Vehicle Counting using Video Image Processing

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Abstract - It is important to know the road traffic density especially in mega cities for effective traffic management and intelligent transportation system (ITS). In recent years, video monitoring have been widely used in intelligent transportation system (ITS). As one of the important research topic in video monitoring based intelligent transportation system (ITS) is vehicle classification and counting. Vehicle classification and counting is challenging task due to problems like motion blurs, varying image resolution etc. So far numerous algorithms have been developed for vehicle classification and counting. This paper proposes an effective Scale Invariant Feature transform (SIFT) algorithm used for moving vehicle classification and after classification counting will be done according to the class. This will help to improve efficiency and reliability of vehicle classification and counting technique.

***Keywords* - Vehicle classification and counting, SIFT.**

1. Introduction

Over the decade, vehicle classification and counting has been an active research topic of intelligent transportation system (ITS). Many methods have been proposed for vehicle classification and counting using different approach. These approaches can be categorized by the types of sensors used in the classification and counting. Two common approaches of vehicle classification and counting are hardware based and another is software based. The hardware based vehicle classification and counting technique includes various sensors such as infrared sensors, radar, magnetic sensors etc.

The traditional hardware based vehicle classification and counting technique are simple and reliable, but with some shortcomings. The traditional hardware based vehicle classification and counting techniques are intrusive, whose installation requires reconstruction of roadways, where they are going to installed. This reconstruction of roadways may decrease pavement life. Another drawback of hardware based vehicle classification and counting technique is that they have fixed location. Drawbacks hardware based vehicle classification and counting technique can be minimized with software based vehicle classification and counting technique. It uses vision sensors. In vehicle classification and counting technique performance of relies very much on the algorithm instead of the sensor. Vehicle classification and counting technique can either be image-based [1] or video based[2]. In this paper, Scale Invariant Feature transform for the vehicle classification.

The Scale Invariant Feature Transform (SIFT) algorithm introduced by David Lowe in 1999. This algorithm is a widely used for keypoint detection. The method is notable for the reason that the features used are invariant to image scaling, translation, rotation, affine or 3D projection and partially invariant to illumination changes. In the keypoint detection algorithm is adopted and modified to fit in vehicle classification task and return a good result. As per Jian Wu et al [4], SIFT keeps the invariance on scale and rotation change, and illumination change. It maintains a certain degree of stability for image blur and affine transformation. The goal of this research paper is to use SIFT algorithm to count the vehicles according to class.

2. Vehicle Classification and Counting Implementation Scheme

The implementation flow of proposed technique of vehicle classification and counting is shown in figure 1.The first function is to read the video clip, which is stored in database and convert that video into number of frames. Second function is to find frame differences and identifying the background with background registration and background subtraction.

Next post-processing is segmentation is performed, and the vehicles are classified with the help of SIFT algorithm. The goal of the algorithm is to design an efficient classification based on SIFT algorithm on highway.

2.1 Binary Detection of Moving Object

As a part of preprocessing, moving objects are detected by taking frame difference of two successive frames. After that binary detection of that object takes place. When that binary object crosses the barrier window, then it is taken into account for further processing.

2.2 Segmentation

The next step is segmentation. The segmentation operation effectively separates the homogeneous regions from the rest of image.

