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Computationally Efficient Algorithm for Detecting Moving Objects with Moving Background

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Abstract**—** The area of moving object detection has been a constant topic of research in more than a decade, where a research community have witnessed various significant contribution in the past that mitigates the problem of real-time and moving object detection. In our prior studies, we have addressed such issues using various sophisticated technique yielding superior results. But, it is felt that some light weight algorithm is required for the purpose of performing moving object detection with complete retention of object detection accuracy. This paper have presented a very simple algorithm that uses visual descriptor for extracting the dynamic features during fast transition of frames. The proposed algorithm is tested with one of the most significant work done recently on same purpose with respect to precision and recall rate along with analysis of processing time of proposed algorithm.

Keywords*-component; Moving Object Detection, Iriented FAST and rotated BRIEF*

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I. Introduction

In object detection mechanism [1], a feature can be spoken of as some progressive structure units, for example, scene, shot and frame. Additionally, multimedia frames is the least level in the progressive structure. The content-based multimedia browsing and recovery, feature content investigation utilize these structure units. In multimedia retrieval system, for the most part, feature applications should first segment a given feature grouping into feature shots. A feature shot is characterized as a picture or video frame grouping that exhibits constant activity. The casings in a feature shot are caught from a solitary operation of one cam. Ongoing moving item discovery is basic for various inserted applications, for example, security observation and visual following. Moving item recognition regularly goes about as a starting venture for further handling, for example, characterization of the caught moving article. So as to perform more modern operations, for example, order, we have to first create an effective and in addition precise calculation for moving item recognition. It is trying to catch a moving protest in an opportune way without obliging extraordinary equipment for picture transforming or devouring a great deal of computational assets. A standout amongst the most widely recognized methodologies for moving item recognition is focused around the foundation subtraction method. It regularly depends on determining the probabilistic model of the foundation. At the point when another picture is caught, the contrast between the picture and foundation model is figured for moving item discovery. Shockingly, the deduction of the model is unpredictable and computationally extravagant. Albeit elective methodologies not focused around probabilistic displaying of the foundation picture exist, they are particular to applications. Accordingly, the vast majority of existing methodologies for moving article recognition are computationally substantial and subject to expansive deferrals, antagonistically influencing the execution of constant reconnaissance.

- Deriving the foundation model is computationally nontrivial. Further, it is obliged to keep up authentic information for displaying purposes. Accordingly, it is hard to send it in implanted frameworks with generally rare assets.
- if an item is moving gradually, would it be a good idea for it to be considered as a foundation? Few authors tackle this issue by arranging pixels into three classes: foundation, mid ground and frontal area to recognize among long haul, medium-term and fleeting changes. Then again, it is not clear how to dependably make clear refinements among them.
- Intermittent arbitrary clamor or sharp enlightenment changes can result in issues for recognizing moving items, on the grounds that it may exasperate the inferred foundation model.
- it is hard to focus at what interim the foundation ought to be redesigned. Excessively successive upgrades may devour inordinate computational assets. Then again, excessively occasional redesigns might altogether diminish the precision of moving article recognition.

To address these issues, we don't depend on any foundation show however straightforwardly figure the contrasts between two sequential pictures frame and perform moving item location focused around the distinctions. Consequently, our methodologies are less delicate to arbitrary clamor or sharp enlightenment changes. Additionally, they are speedier and expend less CPU cycles and memory than the current methodologies focused around foundation processing, in light of the fact that we don't need to determine the foundation model and store a lot of verifiable information for foundation demonstrating. We have really executed our calculations in a minimal effort portable computer with no exceptional equipment for picture transforming utilizing Matlab.

II. Related Work

Keerthana et al. [2] uses fuzzy-Extreme Learning Machine and Self Organizing Map (SOM) to detect the moving objects as well as shadow elimination in dynamic background. The proposed method is the automatic model, it automatically determines the threshold values Th1 and Th2 without human intervention and it doesn't need previous training.

Kermani and Asemani et al. [3] have introduced a model for the detection of moving objects in surveillance applications which combines adaptive filtering technique with the Bayesian change detection algorithm.

