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Speed Determination of a Moving Object of a Video Using Background Extraction and Graph 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 Minimal Graph 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, Minimal Graph 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 Minimal Graph 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 Minimal Graph 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.

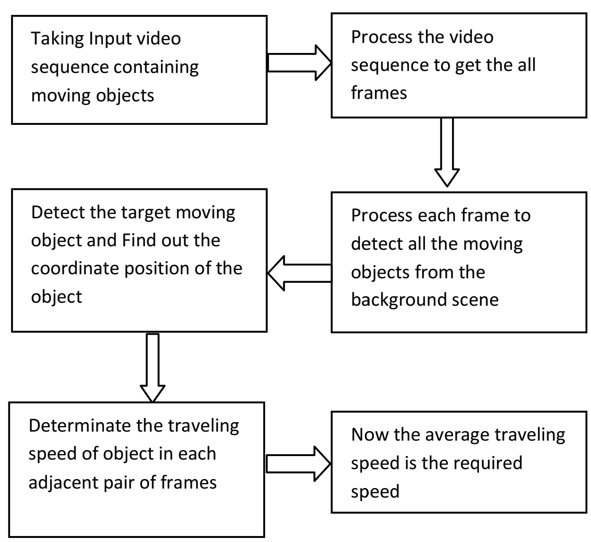

Fig. 1 Schematic diagram of the proposed speed determination of moving object.

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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 Minimal Graph 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]:

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

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:

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

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.

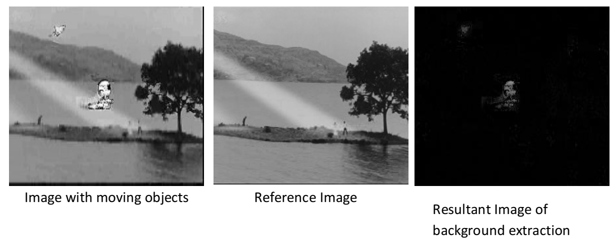

Fig 2: Background Extraction

Graph Cuts Segmentation:

A graph cut is the process of partitioning a directed or undirected graph into disjoint sets. The concept of optimality of such cuts is usually introduced by associating energy to each cut. Problems of this kind have been well studied within the field of graph theory but can for graphs with more than only a few nodes be notoriously difficult. Nevertheless, ever since it became apparent that many low-level vision problems can be posed as finding energy minimizing cuts in graphs these techniques have received a lot of attention in the computer vision community. Graph cut methods have been successfully applied to stereo, image restoration, and texture synthesis and image segmentation. Below we give a brief overview of graph cuts for image segmentation as well as an introduction to some basic definitions [9].

Min-cut/Max-flow cuts

Given a graph $G = \{V, E, W\}$ where V denotes its nodes, E its edges and W the affinity matrix, which associates a weight to each edge in E. A cut on a graph is a partition of V into two subsets A and B such that

$$A \cup B = V, A \cap B = \phi$$

Perhaps the simplest and best known graph cut method is the min-cut formulation. The min-cut of a graph is the cut that partitions G into disjoints segments such that the sum of the weights associated with edges between the different segments are minimized. That is, the partition that minimizes

$$C_{\min}(A,B) = \sum_{u \in A, v \in B} W_{uv} \dots\dots\dots\dots (3)$$

However, as this is an NP-hard combinatorial optimization problem, the task of finding the solution can be a formidable one. In order to overcome this one can relax into a semi-definite program, resulting in a convex problem for which efficient solvers exist. However, the task of finding the solution to the original problem from the relaxed one still remains an open issue. Another commonly used approach is based on a slight reformulation of the original min-cut problem. By adding the requirement that two predefined nodes, denoted terminal nodes or source and sink nodes, in G must be in separate sets, the complexity of the problem is significantly reduced. Finding the min-cut separating the source and the sink, the s-t cut, can be achieved in polynomial time [1]. If one views the weights associated to each node as a flow capacity it can be shown that the maximal amount of a flow from source to sink is equal to the capacity of a minimal cut. Therefore the min-cut problem is also known as the max-flow problem.

The Image Seen as a Graph:

The general approach to constructing an undirected graph from an image is shown in the following figure 3 .

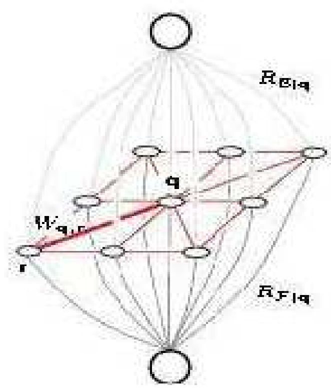

Figure 3: Graph representing a 3-by-3 image.

