Real-time Aerial Targets Detection Algorithm Based Background Subtraction

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Abstract—in his paper, we propose a new technique incorporates several innovative mechanisms for aerial target detection. The traditional algorithm has high time complexity, and when the target size changes, it has greater limitations. It is difficult to meet its critical real-time and accuracy requirements in practical application. Based on this, we propose the air target detection algorithm based background subtraction. Complete modeling of the video in the first frame, detect the target in second frame, the location and size of the target is obtained by connecting area detection. From the third frame, we use the size and position of target from last frame to open a window, and track the target in the window. Tracking target in the window, we can eliminate background interference and reduce the time consumption. Compared with the traditional algorithm, the proposed algorithm is experimentally proved real-time well, detecting and tracking efficient highly, and have a highly practical in practice.
Keywords-local entropy; aerial target detection and tracking; background subtraction; connecting area detection ;window;

I. INTRODUCTION

In modern warfare, the dependence on advanced weapons has increased dramatically over the last decade. So the research of the target detection and tracking [1] technology is particularly important. We need a system which is good at anti-jamming, fast response and stability tracking capability. To accomplish this goal, we must detect, segment and track aerial objects steady and automatically. Local entropy algorithm which is proposed by Shioza Ki in 1986 is a classical one in a variety of aerial targets for detecting and tracking algorithms. Compare with some other algorithms such as correlation matching or image texture feature, Local entropy can effectively restrain background interference, and the whole image of gray distribution has little influence to the algorithm. Therefore, in dealing with the aerial target detection, Local entropy obtains good practical results, but it still has some problems.

Local entropy [2-3] application is confined to the small aerial targets. When the target size changes, the tracking stability is poor. There are a large number of logarithmic in Algorithm process, so the real-time is poor. If the target true position is same entropy to its adjacent positions, the target can't be accurately positioned. And the similarity between the edge texture of background objects and the high-frequency characteristics of the small aerial target disturbs the target tracking. Based on this, we proposed the algorithm real-time aerial targets detection based on background subtraction (Visual Background Extractor). Vibe [4-5] is proposed by Barnich in 2009, it is a universal method for background subtraction. This method has been briefly described in [4] and [5]. We model each background pixel with a set of samples of its immediate neighborhood pixels instead of with an explicit pixel model. Modeling and initializing each background pixel in first frame, detecting the target in the second frame. We obtain the target location and size by connectivity detection, and open a window using the target location and size. Beginning from the third frame, we can track the target which we detect in the second frame in the window which was opened in the last frame.

II. DESCRIPITION OF BACKGROUND SUBTRACTION

VIBE is same to other background subtraction techniques, have to deal with two problems in order to be useful: what is the model and how does it initialized? And how is the model updated over time. This section is given in three subsections to answers to these questions.

A. Pixel Model and Background Model Initialization

To some extent, the problem of background subtraction is a classification problem. We want to classify a new pixel value with respect to its immediate neighborhood pixels in the chosen color space, so as to avoid the effect of any outliers. The underlying idea is that it's more reliable to estimate the statistical distribution of a background pixel with 8-connected spatial neighborhood pixels values than with a large number of samples.

Formally, we denote by $P_{xy,\ t}$ the value in a given euclidean color space taken by the pixel located at(x, y) in the image at time t, and by P_i background sample value with an index i. So we can use 8-connected spatial neighborhood pixels to model each background pixel

$$BG(P_{xy,t}) = \{p_1,\ p_2, \cdots,\ p_8\} \tag{1}$$

Where p_1, $p_2 \dots p_8$ are the 8-connected spatial neighborhood pixel of $P_{xy,\ t,}$ then, we can denote by E_R ($P_{xy,\ t}$) the distance which between P_i and $P_{xy,\ t.}$

$$E_R(P_{xy,t}) = \{p \mid dist(p,\ P_{xy,t}) < R\} \tag{2}$$

$$\#count = \#\{E_R(P_{xy,t}) \cap BG(P_{xy,t})\} \tag{3}$$

In Fig.1 we denote by *#count* the numbers which the P_i intersects the sphere of radius R centered on $P_{xy,t}$.

According to (2), the classification of a pixel value $P_{xy,t}$

involves the computation of distances between $P_{xy,t}$ and model samples, and compare *#count* with a threshold T (T=2 in this paper). This process is illustrated in Fig. 1.

