Video Image Tracking Technique Based On Shape-Based Matching Algorithm

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Abstract: We present an application of digital video images for object tracking. In order to track a fixed object, which was shoot on a moving vehicle, this study develops a shape-based matching algorithm to implement the tracking task. Because the shape-based matching algorithm has scale and rotation invariant characteristics, therefore it can be used to calculate the similarity between two variant shapes. An experiment is performed to track the ship object in the open sea. The result shows that the proposed method can track the object in the video images even the shape change largely.

Key words: Shape Matrix, Video Image Tracking, Mean Square Error.

1. Introduction

This study presents a tracking algorithm to track the object with continuous shape change. Because most of the data are recorded at 30 frames per second, the data are regarded as highly correlated and shape invariant between two adjacent images. However, the shape of object in the video images will continuously change when the camera is mounted on a moving vehicle. The widely used image matching algorithms traditionally adopt the area-based technique to perform the matching [3] [4]. The success of area-based matching algorithms highly depends on the invariance of the shape of the object. Since the object in our study changes the shape all the way in the recording period, the area-based matching algorithms obviously will fail in matching the desired objects. This study develops a shape-based matching algorithm to trace the object.

The main ideal of shape-based matching technique is displacement, rotation and scale invariant. In this study, Shape Matrix Algorithm **(SMA)** [1], [2] is used to develop our matching technique. The position of gravity center obtained by SMA technically is the initial result of the matching process, which needs to be refined to a more accurate position. The refinement is implemented by the method of Mean Square Error **(MSE).** It is clearly shown that the combination of SMA and MSE can be used to track shape changing objects successfully.

All the algorithms used in this study are detailed in section 2. The test data and the results can be found in section 3. The conclusion remarks will be discussed in section 4.

2. Algorithms

There are four main steps in the tracking procedures. The first step is to segment the target object from the image. The second step uses SMA to find both scale and rotation changes between the two adjacent images. In order to make the two images have the same scale and rotation factor, the image will be adjusted by the result of SMA in the third step. Finally, MSE is introduced to find more accurate position.

1) Segmentation

Before the matching can begin, the object has to be segment by the color information of the object. In this study, a rough polygon and its surrounding pixels is manually selected in the first image as the foreground and background data. Then an unsupervised classification technique is used to classify the foreground and the background data. The classified maps of foreground and background are used to separate background and object in the next image. Followings are the brief description of the above algorithm.

For given pixel **P** is the candidate pixel in the search window in next image.

$\{O_c\}$ is the object's class centers, $\{B_c\}$ is the background's class centers and **T** is the threshold of distance in color space that is a trial and error result.

If (P.Minimum Distance to $\{B_c\}$<T)
P is a background pixel.
If (P.Minimum Distance to $\{O_c\}$<T)
P is an object pixel.
Else P is a background pixel.

After the segmentation, we can get one binary shape image. In the binary shape image, the desired object segment may contain some background pixels. In this case, the background pixels are remounted by erosion and dilation operation. In addition, some undesired objects may appear in the background segment. The point-based labeling method is used to eliminate undesired objects that normally are smaller compared with the desired object.

Fig.1 demonstrates the object segment result.

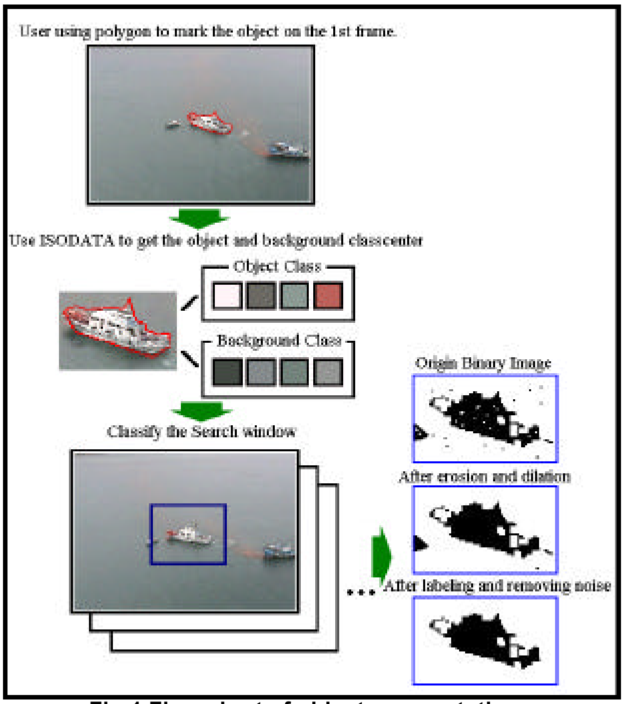

Fig.1 Flow chart of object segmentation.

