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Background Modeling Review Based on Video Synopsis

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***Abstract*—With the intelligent development of urban security construction and video surveillance technology lead to the explosive growth of surveillance video data,which bring seriously challenges to its browsing, retrieval and storage. In order to solve this problem, many domestics and international researchers have been put forward Video Synopsis technology and their improved methods one after another. Video Synopsis provides a way to quickly browse activities of moving objects in the surveillance video. Background Modeling, which is also called Moving Object Detection,is the basis and an important step to implement Video Synopsis. This paper makes a basic classification of Background modeling methods and compares these methods with their improved ones from five aspects: robustness, space complexity, calculation rate, detection effect under dynamic background and the appearance of "ghost ".**

***Index Terms*—Background Modeling; Video Synopsis; Surveillance Video; Moving Target Detection.**

I. INTRODUCTION

Video Synopsis technology was proposed Yael Pritcin 2008[1]. Video Synopsis is a technology that utilizes a series of methods and algorithms to manage video information in time and space. The technology involves the processing of video, the classification of video information, the retrieval of the moving target, and the presentation of the results. On the premise of not losing the moving target information in the original video, the 24-hour video can be shortened to several minutes, and the interested target can be retrieved according to user demand, which greatly liberates human productivity, saves reading cost and reduces storage space. Video Synopsis technology implementation process is shown in Fig.1.

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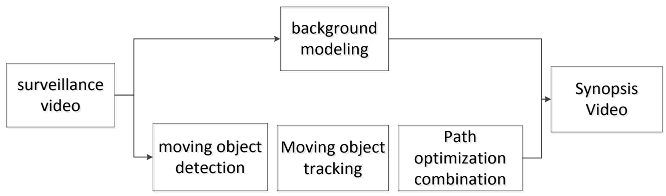

Fig.1.Video Synopsis Process Diagram

(1) After acquiring the surveillance video, the first step is to analyze the original surveillance video first, and then Through background modeling, the background model is extracted to obtain the moving target and the foreground and background in video are obtained for each frame, laying a foundation for the subsequent Mosaic work.

(2) After acquiring the moving target, track the moving target to avoid inaccurate recognition of moving target caused by occlusion and loss of moving target.Then, the trajectory track of the target is extracted to prepare for the trajectory optimization

(3) After that, the trajectory is optimized and combined, that is, the trajectory of each target is transferred on the time axis, delete time redundancy, the trajectory overlaps on the same frame is avoided, and the relevance of the moving target is protected..

(4) Select the extracted background image and fuse the optimized trajectory obtained from the previous moving target and the moving target to generate a synopsis video.

It can be seen from the above process that background modeling runs through the whole process of video concentration, playing a vital role. Whether the effect of video concentration is good or not, and whether the moving target can be accurately extracted depends on whether the foreground and background can be accurately separated during background modeling.The basic idea is: we need to identify the moving target from video, establish the background model, compare the current frame image with the background model, and get the moving target that needs to be detected.Now more

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commonly used moving object detection method is divided into three categories, respectively is: the background modeling based on color feature, background modeling based on pixel level and background modeling based on texture feature, in recent years, many international conferences and authoritative magazines focus on the field research, many scholars put forward many different background modeling method and its improved method, in order to adapt to the ever-changing scenarios.

II. BACKGROUND MODELING TECHNIQUE BASED ONCOLOR FEATURES

The idea of background model based on color feature is to model the color value (gray or color) of each pixel in an image. If the pixel color value on the current image coordinate (x,y) is significantly different from that on the background model (x,y), the current pixel is considered as the foreground; otherwise, it is the background.One of the most obvious defects of the color background model is its sensitivity to shadows, which is the moving target.In certain cases, it is necessary to suppress and eliminate shadow after detection. Table 1 below is a comparison of background modeling techniques based on color features.

