Chapter 8

Comprehension of Approaches to Object Tracking

8.1 Introduction

Five models have been proposed in this thesis from Chapters 3 to 7 to track the object in a scene for different dataset. Object tracking process is a challenging task because of the change in illumination, position, shape, occlusion of objects and computational aspects. This has been the motive behind offering systems for some major applications along with certain postulations. Recently, thrust has been posed in the research of novel algorithms in object tracking of machine vision area like robot navigation, traffic monitoring and video surveillance etc. The much appreciated applications are in the surveillance of places of airport, railway stations, bus stand, super markets and giant shopping malls etc. The detection and tracking of an interested object in scene has drawn enormous notice due to the developing need of safety of society and spotting of crimes.

The object tracking will be quite trivial and straightforward when the background is static. Otherwise, there is essence and urgency of potential strategy to reveal and track the object when background is non-stationary. There are some approaches and research publications proposed in tracking the object based on the classification such as point, kernel and silhouette. The object tracking is precise due to suitability of object representation, motion,
appearance and shape etc. However, object tracking is overburdened with many problems like object scaling, swift movement of objects and computational cost.

The manual tracking of an interested object in sequence of frames leads to the fatigue as a human cannot focus on an object continuously for about 20 minutes. If the object is single in a scene, it will be easy for locating its position but as number of objects increases then some intelligent attention drawing mechanism is essential to track the object.

The tracking could be for single object or multiple objects. For the multiple objects, some novel models have been suggested by employing various benchmark dataset. The comparative analysis of the five models along with routine approaches to object tracking display the importance of each model with respect to various situations of the scene on the basis of tracking efficiency.

The Section 8.2 describes the effectiveness of object tracking approaches and in the Section 8.3, investigation of the proposed strategies is executed. The overall experimental analysis on various dataset is carried out in Section 8.4 and the chapter concludes with Section 8.5.

### 8.2 Effectiveness of Object Tracking Approaches

The difficulties in obtaining moving regions in case of background subtraction or frame differencing are due to changes in illumination, noises and fake motion. The effective and direct object localization concept of NCC is worth appreciation. The irregularity or dynamics in the shape of object and change in illumination leads to failure in tracking which demands the template updating at suitable frequency of frames.

In the meanshift concept, color PDF of template and candidate templates are determined to seek the mode or locate the shift in the mean. But, color PDF is very weak in discriminating the similarly colored but different objects. Therefore, creating the joint histograms of color and CCV will certainly distinguish the objects ensuring improved tracking performance.

Other updating strategies which used in conjunction with color optical flow are such as HRL and Doyle's distance. The minimum Euclidean distance of HRL of template and each of the candidate templates gives the new template.
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The effectiveness of updating strategy lies in nearness of HRL of template and candidate templates.

The FD of proposed GMSC functions for object signature has been estimated. The template updating is achieved by way of Euclidean distances between the FD of template and the FD of candidate templates.

Similarly, the minimum Euclidean distance of WSD descriptor for template and each of the moving objects is updated as new template in case of DWT or LDWT based tracking.

8.3 A Brief Investigation of the Proposed Strategies

Most of the tracking systems require the extraction of moving objects dependably and success of tracking many times depend on them. The quite basic techniques and simple in time aspects to extract the moving regions are background subtraction and frame differencing respectively are employed as routine methodologies. In order to enhance tracking results, another style of object tracking is owing to the matching between the template and image by the NCC score.

The further improvement in the performance has been achieved through updating the template regularly. The initial effort is using NCC between the template and full image with various updating strategies as NCC, PCA and HRL. In the other effort of reducing the search time, establishing NCC between the template and partitioned image with same updating schemes have been attained.

In a similar endeavor, the search region of concerned object had been considerably reduced. Here, meanshift criterion with joint histogram of color and CCV is suggested to offer the robust and increased performance in tracking.

