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Exploration of Normalized Cross Correlation to Track the Object through Various Template Updating Techniques

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Abstract: *Object tracking is a process devoted to locate the pathway of moving object in the succession of frames. The tracking of the object has been emerged as a challenging facet in the fields of robot navigation, military, traffic monitoring and video surveillance etc. In the first phase of contributions, the tracking of object is exercised by means of matching between the template and exhaustive image through the Normalized Cross Correlation (NCCR). In order to update the template, the moving objects are detected using frame difference technique at regular interval of frames. Subsequently, NCCR or Principal Component Analysis (PCA) or Histogram Regression Line (HRL) of the template and moving objects are estimated to find the best match to update the template. The second phase discusses the tracking of object between the template and partitioned image through the NCCR with reduced computational aspects. However, the updating schemes remain same. Here, an exploration with varied bench mark dataset has been carried out. Further, the comparative analysis of the proposed systems with different updating schemes such as NCCR, PCA and HRL has been succeeded. The offered systems considerably reveal the capability to track an object indisputably under diverse illumination conditions.*

Keywords: *Centroid, Frame difference, Histogram Regression Line, Normalized Cross Correlation, Template updating, Object Tracking*

I. Introduction

Object tracking is basically an attention drawing process. It is also a system of establishing the correspondence to the objects in sequence of frames. Perhaps it unearths many applications. However, there is no dearth of relevant literature in tracking object emerged in a moderate scene. It could be possible through spatial or appearance based model. Secondly, several processes are evolved from frequency sphere and also hybrid approaches are celebrating effective performance. There are several approaches for tracking object in a scene that are Point tracking, Kernel tracking and silhouette tracking [1].

The procedure of object tracking by means of template matching is sub-class of Kernel tracking. Some of the factors make object tracking complex due to change in color, illumination, noise in the images, abrupt motion of the objects and computational aspects for real-time processing [2]. In recent times, the prime research in computer vision field is the detection and tracking of an interested object. One such application is analysis of traffic scene. Thus, vehicle detection and tracking is important for civilians as well as military usage especially in aerial and usual traffic scene since vehicles are vital part of human life [3, 4].

Further, the performance analysis and the object tracking worth are demonstrated through the qualitative, quantitative and time analysis. The qualitative analysis of tracking performance is observed by the visual analysis. The quantitative analysis is ascertained by the True Positive (TP), False Positive (FP) and False Negative (FN). The moving objects and detected regions are same in case of True Positive (TP) where as wrong matching of objects is treated as False Positive (FP). If the bounding box is enclosed on neither of the moving objects then it is declared as False Negative (FN). The tracking performance is estimated through the two significant metrics of Detection Rate (DR) Precision (P) and False Alarm Rate (FAR) which use the TP, FP and FN. The Combined Result (CR) is used to furnish the refined results by employing DR and FAR.

$$DR = \frac{TP}{(TP + FN)} * 100 \qquad FAR = \frac{FP}{(TP + FP)} * 100 \qquad CR = \frac{DR}{(DR + FAR)} * 100$$

In this paper, the performance has been enhanced by way of updating the template at suitable interval of frames in order to avoid drift in tracking process because of change in illumination and object shape etc. The updating the template is ensured by NCCR, PCA and HRL in respective proposed techniques.

The section 2 portrays the related work. The section 3 discusses the exhaustive template matching through NCCR and updating procedures like NCCR, PCA and Histogram Regression Line are discussed in 3.1, 3.2 and 3.3 respectively. In section 4, the partitioned image template matching through NCCR and updating procedures like NCCR, PCA and Histogram Regression Line are conferred in 4.1, 4.2 and 4.3 respectively. The comparative analysis of proposed strategies has been described in section 5 and the paper concluded in section 6.

II. Related Work

Lewis .J.P [5] showed in the spatial domain the potentiality of NCCR based template matching. Authors T. N. Hieu, W. Marcel and B. Rein van den [6] attempted to realize the tracking system for a rigid object through Kalman filter. In their work, the template is adapted to changing illumination and orientation of the object by using an adaptive Kalman filter. Alan .J. Lipton et al. [7] attempted to employ the combination of frame differencing and template matching to highlight the object in a scene. The template matching is guided by temporal differencing and image based correlation to make tracking process robust. Further, the Impulse Response filter (IIR) has been applied to update the template.

In the work of Longin Jan Latecki et al. [8] a strategy has been proposed which is based on selective hypothesis tracking. It includes the motion regions, image alignment and minimum cost estimation to update the template dynamically. In other words, the minimum cost matching is established through association between the motion region and the aligned template. Thus, the motion vector is updated.

Dynamic template matching and controlling the field of view of camera by PTZ (Panning Tilting Zooming) was remarked by [9] Karan Gupta et al. using frame difference approach with the proper threshold. This strategy, basically tries to consider the instant updating the template although limited to a single object in a scene.

In the work of Xue mei et al. [10] has the probabilistic algorithm for tracking, which included template matching and incremental subspace update. The templates are modeled using mixed probabilities and updated based on considerable changes of the object appearance. The augmentation of the Kernel Gream matrix with a row and column yields the updating.

The research work of Jiyan Pan and Bo Hu [11] steady shifting away from the template in object tracking is very well tackled through the template drift. Here, it is observed carefully where template drifts occur and accordingly the template is updated. Additionally, Kalman appearance filter utilized to update the template.

