IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Speed Determination of a Moving Object of a Video Using Background Extraction and Normalized Cuts Segmentation

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Abstract

This paper is concerned with the determination of the traveling speed of a moving object of a video clip based on subsequent object detection techniques. After preprocessing of the original image sequence, which is sampled from the video camera, the target moving object is detected with the improved algorithm in which the moving object region can be extracted completely through several processing of background extraction and Normalized Cuts Segmentation. Among the multiple moving objects of the video, the target object has been detected based on particular criteria of region that it occupies. Then the results of these processing can be used to determine the traveling speed of the target moving object from changes of its coordinate position from the video frames. Among the different video file format, Audio Video Interleaved (AVI) format has been used to examine our experiments.

Keyword: Background Extraction, Normalized Cuts Segmentation, Reference Image, Speed Determination.

Introduction

To determinate the traveling speed of a selected moving object of a video clip, one have to process video clips to get all the frames and also process all the images getting from video clip to extract the object region in each frame in a systematic way. The initial focus of research efforts in this field was on the development of object detection method for detecting the object with certain coordinate position in an image. There are so many techniques for object detection, but no one is efficient for all kind of object as well as, all the object detection techniques is not efficient for the same object in the real world [10]. So still now it has not a final stage that may stop the works in that field. In this paper it is described that Background Extraction and Normalized Cuts Segmentation for detect a moving object for determination the traveling speed of that object from a given suitable video sequence. The advantages of these techniques are simplicity, fault tolerance, and efficient for a customized moving object [10]. The key idea of Background Extraction is to extract the static background from the foreground containing some movable image objects that are to be detected. After this, the Normalized Cuts Segmentation works as the objects in the image are differentiated as region and finally the centered location of each region is find out for identifying that object. Finally the traveling speed of that moving object is determined by calculating the changes its coordinate position in each frame in the video sequence.

Proposed Speed Determination Process

First, The proposed speed determination system of a moving object shown in Fig. 1 consists of processing the video clip, after getting all frame of the video, each frame of the video is processed and find out the coordinate position of each object of the frame and finally determinate the speed of target object from its shifting position . Brief details of each component are described in the following sections.

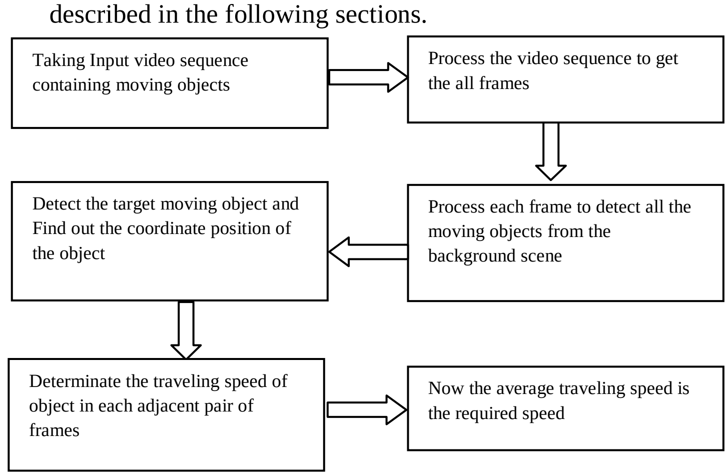

Fig. 1 Schematic diagram of the proposed speed determination of moving object.

Video clip from the video camera is taken and process it as needed to convert AVI format and get all the frames of that video clip which are inputted to the next phase of this work.

Detection of All Moving Objects

Detection of all moving objects is combined result of the procedure Background Extraction and Normalized Cuts Segmentation which is the most important part of this work and is given bellow:

Background Extraction:

Define abbreviations and acronyms the first time they are Background extraction is the process of distinguishing novel (foreground) from non-novel (background) elements in a scene from a video sequence [3]. Movement detection would be sufficient to different application. But we can nonetheless specify two characteristics that we would like to find in any algorithm: real time processing and real environment performance.

In this paper, we have used a simple model for extracting background from each frame in the video sequence with respect to a reference image that is given just later.

For detecting object in Speed analysis can be viewed as three different problems [3].

* The first is the case when the camera is moving and the objects in the world are stationary. In this case, the extraction of camera motion is a challenge.

* In the second case, the camera is stationary, and objects in the world are moving.

* It is the combination of the two, where both the camera and some objects in the world are moving.

As, in our work the camera is stationary, so second case is applicable to this point. Different algorithm is usually applied in the second case. In this case, difference algorithm can be divided into two types: one is difference between continuous images; the other is difference between current image and background images. For difference between current image and background image, suppose that the gray value of current image at position (x, y) is f (x, y), the gray value of background image at position (x, y) is b(x, y), the difference between images can be written as [10]:

$$d(x,y) = f(x,y) - b(x,y) \ldots\ldots\ldots\ldots (1)$$

For difference between continuous images, suppose that the gray value of image at position (x, y) at time t is f (x, y, t), the gray value of image at position (x, y) at time t+1 is f(x, y, t+1), the difference between images can be written as:

$$d(x,y) = f(x,y,t+1) - b(x,y,t) \ldots\ldots\ldots\ldots (2)$$

Reference Image:

Maximum algorithms for speed detection using background extraction proposed a reference image is need to compare the current image in each frame to detect all the moving objects in the video sequence[10]. In our experiments, in this point of view we have used the still image as the reference image getting from the stationary camera just a few ago of taking the video sequence for the moving objects. This is the most general solution and requires the least amount of computations. For most applications however, the reference image may be updated as the scene might change.

