Performance Evaluation of Object Tracking Technique Based on Position Vectors

V Purandhar Reddy vpreddy4@gmail.com
Associate Professor,
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

K Thirumala Reddy kanipakamthirumala@gmail.com
Assistant Professor,
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

Y.B.Dawood dawoodyb@gmail.com
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

K.M.YaagnaTheja yaagnatheja@gmail.com
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

C.Munesh muneshneverstepbacks@gmail.com
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

M.V.L.Sraavani sraavani.mvl@gmail.com
Dept of ECE, S V college of Engineering,
Tirupati, 517507, India.

Abstract

In this paper, a novel algorithm for moving object tracking based on position vectors has proposed. The position vector of an object in first frame of a video has been extracted based on selection of region of interest. Based on position vector in first frame object direction has shown in nine different directions. We extract nine position vectors for nine different directions. With these position vectors next frame is cropped into nine blocks. We exploit block matching of the first frame with nine blocks of the next frame in a simple feature space by Descrete wavelet transform and dual tree complex wavelet transform. The matched block is considered as tracked object and its position vector is a reference location for the next successive frame. We describe performance evaluation and algorithm in detail to perform simulation experiments of object tracking using different feature vectors which verifies the tracking algorithm efficiency.

Keywords: Object Tracking, DWT, DTCWT, Feature Vector, Block Matching.

1. INTRODUCTION

The moving object tracking in video pictures has attracted a great deal of interest in computer vision. For object recognition, navigation systems and surveillance systems, object tracking is an indispensable first-step.

The conventional approach to object tracking is based on the difference between the current image and the background image. However, algorithms based on the difference image cannot simultaneously detect still objects. Furthermore, they cannot be applied to the case of a moving camera. Algorithms including the camera motion information have been proposed previously, but, they still contain problems in separating the information from the background.

In this paper, we propose object tracking in video pictures based on position vectors. Our algorithm is based on position vector calculation and block matching by feature vectors .The proposed method for tracking uses block matching between successive frames. As a consequence, the algorithm can simultaneously track multiple moving and still objects in video pictures.

This paper is organized as follows. The proposed method consisting of stages position vector calculation, feature extraction by different transforms, block matching and minimum distance measure which are described in detail.

2. PROPOSED MOVING OBJECT TRACKING TECHNIQUE

2.1 Extraction of Position Vectors

2.1.1 First Frame position vector extraction

In general, image segmentation and object extraction methods are used to calculate position vectors. In the proposed concept, first select the portion of an object which is to be tracked. The portion of an image is cropped in the first frame which is referred as block.

Based on co-ordinate parameters of an block, we extract the position of the pixel Pxmax (Pxmin) which has the maximum (minimum) x-component.

$$Pxmax = (Xmax,x,Xmax,y),$$
$$Pxmin = (Xmin,x,Xmin,y),$$

Where Xmax,x, Xmax,y, Xmin,x, and Xmin,y are x and y coordinates of the

Rightmost and leftmost boundary of the block, respectively. In addition, we also extract

$$Pymax = (Ymax,x, Ymax,y),$$
$$Pymin = (Ymin,x, Ymin,y).$$

Then we calculate the width w and the height h of the block as follows

$$w_i(t) = Xmax,x - Xmin,x,$$
$$h_i(t) = Ymax,y - Ymin,y.$$

We define the positions of each block in the frame as follows

$$P = (X_1,Y_1)$$
$$X_1(t) = (X\ max,x + X\ min,x)/2$$
$$Y_1(t) = (Ymax,y + Ymin,y)/2$$

2.1.2 Position Vectors in nine different directions

Frame to Frame movement distance of an object is negligible. So, we consider movement shift by “m” units in nine different directions as shown in the figure (1).

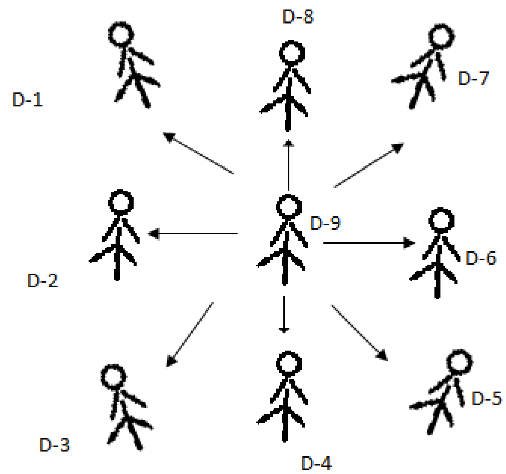

FIGURE 1: Movement of Object in Nine Different Directions.