Table 1.Comparison of background modeling techniques based on color features

method	Robustn-ess	Noise resistance	Spatial complexity	Calculat-ion rate	Applicable scene	Ghost remova-l rate
Traditional frame difference method	Bad	Bad	Easy	Fast	Static scene	No ghost
Threeframe difference method	Bad	Bad	Easy	Fast	Static scene	No ghost
Single Gaussian background modeling	Bad	Bad	Complex	Slow	Static scene	No ghost
Mixed Gaussian Modeling	General	Gener-al	Complex	Slow	Static scene	No ghost
Adaptive hybrid Gaussian modeling	General	Gener-al	Complex	Slow	Static scene	No ghost
Mixed Gaussian Modeling Based on Recursive Equations	General	Gener-al	Complex	Slow	Static scene	No ghost
Traditional CodeBook	General	Gener-al	Complex	Slow	Dynamic background in specific situations	No ghost
Multilayer CodeBook Modeling	Good	Good	Complex	Slow	Static and dynamic scenes	No ghost
CodeBook Background Modeling Based on Gaussian Algorithm	Good	Good	Complex	Slow	Static and dynamic scenes	No ghost
CodeBook Background Modeling Based on LBP Algorithm	Good	General	Complex	Slow	Static and dynamic scenes	No ghost
Traditional SOBS background modeling	Good	Good	Complex	Slow	Static and dynamic scenes	No ghost
SC-SOBS	Good	Good	Complex	Slow	Static and dynamic scenes	No ghost
SACON	General	General	Complex	Slow	Static scene	No ghost
Vibe	General	General	Easy	Fast	Static and dynamic scenes	Ghosting
Vibe+	General	Good	Easy	Fast	Static and dynamic scenes	Ghosting
EVibe	Good	Good	Easy	Fast	Static and dynamic scenes	Slower elimination
The Vibe algorithm incorporating canny operator	Good	Good	Easy	Fast	Static and dynamic scenes	No ghost
PBAS	Good	Good	Complex	Slow	Static and dynamic scenes	No ghost

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A. Frame Difference Method

The frame difference method makes a difference operation on the video image of multiple frames, and compares the result with the set threshold to determine which pixel is the foreground and which pixel is the background [2]. This method is simple in calculation and has good real-time performance. However, if the area of the connected area is large or the object has slow motion, a large void will be generated in the foreground area when determining the foreground area. The images with three consecutive frames are used to make two groups of two adjacent frames of images co-difference, and then the two difference results make AND operation. The schematic diagram is shown in Fig2. The three-frame difference method schematic can effectively reduce the area of the void[3], but it is still poor in adaptability under the dynamic background. In 2014, Xu H and Liu J proposed the depth inter-frame difference method [4], which greatly reduced the noise in image detection and reduced the shadow problem of human..

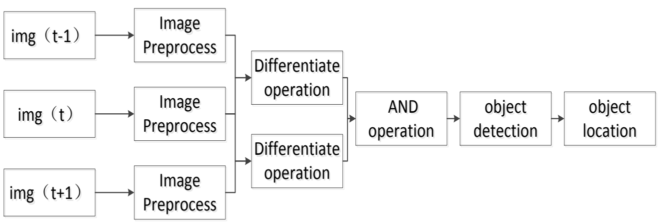

Fig 2. The three-frame difference method schematic

B. Gaussian Background Modeling

Gaussian background modeling mainly has two modes, one is a single modal background model, and the other is a multi-modal background model. The former has a relatively concentrated color distribution on each background pixel, which can be described by the single-distribution model probability, while the latter has a relatively dispersed color distribution, which needs to be described by the multi-distribution probability model.In dynamic background scenarios, such as water surface ripples, shaking of leaves, or camera shake, multi-modal background models are often used to build models.The mixed gaussian model is similar to the single gaussian model. The background modeling is divided into four parts, which are: model initialization, model matching, model update and prospect division.

1) Single Gaussian Background Modeling

In 1997, Christopher Wren proposed using Gaussian functions to perform background modeling [5]. In the single Gaussian background model, for a background image, the luminance distribution of each pixel satisfies a Gaussian distribution, so for each A Gaussian distribution is established for one pixel, and a certain pixel of the current frame image is matched with the established Gaussian model, ie the absolute value of the standard deviation of the two is calculated, and if the matching can be determined, the current pixel is determined as the background point. Since the pixel values of the scenes in the video in real life are not constant and are affected by illumination, breeze, or camera shake, the background of each frame of the video image changes. Therefore, the background needs to be updated while the single Gaussian background model is used. The update is related to the learning rate. If the learning rate is too low, the background update will be slow. If the background model cannot keep up with the actual background changes, the background will be misjudged as the foreground. If the learning rate is too high, when the moving target is moving too fast, the target is very fast. Can easily be used as background information, appear hollow or incomplete, and even lose the goal.