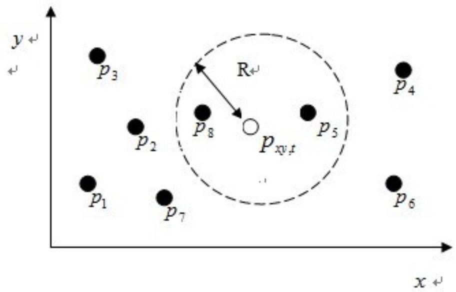

Fig. 1. Comparison of a pixel value with 8-connected spatial neighborhood samples in a 2-D Euclidean color space. To classify $P_{xy,t}$,we count the number of samples of intersecting the sphere of radius R centered on $P_{xy,t}$

B. Updating the Background Model

We model the background model in the fist frame , and detect and track the target in the subsequent frames. But as time goes on, the background changes over time. In order to achieve accurate results over time, we must continuously update the background model with each new frame. The update process must be able to adapt to clouds move, lighting changes, the white lines of plane and the interference of new objects appear in a scene.

The classical approach to the updating of the background model is to replace oldest values with the new ones after a number of frames or after a period of time. But this principle is no so reasonable, as there is no reason to discard a valid value if it corresponds to a background value. Our update method incorporate two important components update the spatial neighborhood pixels of background model and use a random time sampling to update the background model.

1) *Update the spatial neighborhood pixels*

We know a pixel model should contain the recent past of the pixel, but that is not to say all older samples have any contribution to the pixel model. Our method is simple but effective, instead of systematically removing the oldest sample from the pixel model. If the current pixel is classified to the foreground, we need not to update its pixel model; or we choose a pixel from its 8-connected spatial neighborhood pixels to be replaced by the current pixel. This process illustrated in Fig.2.

P_1	P_2	P_3
P_4	$P_{xy,\,t}$	P_4
P_5	P_6	P_7

Fig.2 when $P_{xy,\,t}$ is classified to the background, we can choose a pixel from P_1 to P_7 randomly, then replace it by $P_{xy,\,t}$.

2) *Time sampling*

Our update policy improves the time relevance of the estimation by allowing a few old samples to remain in the pixel model. But in many practical situations, it is not necessary to update each background pixel model for each new frame. By making the background update less frequent, we artificially update the pixel model by a randomly police. This motivates us to use a random time sampling policy either. In practice, when a pixel value has been classified to the background, a random process determines whether this value is used to update the corresponding pixel model. In all our tests, we adopted a time sampling factor, denoted of 10, that’s to say, a background pixel value has one chance in 10 of being selected to update its pixel model.

III. CONNECTING AREA DETECTION

A. Classical Algorithms

The Connected area detection is a method that marks pixels which belong to the same communication in the binary image, and also calculate the position, size, boundary and other features of the region. As the basis process for target detection and tracking, the classical algorithms are based on run-length coding region labeling and pixel region based on labeling.

The algorithm based Pixel regional labeling, by preliminary scan the whole image, label the regions, and generate an adjacent list. Then deal with the adjacent list, merge the adjacent labels. But the unknown complexity of the connected area leads to the adjacent table storage space allocation cannot be determined. And the algorithm based run-length coding region labeling needs to calculate connectivity transitive closure. The algorithm which calculates transitive closure is complex as the image has a number of rows. In this paper, we use the algorithm based run-length coding segmentation label [6]. This algorithm is processed in 8-connected spatial space. When a pixel is equal to the surrounding eight pixel values , we consider them belong to the same connected component.

B. Run-length coding segmentation label

Each point is labeled when the whole image is scanned, and we need not to calculate connectivity transitive closure. It makes our algorithm less complex and has a higher robustness. Formally, we denote by a run-length the pixels which have the same pixel value “1” in a single row in the image. Marking the current pixel use the left, upper left, upper and upper right pixel, form a run-length coding segmentation label. And when the relationship between the two adjacent is upward bifurcation, we replace left segment labels with the right labels and merge the labels. This process illustrated in Fig.3. The results using this algorithm is showed in Fig.4