Wenhui Liao et al. [12] introduced a Case Based Reasoning (CBR) to maintain accurate template of object automatically. In other words, algorithm dynamically updates the case base (template). With this, real time face tracking is built to track the face robustly under different orientations and conditions.

Authors S. N. Manoj et al. [13] made an effort to reduce the computational complexity through fragmentation of previous and current images into four quadrants respectively. Consequently, NCCR score between the respective quadrants are estimated. If the moving object is present in a quadrant, then the correlation score is higher compared with other quadrants. The respective quadrants are used to detect the moving objects using frame differencing. The process of object tracking is carried out based on the centroid information.

Similarly, literature survey has encouraged us to propose the novel approaches. Firstly, the strategies proposed are based on NCCR for exhaustive image search for template matching to track the object and update the template by using NCCR, PCA and HRL. Secondly, the offered policies are based on the partitioned image search for template matching. In other words, image size has been confined to the surrounding of the object to an extent of a quadrant resulting into the reduction of the search region for object tracking. However, the template updating procedures remain same.

In the first bunch of proposed strategies for object tracking and updating mechanisms the foremost research work attempts to propose the systems which track the object in a scene exhaustively (full image) with the correlation between object and template. However it takes care of updating the template with the help of NCCR. In order to emphasize the proposed process such as correlating the template and image is aspired. Secondly the frame differencing algorithm is employed to produce the motion regions. Finally, sub-images are cropped and stored via frames which are corresponding to motion regions. In the sequel, existing template will be correlated with sub-images and the best match will be replaced as a new template. This process is repeated for every fixed interval of six frames empirically.

In another attempt of research, a system has been proposed which tracks the object in the scene with the correlation between object and template. However, it takes care of updating the template with the help of PCA [14] for updating the template. Similarly, PCA based process of updating performed in which the existing template is compared with the sub-images and hence the best match is declared as new template based on the Euclidean distance values. It gives low value when the template (test image) has a best match with sub-images (training images) as a new template.

Lastly, an attempt in exhaustive template matching through histogram regression line has been put forth. In this proposed method involves three stages, such as estimating the correlation score by using normalized correlation between the template and sub-image. Next, the motion regions are detected by frame differencing algorithm. Finally, detected moving objects are cropped and stored as candidate templates.

Subsequently, product correlation coefficient through histogram regression lines of recent template and candidate templates are tabulated to find the best match. Consequently, corresponding to the minimum matching score of candidate template is replaced as a new template.

In the second bunch of intended strategies for object tracking and updating mechanisms the initial work cracks to propose the systems which track the object in a partitioned image with the correlation between template and object in a scene. Computational complexity has drastically been reduced as the correlation matching is exercised between the template and partitioned image and thereby it yields best possible outcomes. Here, object surrounding to an extent of a quadrant has been acquired by way of proposed image partitioning algorithm. The template in hand is matched in this partitioned image against the object through NCCR to reduce the search time. The task of updating involves routine steps like the extraction of the motion regions by frame differencing and stored as candidate templates.

The object tracking in partitioned image category consist initial segment of a proposed scheme of matching through NCCR between the template and a partitioned image and updating by NCCR. In other words, existing template will be correlated with sub-images and the best match will be replaced as a new template. In the second part, correlating the template and partitioned image is desired which is motivated based on the correlation score. But for updating, PCA for template and candidate templates are estimated to get the Euclidean distances. Hence the best match is declared as new template based on the Euclidean distances values. It gives low value when the template (test image) has a best match with sub-images (training images) as a new template.

In the last part, an attempt in the case of partitioned image template matching through histogram regression line has been put forth. Here, object tracking is achieved through the NCCR between the template and partitioned image. The process of updating has been carried out through the histogram regression lines of recent template and candidate templates to find the best match. Consequently, corresponding to the minimum matching score of candidate template is replaced as a new template. The course of updating is repeated for fixed number of frames and the experiment has been conducted profoundly employing the benchmark datasets such as PETS2001 (Performance Evaluation of Tracking and Surveillance) and PETS2000.

III. Exhaustive Template Matching Through NCCR

In this effort, the correlation between template and exhaustive or full image has been exercised to track the object and various updating mechanisms are proposed such as NCCR, PCA and HRL. In other words, the offered strategies are performing object tracking with NCCR and updating through NCCR, PCA and HRL respectively.

Normalized Cross Correlation Model

The cross correlation between the template and image has been elaborated.

$$d_{f,t}^{2}(u,v) = \sum_{x,y}[f(x,y) - t(x-u,y-v)]^2 \quad (1)$$

Where $f(x,y)$ is image and $t(x-u,y-v)$ is template positioned upon u & v.

