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Comparison of CAMSHIFT with Highly Efficient Object Tracking Algorithm

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***Abstract*- Object tracking is a significant task in computer vision. Object Tracking is a process to track an object or multiple objects with the help of cameras. There are a lot of tracking algorithms but the Mean Shift Tracking for its robustness and it is easy to implement. This paper compares the two distinct Mean Shift algorithms first is Continuously Adaptive Mean Shift Algorithm (CAMSHIFT) which is adaption of mean shift algorithm and second method is when scale and orientation is introduced in adaptive mean shift algorithm then it is more efficient and it is called Modified Mean Shift Algorithm (MMST). This paper shows how CAMSHIFT is used for face tracking and how modified mean shift tracking deals with the problem to estimate scale and orientation changes of the target in the mean shift tracking framework. The main aim of this paper is to examine the effectiveness of the different mean shift algorithm. This paper helps for the future work in real time object tracking.**

Keywords: object tracking, Mean Shift, CAMSHIFT, and MMST

I. INTRODUCTION

Object tracking refers to method to track an object (or multiple objects) over a sequence of images. Tracking of visual objects can be done either by forward-tracking or by back-tracking. Mean shift analysis is a possible forward-tracking technique because it estimates the positions of the regions in the current frame from the previous frame. Mean-shift tracking is a technique for following an object of interest as it moves through a video sequence. It is a gradient ascent approach that models the image region to be tracked by its color histogram. The mean shift is a non-parametric feature space analysis technique. The mean shift is a method for finding local maxima of a density function from given discrete data samples. It works with a search window that is positioned over a section of the distribution. The mean shift technique is an application independent tool .It is suitable for real data analysis because it does not assume any prior shape (e.g. elliptical) on data clusters. Therefore, there are numerous approaches employing the mean shift algorithm in object tracking. A large number of papers exist on mean shift tracking techniques.

In the classical mean shift tracking algorithm the estimation of scale and orientation changes of the target is not solved. Although it is not robust, the CAMSHIFT algorithm as the earliest mean shift based tracking scheme, could actually deal with various types of movements of the object. In CAMSHIFT, the moment of the weight image determined by the target model was used to estimate the scale (also called area) and orientation of the object being tracked. Based on Comaniciu *et* al's work many tracking schemes were proposed to solve the problem of target scale and/or orientation estimation. Collins adopted Lindeberg *et aVs* scale space theory for kernel scale selection in mean-shift based blob tracking. However, it cannot handle the rotation changes of the target. An EM-shift algorithm was proposed by Zivkovic and Krose which simultaneously estimates the position of the local mode and the covariance matrix that can approximately describe the shape of the local mode. In a distance transform based asymmetric kernel is used to fit the object shape through a scale adaptation followed by a segmentation process. Hu *et al* developed a scheme to estimate the scale and orientation changes of the object by using spatial-color features and a novel similarity measure function. In this paper, a Modified mean shift tracking (MMST) algorithm is proposed under the mean shift framework.

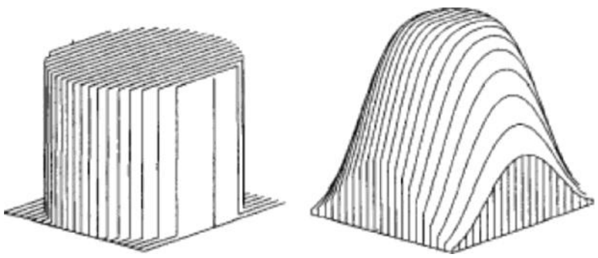
II. Mean Shift Algorithm

The mean shift algorithm is a non-parametric method. It provides accurate localization and efficient matching without expensive exhaustive search. It is an iterative process, that is to say, first compute the mean shift value for the current point position, then move the point to its mean shift value as the new position, then compute the mean shift until it fulfill certain condition. The mean shift is applied in real-time object tracking, named kernel based tracking or mean shift tracking. The size and shape of the interest area is usually described by two kinds of kernel function: One is Epanechnikov K_E (x) kernel, and its kernel profile is:

$$\begin{cases} K_E(x) = \frac{1}{2} C_d^{-1}(d+2)(1-X^T X) & if \quad X^T X < 1 \\ 0 & \text{otherwise} \end{cases}$$

where C_d is the volume of the unit d-dimensional sphere, $\{x_i\}$, (i=1,...,n) be an arbitrary set of n points in the d-dimensional Euclidean space R^d. Under the shape of this kernel, the pixels near the centre would weight greater value than the pixels in the edges which helps tracking the center position of the object. The other one is the normal K_N *(x)* kernel, and its kernel profile is:

$$k_N(x) = \exp(-\frac{1}{2}x) \quad for \quad x \geq 0$$



(a) (b)