In 2014, Chen Yin improved the modeling of single gaussian background [6], which combined the algorithm of single gaussian model and the principle of mean shift to detect moving objects.Take the average of the previous N frames of video samples as the initial background model. The initial detection of the moving object in the current frame image is performed by using the single Gaussian model algorithm update principle to update the background model with the current frame image as the background point, and the pixel points not belonging to the background point in the updated background model pass the mean shift. Make corrections. The model obtained by the mean shift correction is used as the final background model, and then the background target difference is used to finally obtain the moving target. The paper shows that the algorithm can be updated quickly under the dynamic background to adapt to the changes of

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the background, but it will still cause misjudgment when the background is shaken. The integrity of the target detection is higher than that of the traditional single Gaussian model.

2) Gaussian Mixture Background Modeling

In 1999, Stauffer proposed a classical background modeling method named Gaussian Mixture Background Modeling [7]. This method can well adapt to complex scenes and has been widely used in the modeling of complex scenes. The basic principle is to use the Gaussian density function to describe the distribution of different pixels in the image. In the pixel unit，defined K states，In the unit of pixel points, K states are defined. Each state is defined by a gaussian model, and K gaussian functions are used to describe the value of each pixel in the frame.Generally, K values are about 3-5. The larger K is, the more accurate the background model is, and the stronger the anti-interference ability is, but the calculation amount increases accordingly, which affects the real-time performance. Different from single-Gaussian background modeling,Gaussian ，gaussian mixture background model of the distribution law can be unimodal can also be a multimodal, So, the mixed gaussian model has certain optimization effect under the dynamic background., but the learning rate is still slow, for fast moving target detection is still there will be false negatives or hollow phenomenon.Therefore,in the subsequent development, there are many domestic and foreign scholars who have proposed effective improvement methods for the classical mixed gaussian background modeling

In 2002, Kaewtrakulpong P proposed an adaptive hybrid Gaussian modeling update algorithm[8], which improved the learning rate and model accuracy of Gaussian mixture modeling, and proposed the use of existing Gaussian mixture model to detect moving shadows. The method not only makes the positioning of the moving object more accurate, but also does not include a shadow part, reduces the effect of repeated movement in the background scene, and makes the recognition area more accurate. In 2004, Zoran Zivkovic proposed that the gaussian model parameters were constantly updated by using the recursive equation. Both the segmentation effect and learning speed were slightly improved, but misjudgment still occurred when detecting cars walking on high roads, and there was a long 'shadow', which was easily affected by noise in the dynamic background. [9] In 2005, Kim K proposed an improved method for solve the problem that the slow convergence rate and poor stability of the Gaussian Mixture Background Modeling in the literature[10]. Based on the stability, a method of high convergence speed was proposed. The frame-adaptive learning rate replaces the previous overall situation learning rate. To solve background updates in complex scenarios.

In general, the effect of Gaussian Mixture Background Modeling is much better than that of single Gaussian background modeling in practical applications, but both are not ideal under complex scenarios. Mixed Gaussian modeling has been applied in many fields, but All are in an ideal scence, and the environment is more stable for scientific research.

C. CodeBook

CodeBook is a classical algorithm based on K-means of background modeling, this algorithm was proposed by Kim in [11], the basic idea is to get time series model of each pixel in each frame, each pixel of the background pixel values are placed into the one called CodeBook compression background model, classify the pixels to establish a structured background model, so as to adapt to complex scene background in certain situations, in this method include movement background and illumination change scenarios have good robustness, However, in the complex scene, the code word in the code book increases continuously, which will consume a lot of memory, and the real time is limited.

Because the CodeBook algorithm gets the size of the time model depending on the video length, but the video we studied was concentrated for several hours or even dozens of hours video, so the time series model will occupy a lot of memory and is not suitable for so the time series model takes up a lot of memory, which is not suitable Video Synopsis technology.After that,Kim proposed a multi-layer CodeBook modeling and adaptive

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background update method based on his own algorithm in [12]. Many domestic and foreign scholars also improved the CodeBook algorithm itself , In 2006, Doshi A proposed the background hypothesis of conical cylinder mixing model to establish the background model[15]. Ilyas A to modify the parameter in the algorithm, the effect of improved background modeling [13], Tu Qproposedusing the background model is simplified to BOX model is put forward[14].In 2010, Wu M the context of time and space is added to the CodeBook algorithms[16], there are many scholars in the use of other background modeling method and the combination of, respectively CodeBook and the integration of gaussian background modeling, LBP features[17]-[19].