$d_{f,t}^{2}(u,v)$ is squared Euclidean distance and summation is done over x and y.

$$d_{f,t}^{2}(u,v) = \sum_{x,y}[f^2(x,y) - 2f(x,y)t(x-u,y-v) + t^2(x-u,y-u)] \quad (2)$$

If the terms $\sum f^2(x,y)$ and $\sum t^2(x-u,y-v)$ are treated as constants

The approximate equation of cross-correlation is as given.

$$C(u,v) = \sum_{x,y} f(x,y)t(x-u,y-v) \quad (3)$$

This correlation score is a measuring unit of similarity between the image and the template. The basic correlation has been given through the equations (1) – (3). The difficulties are noticed such as image energy which causes correlation score minimum, sorting of $C(u,v)$ depends on template size, change in illuminations not affecting the (4) are eliminated through a process of normalization. Therefore the NCCR (γ) expressed through equation (4) as follows.

$$\gamma(u,v) = \frac{\sum_{x,y}[f(x,y)-\bar{f}_{u,v}][t(x-u,y-v)-\bar{t}]}{\{\sum_{x,y}[f(x,y)-\bar{f}_{u,v}]^2 \sum_{x,y}[t(x-u,y-v)-\bar{t}]^2\}^{0.5}} \quad (4)$$

Where $\overline{f_{u,v}}$ and $\bar{t}$ are the means of image and template respectively.

3.1 Template updating through NCCR

This work attempts to propose a system which tracks the object vigorously with the correlation between object and template. However, it takes care of updating the template with the help of approach of NCCR. It can be attained through the following such as correlating the template and image. Next the frame differencing algorithm is employed to produce the motion areas. Finally, candidate templates are cropped and hoarded which correspond to motion regions. Consequently, existing template will be correlated with each of the moving regions and the best match is declared as new template.

Proposed Methodology

The proposed algorithm has two phases such as tracking and updating. The first one is predominantly related to object tracking and second phase is dedicated to update the template.

Tracking

1. Renovate input video into frames.
2. Preprocess the frame & initialize with template.
3. Read the r^{th} frame and the template; compute the correlation score through NCCR.
4. Put the bounding box over the object for the best match.
5. Generating and updating the template after every fixed interval of frames.
6. Step **3 - 5** is repeated for **n** frames.

Updating

1. Initialization of count through **k** interval of frames.
2. Get absolute value by subtracting m^{th} frame from $(m-1)^{th}$ frame to produce difference image
3. Using threshold, the difference image is converted to binary form
4. The moving objects are labeled using connected component analysis.
5. Determine the centroids of moving objects.
6. Cropped sub-images corresponding to centroids are stored.
7. Declare a new template using NCCR between the template and the moving regions.

Experimental Results

It is observed that updating template at every alternate frame becomes computationally expensive. On the other hand updating after many frames will fail the tracking. Here, the updating frequency has been empirically fixed as **k** interval with the help of experimental evidences for stable tracking. It is also further noticed by trialing, that the tracking performance is directly proportional to the size of template. In other words larger the template, tracking is better.

As a first part of testing, PETS2001 dataset has been considered. The experimental result of the proposed criteria reveals that the DR and FAR have high values which diminishes the CR. In other words, high value of FAR is indication of poor performance.

In the second part, the experimentation on the PETS2000 has disclosed that the value of DR is highest because FN is negligible. However, the value of FAR is reduced comparatively yielding high CR to confirm the better performance of tracking. Hence, the performance of the system is better with PETS2000. The results are shown in Table 1 and same is exemplified through the Fig.1. Some samples of the tracked frames are depicted through the Fig. 2 and 3.

Table 1 Performance Indices of Tracking & Updating using NCCR.

Sl No	Dataset	TP	FP	FN	DR	FAR in %	CR in %
1	PETS2001	11	88	01	92	89	51
2	PETS2000	38	12	00	100	24	81

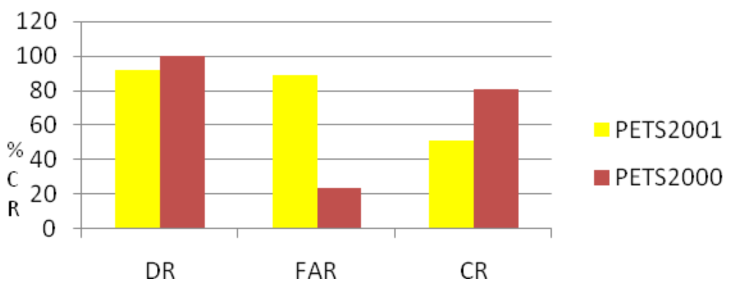

Figure 1 Plot of DR, FAR and CR for NCCR Tracking and NCCR updating

Figure 2 PETS2001

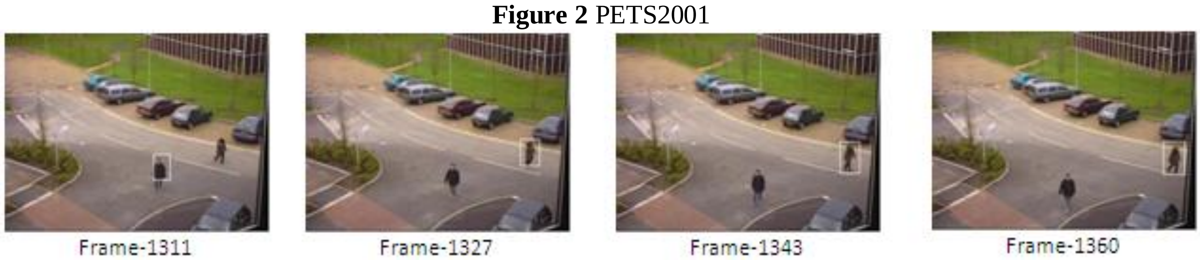

Figure 3 PETS2000

3.2 Template updating through PCA

The process of updating is done by computing PCA of the recent template and stored moving objects. Subsequently, the Euclidean distances between the PCA of template and moving regions are estimated. Thus, the moving object of minimum distance will be updated as a new template.