Subsequently, the range of tracking systems using the color optical flow concept have been presented. The moving regions are obtained by either of the optical flow techniques of Horn-Schunck or Lukas-Kanade. The template updating is carried out by employing Histogram Regression Line or Doyle’s distance. Hence, the suggested methodologies are Horn-Schunck with HRL,
Lukas-Kanade with HRL, Horn-Schunck with Doyle’s distance and Lukas-Kanade with Doyle’s distance. The performance of tracking is improved at the cost of computational expenditure.

Similarly, the moving regions are mined through gray optical flow technique of Horn-Schunck in order to reduce the computational aspect significantly. Further, one of the frequency domain criteria like Fourier Descriptors (FD) is employed. Here, FDs for proposed GMSC of template and moving objects are estimated. The minimum Euclidean distance between the template and candidate templates is asserted the best match to update the template.

Another frequency domain concept of DWT or LDWT to get moving objects by way of DCD is employed. The template updating is performed by estimating the Euclidean distance between the WSD of template and each of moving regions. The effort has been compared with Cheng’s work.

8.4 Overall Experimental Analysis

In the beginning, review of existing routine methods of tracking have been verified by experimentation in Chapter 2. Exhaustive experiments on the proposed five approaches for tracking have been discussed in Chapters 3 to 7. Tracking performance of all the proposed methodologies for various dataset have been evaluated by experimentation. The same are shown in the following tables.

There are sub-contributions in each of the proposed schemes and therefore the best performing contribution from each chapter is considered as contender for comparative analysis. In other words, the outperforming contribution from each approach will be a candidate for comparison.

The performance of NCC based object tracking is superior compared with background subtraction and frame differencing schemes from Chapter 2.

From Chapter 3, the result analysis has unveiled that the F value is better for partitioned image NCC based tracking and HRL based template updating as compared to exhaustive template matching.

Chapter 4 discloses that the performance of meanshift with joint histogram is finer compared with Color and CCV respectively.
Chapter 5 contributes various color optical flow based strategies for tracking and template updating. The performance of the Lukas-Kanade color optical flow and HRL is better as compared to other strategies.

GMSC shape signature using FD has shown remarkable performance in respect of conventional centroid and other shape signatures in Chapter 6.

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PETS2001 (3) dataset from 2526-2625 (100 frames)

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PETS2000 dataset from 1291-1360 (70 frames)

Table 8.1: Comparison of results of the proposed approaches.
In Chapter 7, it is inferred that the performance of LDWT is excellent as compared with the third level DWT and Cheng’s work.

Therefore, the best performing schemes of each approaches have been considered for conducting comparative experiment and the outdoor surveillance clip of PETS2001(3) and PETS2000 are utilized for the trail to divulge the outcome and robustness of the systems. The tracking efficiency is analyzed quantitatively through the parameters of TP, FP, FN, DR, FAR and CR. The performance indices are given in Table 8.1 and same is shown graphically in Figure 8.1.

Tables 8.2 and 8.3 show a comparison of tracking performance in respect of PETS2001(3), PETS2000 dataset for all approaches. Table 8.4 shows the F-Score for all approaches for various datasets. In these tables the values shown in bold font indicate the optimum tracking performance.
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1. ROUTINE APPROACHES

| BS     | Nil | 20  | 42  | 38  | 32  | 34  | 68  | 33  | 33  | 33  | $O(N^3)$ |
| FD     | Nil | 23  | 35  | 42  | 40  | 35  | 60  | 37  | 37  | 37  | $O(N^3)$ |
| NCC    | Nil | 26  | 4   | 70  | 87  | 27  | 13  | 68  | 41  | 48  | $O(N^3)$ |