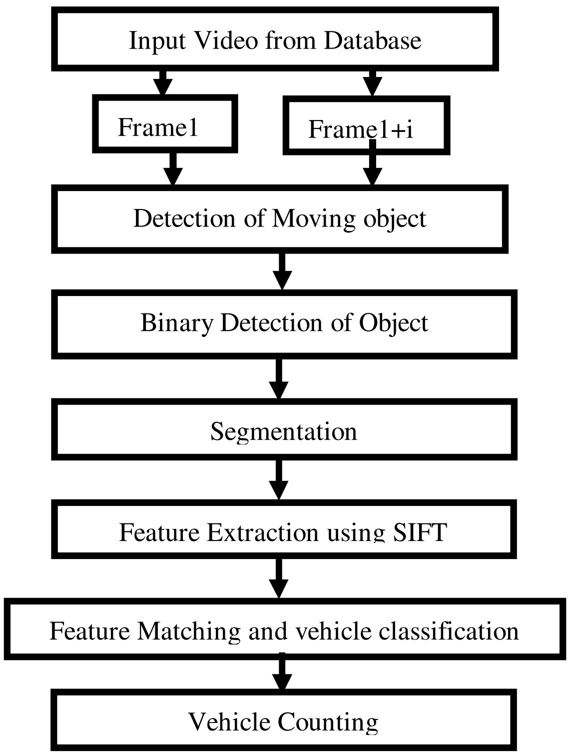


Fig 1.Schematic flow of proposed vehicle classification and counting

2.3 Feature Extraction Using Scale Invariant Feature Transform

SIFT is the Scale Invariant Feature Transform introduced by David Lowe. It is widely used for image matching applications. The vehicle regions extracted using above procedure is given as input to the SIFT based classifier for classification.The SIFT algorithm [5] has four major steps as illustrated in Fig 2.
(a) Scale-Space Extrema Detection, (b) Keypoint Localization, (c) Orientation Assignment, (d) Keypoint Descriptor Generation.

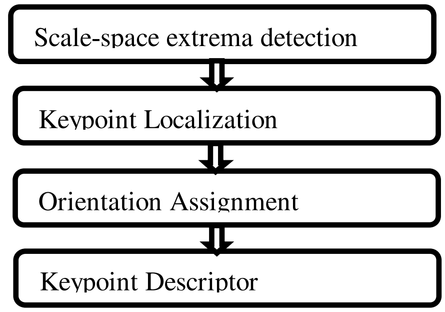


Fig 2. Scale Invariant Feature Transform algorithm

2.3.1 Scale Space Extrema Detection

In this step is extraction of the keypoints takes place.These are the keypints are invariant to scale change. Hence,it is necessary to search for stable features in all possible changes. The scale-space of an image L(x,y,σ) is obtained from the convolution of an input image, I(x,y), with a variable scale-space Gaussian function, G(x,y,σ) as shown in equation (1).

$$L(x,y,\sigma)=G(x,y,\sigma)*I(x,y) \quad (1)$$

For the detction of stable keypoint locations, the scale-space extrema in difference-of- Gaussian (DoG) function, D(x,y,σ) is proposed by David Lowe, as shown in equation (2).

$$D(x,y,\sigma)= L(x,y,k\sigma)- L(x,y,\sigma) \quad (2)$$

For the computation of extrema, compute the difference of two nearby scales separated by a constant factor K. The above process for several octaves.The process is shown Figure 3.

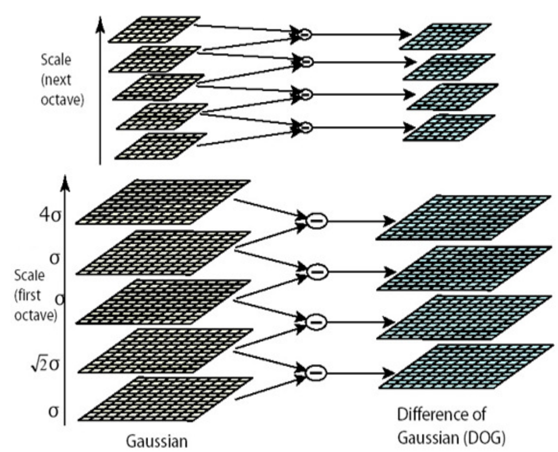


Fig 3. Visual representation of DOG

Then comparison of each sample point or pixel is made with its neighbours, according to their intensities for finding out whether is smaller or larger than neighbours. Each sample point or pixel is checked with the eight closest neighbours in image location and nine neighbours in the scale above and below as shown in figure 4. If the sample point or pixel is an extrema against all 26 neighbours, then that sample point or pixel is selected as candidate keypoint. The cost of this comparison is reasonably low because most sample point or pixel will be eliminated with first few checks.

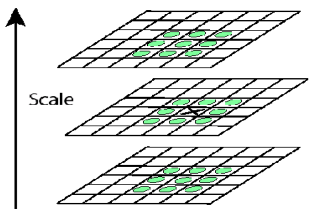


Fig 4. Local extrema detection in DOG

2.3.2 Accurate Keypoint Localization

Interpolation of nearby data is used to accurately determine the position of each candidate keypoint and then the keypoints, which are unstable and sensitive to noise such as the points with low contrast and the points that are on the edge, will be eliminated. Taylor expansion (up to the quadratic terms) of the scale-space function, D(x,y,σ), shifted so that the origin is at the sample point :

$$D(x) = D + \frac{\partial D^T}{\partial x} + \frac{1}{2} x^T \frac{\partial^2 D}{\partial x^2} x \qquad (3)$$

2.3.3 Assigning an Orientation

In this step, to obtain invariance to image rotation, the keypoint descriptor are represented relative to this orientation. For each Gaussian smoothed image sample, the points in regions around keypoint are selected and magnitude m and orientations θ of gradient are calculated.