PCA Model

Karhunen Loeve transform is also known to be PCA

$$x = \begin{bmatrix} x1 \\ x2 \\ \vdots \\ xn \end{bmatrix} \qquad \text{n x1} \quad \text{vector} \qquad (5)$$

$$mean \quad m_x = \frac{1}{m} \sum_{k=1}^{m} x_k \qquad (6)$$

$$c_x = \frac{1}{m} \sum_{k=1}^{m} x_k \, x_k{}^T - m_x m_x^T \qquad \text{Co-variance matrix} \qquad (7)$$

The goal of PCA is to find a set of μ_i for i=1, 2…………n, which have largest projection on to each $x_k - m$, which is maximization of quantity

$$\lambda_i = \frac{1}{m} \sum_{k=1}^{m} \left(\mu_i^T [x_k - m] \right) \qquad (8)$$

Using Rayleigh's principle it can be proved that the solution of this equation is given by eigen values λ_i and eigen vectors of co-variance matrix c_x

$$Y = \psi(x - m_x) \qquad (9)$$

$$c_y = \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} \qquad (10)$$

Eigen values of c_x and c_y are identical. The PCA values are determined through the equations (5) - (10).

Proposed Methodology

Tracking

1. Unfurl video into frames.
2. Preprocess the frame and initialize with template.
3. Read the r^{th} frame and the template; compute the correlation score through NCCR.
4. Place the bounding envelope on the object for the best match.
5. Producing and updating the template after every fixed interval of frames by algorithm-II.
6. Steps **3** to **5** are repeated for **n** frames**.**

Updating

1. Initialization of count through **k** interval of frames.
2. Obtain difference image by subtracting m^{th} image from $(m\text{-}1)^{th}$ image.
3. The difference image is altered to binary image through suitable threshold.
4. Spatial information such as area, centroid and bounding box are derived by way of

connected component analysis.
5. Moving regions are cropped corresponding to spatial information.
6. PCA for template and moving objects are estimated.
7. Affirm a new template using Euclidean distance between PCA of template and moving regions

Experimental Results

Individual objects are tracked for PETS2001and PETS2000 using respective templates at fixed updating frequency of 6 for tracking stability. The efficient object tracking involves two steps such as mainly template matching and intermittently updating. The attempt of template matching is done by NCCR between template and the scene. The process of updating has been carried out by proposed PCA approach. In this scheme, PCA for template and moving regions are structured. Consequently, Euclidean distance between the template and each of moving objects are enumerated. The moving object of minimum Euclidean distance will be replaced as a new template which symbolizes the mark of updating the template.

The experimentation on both dataset shows that the value of CR for PETS2000 is higher as compared to that of PETS2001 which shows better performance of tracking.

Fig. 4 gives the graphical representation of the tracking efficacy. On the other hand object tracking in video sequences are depicted through the Fig. 5 and 6.

Figure 4 Plot of DR, FAR and CR for Tracking with NCCR and PCA updating

Figure 5 PETS2001

Figure 6 PETS2000

3.3 Template updating through Histogram Regression Line (HRL).

In this, the process of template updating through HRL has been presented. The procedure consisted the essential steps like the constructing the moving objects through frame differencing, computing the HRL for template as well as the moving regions. Subsequently, estimation of the Euclidean distance between the template and objects is achieved. The minimum Euclidean distance object is taken as the accurate match.

HRL Model

Acquired image is converted into number of bins and is used for erecting the histogram. The information related to histogram such as number of bins versus number of pixels is converted into the regression line employing the following mathematical substance [15]. S_X is the summation of bins and S_Y is the number of pixels respectively. Equations (11 - 15) are harnessed to determine the regression coefficient such as product-moment correlation coefficient as given in (16).

$$S_X = \sum_{i=1}^{n} X_i \qquad (11)$$
$$S_Y = \sum_{i=1}^{n} Y_i \qquad (12)$$
$$S_{XX} = \sum_{i=1}^{n} X_i^2 \qquad (13)$$
$$S_{XY} = \sum_{i=1}^{n} X_i Y_i \qquad (14)$$
$$S_{YY} = \sum_{i=1}^{n} Y_i^2 \qquad (15)$$
$$r = \frac{nS_{XY} - S_X S_Y}{\sqrt{(nS_{XX} - S_X^2)(nS_{YY} - S_Y^2)}} \qquad (16)$$

Proposed Algorithm

Tracking
1. Choose one of the moving objects as model template to track.
2. Estimate the NCCR between the template and image to mark the bounding box for best match.
3. Creating and updating the template after every fixed interval of frames.
4. Step **1 to 3** are repeated for **n** frames

Updating
1. Initialization of **k** interval.
2. Median filter is occupied to remove noise from the image. Moving objects are detected by way of frame difference, connected component analysis and morphological operations.
3. Based on spatial information like centroids and bounding box, candidate templates are cropped and stored.
4. Compute the product correlation coefficient through HRL between the model and candidate templates.
5. Best match candidate template will be updated as model template and its spatial information is stored.