D. SOBS

In 2008, Lucia Maddalena proposed SOBS（Self-Organizing through artificial neural networks)[20]. This algorithm mainly uses the characteristics of neural networks. Neurons of the weight vector was used to construct background model, neural network, each node will represent the model, a corresponding pixel network constitute a two-dimensional matrix, use of adjacent pixels in the continuity of space distribution, under the background of dynamic have good robustness, but similar with CodeBook algorithms, the background model of memory is bigger, and need in the color space conversion, complete the HSV color space conversion to RGB space, increase the amount of calculation of the algorithm.Then, Maddalena . improved the SOBS again until 2012, and proposed SC-SOBS[21], which introduced the spatial consistency into the background updating stage and further improved the robustness of the algorithm.

E. Non-parametric Background Modeling

In 2005, Wang. proposed SACON（Sample Consensus)[22], [23] This method first calculates the distance between the current frame pixel and the sample in the background model, then counts the number of samples with similar distance, and finally judges whether it is the foreground based on the number of samples. The algorithm is mainly divided into four main parts, namely, neighborhood difference, SACON algorithm core processing, hole filling post-processing, TOM (Time Out Map), where TOM (Time Out Map) is mainly used for background model update, TOM is used separately. Two update strategies: Pixel-level and Blob-level, the latter's update strategy is mainly to make up for the former's deficiencies. When the moving target enters the monitor screen and stays in the screen with only slight shaking, the area will not be shaken by Pixel. The -level update is the background, and the shaking part is always judged as the foreground. This results in the incomplete detection of the moving target. The Blob-level judges whether the target is still or moving by the whole, so that the target is completely updated to ensure the integrity of the target.

In 2009, Barnich. Proposed the Vibe algorithm [24], [25] The proposed Vibe algorithm provides a new idea for the detection of moving targets. Compared with other algorithms, the use of Vibe to complete the detection of moving targets is less computationally intensive, the processing speed is faster, the sample attenuation is optimal, and the moving target detection performance is better. In most practical application scenarios, there is a good test effect. Due to the Vibe algorithm uses the first frame to create a background sample set for each pixel, when the first frame has a moving target, the pixels of the moving target will be included in the sample set. When detected from the second frame, the moving object in the first frame is determined as the background. When the moving object moves, the background is determined as the foreground. M. Van Droogenbroec added complex morphological processing to the Vibe algorithm and proposed the Vibe+ algorithm in [26]. This method has a very good effect when dealing with dynamic background video. Yu Ye proposed EVibe algorithm in [27]. This algorithm increases the range of background samples set.The background update method used interlaced updates to eliminate ghosting and also added a shadow removal module. Later, Sun Shuifa .proposed the Vibe improved algorithm after morphological treatment[28]-[30], which can effectively eliminate the interference of sports background in outdoor monitoring video and basically eliminate the influence of noise Vibe

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is the best detection algorithm for real-time detection in all detection algorithms[31]. At the same time, Vibe algorithm is also the first application of random clustering technology in target detection algorithms. Therefore, Vibe is at the forefront of many target detection algorithms in both simplicity and innovation. In 2015, Zhang Du proposed the combination of the Vibe algorithm and the canny edge detection algorithm [38], effectively avoid the appearance of 'ghosting' in some scenarios.

In 2012, Martin Hofmann and others proposed PBAS (Pixel-Based Adaptive Segmenter)[39].This algorithm made relevant combination and improvement. Based on the advantages of SACON and Vibe, which further improved the accuracy of target detection. However, this algorithm has a large amount of computation and poor real-time performance.

III. BACKGROUND MODELING TECHNOLOGY BASED ON TEXTURE FEATURES

Table 2.Comparison of background modeling techniques based on ttexture features

Method	Shadow detection effect	Noise resistance	Spatial complexity	Calculation rate	Applicable scene	Ghost removal speed
Background Modeling Method Based on LBP	Good	Good	Complex	Slow	Dynamic background	No ghost
CS-LBP	Good	Good	Complex	Slow	Dynamic background	No ghost
XCS-LBP	Good	Good	Complex	Slow	Dynamic background	No ghost
Background modeling based on SILTP	Good	Good	Complex	Slow	Complex dynamic background	No ghost

Like color, texture is also an image feature. HTD (Texture descriptors) are described in terms of directionality, regularity, and roughness. In 2006, Marko and Matti used texture feature descriptors for background modeling for the first time. Table 2 is a comparison of background modeling techniques based on texture features.

