Underwater Moving Object Detection by Temporal Information

Pankaj kumar

Abstract*: Underwater moving object detection is a critical task for many computer vision application such as object recognizing, locating and tracing. The low accuracy rate and absence of prior knowledge learning limits its application in various underwater application. This work proposes underwater moving object detection technique based on a temporal difference technique that extends basic frame difference method to multiple frames. The proposed technique does not require any prior knowledge such as background modeling nor interaction by user such as empirical thresholds tuning. Based on continuous symmetric difference of adjacent frames, we generate full resolution saliency map of current frame to highlight moving objects with higher saliency values. This process also aids in inhibiting saliency of background also. Individual frames are obtained from the video. Frame difference is calculated of two consecutive frames. Range filters are used to get edges of object and Morphological operations are used to suppress the noise present in the foreground. The proposed algorithm is tested for performance evaluation by performing various experiments under different conditions. The testing of proposed algorithm is done by visual and statistical parameters evaluated by simulation of different videos. Versatile Experiments have done to check performance of algorithm i.e. performance of proposed algorithm in low lighting conditions, performance of proposed method in case of shadow elimination, performance of proposed method in turbulent conditions, performance of proposed method in presence of multiple objects and performance of proposed method in case of false detections. In addition, comparison with most commonly techniques for object detection like GMM and Optical Flow is also done. The proposed technique provides effective results as contrast to GMM and Optical Flow

***Keywords* : Underwater Moving Object Detection, GMM, optical Flow.**

I. INTRODUCTION

Computer vision is an area that consists of methods for incorporating, analyzing and visualizing images. Object detection is an important, yet challenging computer vision task. It is a critical part in many applications such as image search, image auto-annotation and scene understanding; however it is still an open problem due to the complexity of object classes and images. Current approaches to object detection can be categorized by top-down, bottom-up or combination of the two. Top-down approaches often include a training stage to obtain class-specific model features or to define object configurations. Hypotheses are found by matching models to the image features. Bottom-up approaches start from low-level or mid-level image features, i.e. edges or segments. These methods build up hypotheses from such features, extend them by construction rules and then evaluate by certain cost functions. The third category of approaches combining top-down and bottom-up methods have become prevalent because they take advantage of both aspects.

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A. Moving Object Detection

A video is a group of basic structural units, such as scene, shot and frame associated with audio data. A frame is defined as a single picture shot of movie camera, led by many successive frames for seamless video .Moving object detection is the act of segmenting non-stationary objects of interest with respect to surrounding area or region from a given sequence of video frames. Moving object detection forms the base part of many research applications ranging from video surveillances just outside the house to sophisticated planes during wartime Determination of the moving target forms the basic step for classification and tracking process of object in motion. The main aim of moving object detection and tracking activity is to discover foreground moving target(s) either in every video frame or at very first appearance of moving target in video .

II. MOVING OBJECT DETECTION

Moving object detection has been an active research area for quite some time . Various techniques have come from time to time to detect moving object detection .Moving object detection form the base of many real time applications. However, there are three main problems that make it difficult (1) presence of complex backgrounds i.e. moving backgrounds (2) camera motion e.g. tripod motion (3) requirement of prior knowledge e.g. training data for modeling the background[1]. Furthermore, most existing moving object detection algorithms are not intelligent enough, for that they need user interaction or experiential parameter tuning

A. Temporal based moving object detection

Temporal algorithms use time information like frame difference etc to detect moving objects. Temporal methods uses the pixel wise difference between two or three frames in frame sequences to extract a moving object.

Temporal method is computationally simple and fast as well as is adaptive to dynamic environment.[2] It takes difference of the current and previous frames with some predefined threshold.

B. Spatial based moving object detection

Spatial algorithms uses spatial features like texture, contour etc to detect moving objects. Background subtraction is core of spatial based moving object detection.

In background subtraction methods background is modeled and deviations from such model is used to detect foreground

C. Spatial-Temporal

Spatio-temporal is most widely used approach to detect moving objects. It makes use of best features of both the techniques. The process of hybrid method can be divided into three stages: (1) Pre-processing on the frames from the camera to quickly obtain moving areas; (2) Basic treatments to obtain masks of pixels with lower entropy and the speed of each pixel; and (3) Fusion of the results to finally obtain masks of moving pixels

segmentation of an arbitrary number of multiply connected moving objects. In this method all normalizations in the equation are derived in a consistent manner. The level set formulation permits the segmentation of several multiply connected objects. This approach is based on the assumption of small motion. And it is also assumed that objects do not change their brightness throughout time. But the problem is that it is not well-suited to deal with new objects entering the scene. Computational complexity is high for this method. Another problem is that segmentation of images in terms of piecewise

III. UNDERWATER MOVING OBJECT DETECTION

Walther, D., Edgington, D. R., & Koch, C[3] addressed the problem of manual processing of large number of videos captured by Remotely operated underwater vehicles(ROV's). It proposed an automated system to process large amount of video data captured by ROV's. It reduces the complexity of multi-target tracking by pre-selecting salient targets for track initiation using selective attention algorithm. Visual event is created for a tracked object and passed to a Bayesian classifier using Gaussian mixture model to determine the object class of detected event. Detection of this method was good. It overcome noise due to variable lighting conditions and ubiquities noise from high contrast organic debris. This method was highly specific to particular application.