Experimental Results

The experimentation with the said dataset is performed for fixed frequency of template updating. Here, object tracking is accomplished by NCCR between template and the image. The course of updating has been achieved by way of histogram regression line. In the proposed plot, regression lines for template and moving regions are created. Accordingly, Euclidean distances between the template and moving regions are detailed. In order to update the template, the minimum Euclidean distance is identified and correspondingly the moving object will be substituted as a fresh template. Additionally, the trial result on both dataset has shown that the highest value of CR for PETS2001 proving better performance of tracking in contrast with PETS2000.
The results of tracking presentation are displayed in the Fig. 7. Moving object localization in video frames is illustrated with the help of Fig. 8 and 9.

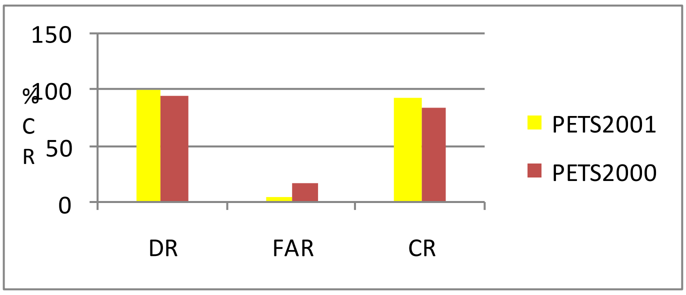

Figure 7 Plot of DR, FAR and CR for Tracking with NCCR and HRL updating

Frame-2526 Frame-2559 Frame-2592 Frame-2625

Figure 8 PETS2001

Figure 9 PETS2000

IV. Partitioned Image Template Matching through NCCR

Here, the correlation between template and the partitioned image (PT) or quadrant has been worked out to track the object and different updating systems are suggested like NCCR, PCA and HRL. In other words, the recommended plans of object tracking are using NCCR between the partitioned image and template. But updating has been carried out through NCCR, PCA and HRL respectively.

Acquisition of the Partitioned Image

Consider the image of size n x n in order to acquire the sub-image or partitioned image. Sliding Window (SW) is given as $\frac{n}{2^p}$ $where\ p = 0,1,2,3$ .... and the Grid Size (GS) is given by $\frac{n}{4*2^p}$. We have experimented for p=1 and its SW is n/2 and GS is n/8. The sliding window is positioned at the centre of image as shown in Fig.10 (a). Provide the centroid information of object to locate its bounding area. If it is within the bound of (x_1,y_1), (x_2,y_1), (x_2,y_2) and (x_1,y_2) then crop the image surrounding to this centroid to the size of a quadrant and declare as a sub-image. Slide the window to the right by one grid size when the centroid is not located as shown in Fig. 10 (b) and this process is repeated till the object is located as indicated in Fig.10 (c)-(d). Subsequently, crop the image surrounding to this centroid to the size of a quadrant and declare as a partitioned image. Exhaustive image is described by Fig.11 (a) and matching template along with the partitioned image is portrayed in Fig. 11 (b).