Image with moving objects | Reference Image | Resultant Image of background extraction

Fig 2: Background Extraction

Normalized Cuts Segmentation:

Normalized Cuts for image segmentation problem is based on Graph Theory[9] .The objective of graph based segmentation is to partition an image into regions. When a moving object is segmented, a region of pixels assigned to the object is available. This region can be tracked using approaches like cross-correlation. The location of the region in the next frame is to be determined. A moving object usually corresponds to one or several tracked regions. Combination of several regions to one object is then performed at a higher level of abstraction. This technique treats an image pixel as a node of graph, and considers segmentation as a graph partitioning problem. The Normalized Cuts measures both the total dissimilarity between the different groups as well as the total similarity within the groups. Amazingly, the optimal solution of splitting points is easily computed by solving a generalized eigen value problem. A graph G = (V,E) can be partitioned into two disjoint sets A, B. The degree of dissimilarity between these two pieces can be computed as

$$cut(A,B) = \sum_{u \in A, v \in B} w(u,v) \ldots\ldots\ldots (3)$$

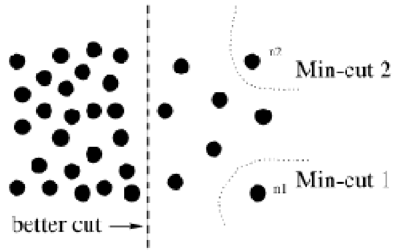

Figure 3: A case where minimum cut gives a bad partition.

Shi an Malik proposed a new measure o disassociation, the normalized cut (Ncut)[9]:

$$Ncut\,(A,B) = \frac{cut\,(A,B)}{assoc\,(A,V)} + \frac{cut\,(A,B)}{assoc\,(B,V)} \ldots\ldots\ldots (4)$$

Where *assoc* $(A,V) = \sum_{u \in A, t \in V} w(u,t)$ is the total connection from nodes in A to all nodes in the graph and *assoc (A,V)* is similarly defined.

Let d(i) = $\sum_j w(i,j)$ be the total connection from the node i to all other nodes. Let D be an N×N diagonal matrix with d on its diagonal, W be an N × N symmetric matrix with

W(i, j) = w(i, j). Then it turns out that we can minimize Ncut(A,B) by

$$\min_{A,B} \; Ncut \;\; (A,B) = \min_{y} \; \frac{y^T (D - W)\, y}{y^T D y} \ldots \ldots (5)$$

If y is relaxed to take real values, the above equation can be minimized by solving the generalized eigen value system,

$$(D - W)\, y = \lambda D y \ldots\ldots\ldots (6)$$

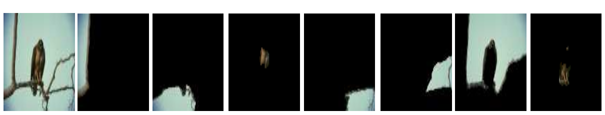

Fig. 4 shows the result of segmentation of a color image using Normalized cuts

Detection of the Target Object And Find Its Position

To identify a single object as target object with its 2D coordinate position from multiple object in each frame from a video sequence, our algorithm always detect the object that is occupied the maximum region. So, when we will take the video sequence for speed determination of the target object, we will focus on the target object as much as possible that the object will occupy maximum region compared to the other moving object. And of course the camera is to be static. To identify the position of the target object in each frame of input video sequence the centered point of the total region that is occupied by the object have been considered as reference point.

Improved Image with multiple objects	Improved Image with target object	Improved Image with indicating centered location of Object

Fig 5: Target object detection

In the similar way, the reference point of target object in each frame of the video is find out and stores these positions. Finally from these positions, the movement of target object is measured and the traveling speed is calculated according to the speed calculation procedure.

Procedure for object detection

1 for i=0 to (totalFrame-1) do
  - a. Read frame[i],
  - b. take the reference image, rImg,
  - c. Update frame[i] using Extract background by rImg and Ncuts,
  - d. process frame[i] as follows :
    - i. Determine the connected components.
      1. Run-length encodes the input image.
      2. Scan the runs, assigning preliminary labels and recording label equivalences in a local equivalence table.
      3. Resolve the equivalence classes. Relabel the runs based on the resolved equivalence classes.
    - ii. Compute the area of each component.
    - iii. Remove small objects bellow a threshold.
  - e. Create morphological structuring element, i.e.; Assign the structuring element as follows:

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 \end{bmatrix}$$

  - f. Close the binary image by the structuring element.
  - g. Measure image regions
  - h. Find the maximum region

i. Identify the centered location (x, y) of that region.
j. Return x-coordinate value and y-coordinate value.
k. End.