Wang et al. [4] have presented a moving object detection system named Flux Tensor with Split Gaussian models (FTSG) that exploits the benefits of fusing a motion computation method based on spatio-temporal tensor formulation, a novel foreground and background modeling scheme, and a multi-cue appearance comparison.

Oneata et al. [5] have made two contributions towards exploiting detection proposals for spatio-temporal detection problems. First, a recent 2D object proposal method have been extended to produce spatiotemporal proposals by a randomized supervoxel merging process. A spatial, temporal, and spatio-temporal pairwise supervoxel features was introduced that are used to guide the merging process. Second, a new efficient supervoxel method has been proposed.

Saif et al. [6] have applied moments based dynamic motion model under the proposed frame difference based segmentation approach which ensures that robust handling of motion as translation invariant, scale invariant, and rotation invariant moments value is unique.

Ali et al. [7] have presented a method for the integration of prior object motion in foreground/background segmentation. The authors propose a background subtraction technique for wood detection and incorporate a motion model into wood detection. The authors performed comparative analysis of image segmentation which we obtain with and without incorporation of prior object motion.

Kadim et al. [8] have proposed a method to estimate the blur level of the image. For the moving object detection part, the authors have combined the Wroskian's change detection method to detect the moving pixels and refine the result by utilizing the neighbor pixels concept to reduce the noise resulted from imperfect alignment of successive images.

Sharma and Nevatia [9] present a novel and efficient detector adaptation method which improves the performance of an offline trained classifier (baseline classifier) by adapting it to new test datasets. The authors propose an adaptation method, which can be applied to various baseline classifiers and is computationally efficient also.

Cui et al. [10] have proposed method based the frame difference to automate choosing the seeds. The authors have used the concept of frame difference with the graph cut method for performing segmentation. The experiments have been performed in both indoor and outdoor views to find the solution is effective in object detection in most challenging environment.

III. RATIONALE

In 2011 Ethan Rublee et al [11] they have displayed first time a quick powerful peculiarity identifier called oriented FAST and rotated BRIEF. It is focused around the visual descriptor called Binary Robust Independent Elementary Features (BRIEF) & FAST. The SIFT key point identifier descriptor is decade old idea where as it has given significant measure of achievement in various application, for example, visual mapping, picture sewing & object distinguishment utilizing visual gimmick. For continuous framework it forces an extensive computational overhead, in this way an interchange system. SURF were advanced which guarantees relatively lower computational overhead. Further the point of ORB was to supplant SIFT/SURF for getting comparative matching performs however in a less computational overhead. So it could be synchronized with constant application. In an issue like discovery an item particularly when it is moving with element foundation, there would be huge progression in picture matching & gimmick matching with utilizing ORB. Applications like signal distinguishment, item following, confining moving article is most essential preprocessing stage the most well-known system which is constantly utilized is the strategy for subtraction. In this system the current casing subtractive from foundation picture and grouping of every pixels either as moving protest or foundation is contrasted and distinction by an edge and this is the way the moving item is recognized and followed by redesigning the inclining models certain studies allude a paper where moving article distinguish & followed utilizing foundation subtraction. An alternate comparative strategy were created casing distinction system certain studies allude outline contrast technique. In the over two system, the suspicion made is that the cam stationary there for it neglects to recognize moving item with moving cams without accessibility of cam movement parameters. To beat these troublesome and optical stream strategy where created which could locate moving question either cam is static or element. In any case the optical stream strategy is computationally higher overhead & having different genuine times obliges. Where movement estimation payment expand intricacy of general calculation. Along these lines a proficient & computationally quick calculation required for identifying moving article with element cam dataset to meet continuous execution. A system for arranged quick and turned short [orb] is utilized to concentrate the peculiarities & match between two casings is proposed where the repetitive spatial descriptors are separated to regurgitation. The relative change is registered so as to portray movement parameters among successive casings to remunerate cam movement then the strategy for subtraction is utilized to recognize moving item. The execution assessment of the proposed strategy might be possible observational approach by contrasting the properties and SURF & SIFT systems as far as constant precision and proficiency parameters. Our prior work [12] was focused on multiple homogenous object detection on dense crowd, where we have mainly used feature attributes. Our next study was focused on heterogeneous object detection using Kalman filter [13] followed by homography based single object detection [14]. We have introduced an efficient but yet sophisticated technique, however, this paper intends to implement certain simpler technique for the same purpose.