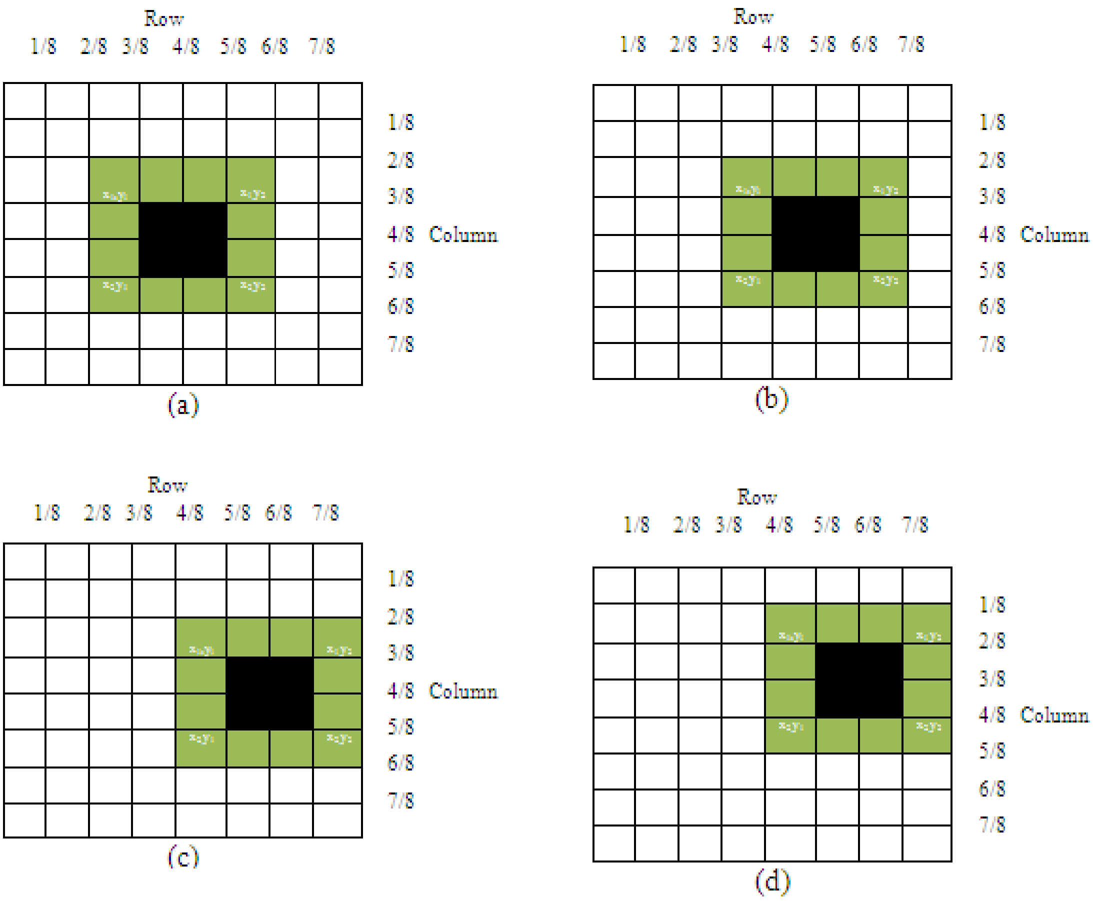

Figure 10

(a)

(b)

Figure 11

4.1 Template updating through NCCR

The process has been divided into the basic blocks such as the fabricating the motion regions by means of frame differencing, estimating the NCCR between the template and each of the moving objects. The object having maximum NCCR score is declared as the best match and same is replaced as new template as a blotch of updating mechanism.

Proposed Methodology

Tracking

1. Initialize the model template and spatial information is passed on to the next stage.
2. If the centroid of template is in the bounds of $(x_{1,}y_1)$, $(x_{2,}y_1)$, $(x_{2,}y_2)$ and $(x_{1,}y_2)$, then crop the quadrant (partitioned image) otherwise repeat sliding the window till the centroid is detected.
3. Estimate the NCCR score between the template and partitioned image to mark the bounding box over the moving object for best match.
4. Creating and updating the template after every fixed interval of frames.
5. Steps **1 to 4** are repeated for **n** frames

Updating

1. Initialization of **k** interval.
2. Median filter is occupied to remove noise from the image. Moving objects are detected by way of frame difference, connected component and morphological operations.
3. Based on spatial information like centroids and bounding box, candidate templates are cropped and stored.
4. Compute the NCCR between the model and candidate templates.
5. Best match candidate template will be updated as model and its spatial information is stored.

Experimental Results

The experiment on outdoor video surveillance dataset of PETS 2001 and PETS 2000 has been conducted to substantiate the performance efficacy of the proposed novel system. The computational complexity of the developed method churns out to be polynomial. In the first illustration, the experiment has been conducted on PETS2001 and NCCR score is estimated by sliding the template over the partitioned image. The maximum score highlights the location of the object to put the bounding box. Template updating is also performed at regular interval of frames to evade the template drift through the NCCR between the template and each of the moving regions. The moving region of maximum score will be replaced as new template to claim the updating process. Secondly, an experimental analysis on PETS2000 has too been accomplished.

The performance of tracking is best for PETS2001 since CR value is higher compared to the PETS2000. The tracking performance is tabulated in the Table 2 and the outcome has been depicted through Fig.12. The tracked frames are portrayed in Fig.13 and 14 respectively.

Table 2 Tracking for partitioned image with NCCR and NCCR updating

Sl No	Dataset	TP	FP	FN	DR	FAR in %	CR in %
1	PETS2001	99	01	00	99	01	99
2	PETS2000	26	24	00	100	48	68

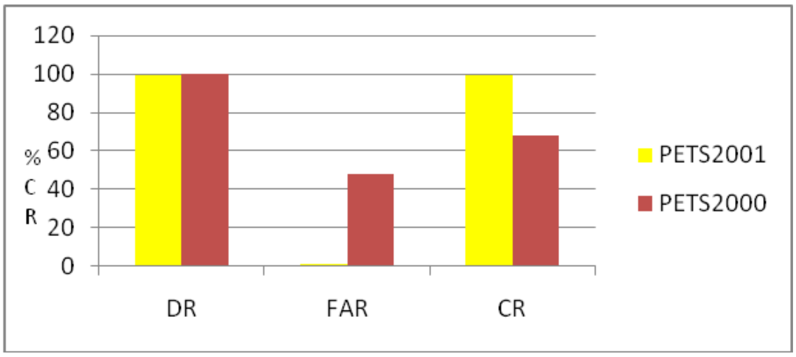

Figure 12 Plot of DR, FAR and CR for Tracking in partitioned image with NCCR and NCCR updating

Frame-2526 Frame-2559 Frame-2592 Frame-2625

Figure 13 PETS2001

Frame-1311 Frame-1327 Frame-1343 Frame-1360

Figure 14 PETS2000

4.2 Template updating through PCA

The practice of template updating through PCA has been described. The system has the important building blocks such as the acquiring the moving objects through frame differencing, generating the PCA for template and the moving objects. Consequently, the Euclidean distance between the template and objects has been calculated. The object of minimum Euclidean distance is best match and changed as new template.

Proposed Methodology

Tracking

1. Initialization of model template and spatial information is passed on to the next stage.
2. If the centroid of template is in the bounds of $(x_{1,}y_1)$, $(x_{2,}y_1)$, $(x_{2,}y_2)$ and $(x_{1,}y_2)$, then crop the quadrant (sub-image) otherwise repeat sliding the window till the centroid is detected.
3. Determine the NCCR score between the template and sub-image to mark the bounding box over the moving object for best match.
4. Creating and updating the template after every fixed interval of frames.
5. Steps **1 to 4** are repeated for **n** frames.