Edgington, D. R., Cline, D. E., Mariette, J., & Kerkez, I.[4] proposed a further work to its research in by classifying the object using Bayesian classifier.

Matulewski, K. V., & McBride, W.[5] proposed NOVAS (Non acoustical optical vulnerability assessment software) to detect underwater objects. NOVAS had two types of predictions:

1. vertical visibility depth of water

2. bioluminescence signature of underwater man-made objects.

NOVAS also has data maps that can display other survey stations taken during a particular NAVOCEANO cruise. Resolution lost in the intensification process is modeled with help of Modulation Transfer Function. Detection of static objects was good but can't detect moving objects.

IV. DESIGN OF EXPERIMENTS

To justify performance of our method video 1 from computational laboratory of CSIO has been obtained. We have performed our experiment on different videos Simulation based experiments are performed using MATLAB .Following Experiments are conducted to check performance of our proposed method.

- **Experiment 1**:Performance of proposed algorithm in low lighting conditions. Performance is measured by visual analysis of results
- **Experiment 2:** Performance of Proposed Method in Case of Shadow Elimination. Performance is measured by visual analysis of results
- **Experiment 3:** Performance of Proposed Method in Turbulent Conditions. Performance is measured by visual analysis of results.
- **Experiment 4:** Performance of Proposed Method in Presence of Multiple Objects. Performance is measured by visual analysis of results.
- **Experiment 5:** Performance of Proposed Method in case of False Detection. Performance is measured by visual analysis of results.
- **Experiment 6:**To do Visual Comparison of the Detection Output by the Proposed Method and Other Techniques I.E. GMM and Optical Flow.
- **Experiment 7:**To do quantitative Comparison of Proposed method with GMM and Optical Flow. Statistical Parameters Sensitivity, Specificity, TPR, FPR, Precision, Recall and Accuracy are used to measure performance quantitatively

V. RESULTS

Various experiments have been conducted to analyze the problem. The Experiment are done for visual as well as quantitative analysis of proposed method. The Experiments include performance of proposed algorithm in low lighting conditions ,performance of proposed algorithm in case of shadow elimination, performance of proposed algorithm in turbulent conditions, performance of proposed algorithm in case of detection of multiple objects .Quantitatively results are shown by precision recall graphs and in terms of TPR,FPR.

A. *Visual Analysis of Proposed Method*

a) First RGB frame of video, b) Second RGB frame of video, c) Third RGB frame of video.

[1] Videos are taken from CSIO laboratory, Chandigarh. Authors are extremely thankful for this kind gesture


d) conversion of first RGB to GRAY


e) conversion of second RGB to GRAY


f) conversion of third RGB to GRAY

Figure 1: Three Consecutive RGB Frames represented in (a),(b),(c) and three corresponding Consecutive GRAY Frames represented in (d), (e), (f).

Video is in mp4 format having frame width704 and frame height 480.In the first step of the algorithm, three consecutive frames 204, 205 and 206 of video 1 has been taken in the RGB level. These frames are converted into respective GRAY levels using the command rgb2gray in MATLAB. Visual representation of RGB frames and their corresponding GRAY level frames is shown in the Fig 1. Frames are converted into GRAY levels as processing in the gray levels decrease the computational time.


(a)


(b)

Figure 2: (a) Frame Difference 1(b) Frame Difference 2

In the next step of the proposed algorithm two consecutive frames i.e. 204 and 205 are chosen and their frame difference is calculated by using the standard subtraction function. Similarly the frame difference of the next two frames i.e. 205 and 206 is calculated by using the same function. The frame difference is calculated so that we can get temporal information about pixels which will be used later for extraction for moving objects . Fig 2 shows visual results of the frame difference step as applied to frame 204 taken from video.

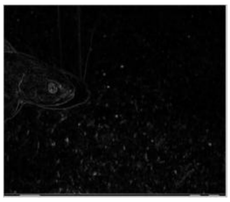

Figure 3: Result after applying Range Filter

In the next step of the algorithm, the range filter is applied on the RGB frame . It is applied to detect the edges of the fish in particular chosen frame. *Range filter* uses the morphological functions *imdilate and imerode* to determine the maximum and minimum intensity values of the pixels in specified neighborhood. Fig 3 shows the presence of fish with its edges highlighted.