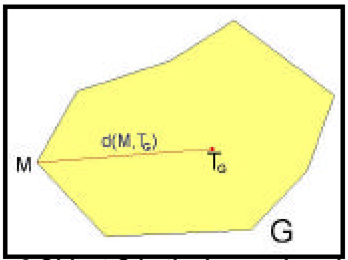

Fig.2 Object G in the image domain.

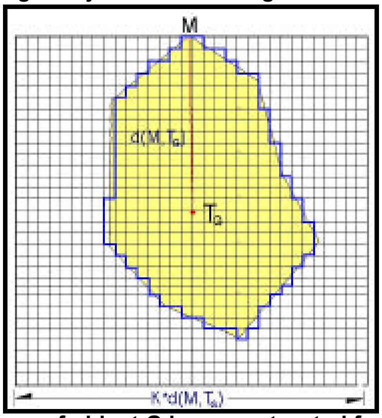

Fig.3 Shape of object G is reconstructed from SMA.

2) Shape-based Matching (SMA)

The object in the binary shape image can be reconstructed a shape matrix (Fig.2, Fig.3). In order to determine the degree of similarity between two objects OT and OS, their shape matrixes B^{OT} and B^{OS} are compared. Because the dimensions of the matrixes should be equal, we assign the dimension of the matrix $n = K * \max[\max_{A \in OT} d(A, T_{OT}), \max_{A \in OS} d(A, T_{OS})]$.

The similarity p (B^{OT}, B^{OS}) is defined by the following formula:

$$p(B^{OT}, B^{OS}) = 1 - \frac{1}{n \times n} \sum_{j=1}^{n} \sum_{i=1}^{n} \left| B_{ij}^{OT} - B_{ij}^{OS} \right|$$

For each point M that is a pixel of the boundary of the object G, it will produce difference shape matrix depending on the point M used. Let object OT can be described by X matrixes and OS can be described by Y matrixes. The similarity p(OT,OS) is shown as follow:

$$p(OT, OS) = \max_{ij} \; p(B_i^{OT}, B_j^{OS})$$

$$i = 1 \text{ to } X \;\;,\;\; j = 1 \text{ to } Y$$

The scale factor K influences the accuracy of similarity; the higher K gets higher accuracy. Considering saving compute time, we set K=3 in this study. By using SMA we can find the similarity between two objects and can identify the block as object's block or not. Through the coefficients of the transformation, it can also get the rotation, scale and displacement relations between the two shapes.

3) Mean Square Error

In attempt to refine the matching result, this study uses the mean square error criterion. It has to examine every single candidate block inside the search window to find the best block match inside the search window. Using the result of SMA, it is posssible to eliminate the shape change of the object. Therefore it can be used to find the best match block position which with highest probability.

The size of target block is 7 by 7 in this research and center of the block is given by the result of TDGO [5]. TDGO is an interest operator, which can find the feature point in an image. The boundary of the search window is decided by the object's boundary rectangle on the next frame. MSE measures the magnitude of error as a result of two blocks' comparison. The detail of MSE are shown as follows.

Let B_{pq} is the candidate block with position (p,q) in next image and T_{rs} is the target block with position (r,s) in current image. The Mean Square Error of two blocks is given as:

$$MSE(B_{pq}, T_{rs}) = \frac{1}{N \times M} \sum_{i=1}^{N} \sum_{j=1}^{M} \left(B_{pq}^{ij} - T_{rs}^{ij} \right)^2$$

Where:

M,N are the dimensions of the block.

i,j represent the position of pixels in blocks.

3. Test data and results

The test data used in this study were acquired by the helicopter flied over the open sea. The target attempted to trace in the video images is a steady ship. The time interval between the two images is 100ms and the image size is 320 by 240 pixels. Experiments have shown that the shape of the object can be segment from the image successfully; moreover, the SMA can recognize the object block and calculate the rotation and scale change of the object. The displacement of the object in video images can be computed by moving window and MSE.

The results are shown in Fig.4 (a), Fig. 4(b) and Fig. 4 (c). The red contour is the result of segmentation and SMA, and the green cross is the more accurate matching result that is produced by MSE. Even though the shape of the object has a big change, the proposed algorithm can still trace the object well. The execute time of object tracking on AMD 1.8GHz based PC is about 150~250ms per image. The size of the experiment object is about 40 by 80 pixels.

Fig. 4(a) the 1st image

Fig. 4(b) the 137th image

Fig. 4(c) the 247th image

4. Conclusion

In this paper, we have presented a shape-based matching method for video image tracking. The method uses unsupervised classifier to segment the object from background and SMA and MSE is used to find the object's position in next image. The result shows that the proposed method can track the object even though the shape of the tracking object changed.

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