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Background Subtraction Techniques-Review

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ABSTRACT- Background subtraction approach is used to detect the moving object from background. Different methods have been proposed to detect object motion by using different background subtraction techniques over recent years. Each technique has its own benefits and limitations such as some techniques can only applied for static background and some for dynamic backgrounds. This paper provides review of main methods used to detect foreground object with its merits and demerits. It would help the researchers to select the most appropriate technique according to the application.

Keywords: Background subtraction, Gaussian mixture model, Region based ,pixel based

I. INTRODUCTION

Background subtraction is process of extracting foreground objects from maintained background model. A foreground object is any entity that detected by producing difference of the every frame of sequence to background model. This result can be further used for tracking targets ,motion detection. Background subtraction further divides into parametric and non-parametric background subtraction. There are different background subtractions techniques have been proposed in literature. The background model can be static or dynamic. Dynamic background model is one in which the background of scene may contain moving objects in outdoor environment, Pixel-based and block based are two major kind of approached are for background Subtraction.To construct a statistical representation of background scene non-parametric statistical Modeling of pixel process is used. The different challenges that has to face to construct a good background subtraction algorithm are robustness against the changes in illumination and shadow detection[6].

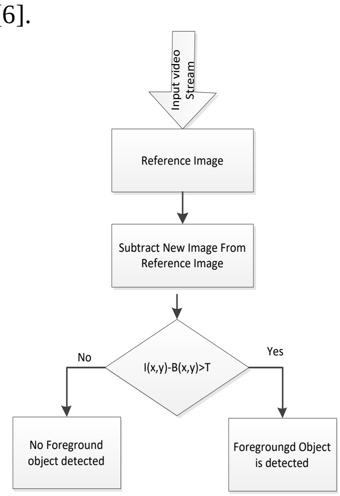

Fig1. Flow chart of Background Subtraction

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If the difference of current frame and referencing frame is less than the threshold value, then no foreground object is detected otherwise foreground object is detected. Where T = predefined threshold which shows whether pixel belongs to background or not.
I(x, y) = current incoming video frame
B(x, y) = reference image

II. DIFFERENT REVIEWED APPROACHES FOR BACKGROUND SUBTRACTION:

(1) QR DECOMPOSITION BASED ALGORITHM

Mahmood Amintoosi, Farzam Farbiz, Mahmood Fathy, Morteza Analoui, Naser Mozayani [1].proposed QR decomposition is method of linear algebra in which they split the image into small blocks and according to the R values they select the background blocks with the weakest contribution. This method can distinguish the foreground object from background object with the scene having moving object during initialization.

In this technique , N different blocks are obtained by splitting the input image frame. Now to identify the background part in image we apply QR decomposition method on each block .Consider the time series of intensity values of pixel (x_i,y_i) of block a at time t as follows:

$$\{X_{i,1},X_{i,2},X_{i,3},\ldots\ldots\ldots X_{i,,t}\}$$

Now construct a matrix M for a^{th} block. QR decomposition of matrix M is given by:

$M\pi=QR$

Where π =Permutation matrix

Q= orthogonal matrix

R=upper triangular method. The diagonal values of matrix R is called R- values which are in decreasing order. The R-values of background data will be smaller than moving object[2]. Suppose the intensity values of i^{th} pixel at a^{th} block $\{X^a_{i,f1},X^a_{i,f2},\ldots\ldots.X^a_{i,ft}\}$ which are in sorted order according to R-values, where $\{f_1,f_2.\ldots.f_t\}$ is ordered frame number indices. We consider according to R values.

$P(B|X^a_{i,fj})=1$, if $j>(1-\alpha)$ otherwise 0 (1)

α shows the percentage of blocks belongs to background.

(2). PIXEL-WISE LOCAL INFORMATION BASED APPROACH

Zhong Wei, Shuqiang, Qingming Huang [2]. Proposed a new background subtraction method in which they use neighboring spatial distribution for each pixel.

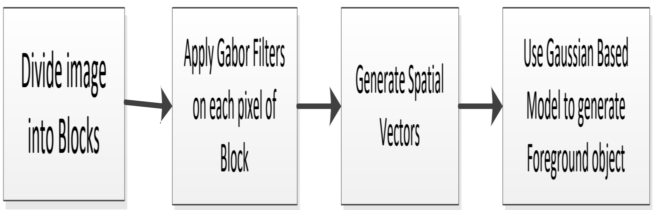

Fig2.Fore ground object detection by QR decomposition

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They use Gabor filters with multi-scale and multi orientation to extract the Gabor features. Spatial feature vectors are generated based upon these Gabor filters. The Gabor representation of an input image is as follows:

$G(x, y, \mu, v) = F(x, y) * \varphi_{x,y}(z)$ (2)

Where $*$ is convolution F(x,y) is input image $\varphi_{x,y}(z)$ is Gabor filter with v={0,1,2…,p-1} p scale and μ ={1,2,3…,q-1} q orientation[2]. Obtain spatial feature vector for pixel (x, y) by using the equation(2) as follows:

$SfV(x,y)=(G(x,y,0,0),\ldots,G(x,y,0,p-1),G(x,y,1,0)\ldots,G(x,y,q-1,p-1))^T$ (3)

Spatial vector of each pixel $\{SV_1, SV2, SV3\ldots\ldots\ldots,SV_t\}$ can be modeled by K Gaussian Mixture model at time t as $P(SV_t)$ by equation(6). For pixel SV_{t+1} equation is given by:

$(SV_{t+1}-\mu_{i,t})/\sigma_{i,t}<2.5)$ (4)

If SV_{t+1} satisfy equation (4) it shows that at least one matched model is found and this pixel is marked as foreground. B distributions are generated by sorting the K Gaussian distribution in descending order as follows:

$B=\arg\min (\sum_{k=1}^{b} w_k > T)$ (5)

Where T is threshold and first B distribution is considered as background model.

(3). Local-Patch Gaussian Mixture Model

Shih-Chieh Wang, Te-Feng Su and Shang-Hong Lai[3] proposed Local-Patch Gaussian Mixture Model to detecting moving objects from dynamic background. As Massimo Piccardi [4] reviewed different techniques out of which Gaussian mixture model proved very good accuracy model. So they build background model by using several frames in beginning of input video as training data i.e. $\{X_1,X_2,\ldots\ldots\ldots X_N\}$, which is modeled by mixture of K Gaussian distribution at time t as follows:

$P(X_t)=\sum^{K}_{i=1} w_{i,t}.\ \eta(X_t,\mu_{i,t},\sum_{i,t})$ (6)

Where η is probability density function[3] .

Local Patch size for each pixel is defined as d×d. Let intensity value of observed pixel is $f_t(x,y)$,for each observed pixel window is set around the pixel as center .The original X_t in GMM model is extended to a d^2 – dimensional vector for each observed pixel as follow:

$X_t(x,y)=[f_t(x\text{-}d',y\text{-}d')..f(x,y)\ldots f(x+d',y+d')]^T$ (7)

Where d′=(d-1)/2

$D(X_t(x,y),\mu_t(x,y))$ is mean difference between $X_t(x,y)$ and $\mu_t(x,y)$.If the observed pixel is said to be background if it satisfies equation as follows:

$D(X_t(x,y),\mu_t(x,y))\leq 2.5 \sum_{-d'\leq i,j}\sigma_t(x+i,y+j)$. (8)

Otherwise pixel is classified as foreground.

(4).RECTGUASS-TEX BLOCK-BASED BACKGROUND SUBTRACTION

Dorra Riahi, Pier-Luc St-Ong and Guillaume-Alexandre Bilodeau[5] proposed background subtraction technique based on blocks of image.

For this reference image is divided into rectangular regions or blocks. Color histogram and variance is calculated for each pixel of different block. This measures the statics of pixels in block and then of the background. This is finest scale. These different blocks are merged together with their statistics to obtain minimum number Q_c (Maxixmun number of merged block in image) which is user defined. It gives the background image B_r. Thus blocks are compared using the variance and color histograms. Consider I_r is new frame and the background image B_r. H_B and H_I are their color histogram respectively. Firstly the blocks in I_r and B_r are compared at coarsest scale if there is difference then these blocks are again compared at finer scale to reach the finest scale. Blocks are compared using the color histograms (H_B,H_I) by using MDPA(Mean distance of pair assignment) distance D_h. If D_h is less than T then only two histograms are similar, where T is threshold value change for each scale.

Now each pixel of foreground block is modeled by K distribution of GMM by using equation(6).

If $|X_t\text{-}\mu_t|>T\ \sigma$

Then pixel belong to foreground. Where T is threshold value and σ is variance.

III. TABLE OF COMPARISION

SOLUTIONS / PARAMETERS	Mahmood Amintoosi, Farzam Farbiz, Mahmood Fathy,Morteza Analoui,Naser Mozayan [1]	Zhong Wei, Shuqiang, Qingming Huang [2]	Shih-Chieh Wang, Te-Feng Su and Shang-HongLai [3]	Dorra Riahi, Pier-Luc St-Onge and Guillaume-Alexandre Bilodeau [5]
Background Model	Initialization with moving objects	NA	Dynamic	Dynamic
Robustness towards illumination and shadow	NA	Robust	NA	Deal with shadowsnot with large illumination
Background subtraction Approach	Block based	Pixel based	Pixel based	Block based
Methodology	QR Decomposition	Gabor filters GMM	LPGMM	MDPA and GMM

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IV. CONCLUSION

In this paper we have presented the review of four different Background subtraction techniques. Each of above mentioned techniques has its own merits and demerits. Comparison table shows the comparative analysis of reviewed techniques based on some parameters. It would help the experts and newcomer to choose the appropriate technique to their research work.

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