IV. PROPOSED SYSTEM

The prime purpose of the proposed system is to evolve up with a technique that can perform an efficient detection of the moving object exclusively for the scenario when the background is also moving. This is one of the most challenging scenario to be evaluated as both objects as well as background can have various dynamic charecteristics that needs to be captured as well as computed faster in synchronous with the event of both object and background movement. The proposed system emphasize on adopting the principles of affine homography [15]. The schema of the proposed system is highlighted in Figure 1.

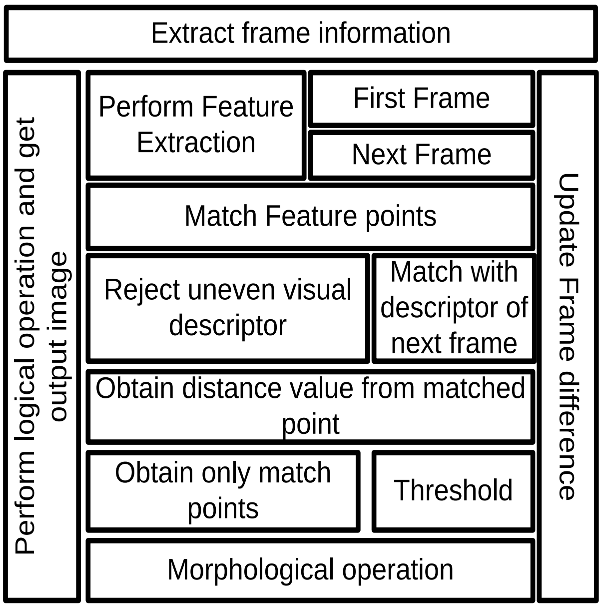

Figure 1 Schema of the proposed system

The system considers designing the essential attributes of affine homography for the purpose of tracking the object from one to another frame. The principle operation of computation for essential attributes is motivated from the study of Deniz et al. [16], who have discussed a technique for precise global motion detection. For this purpose, we choose to adopt oriented FAST and rotated BRIEF or commonly known as ORB, which is a type of local feature detector [17] based on visual descriptor Binary Robust Independent Elementary Features or commonly known as BRIEF. The prime objective of implementing ORB is to give better tracking and detection outcomes compared to conventional SIFT techniques [18]. However, the proposed system will be also focused on deploying for faster motion compensation issues. The design of the proposed study is based on consisting of three essential steps e.g. i) *computing attributes for ORB*, ii) *evaluating affine transform factors*, and iii) *identifying moving objects*. The initial step comprises of extracting the ORB attributes from two consecutive frames and compared. The computation involved in the proposed study calls for studying both matched as well as mismatched pairs of visual descriptors. Any event of the mismatch will lead to wrong detection of the object, and hence is considered for serious analysis. Whereas the matching pairs of the visual descriptors will be used for computation of the preciseness in the detection method with the support of the attributes of affine homography. The consecutive phase of the design will consider transformation of the extracted frame for the purpose of compensating for the dynamic motion involved in feed captured from camera. Finally, the difference in the frame will be done for checking of the significance background details, which will be filtered or removed instantly for better object detection and tracking. However, for challenging videos, it is quite possible that certain level of residues are still left owing to the computation of frame differences, which will be again filtered using logical and morphological operations for better accuracy. Hence, the proposed system is quite simple and yet effective method for performing detection and tracking of an object from challenging mobility of the background. The next section discusses about the algorithm involved in the study and techniques used to implement it.