After that computation of created weighted histogram of local gradient directions at selected scale is carried out. Histogram is obtained by quantizing the orientations into 36 bin to covering 360 degree orientation range.

The highest peak in the histogram is detected where peaks in the orientation histogram gives dominant directions of local gradient.

2.3.4 Keypoint Descriptor

The above operation gives location, scale, and orientation to each keypoint, which provides invariance to these parameters. For is image sample , L(x,y) at this scale, the gradient magnitude m(x,y), and orientation Θ(x,y), is calculated using equation (4) and (5):

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \qquad (4)$$

$$\theta(x,y) = tan^{-1}((x,y+1) - L(x,y-1))/(L(x+1,y) - L(x-1,y))) \qquad (5)$$

The descriptor is based on 16×16 samples and that the keypoint is in the centre of. These samples are divided into 4×4 sub regions in 8 direction around the keypoint. Each point have weighted magnitude and gives less weight to gradients far from keypoint as shown in figure 4. Hence feature vector dimensional is 128 (4×4×8).

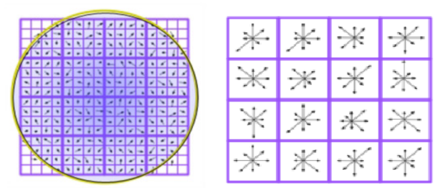


Fig 5. Key point descriptor

At last, the vector is normalized to unit length. A change in image contrast in which each pixel value is multiplied by a constant will multiply gradients by the same constant. Contrast change will be cancelled by vector normalization and brightness change in which a constant is added to each image pixel will not affect the gradient values, as they are computed from pixel differences.

SIFT based features are local and these SIFT features are based on the appearance of the vehicle at particular interest regions. The invariant features are detected and extracted, for input image.

2.4 Feature Matching

With above process, scale invariant key points of the given objects or vehicle is determined and for each keypoint local descriptors are determined. Hence for each vehicle a set of keypoint, local descriptors are stored in the database. When an object is tested for its identity, that object is firstly tested for the area ranges defined for three types of vehicles like Two wheeler, Car, Truck. Based on typical values, vehicles having area greater than 6500 are considered trucks, vehicles having area greater than or equal to 1900 and less than or equal to 6200 are considered as cars ,while all other vehicles are classified as two-wheelers. After satisfying defined area range then the input segmented object is given as input to the SIFT algorithm, where feature extraction of that object takes place, with the above procedure. The SIFT features are extracted and these obtained features are matched to the SIFT feature database which is obtained from the training images. In feature matching [7], for each feature in the query image, the descriptor is used to search for its nearest neighbour matches among all the features from all the images contained in a feature database. The nearest neighbours are selected by satisfying a minimum Euclidean distance criterion for the descriptor vectors and for the query and database image , respectively.

2.5 Vehicle Counting

The concepts of distinctive invariant features are used for reliable matching of vehicles. While the tracked image forms the input image for counting [7]. The presence of vehicle is detected, with the help of binary detection of moving vehicle. The three variables are maintained that keeps track of the number of vehicles according to their class . In this project three classes of vehicles are defined, which are Two Wheelers, Car and Truck. This count register contains the information of number of vehicles passed. When a new vehicle is encountered it is first tested for identification of its class. After identifying its class, count is incremented according to class.

3. Experimental Results

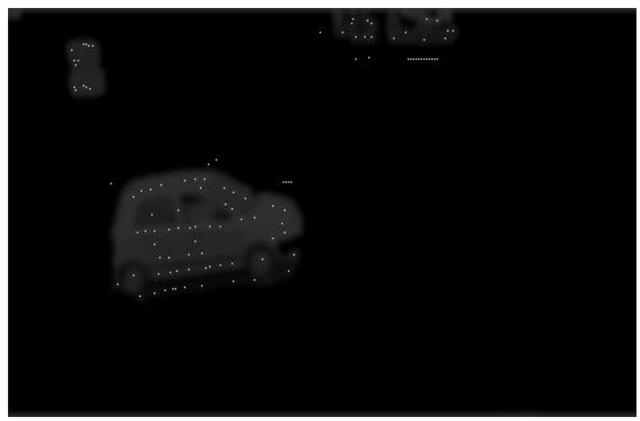
As in figure 6. (a), (b), (c), (d) and (e) Original Frame, Edge detected Frame, Dilated Frame and Segmented Frame are shown respectively. As a part of preprocessing in the proposed method, moving regions are extracted using frame difference and binary detection of object. Then in next step segmentation is performed. The segmentation operation effectively separates the homogeneous regions from the rest of image. The result of segmentation is shown in figure 6(e).Segmentation step is followed by Feature extraction using SIFT. During this step segmented frame is given as input and keypoint detection of that segmented object takes place. After plotting of keypoints over that object, that obtained keypoints are matched with the database image. GUI of the vehicle classification and counting is shown in figure 6(f),(g),(h).