Fig 2.1 (a) Epanechnikov K_E (x) kernel; (b) normal K_N (x) kernel

In mean shift tracking, the kernel bandwidth is of importance, because it not only determines the number of participating samples, but also reflects the scale of the tracking window. The traditional mean shift process was limited by the fixed kernel bandwidth. When the object scale changes obviously, especially too big to be covered by the kernel window, the fixed bandwidth leads to the closing of the target. The modified algorithm is called Continually Adaptive Mean Shift algorithm (CAMSHIFT). It adjusts the size of searching window by invariant moments. The computation of the moments destroys the real-time property in tracking. The bandwidth is modified by positive and negative ten percents of increment. It requires three times of the iteration and selects the bandwidth with the biggest Bhattacharyya coefficient. When the object size is reducing, it makes a good result. However, the bandwidth hardly grows while the object size is increasing. It is because the similarity of Bhattacharyya coefficients tends to reach the local maximum in small tracking window. Collins combines the scale space and mean shift algorithm to update the kernel bandwidth dynamically. Since the derivative of adopted kernel, Epanechnikov, is the constant, the iteration of mean shift equals averaging the scale space on the basis of space localization. Consequently this method is like the result in and has complex computation.

III. CAMSHIFT

It is Continuously Adaptive Mean Shift Tracking. It is based on an adaptation of Mean Shift that, given a probability density image, finds the mean (mode) of the distribution by iterating in the direction of maximum increase in probability density. Unlike Mean Shift that uses Static Distributions, it uses continuously adaptive probability distributions (that is, distributions that may be recomputed for each frame). It is one of the simplest methods and supplies reliable and robust results, if the colors in the background differ significantly from those in the target object.

- Set the region of interest (ROI) of the probability distribution image to the entire image.
- Select an initial location of the Mean Shift search window. The selected location is the target distribution to be tracked.
- Calculate a color probability distribution of the region centered at the Mean Shift search window.
- Iterate Mean Shift algorithm to find the centroid of the probability image. Store the zero* moment (distribution area) and centroid location.

$$M_{00} = \sum_x \sum_y I(x,y)$$

$$M_{01} = \sum_x \sum_y yI(x,y)$$

$$M_{10} = \sum_x \sum_y xI(x,y)$$

For the following frame, center the search window at the mean location found in Step 4 and set the window size to a function of the zero* moment. Go to Step 3.

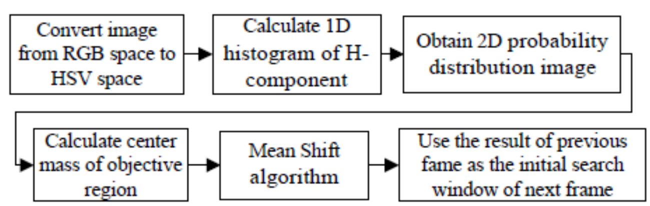


Fig 3.1 CAMshift algorithm calculation process

IV. Modified Mean Shift Algorithm

The enlarging or shrinking of the target is usually a gradual process in consecutive frames. Thus we can assume that the scale change of the target is smooth and this assumption holds reasonably well in most video sequences. If the scale of the target changes abruptly in adjacent frames, no general tracking algorithm can track it effectively. With this assumption, we can make a small modification of the original mean shift tracking algorithm. Suppose that we have estimated the area of the target in the previous frame, in the current frame we let the window size or the area of the target candidate region be a little bigger than the estimated area of the target. Therefore, no matter how the scale and orientation of the target change, it should be still in this bigger target candidate region in the current frame. Now the problem turns to how to estimate the real area and orientation from the target candidate region.

Algorithm for Modified Mean Shift Algorithm

1) Initialization: calculate the target model $\hat{q}$ and initialize the position y0 of the target candidate model in the previous frame.

$$\begin{cases} \hat{q} = \{\hat{q}_u\}_{u=1\cdots m} \\ \hat{q}_u = C\sum_{i=1}^{n} k\left(\left\|x_i^*\right\|^2\right)\delta\left[b\left(x_i^*\right)-u\right] \end{cases}$$

2) Initialize the iteration number k ←0.