A. LBP

In 1994, T. Ojala. proposed LBP (the Local Binary Patterns)[32], which is an operator used to describe local texture features of an image, It has the advantages of scale invariance and gray invariance The basic thought is to set the gray value and threshold of the center point, and compare the gray value of the pixel in the center point field with the threshold value. LBP has been applied in all fields of computer vision. Mainly used in fingerprint recognition, face recognition and other fields. In 2006, Marko and Matti used the LBP [33], in performing background modeling and extracting moving target,this algorithm is a background modeling method based on texture features. Background modeling methods based on LBP mainly include background modeling and foreground extraction. In the background modeling, first calculate the LBP value of each pixel, then calculate the LBP statistical histogram in the spatial of the point, and establish an LBP texture background model for each pixel. This method can effectively adapt to the changes of dynamic scenes. The contour blur has certain adaptability to lighting. However, this method has its own limitations. The background describes that the dimension of the histogram is too high, which affects the speed of detection, and the detected moving target may even be deformed.

In recent years, many domestic and foreign scholars have improved the background modeling of the LBP algorithm. Heikkila proposed a central symmetric local binary pattern CS-LBP (center symmetric local binary pattern)[34]. The neighborhood points reduce the dimensionality of the background histogram. Xue proposed SCS-LBP (spatial extended center symmetric local binary pattern) [35] to reduce the computational complexity of CS-LBP. This method extracts more detailed texture information. Later, Silva. Proposed a XCS-LBP (extended center symmetrical local binary pattern)[36], combining texture features of LBP and CS-LBP, extracting textures. More accurate features.

B. SILTP

The research on the background modeling method based on texture has achieved good results in China. In

2010, a new texture description method, SILTP was proposed by Dr. Liao from the automation of the Chinese academy of sciences in paper. In this paper, combined the model kernel density estimation method. To segment the foreground and background. This algorithm can handle the detection of moving objects in complex dynamic backgrounds. It uses principal component analysis (PCA) to perform feature decomposition on continuous multi-frame video and extracts the foreground. The proposed method also creates a new direction for background modeling.

Compared to LBP, the SILTP operator is more adaptable to the change of light in the detection area and has certain robustness to noise in the area. Because of the invariance of scale of SILTP, the value of SILTP remains unchanged even if the light in the detection area changes suddenly. In addition, when there is a weak shadow in the surveillance video, This operator can also be well recognized and judged as the background, because the weak shadow retains the dark texture information in the background, rather than the texture information represented by the scale factor of the local background area.

IV. EXISTING PROBLEMS

In recent years, although the background modeling technology in video surveillance had great progress in the research and application, many scholars have integrated the image processing technology, neural network and other methods emerging this year with the traditional background modeling technology, but the technology is not mature, the problem is as follows:

(1) Each technology has certain limitations on the application background and objects, and no algorithm can be applied to all scenarios.

(2) Each method has their advantages and disadvantages. In the video Synopsis system, we should combine the data we used to monitor video to select the appropriate algorithm to make the best of the advantages and avoid the disadvantages, and combine the two or more methods organically to reduce the negative impact as much as possible.

(3) For background modeling methods, robustness, computational rate, real-time performance, and noise resistance are important indicators.However, at present, there is no standard data set to evaluate the background modeling method, which results in that many methods do not have a unified evaluation and measurement standard.

V. CONCLUSION

This paper summarized two basic algorithms applied to Background Modeling in Video Synopsis technology. According to the above description and comparison, we concluded the advantages and disadvantages of these algorithms.The Background Modeling methods based on color feature are all applicable to static background. In terms of comprehensive performance,Vibe algorithm is optimal because of its characteristics of setting up the first frame image’s background model.It caused the appearance of the "ghost" when the first frame image has moving objects in surveillance video. Therefore,Video Synopsis misjudges when identifying moving objects.Background Modeling algorithms based on texture features have good adaptability to dynamic background and good noise immunity, but they are not applicable to Video Synopsis technology because of a huge amount of calculation and poor real-time performance. We should use appropriate Background Modeling methods according to different background and environment in surveillance video. Or aiming at this scene, we are supposed to propose an optimal algorithm that only adapts to it..

Due to the good performance of Vibe algorithm,in the future，the research should focus on eliminating the influence of "ghost" on the detection results in Vibe algorithms，as to make full use of the advantages of Vibe algorithm, such as simple calculation, small computation amount and low noise impact, into the Video Synopsistechnology.

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