2. NCC WITH UPDATING

| EI          | NCC   | 61  | 37  | 2   | 62  | 97  | 38  | 72  | 76  | 78  | $O(N^4)$ |
| PCA         | 80    | 15  | 5   | 84  | 94  | 16  | 85  | 89  | 89  |    | $O(N^3)$ |
| HRL         | 90    | 5   | 5   | 95  | 95  | 5   | 95  | 95  | 95  |    | $O(N^3)$ |
| PI          | NCC   | 70  | 20  | 10  | 78  | 88  | 22  | 80  | 83  | 83  | $O(N^4)$ |
| PCA         | 90    | 5   | 5   | 95  | 95  | 5   | 95  | 95  | 95  |    | $O(N^3)$ |
| HRL         | 96    | 4   | 0   | 96  | 100 | 4   | 96  | 98  | 98  |    | $O(N^3)$ |

3. MEANSHIFT

| MS          | Color  | 88  | 0   | 12  | 100 | 88  | 0   | 100 | 94  | 94  | $O(N^3)$ |
| CCV         | 90    | 0   | 10  | 100 | 90  | 0   | 100 | 95  | 95  |    | $O(N^3)$ |
| JH          | 97    | 0   | 3   | 100 | 97  | 0   | 100 | 98  | 98  |    | $O(N^3)$ |

4. Color Optical Flow with Updating

| HS          | HRL   | 98  | 2   | 0   | 98  | 100 | 2   | 98  | 99  | 99  | $O(N^5)$ |
| LKPR        | HRL   | 99  | 1   | 0   | 99  | 100 | 1   | 99  | 99  | 99  | $O(N^6)$ |
| HS          | DD    | 98  | 2   | 0   | 98  | 100 | 2   | 98  | 99  | 99  | $O(N^5)$ |
| LKPR        | DD    | 98  | 2   | 0   | 98  | 100 | 2   | 98  | 99  | 99  | $O(N^6)$ |

5. FOURIER DESCRIPTORS

| FD          | Centroid | 80  | 15  | 5   | 84  | 94  | 16  | 85  | 89  | 89  | $O(N^3)$ |
| FD          | GMSC    | 97  | 3   | 0   | 97  | 100 | 3   | 97  | 98  | 98  | $O(N^3)$ |

6. WAVELET TRANSFORMS

| DWT         | WSD    | 97  | 3   | 0   | 97  | 100 | 3   | 97  | 98  | 98  | $O(N^3)$ |
| LDWT        | WSD    | 100 | 0   | 0   | 100 | 100 | 0   | 100 | 100 | 100 | $O(N^3)$ |

Note: P, R, FAR, CR, F, and G are in per cent. CC – Computational Complexity

Table 8.2: Performance of all approaches for PETS2001(3) dataset.
### Chapter 8. Comprehension of Approaches to Object Tracking

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Note: P, R, FAR, CR, F, and G are in per cent.

Table 8.3: Performance of all approaches for PETS2000 dataset.
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### Table 8.4: Performance of F-Score for all approaches for various dataset.

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Note: P, R, FAR, CR, F, and G are in per cent.

I-Ball; II-Sample; III-PETS2001(1); IV-PETS2001(2); V-PETS2001(3);
VI-PETS2000; VII-Visor; VIII-Taxi; IX-dtneuWinter.

Table 8.4: Performance of F-Score for all approaches for various dataset.
8.5 Conclusion

In the proposed works, five different tracking models have been evolved. This chapter attempts to present a systematic comparative analysis of the intended approaches for tracking through various updating schemes.

The best performing approaches with appropriate updating techniques have been scrutinized along with tracking efficiency. The performance of the routine NCC based tracking occurs very weak and can be attributed to the absence of updating. The approaches of NCC with HRL updating, meanshift with joint histogram and Lukas-Kanade with HRL have demonstrated improved results in tracking monotonously. Further, the tracking performance is improved in case of FD with GMSC shape signature as compared to routine NCC system but shows decreased performance compared to the other proposed schemes. LDWT with WSD updating scheme shows the highest efficacy for the dataset considered. Hence, it can be concluded that the tracking efficiency is superior in LDWT with WSD.