(a)

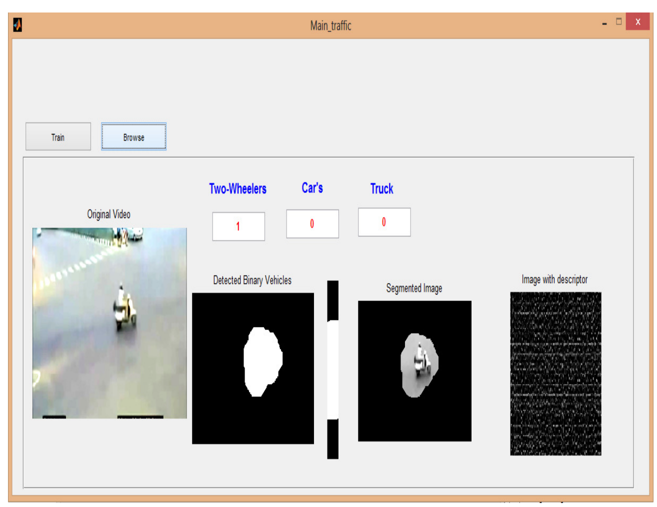
(b)

(c)

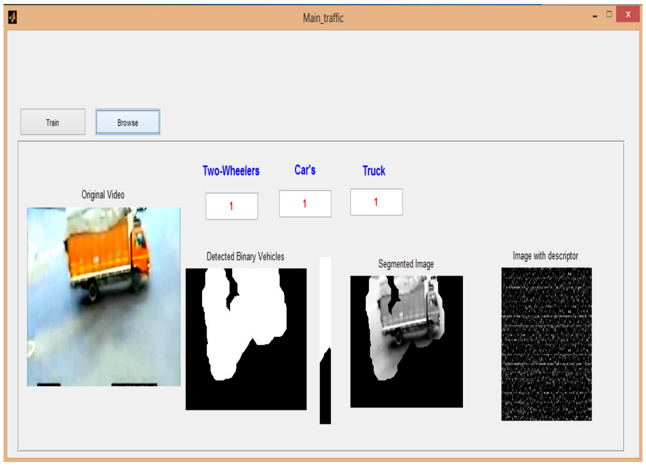
(d)



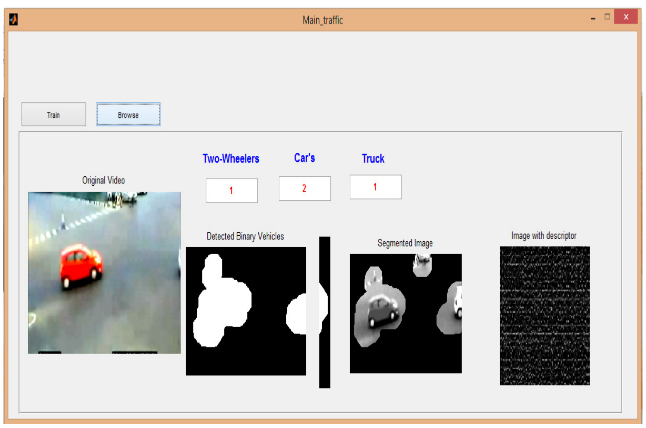
(e)



(f)



(g)



(h)

Fig 6.(a) Original Frame, (b)Edge detected Frame, (c)Dilated Frame, (d) Segmented Frame (e)Keypoints mapped onto the vehicle, (f),(g),(h) GUI of Vehicle Classification and Counting

4. Conclusion

In this paper Scale Invariant Feature Transform (SIFT) is used for vehicle classification and counting is done according to class of vehicle is described. In this paper keypoint detection , feature matching and classification is done using Matlab R2013a. With the help of SIFT algorithm, extraction invariant image features, that are stable over image translation, rotation, scaling, camera viewpoint and somewhat invariant to changes in the illumination will be possible.

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