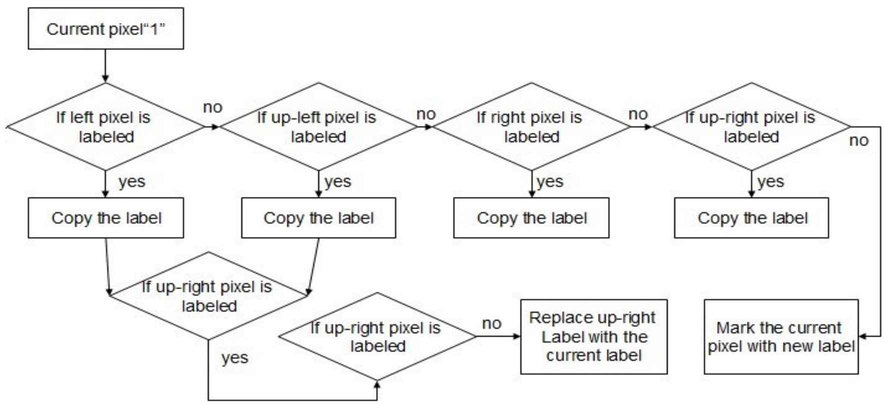

Fig.4 The flow chart of Segment Labeling algorithm of connecting area in binary images

(a) Original video （b）Image binary （c）Connectivity detection

Fig.5 Connectivity detection in the binary image

IV. TARGET TRACKING

The size of the target changes little in a limited number of consecutive frames. So when we get the size and position of the target, a window is opened by the size and the position of the target in the previous frame .Then target detection is accomplished in the window [7-8]. This policy has two advantages: 1) we only process the window region instead of the whole image, and achieve a faster execution speed; 2) some potential moving targets such as bird, cloud and other objects, can be removed, while Local entropy will discard the target and catch the new objects, because the new objects have higher entropy.

A. *Faster execution Ability*

In this paper, we use the adaptive window to track target [9], the size of the window is determined by the target. As we must ensure the target in the window, the size of window is triple that of the target. For an image 640*480, if the target size is 30*30, the window size can be 90*90. The processed times that we process in the whole image is:

$$(640-30)*(480-30) = 274500$$

And process in window is:

$$(90-30)*(90-30) = 3600$$

Our algorithm makes it as 76.25 times as faster the speed of the original algorithm.

B. *Remove interfrence*

The objects which appear in the new frames, make the detection and tracking processes extremely difficultly [10]. These potential moving targets have higher entropy; the local entropy will lose the target. And our algorithm also has bad results showing in the Fig.6. The 6(c) shows that the new object is seriously interfere with the progress of the original algorithm. But in Fig.7, we can see the improved algorithm get a good result.

(a) Original video （b） Vibe （c） Connectivity detection

Fig.6 Original algorithm

(a) Original video （b） Vibe （c） Connectivity detection

Fig.7 Combined window

V. EXPERIMENTS AND ANALYSIS

This section is dedicated to the evaluation of proposed detecting and tracking algorithm. We compare proposed technique with the classical algorithm. The experimental conditions: Windows 7operating system, visual studio 2010 used opencv2.4 programming environment. In order to verify the feasibility of the proposed algorithm, compare the stability and accuracy of the tracking algorithm with the traditional local entropy respectively (Local entropy neighborhood is 9*9).

Fig.8 shows six frames of a video sequences processed by proposed algorithm. We model the background pixel model and initialize the model in the first frame, detect target and get the size of the position of the target. From the third frame, we use the size and position of the target which get from the last frame to open a window. And track the target in the window in the following frames. We can see in the following frames, the improved algorithm can effectively and steady track the target, with good tracking and robustness. From 53rd frame to 175th frame, we could see that the proposed algorithm is able to adapt to target size changes and new object that appear in a scene.

(a) The first frame （b）The second frame （c）The third frame (d) Frame 53 (d) Frame 102 （e）Frame 175

Fig.8 tracking results of Local entropy proposed algorithm

(a) The first frame (b) Frame 53 (c) Frame 102 （d）Frame 175

Fig.9 Tracking results of Local entropy

Fig.9 shows four frames of a video sequences processed by local entropy, which is different from the proposed algorithm that the background pixel model is not needed to build, and the target may be detected and tracked in the first frame. But in the 53rd frame, it is easy to lose the target when new object that appears in the scene. And when the size of the target changes, the tracking stability of local entropy is very poor.

VI. CONCLUSION

Considering the high level requirements of advanced weapon system in modern war, it is necessary to study the target detection and tracking technology. This paper proposes aerial targets detection and tracking algorithm based on background subtraction, added the connecting area detection to the original algorithm to get the location and size of the target. At the same time, the interference of the new object in the background which was a big problem in the original algorithm can be eliminated by combining window to speed up the algorithm. Compare with traditional local entropy algorithm, through the experimental demonstration analysis, it can be seen that the proposed algorithm in this paper is simple and effective, not only with High detection accuracy and strong tracking stability, but also have the higher real-time performance and robustness. So, the use of background Subtraction for aerial targets detection and tracking has a certain practicality.

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