Tracking Application.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology, Volume 12, Special Issue (3), 163-167.

Source of support : Nil

Conflict of interest : None

Camera Format

The size of camera's imaging device (image sensor) affects the angle of view, the smaller devices create narrower angles of view when used on the same lens. Lenses of camera are designed for a particular sensor size. There are millions of photosensitive diodes, called photosites are located on the surface of image sensor. Each sensor captures a single pixel of the photograph to be captured. Cameras having high resolution and large number of sensors collect more light to the lens with same F- number and field of view. Table 1: shows some standard sensor sizes used for calculating fields of view and angles of view.

Table-1: Image Sensor Size

FORMAT	$^2/_3$ inch	$^1/_2$ inch	$^1/_3$ inch	$^1/_4$ inch	$^1/_8$ inch
v(mm) (width of sensor)	6.6	4.8	3.6	2.7	0.7
h (mm) (height of Sensor)	8.8	6.4	4.8	3.6	1.6

To evaluate the performance of an image sensor, many parameter are considered like which includes dynamic range, signal-to-noise ratio, low-light sensitivity, etc. sensors The signal-to-noise ratio and dynamic range improve as the size increases for comparable types of sensors.

The focal length of the lens is related with angle of view. It is measured millimeter (mm) . Short focal length captures wide angle of view while long focal length captures the narrow angle of view. A normal angle of view is similar to what we see with our own eye and has a relative focal length equal to that of the pickup device.

Motion Estimation Using Camera

To find the vehicle speed, successive frame images of the camera can be used. In this case, only the instantaneous speed can be found. This instantaneous speed is computed as follows [2]:

$$v = \frac{\Delta p}{\Delta t} \tag{1}$$

Where v is instantaneous velocity vector of a point projected on 2D image space and Δp is the displacement vector of that point in 2D image space.

The displacement vector expresses the spatial displacement of a point during the time interval Δt. The time interval Δt is equal to the time of motion between two consecutive video frames which is equal to the frame replay rate (or frame capture rate) of the camera. In this proposed method frame capture rate of 30 fps (frame per second) is used. So the value of Δt to be used in equation (1) is 33.3 milliseconds.

To calculate the absolute value of velocity, the vectors computed in the video or image coordinate system must be transformed to the object space or object coordinate system. In proposed method, object scene is considered flat. In the ideal situation, as shown in the figure 1 [3], the flat scene is similar to vertical plane. Due to the depth in the plane, distance from the camera to the object plane are different. The difference due to the distance causes the object plane to have different scales in the image plane. In the video sequences or from 2-d image frames, it is not possible to detect the depths parameters and so the scales of image plane.

As shown in the fig.1., we assume that vehicle is moving from left to right to calculate the different scales. Considering camera is mounted on right side which is closer to plane $\Pi_1$with the scale λ_1 while vehicle moving from right to left is having plane Π_2 with scale l_2. With distance d_1 and d_2 in the object plane and their equivalent distance on image plane, scales and l_2 are calculated using ratio of distance of image plane and distance of object plane. Many of times considering central road axis scale is taken is averaging of scale of near plane and scale of depth plane. Considering assumption made according to the object plane, different sacle factors are used to calculate the absolute velocity.

The scale of the camera in the proposed method is calculated using magnification ratio of the object space to the image space. That is used to find the absolute velocity of the actual object. The distance between two points of object plane are measured either by physical measurement or using the format specified in table 1.

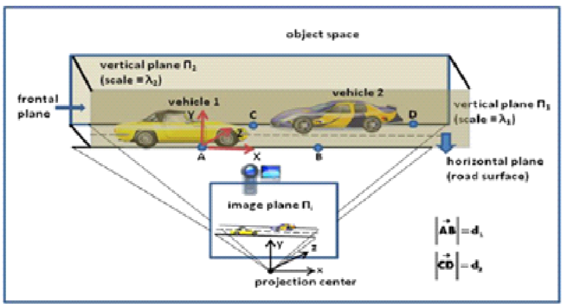

Figure 1 : View of Image Acquisition Plane [3]

Speed Calculation Using Camera Modeling

To find the actual velocity of the vehicle, the field of view (FOV) of the camera is set up such that it is easily capture the moving direction of the vehicles and ablso able to capture the side vies of vehicle movement. This type of camera setup provides the solution of the scale problem as well also efficiently used to track the object in motion. But it also shortens the time for analysis as entrance and exit time of a vehicle into the FOV of the camera is shortened. For performing the real time procedures for speed estimation, this situation requires less time for calculations. The mounting of camera on the front side needs highly accurate information about the depth of the road for measuring the speed of vehicle on object space. Thus selection of the camera mounting on side view or front viewing depends upon the view location of the objects to be tracked [4,5].