V. ALGORITHM IMPLEMENTATION

The proposed system is implemented using Matlab where the significance was given to the design of the ORB for performing identification of local points in a frame with better performance and minimized cost of computation. For the purpose of computing the local keypoints more precisely, the system adopts the principle of the study performed in [19] for identifying features. According to the principle of study [19], a ring of 16 pixels were selected around the corner candidate *c*. The visual descriptors used in the proposed system considers the significance of *c* and categorized it as a corner point if there are a group of 12 contiguous pixels in the ring that have highest pixel intensity compared to the intensity of the candidate pixel I(*c*) and threshold *t* or all the pixels that are darker than *I(c)-t*. This part of the analysis is carried out for four directions of a frame only and if the point *c* is considered to be a corner point that the system should consider minimum 3 of such points to have higher intensity compared to *I(c)+t* or darker than *I(c)+t*. The global keypoints involved in the study is evaluated with moments of keypoints for understanding its orientation patterns as,

$$\phi = a\tan 2\Big(\sum_{x,y} y.I(x,y), \sum_{x,y} x.I(x,y)\Big) \quad (1)$$

In the above eq.(1), I(x, y) is considered as intensity of pixel at a specific location x and y of the global key point. The role of keypoints is very crucial in proposed study for understanding robust similarity of an object in two consecutive frames. The next part of the study is focused on designing the system that can perform the extraction as well as matching of the identified ORB features. ORB is essentially a descriptors designed from binary strings and similarity of any two ORB features is evaluated effectively by adopting Hamming distance. It was also seen that in conventional motion compensation techniques, the prime part of the processing time is consumed by the ongoing operations of extraction of feature while rest computational resources are consumed for performing comparing with similarity matching between the two similar points of two different consecutive frames for performing exact identification of an object. Hence, the system performs much faster computation compared to the existing system of SURF and SIFT. The outcome of the result could be anticipated for enhanced motion compensation charecteristics along with algorithm efficiency.

Algorithm: MOD-MB
Input: video file in mpeg format
Output: detection of moving object
Start
1. Read video object
2. Specify total frames
3. For all frames find out difference
4. Read current frame
5. Read next frame
6. Convert input frames to gray scale
7. ORB feature extraction for input (A)

8. ORB feature extraction for next frame (B)
9. Match the ORB points
10. Reject uneven visual descriptor pairs using distance constraint
10. If size(A)>size(B)
11. ex = size(A)-size(B)
12. Remove extra entries
13. Else size(A)< size(B)
14. ex = size(B)- size(A);
15. Match the points
16. Add descriptor of current frame to matcher
17. Match with descriptor of next frame
18. Draw the matching points
19. Show the matched points
20. Remove the entry less then distance
21. Obtain distance value from matched point
22. Get index points which has less distance than threshold
23. Obtain only match points <Threshold
24. Create an image to draw match points
25. Morphological operation
26. Update Frame difference:

$$F_d(x,y) = \begin{cases} 255 & |B - A| > T_h \\ 0 & else \end{cases}$$

27. Perform logical operation and get output image as:

$$I_o = \begin{cases} 255 & if \quad F_d(x,y) = 255, F_{d+1}(x,y) = 255 \\ 0 & else \end{cases}$$

The next phase of the algorithm implementation will focus on designing a policy that can perform elimination of the inequality pairs of the features. The system considers using Brute-Force method for performing matching of one to another consecutive frame. Even after that there are higher likelihood that certain level of unequal pairs of the visual descriptors still are present (as see in Fig. 2). The system understands that event of such pairs of features that do not match with each other shouldn't be present as it tends to reduce the performance effectiveness and results in false detection even. Hence, the system considers a technique with distance constraint method for eliminating unequal pairs of visual descriptors. The study also understands that there is a possibility of two neighbour frames to be very small from distance viewpoint if the video is taken for a fast moving object. This consideration will also mean that if the local key-point is positioned in (x, y) in the prior frame than the corresponding similarly matched key-point should be somewhere in the similar position of the consecutive frames. The system thereby uses distance based relationship and confines that such distance is very less than a specific distance. However, if the distance between any two local visual descriptor of the two similar types of frames is greater than the specific distance, that the visual descriptor is discarded for the optimal matching outcomes. The results can be seen in Fig.2.

The final phase of the algorithm is primarily targeted for further optimization. While carrying out the transformation process using affine transformation on the motion analysis, it is quite possible that certain residues and artifacts appears in the frame (which is mostly the case of SIFT and SURF). Hence, the proposed system considers mitigating this problem by adopting logical AND operation between two consecutive frames after performing comparison of two frames. The remaining moving object is then subjected to segmentation for better detection and tracking procedure. Hence, the considered value of 255 will be considered for moving object while 0 will signify static object.