3) Calculate the target candidate model $\hat{p}(y_0)$ in the current frame.

$$\begin{cases} \hat{p}(y) = \{\hat{p}_u(y)\}_{u=1\cdots m} \\ \hat{p}_u(y) = C_h\sum_{i=1}^{n_h} k\left(\left\|\frac{y-x_i}{h}\right\|^2\right)\delta\left[b(x_i)-u\right] \end{cases}$$

Now the Bhattacharya coefficient is defined by the two normalized histograms is as follows:

$$\rho[\hat{p}(y),\hat{q}] = \sum_{u=1}^{m}\sqrt{\hat{p}_u(y)\hat{q}_u}$$

The distance between them is defined as:

$$d[\hat{p}(y),\hat{q}] = \sqrt{1-\rho[\hat{p}(y),\hat{q}]}$$

4) Calculate the weight vector $\{w_i\}_{i=1\ldots n}$.

$$w_i = \sum_{u=1}^{m}\sqrt{\frac{\hat{q}_u}{\hat{p}_u(y_0)}}\delta[b(x_i)-u]$$

5) Calculate the new position y1 of the target candidate model which is defined as:

$$y_1 = \frac{\sum_{i=1}^{n_h} x_i w_i}{\sum_{i=1}^{n_h} w_i}$$

6) Let d $\leftarrow \|y_1 - y_0\|$, y0 ← y1. Set the error threshold ε (default 0.1) and the maximum Iteration number N (default 15).If (d<ε or k ≥ N) then Stop and go to step 7; Otherwise k ←k +1 and go to step 3.

7) Estimate the width, height and orientation from the target candidate model.

$$Cov = \begin{bmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{bmatrix} \times \begin{bmatrix} a^2 & 0 \\ 0 & b^2 \end{bmatrix} \times \begin{bmatrix} u_{11} & u_{12} \\ u_{21} & u_{22} \end{bmatrix}^T$$

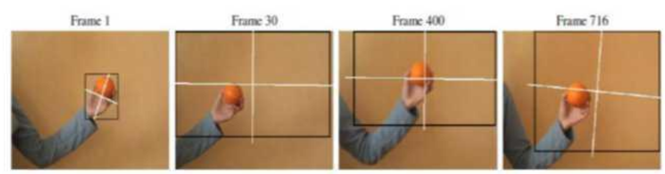
8) Estimate the initial target candidate model for next frame.

$$(x-y_1)\times Cov_1^{-1}\times(x-y_1)^T \le 1$$

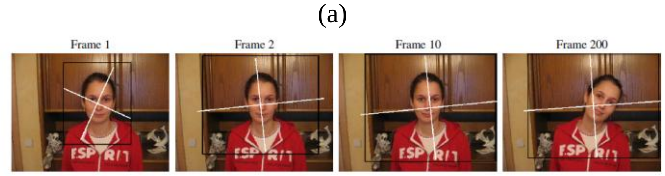
Though above process scale and orientation can be estimated easily of an object. The scale and orientation of adaptive mean shift algorithm is the Modified mean shift algorithm. This algorithm is an efficient object racking algorithm.

V. RESULT AND DISCUSSION

In this section, the result of both mean shift methods is shown. Fig 5.1(a) shows the result of CAMshift method for sequence of an orange ball. In this example, the colour of the object is tracked i.e. orange ball which has similarity with its background. In this type of case, the CAMshift algorithm is fails to track the object. It works only when the object has different colour from its background but the CAMshift method is more efficient for face tracking (Fig 5.2(b)).



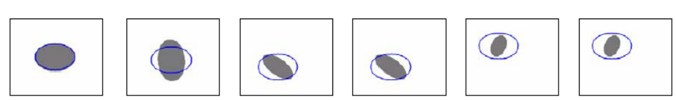
(a)



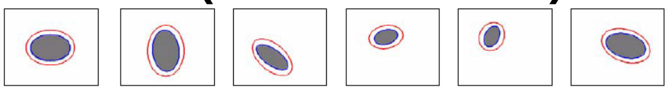
(b)

Fig 5.1 (a) CAMshift at various frames; (b) CAMshift for Face tracking

On another end Fig 5.2 shows the result of Modified mean shift tracking for a synthetic sequence with changes in scale and orientation. Fig 5.2(a) shows the original mean shift method or fixed scale mean shift method which is unable to adapt the changes in scale and orientation so it fails to track object efficiently. But Modified mean shift method can track an object with change in scale orientation as shown in Fig 5.2(b).



(a)



(b)

Fig 5.2 (a) original mean shift method (b) Modified mean shift method

VI. CONCLUSION

Both Camshift and modified mean shift methods of object tracking are taken, discussed and analyzed with their advantages and disadvantages. The traditional mean shift method has been improved by CAMshift algorithm and continuous adaptive mean shift method tracks an object well when object significantly differ in colour from its background. CAMshift method can track face efficiently.

By analyzing the moment, features of weighted image of a targeted model and Bhattacharya coefficient we can track an object with change in scale and orientation which method is called the Modified mean shift method. This method is improvement of a traditional mean shift method which inherits the merits of mean shift tracking like simplicity, efficiency and robustness. Thus these all methods are the modification of mean shift tracking method. To improve the complexity of standard mean shift tracking algorithm, fast mean shift tracking has been proposed which includes the Parallel mean shift and PAMS.

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