Calculations for image space to object space conversion

The direction of the object has been calculated by finding the angle using the equation (2)

$$\text{Direction} = \tan^{-1} y/x \qquad (2)$$

Where y and x are the y coordinate and x coordinate of the Centroid pixel respectively.

Actual velocity of the vehicle or moving object is calculated by projecting the object from the image space to actual object space using the camera parameters specified above. Camera parameters are calculated to find magnification ratio considering camera mounting on height and camera is tilted at some degree of angle. The camera parameter calculation software has developed to find the actual magnification ratio. Considering the targeted application for video surveillance system, the camera parameter calculation software designed to increase efficiency of security system with reducing costs for finding the best location for mounting camera. To find the magnification ratio from optimal positions CCD /CCTV cameras, a field of view, viewing angles and lens focal length are calculated using trigonometry functions as shown in the Fig. 2.

Parameters are required calculate the magnification ratio is [11]:

- o **Distance from Camera** –Distance between Camera and target object.
- o **Camera Installation Height** – CCTV camera installation height.
- o **Field of View: Height** – Height of the target. When user select the Field of View (FOV) Software calculates the camera Tilt from FOV.
- o **Field of View: Width** –From FOV width instead of the FOV height the **Focal Length** and the **Viewing Angles** is calculated using trigonometry funcions.
- o **Camera Sensor Format** – CCD or CMOS sensor size (sensor format). User can select the sensor format from: 1/43 , 1/3.63 , 1/33 , 1/2.53 , 1/23 , 2/ 33 , 13 and 1.253 . Usually user can find the sensor format in the camera specification.

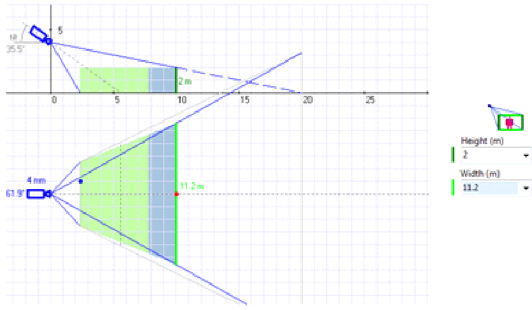

Figure 2: Camera Parameters Calculations using Trigonometry Functions[11]

Magnification ratio is calculated using the ratio of the distance of the object to lens focal length [9,10]. Table 4.10 reports the different input parameters considering the height of mounting camera, distance of the object and minimum height of the object required for tracking. Camera motion parameter software calculates the focal length, width of the object visible according to the height consider as input parameter of the object. It also calculates span of the Horizontal Angle of View (H.A.V) and Vertical Angle of View (V.A.V). The camera parameter software calculates the tilting angle of camera required to track the object with reference to the given input parameters. Table 2. reports the some of the camera parameters calculations using different input parameters. Simulation is done on different camera parameters having different sensor size (2",2.5",3"), different values of camera mounting height (Range: 4,6,8 and 10 meter) to and distance of the object from camera and different focal length is performed.

For experiment purpose some of the real time road sequences captured from the ordinary Sony DSC s650 camera have been used. A camera with a frame rate of 30 fps with 320 × 240 pixels has been used. The focal length of camera can be adjusted from 5.8 to 17.4 mm using 3 × zoom. Experiment has been performed with zoom and without zoom. The scale or magnification factor of the images is associated with the camera-to object distance and the focal length of the camera. Scale of a rectified image can be obtained approximately by the equation

$$s = \frac{d}{f} = \frac{h}{H} = \frac{w}{W} \tag{3}$$

Where d is the camera to object distance
f is the focal length of the camera, h is the sensor height, H is the original Height of the object, w is the sensor width , W is the actual width of the object

Actual velocity V can be calculated using

$$V = m * s * 3.6 \tag{4}$$

Where, m is the distance in the image space that is calculated using the blob statistics derived in the proposed algorithm. Magnification factor or scale factor is calculated using equation (3). Product of m and s calculates the velocity in the meters per millisecond that is converted in to the kilometer per hour.

Table-2: Camera Parameters Calculations for Different Image Sensor Size using the Proposed Software