Basically each pixel in the image is viewed as a node in a graph, edges are formed between nodes with weights corresponding to how alike two pixels are, given some measure of similarity, as well as the distance between them. In attempt to reduce the number of edges in the graph only pixels within a smaller, predetermined neighborhood N of each other are considered. The two terminal nodes, the source and the sink does not correspond to any pixel in the image but instead are viewed as representing the object and background respectively. Edges are formed between the source and sink and all other non-terminal nodes, where the corresponding weights are determined using models for the object and background.

The min-cut of the resulting graph will then be the segmentation of the image at hand. This segmentation should then be a partition such that, owing to the definition of image-pixel resemblance, similar pixels close to each other will belong to the same partition. In addition, as a result of the terminal weights, pixels should also be segmented in such a manner so they end up in the same partition as the terminal node corresponding to the model (object or background) they are most similar to.An illustration of the segmentation process can be seen in the following figure 4

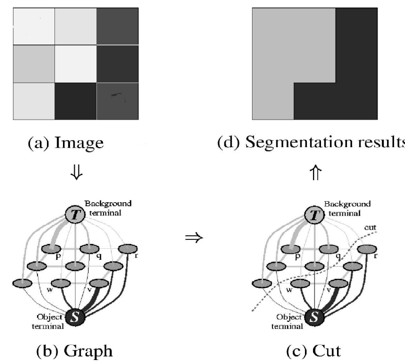

Figure 4: Example segmentation of a very simple 3-by-3 image. Edge thickness corresponds to the associated edge weight. (Image courtesy of Yuri Boykov.)

The edge weight between pixel i and j will be denoted W_i^t and the terminal weights between pixel i and the source (s) and sink (t) as W_i^s and W_i^t respectively and are given by

$$W_{ij}^{I} = e^{(-\frac{r(i,j)}{\sigma_R})} e^{(-\frac{||\mathbf{w}(i)-\mathbf{w}(j)||^2}{\sigma_W})}$$

$$W_i^s = \frac{p(\mathbf{w}(i)|i\in s)}{p(\mathbf{w}(i)|i\in s)+p(\mathbf{w}(i)|i\in t)}$$

$$W_i^t = \frac{p(\mathbf{w}(i)|i\in t)}{p(\mathbf{w}(i)|i\in s)+p(\mathbf{w}(i)|i\in t)}$$

---(4)

Here || .|| denotes the euclidian norm, r(i; j) the distance between pixel i and j and $\lambda \partial_R$ *and* ∂_W are tuning parameters weighing the importance of the different features. Hence, W_{ij}^I contains the inter-pixel similarity, that ensures that the segmentation more coherent. W_i^t And W_i^s describes how likely a pixel is to being background and foreground respectively.

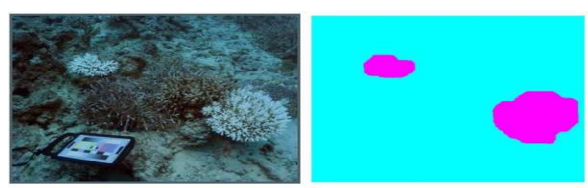

Figure 5: Graph Cuts Segmentation

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 | Improved Image with | Improved Image with indicating

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.

End.

Determination on 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 below:

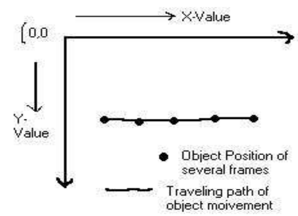

Figure 6: Sample traveling path of a moving object

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.

Mathematical evaluation for traveling speed determination

Let $f_1, f_2, \ldots\ldots, f_{n-1}$ t_0 are the n frames getting from the processed input video sequence, Then we process the each images with background extraction and Graph 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

$$S_0 = \sqrt{((x_0 - x_1)^2 + (y_0 - y_1)^2)} / \Delta t_0 \ldots\ldots (5)$$

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

$$S_1 = (\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}) / \Delta t_1 \ldots\ldots (6)$$

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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:

$$S = S_0 + S_1 + \ldots\ldots\ldots\ldots\ldots + S_{n-2}) / (n-1) \cdots\cdots (7)$$

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 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 position (152,93) | Frame No: 7, Object position (132, 93) | Frame No: 13,Object position (112,93) | Frame No: 20,Object position (89,95)

Fig 8: Several frame

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 Minimal Graph Cuts Segmentation near to the real time. Background extraction and the Minimal Graph 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 allover 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.

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