Updating

1. Count Initialization **k** interval of frames.
2. Median filter is occupied to remove noise from the image. Moving objects are detected by way of frame difference, connected component and morphological operations.
3. Based on spatial information like centroids and bounding box, candidate templates are cropped and stored.
4. Compute the PCA^s of the model and candidate templates. Also compute using enumerate Euclidean distances.
5. Best match candidate template will be updated as model and it's spatial information is accumulated.

Experimental Results

In an attempt to reveal the performance analysis, firstly an experiment has been conducted on PETS2001. The template matching process to track the object remains same that the NCCR score is approximated by sliding the template over the partitioned image. The bounding box is enclosed on the spot where maximum score occurs. In order to avoid the loss of tracking, the template updating is executed at regular interval of frames through the PCA between the template and moving objects. Additionally, the Euclidean distance between the template and moving regions are tabulated. The moving region of minimum distance will be reinstated as new template to complete the updating process. In the second part, an experimental investigation is extended on PETS2000 and realized the ground truth.

The performance efficacy of tracking with PETS2001 is not effective compared to the results of CR for PETS2000. The pictorial representation of the experimental outcome has been described through the Fig.15.
The marked frames on the interested moving object are represented in Fig.16 and 17 respectively. The computational complexity of the developed method churns out to be polynomial.

Figure 15 Plot of DR, FAR and CR for Tracking in partitioned image with NCCR and PCA updating

Figure 16 PETS2001

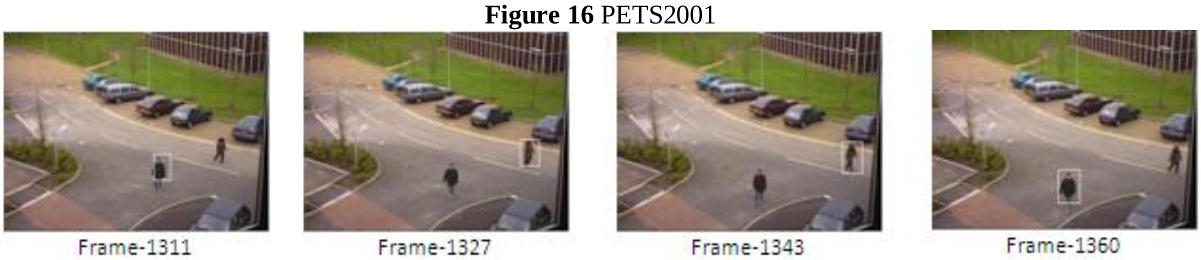

Figure 17 PETS2000

4.3 Template updating through Histogram Regression Line

Here, the process of updating has been performed using the main stages like acquiring the moving objects through frame differencing, determination of HRL for template and moving objects. Consequently, assessment of the Euclidean distance between the template and moving regions has been realized. The object of minimum Euclidean distance is substituted as new template.

Proposed Algorithm
Tracking
1. Declare the template and spatial information is passed on to the next stage.
2. If the centroid of template is in the bounds of (x_1,y_1), (x_2,y_1), (x_2,y_2) and (x_1,y_2), then crop the quadrant (partitioned image) otherwise repeat sliding the window till the centroid is detected.
3. Estimate the NCCR score between the template and partitioned image to mark the bounding box over the moving object for best match.

4. Creating and updating the template after every fixed interval of frames.
5. Step **1 to 4** are repeated for **n** frames

Updating

1. Count Initialization k interval of frames.
2. Median filter is occupied to remove noise from the image. Moving objects are detected by way of frame difference, connected component and morphological operations.
3. Based on spatial information like Centroids and bounding box, candidate templates are cropped and recorded.
4. Compute the PCA for model and candidate templates. Estimate the Euclidean distance between the template and moving regions.
5. The minimum distance candidate template is best match and will be updated as new model template and it's spatial information is heaped.

Experimental Results

The test has been conducted to substantiate the performance effectiveness of the proposed method on PETS2000 and PETS 2001. The NCCR score is determined between the template and the partitioned image. The maximum score of the search process is the location of the object which is similar to the template and this allows us to put the bounding box.

Further, in the task of template updating, moving objects are extracted and their spatial information is stored to crop the moving regions from the scene. Subsequently, the histogram regression line for the template and moving regions are established and Euclidean distance between the template and moving regions has been listed. However, the minimum distance will declare corresponding moving object as best match and replaced as new template to honor the updating task. The investigational scrutiny revealed that the value of CR is superior for PETS2001 which is proving efficient performance of tracking compared to PETS2000. Fig. 18 shows the plots of performance indices. Tracked objects in the sequences are shown in Fig. 19 and 20.