Input Parameters				Calculated Parameters							
				Image Sensor Size = $\frac{1}{2.5''}$ (h = 4.2 mm ,w = 5.6 mm)				Image Sensor Size = $\frac{1}{3''}$ (h = 3.6mm ,w = 4.8mm)			
Camera Mounting Height (m)	Distance of Object (m)	Object Height (m)	Focal Length (mm)	Object Width (m)	Angle of Tilt (degree)	H.A.V (degree)	V.A.V (degree)	Object Width (m)	Angle of Tilt (degree)	H.A.V (degree)	V.A.V (degree)
10	20	2	10	11.2	34.7	31.2	23.7	9.6	33.1	26.9	20.4
10	20	2	8	14.0	37.6	38.5	29.4	12.0	35.6	33.4	25.3
10	20	2	6	18.6	42.2	50.0	38.5	16.0	39.6	43.6	33.4
10	20	2	4	28.0	50.6	69.9	55.3	24.0	47.1	61.9	48.4
10	10	2	10	5.6	57.6	31.2	23.7	4.8	56.0	26.9	20.4
10	10	2	8	7.0	60.5	38.5	29.4	6.0	58.4	33.4	25.3
10	10	2	6	9.3	65.0	50.0	38.5	8.0	62.5	43.6	33.4
10	10	2	4	14.0	73.5	69.9	55.3	12.0	69.9	61.9	48.4

Figure 3: Speed Measurement of Vehicle from the "Traffic 1" Sequence
(a) Frame Number 655 (b) Frame Number 656

Table-3: Minimum Speed Measured with Camera with different Camera to Object Distance

Focal Length(mm)	Distance (m)	Minimum Speed measured in km/hr with 5.8 mm / 3 × zoom
5.8mm /	10	6.2 / 2.06
3 × zoom =	20	12.4 / 4.13
17.4 mm	30	18.6 / 6.2

Actual speed measure is calculated using image space istance. As shown in the Figure 3, the image space distance of vehicle is 6 pixels per frame calculated using the proposed algorithm. Speed in object space is calculated using the equation (3) and (4).

Table 3 reports the minimum speed calculated with equation. (4) at different distances from camera to object. To measure the performance of the algorithm, different vehicles are used to measure the speed. Vehicle speed is measured with the speedometer of the vehicle and compared with the calculated speed using the proposed method. Table 4 reports the actual speed and speed calculated using the proposed method. The relative errors of estimation using the proposed method are obtained by computing the differences between actual speed and calculated speed.

Table-4: Accuracy Measurement Test

Experiment	Calculated Speed using Proposed Method (A) km/hour	Actual Speed measured using Speedometer (B) km/hour	Error |A-B|
1	34.14	35	0.86
2	37.6	38	0.4
3	44.75	45	0.25
4	57.8	58	0.2
5	74.88	75	0.12

CONCLUSION AND FUTURE SCOPE

Experimental results of the speed from visual tracking sequences are compared with the actual speed. The performances of the results have been tested using number of image sequences. The motion parameters of the objects have been calculated using camera model parameters and implemented for best location of camera for object tracking. To improve the accuracy of the speed two camera can be used which is used to measure the depth information of object.

REFERENCES

[1] R.Szeiliski, Computer Vision: Algorithms and Applications. New York: Springer, 2010..

[2] "Technical information on CCTV camera modelling," www.videosec.com/education/lens-glossary.pdf.

[3] S. Doðan, M. S. Temiz, and S.Külür, "Real Time Speed Estimation of Moving Vehicles from Side View Images from an Uncalibrated Video Camera," Sensors, vol. 10, pp. 4805-4824, 2010.

[4] J. C. Nascimento and J. S. Marques, “Performance Evaluation of Object Detection algorithms for video Surveillance,” IEEE Transactions on Multemedia, vol. 8, no. 4, pp. 761-774, 2006.

[5] Huei-Yung Lin and Chia-Hong Chang, “Automatic speed measurements of spherical objects using an off-the-shelf digital camera,” *IEEE International Conference on Mechatronics, 2005. ICM ’05.*, Taipei, 2005, pp. 66-71.

[6] S.Indu ,M.Gupta,A.Bjattacjarua,”Vehicle tracking and Speed Estimatin using optical flow method,”,International journal of Engineering Science and Technology, Vol,3,pp 429-434.

[7] Czajewski W., Iwanowski M. Vision-Based Vehicle Speed Measurement Method. In: Bolc L., Tadeusiewicz R., Chmielewski L.J., Wojciechowski K. (eds) Computer Vision and Graphics. ICCVG 2010. Lecture Notes in Computer Science, vol 6374. Springer, Berlin, Heidelberg

[8] Y. Goda, L. Zhang and S. Serikawa, “Proposal a Vehicle Speed Measuring System Using Image Processing,” *2014 International Symposium on Computer, Consumer and Control*, Taichung, 2014, pp. 541-543.doi: 10.1109/IS3C.2014.146

[9] Y. Yan, S. Yancong and M. Zengqiang, “Research on vehicle speed measurement by video image based on Tsai’s two stage method,” *2010 5th International Conference on Computer Science & Education*, Hefei, 2010, pp. 502-506.

[10] Gholami, Arash & Dehghani, Abbas & Karim, Mohamed,”Vehicle speed detection in video image sequences using CVS method”. International Journal of Physical Sciences.vo. 5.2010.

[11] https://www.jvsg.com/cctv-field-of-view-calculation/