VI. RESULT DISCUSSION

The outcome of the proposed study has been compared with the Yi et al. [20], where the author introduced a similar technique of identifying moving objects in real time. The work of Yi et al. [20] have modelled the background using dual mode single Gaussian approach with time to prevent cluttering of foreground and background pixels.

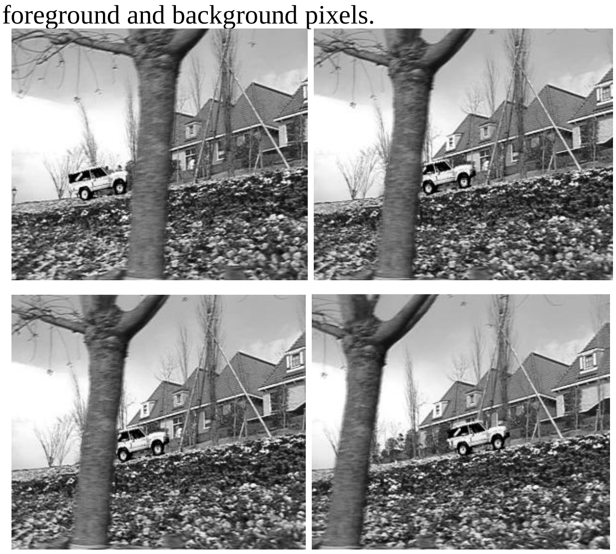

Fig. 2 Visual outcomes of the proposed study

The outcome of the proposed system was tested on various complexities of video e.g. complete occlusion, partial occlusion, mobility of multiple objects etc. The visual outcomes of the proposed system is shown in Fig.2 that shows basically k^{th} frame, $(k+1)^{th}$ frame, $(k+2)^{th}$ frame, and $(k+3)^{th}$ frame. The effectiveness of the proposed system is evaluated using standard computation of accuracy in tracking of the objects from the input frame sequence in the application designed. The video used in the proposed system consists of 5 moving objects and hence based on the detection type, we choose to classify out object detection factor as

- Actually Recognized Object Region (AROR) consisting of Object.
- False Identified Object Region (FIOR) which do not contain any object.
- Missing Object (MO) which ignores some object statistics.

The approach manually estimates the Original Object region (OOR) where the Object Identification Rate (OIR) can be evaluated as:

$$OIR = AROR / OOR$$

And Error in Object Identification rate (EOIR) as given by,

$$EOIR = FIOR / (AROR + FIOR)$$

Non-Object Identification Rate is given as

$$(NOIR) = MO / AROR$$

The comparative analysis is done by estimating the above empirical parameters for the proposed work with all the

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significant research work specified in this paper. Same sets of the input type and considerations are made towards the analysis done in 10 iterations.

Table 1 Comparative Performance analysis-I

	OOR	AROR	FIOR	MO
Proposed	5	3	1	0
Yi et al.[AR]	5	1	2	2

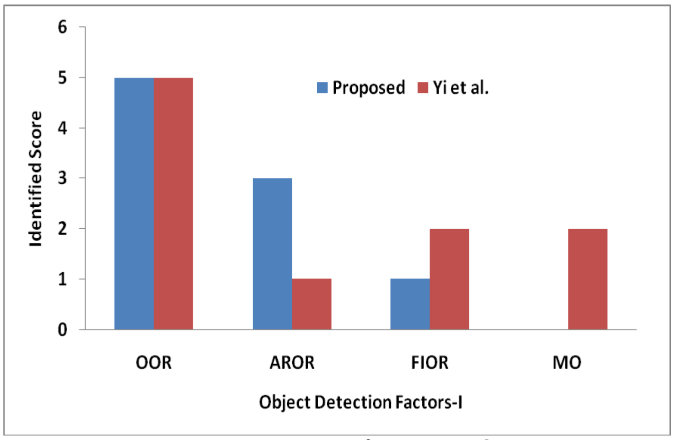

Figure 3 Comparative Performance Analysis-I

Fig.3 shows the comparative performance analysis of the proposed system with Yi et al. [20] studies. The outcome shows that proposed system is able to identify 3 objects accurately among 5 total moving objects with only one object identified falsely. There is no object that has been found missing in the analysis. Yi et al. [20] have used motion compensation by mixing Gaussian models for reason the complexity of the algorithm calls for higher processing for the video where the objects are moving very fast. Hence, the performance of Yi et al. [20] is found little degraded compared to proposed system.