V. DETERMINATION OF THE TRAVELING SPEED OF A SELECTED MOVING OBJECT

Several methods for speed determination of some customized moving object from video sequence have developed to date. All of the methods required to detect the image object due to the positional shift in each frame in the given video clip. In our work our proposed method is quite simple and efficient to determinate the traveling speed of the moving object from video sequence. In this method, firstly, we need to detect the target object that moves from initial frame to the last frame in the given video clip that has already been discussed above.

A sample traveling path of a target object and its coordinate position is shown bellow:

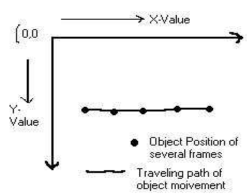

Figure 6: Sample traveling path of a moving object

Our algorithm will work for traveling of object in case of straight line path as well as curvature path approximately. The speed of a moving object is defined as the total amount of distance traveling in unit time.

V (a). Mathematical evaluation for traveling speed determination

Let, $f_1, f_2, \ldots\ldots, f_{n-1}$ are the n frames getting from the processed input video sequence, Then we process the each images with background extraction and Normalized Cut segmentation technique to detect the moving object that change their own coordinate position in each frame and find out the target object according to their region that it occupies. If the initial position of the target object in first frame f_0 is (x_0, y_0) at time t_0, the next shifted position in the Second frame f_1 is (x_1, y_1) at time t_1, then the speed between two points is given by

$$S_0 = \sqrt{((x_0 - x_1)^2 + (y_0 - y_1)^2)} / \Delta t_0 \ldots\ldots (7)$$

Where, $\Delta t_0 = t_1 - t_0$

In that way, the next speed between the point (x_1, y_1) and (x_2, y_2) is given by

$$S_1 = (\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}) / \Delta t_1 \ldots\ldots (8)$$

Where, $\Delta t_1 = t_2 - t_1$

In the similar way $S_2, S_3, \ldots\ldots, S_{n-2}$ are calculated.

Now the average speed is the final speed of the target object and is given by:

$$S = S_0 + S_1 + \ldots\ldots\ldots\ldots + S_{n-2}) / (n-1) \cdots\cdots (9)$$

The value of S is the required speed of the target object in pixel per unit time. The real speed is find out by comparing the pixel with the distance from the left to right point of the scene of a video frame and it is predefined for a specific camera (as the camera stationary). The real distance capture by camera (widely) is taken either from camera parameter or manually.

Procedure for speed determination of a selected moving object

1. Load the input video file containing moving objects.
2. Process the file to get the required information about the video file
3. Find the number of frames N_F of the video
4. Find the frame rate R_F of the video.
5. Calculate the total duration of the video as: $T \leftarrow N_F / R_F$ second and unit time $\Delta t = T / N_F - 1$
6. Determinate the displacement D_i of the object between the i-th frame and (i+1) -th frame using the Object detection procedure.
7. Calculate the speed S_i between the frames F_i and F_{i+1} as $S_i = D_i / \Delta t$
8. Repeat step 6 to 7 for i= 0 to $N_F - 2$, to determinate f_1 all the speed between the frames.\
9. Calculate the average value of speed as $S = sum(S_i) / N_F - 1$
10. $S_{final} = \frac{TotalDisanCapteredByCameraInMeter(widely)}{TotalPixel(Widely)} \times S$
11. S_{final} is the real speed (meter/ second) of the moving object.
12. End.

Result and Discussions

Firstly, here a sample video clip (first and last frame) which contains a moving object (Ambulance) is shown:

Fig 7: The initial and final stage of a sample video clip with moving object indication with the circle

Several frames of the sample video (ambulance3.AVI) are given bellow and the coordinate positions of the moving target object are also mentioned with improved frames:

Frame No: 1, Object

Frame No: 7, Object position (132, 93)

Frame No: 13,Object position (112,93)

Frame No: 20,Object position (89,95)

Several frame of input video

Finally, according to the speed calculation procedure, the traveling speed of the moving object of the sample video (ambulance3.avi) is 9.55402 meters per second.

Conclusion

In this paper, an attempt has been made to develop a virtual system for determination the traveling speed of a selectable moving object of a suitable video clip using subsequent object detection technique based on background extraction and Normalized Cuts Segmentation near to the real time. Background extraction and the Normalized Cuts Segmentation techniques are relevant to detect multiple moving object to determinate the traveling speed of target moving object of a video clip. As we know that object detection technique is not completely efficient for all kinds of objects which is available presently all over the world, so this work demonstrated some gateway to overcome those limitations. After all, for the test bench for this work, the traveling speed of a selected moving object of a suitable video clip has been determined at a satisfactory level. In this research, the primary works are the video processing as well as image processing for the detection of moving object within the video clip, but it focuses on the detection of multiple objects from images in the video sequences and detecting the target object based on region that it occupies to determine the traveling speed of the moving object.

Acknowledgments

I am very much grateful to my almighty Allah and also would like to thank *Dr. A. K.M. Akhtar Hossain*, *S. M Hasan Sazzad Iqbal*, *Md. Rashedul Islam*, and all the faculties of my departments for attracting my attention to the Image Processing fields some ago.

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