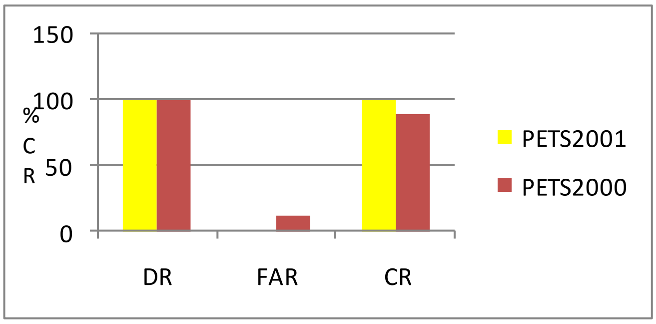

Figure 18 Plot of DR, FAR and CR for Tracking in partitioned image with NCCR and HRL updating

Figure 19 PETS2001

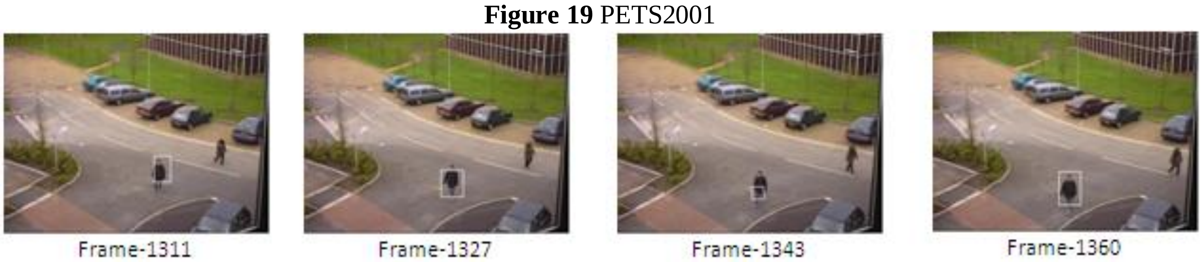

Figure 20 PETS2000

V. Comparative Analysis

The comparative analysis of proposed strategies by way of exhaustive template matching (ET) and partitioned image template matching (PT) is given below for dataset PETS 2000 and PETS 2001.

The experimentation has divulged the results of the object tracking approaches for exhaustive image using NCCR through template updating schemes. The offered approaches are NCCR, PCA and HRL for updating the template at the regular interval. Further, results demonstrate that the performance is better when HRL is used for updating the template.

In the instance of exhaustive template matching (ET), three strategies are proposed namely NCCR based tracking and updating, NCCR based tracking and PCA based updating and NCCR based tracking and HRL based updating.

In another occasion of partitioned image template matching (PT), similar three strategies have been recommended that are Partitioned Image NCCR based tracking and updating, Partitioned Image NCCR based tracking and PCA based updating and Partitioned Image NCCR based tracking and HRL based updating.

Here, result analysis through Fig. 21 has revealed that the CR portrayed superior value for partitioned image NCCR based tracking and HRL based template updating than ET for PETS2001. There is no significant improvement in the results of both Partitioned Image NCCR based tracking and updating, Partitioned Image NCCR based tracking and PCA based updating.

The results for PETS2000 has shown remarkable improvements in all three proposed strategies for Partitioned Image NCCR based tracking and NCCR or PCA or HRL based updating than its counterpart.

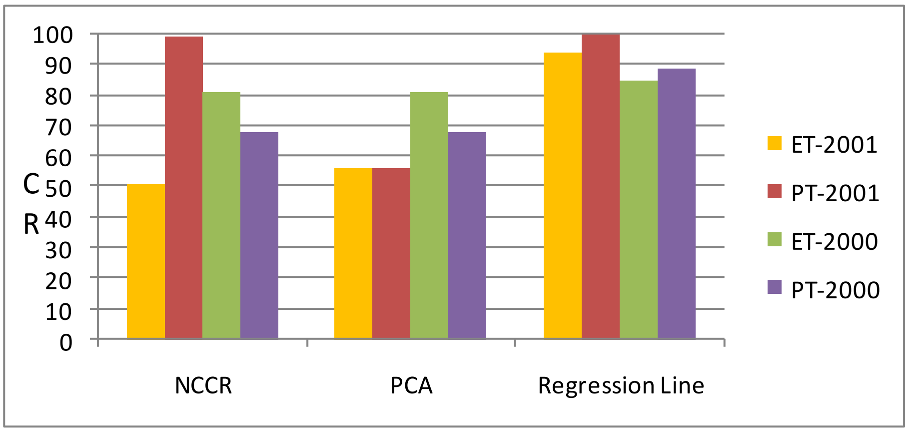

Figure 21 Comparative plots for CR versus proposed strategies

VI. Conclusion

In this work, it is established through NCCR feature to track multiple objects. The procedure being able to track object as small as 50 pixels and update frequency is empirically decided as **k** frames. It is observed that larger the template, tracking is better, but on the contrary poor tracking. Experimental results on PETS 2001 and PETS2000 reveal that the approach is capable of spotting and tracking the object correctly.

The proposed works of exhaustive template matching have established template association through NCCR feature to track the interested object. Here, experiments have been conducted through different methodologies of tracking in an exhaustive image using NCCR through template updating tasks such as NCCR, PCA and HRL respectively at the regular interval. Further, experimental results comprehend the performance of HRL for updating template has shown remarkable observations.

The result analysis has attempted to disclose the superior CR value for partitioned image NCCR based tracking and HRL based template updating compared with exhaustive template matching on PETS2001. Further, the experimentation revealed that the performance on PETS2000 has confirmed significant perfections in the proposed methodologies for Partitioned Image NCCR based tracking and NCCR or PCA or HRL based template updating against the exhaustive image template matching approaches.

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