Table 2 Estimation of OIR, EOIR, and NOIR

	OIR	EOIR	NOIR
Proposed	0.6	0.25	0
Yi et al.[AR]	0.2	0.5	0.4

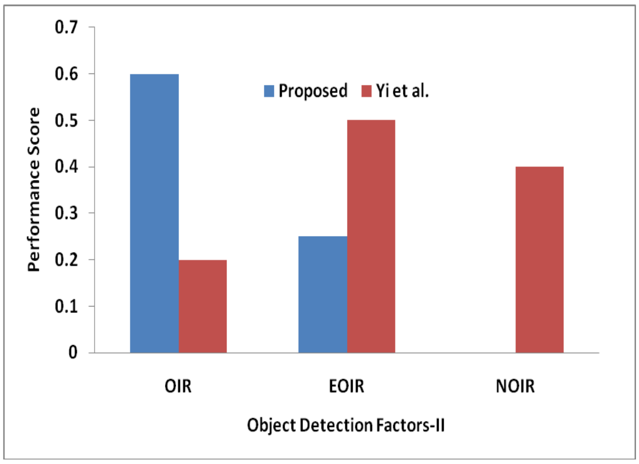

Figure 4 Comparative Performance Analysis-II

Fig. 4 exhibits the comparative performance analysis, where it can be seen that proposed system shows superior detection capability with considerable less error in object identification process. False positives outcomes for the proposed system are found to be zero.

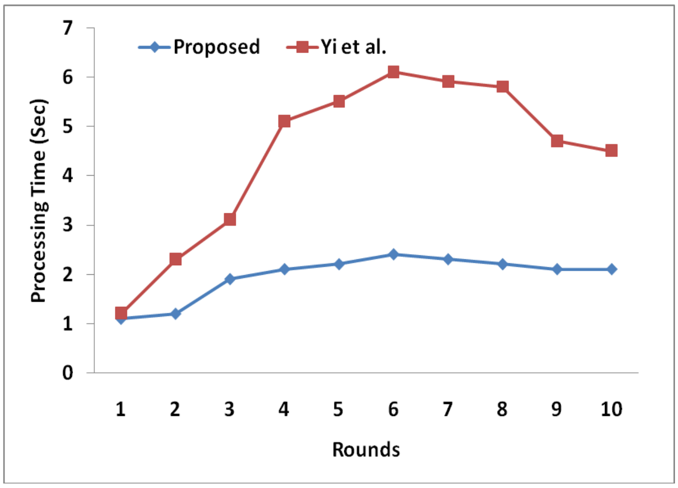

Figure 5 Analysis of Processing Time of Algorithms

Fig.5 shows the processing time required by proposed system as well as Yi et al. [20]. It can be seen that proposed algorithm requires very less time to perform detection of multiple moving object irrespective of the video size and resolution. The outcome for processing time of the proposed system is almost equivalent to real-time outcomes, which ensures that detection process doesn't miss any object while performing computation. Hence, cameras to identify fast moving objects may be incorporated with such algorithms in future for better application design.

VII. Conclusion

The proposed system discusses about an algorithm that has the capability of identifying the moving objects with fastest computation of the algorithms. Usually algorithm computation can take either seconds or minutes (sometimes) to perform computation, hence, capturing the fast moving objects are quite challenging phenomenon in the area of object detection. Hence, the proposed algorithm is highly efficient enough to perform computation along with the mobility of the objects. The incorporated features of the proposed system ensure to perform motion compensation and it also ensures to reduce false positives to a larger extents. The motion compensation phenomenon process takes place precisely without missing any fast moving objects. The algorithm is compared with recently completed research work for similar problem to find that proposed system outperforms it superiorly.

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