For Direction 1, position vector shift $P_1= (X_1\text{-m},Y_1)$

For Direction 2, position vector shift $P_2= (X_1\text{+m},Y_1)$

For Direction 3, position vector shift $P_3= (X_1,Y_1\text{+m})$

For Direction 4, position vector shift $P_4= (X_1,Y_1\text{-m})$

For Direction 5, position vector shift $P_5= (X_1\text{-m},Y_1\text{-m})$

For Direction 6, position vector shift $P_6= (X_1\text{+m},Y_1\text{+m})$

For Direction 7, position vector shift $P_7= (X_1\text{-m},Y_1\text{+m})$

For Direction 8, position vector shift $P_8= (X_1\text{+m},Y_1\text{-m})$

For Direction 9, position vector shift $P_9= (X_1,Y_1)$

Based on the position vectors $P_1,P_2,P_3,P_4,P_5,P_6,P_7,P_8$ and P_9 crop the second frame into nine blocks.

2.2 Feature Vectors Using DWT & DTCWT

For testing the developed algorithm, Feature vectors are calculated by two methods one is by using Descrete Wavelet Transform (DWT) and the other is Dual Tree Complex Wavelet Transform (DTCWT).

2.2.1 2D-Discrete Wavelet Transform

A weakness shared by most of the texture analysis schemes is that the image is analyzed at one single-scale. A limitation that can be lifted by employing multi-scale representation of the textures such as the one offered by the wavelet transform. Wavelets have been shown to be useful for texture analysis in literature, possibly due to their finite duration, which provides both frequency and spatial locality. The hierarchical wavelet transform uses a family of wavelet functions is associated scaling functions to decompose the original signal/image into different sub bands. The decomposition process is recursively applied to the sub bands to generate the next level of the hierarchy. At every iteration of the DWT, the lines of the input image (obtained at the end of the previous iteration) are low-pass filtered and high pass filtered. Then the lines of the two images obtained at the output of the two filters are decimated with a factor of 2.

Next, the columns of the two images obtained are low and high pass filtered. The columns of those four images are also decimated with a factor of 2. Four new sub-images representing the result of the current iteration are generated. The first one, obtained after two low-pass filtering, is named approximation sub-image (or LL image). The others three are named as detail sub-images: LH, HL and HH. The LL image represents the input for the next iteration.

In this paper we have used level 2 Haar transform. Only the second level LL image is used for the analysis as that contains most of the important information for feature vector calculation. For first frame the feature vector is f1 based on cropped image using position vector P1.For next frame feature vector set is V={V1,V2,V3,V4,V5,V6,V7,V8,V9} based on position vectors P1,P2,P3,P4,P5,P6,P7,P8 &P9.

2.2.2 Dual Tree Complex Wavelet Transform

Dual Tree Complex Wavelet Transform is a recent enhancement technique to the Discrete Wavelet Transform with some additional properties and changes. It is a effective method for implementing an analytical wavelet transform.

DTCWT gives the complex transform of a signal using two separate DWT decompositions ie., tree ‘a’ and tree ‘b’. DTCWT produces complex coefficients by using a dual tree of wavelet filters and gives real and imaginary parts.

The DTCWT has following properties:

- Approximate shift invariance;
- Good directional selectivity in 2-dimensions (2-D) with Gabor-like filters also true for higher dimensionality: m-D);
- Perfect reconstruction (PR) using short linear-phase filters;
- Limited redundancy: independent of the number of scales: 2:1 for 1-D 2m :1 for m-D)
- Efficient order-N computation - only.
- DTCWT differentiates positive and negative frequencies and generates

Six sub bands oriented in ±15°, ±45°, and ±75 °. The different levels of DTCWT such as levels 5, 6, and 7 are applied on Cropped Blocks.

For performance analysis of algorithm we have used DTCWT Vectors for feature vector calculation. For first frame the feature vector is f1 based on cropped image using position vector P1.For next frame feature vector set is V={V1,V2,V3,V4,V5,V6,V7,V8,V9} based on position vectors P1,P2,P3,P4,P5,P6,P7,P8 &P9.

2.3 Block Matching and Distance Measure

Using the Feature Vector in the first frame and feature vectors of next frame we perform the minimum distance by Euclidean distance between feature vectors. Finally the cropped image is identified with minimum distance feature vector of next frame. Repeating this matching procedure for all the frames with first frame, we can identify all cropped area one by one and can keep track of cropped area between frames.

2.3.1 Object Tracking Algorithm

1. Input video
2. Crop the first frame for ROI(Region Of Interest)
3. Calculate position vector for cropped portion.P=(X_1,Y_1)
4. Based on position vector calculate nine position vectors with X and Y co-ordinate shift by 'm' units. $P_1=(X_1\text{-}m,Y_1)$, $P_2=(X_1+m,Y_1)$, $P_3=(X_1,Y_1+m)$,$P_4=(X_1,Y_1\text{-}m)$, $P_5=(X_1\text{-}m,Y_1\text{-}m)$,$P_6=(X_1+m,Y_1+m)$, $P_7=(X_1\text{-}m,Y_1+m)$, $P_8=(X_1+m,Y_1\text{-}m)$, $P_9=(X_1,Y_1)$
5. For previous frame i.e first frame perform feature vector extraction method for cropped block to get feature vector f_1.
6. Similarly perform DWT for all cropped blocks in the next frame K+1 to get the feature vectors and for vector set V.
7. Block matching distance measure
   a.) Calculate the distance measured using Manhattan distance between f_1 and V.

   b.) Apply Feature Vector matching of K^{th} frame cropped image with minimum distance block of $K+1^{th}$ frame. If not matched, perform for next successive frame.

   c.) After matching remove the position vector data of N^{th} frame and store the data of position vector of $K+1^{th}$ frame.

   d.) Increase the value of K by K+1.
8. Repeat the steps from 1 to 7.

3. IMPLEMENTATION

The implementation of proposed object tracking technique using DWT & DTCWT Feature Vectors is done in MATLAB 7.0.

3.1 Video Data

The object tracking techniques by DWT & DTCWT are tested on the Video Pictures. To compare the techniques and to check their performance we have used the Precision of object Tracking and tracking speed.

3.2 Precision of Object Tracking

Here we address some of the features of an efficient Object tracking system such as accuracy, stability and speed. To assess the object tracking effectiveness, we have used the precision as Statistical comparison parameters for the DWT and DTCWT. The definitions of Precision is given by the equation

$$Object\ Tracking\ Precision = \frac{Number\ of\ frames\ with\ object\ tracking\ Result}{Number\ frames\ given\ for\ object\ tracking\ test} x100$$

4. RESULTS AND DISCUSSION

The object tracking methods by DWT and DTCWT were applied to the Video frames. The precession is 95% in case of DTCWT and 92 % in case of DWT for 100 frames. This shows that DTCWT outperforms DWT. As far as precision is concerned DTCWT gives best performance.

Table 1 shows the actual precision values computed for considered query frame at percentage precision using two techniques discussed in the paper.

FIGURE 2: Tracking Results from Successive Frames Using DTCWT Feature Vectors.

FIGURE 3: Tracking Results from Successive Frames Using DWT Feature Vectors.

Method	Precision based on number of frames						Execution time between two frames
	5	10	15	20	25	30	
DWT	100%	100%	93.3%	90%	92%	93.3%	0.4msec
DTCWT	100%	100%	100%	95%	96%	96.66%	0.2msec

TABLE 1: Percentage Precision Values for Object Tracking by DWT and DTCWT Feature Vectors.

5. CONCLUSION

The performance of object tracking system depends on the precision and speed. Percentage Precision is taken as criteria for judging the performance of object tracking technique. Thus DTCWT gives the best performance if precision and speed both are considered. Simulation results for frame sequences with moving objects verify the suitability of the algorithm for reliable moving object tracking. We also have confirmed that the algorithm works very well for more complicated video pictures including rotating objects and occlusion of objects. It is obvious that, the simulation result in the proposed algorithm is quite enough to apply for the real time applications. We would like to implement this algorithm with feature vectors in different vectors for future applications too.

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