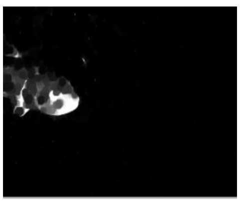

Figure 4: Result after applying Morphological Closing

At next step of algorithm Morphological Closing operation has been performed. This step has been implemented to remove holes present in foreground and to suppress the noise present in the foreground of the image obtained by using the *Range filter* function .The morphological closing has been implemented using morphological closing function *imclose*. Fig 4 shows the results obtained after applying the morphological function *imclose* .In the figure all the noise in the foreground is suppressed and holes are removed

Figure 5: Detection of the moving object in water

In the final step frame multiplication is performed on the output of in order to get the saliency area of the image which is combined with the image obtained by using *Range filt & imclose* to get the final output which is the detection of the moving object in water. Fig 4.5 shows the image of the moving fish in water.

B. *Analysis of Robustness of Proposed Method*

In this section performance of proposed method in different conditions has been done. Performance of proposed method is checked in case of low lighting conditions, turbulent conditions, in case of detection of multiple objects, in elimination of shadows, in case of false detections. Visual results of our proposed method are also shown in the section.

a. ***Performance of proposed algorithm in low lighting conditions:***

Underwater images are captured in low lighting conditions. As it is not easy to take videos inside water, lighting conditions suffer considerably resulting in light varying conditions. The experiment has been done to check performance of proposed algorithm in low lighting conditions. Detection of moving objects in low lighting is a good feature of any moving object detection algorithm. The moving object detection method shall be able to detect moving objects in such conditions. To examine the performance of proposed algorithm sample videos have chosen having presence of varying lighting. Fig 4.5 a) shows RGB frame having low lighting 4.5b) Detection of fish in low lighting. Proposed method detected fish despite low lighting conditions, thus performing well in low lighting conditions.


(a)


(b)

Figure 6: (a)RGB representation and (b) Detection output of 200 frames.

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b. Performance of Proposed Method in Presence of Shadow:

Majority of object detection methods have problem in coping with shadows of the object as object itself which eventually leads to false detection or detecting of multiple objects. This experiment has been done to check the correctness of the algorithm in the presence of shadows

The moving detection algorithm should be able to detect shadow of the moving object and shall take necessary step not to count it as original object. In order to examine performance of proposed method sample videos have been chosen for presence of frames with shadows together with objects. The method shall be able to overcome this hurdle and shall be able to neglect shadows. The video considered in this case consists of 585 frames with frame width 704 and frame height 480.Video has frame rate 27 frame/sec and has a mp4 format. The figure a) shows the presence of shadow together with object, fish in this case, (b) shows that proposed method has detected the object only and
no shadow of the object is present in the final detection.

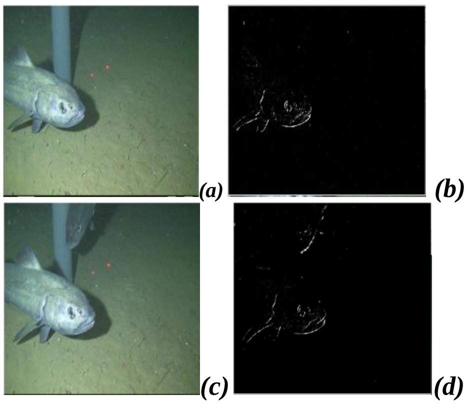
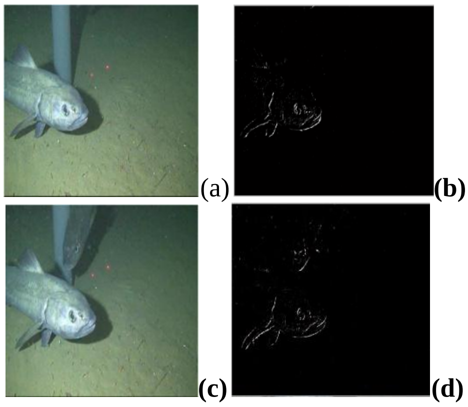


Figure 7: (a) and (c) RGB representation of frame 223 and 279showing presence of shadow (b) & (d) Results of detection in presence of shadows for frame 223 and 279

c. *Performance of Proposed Method in Turbulent Water Conditions:*

The moving detection algorithm should detect the moving object in the turbulent conditions. Turbulent conditions are those in which water is running very fast. Due to fast moving water in the foreground false detection can happen. The experiment is performed to check the performance of propose method in turbulent conditions. In order to check performance of propose method sample frames are chosen in which there is object along with turbulent conditions. The method shall be able to detect moving objects in turbulent conditions. Fig 4.7 a) and 4.7 b) shows the frames of two different videos, in which conditions are turbulent Fig 4.7 c) and 4.7 d) shows the result of detected fish in turbulent water. Proposed method detected fish in turbulent water conditions, thus performing well in case of detection in turbulent conditions.



Video 2 and 3 has been chosen. Video 2 consist of 3076 frames having frame width 704 and frame height 480.Frame rate of video 2 is 29frames/sec and is in mp4 format. Video 3 consist of 9099 frames having frame width 704 and frame height 480.Frame rate of video 3 is 29frames/sec and is in mp4 format. When the proposed algorithm is applied on the input videos 2 and 3 on the frames 240 and 290 respectively, the object is detected clearly despite the presence of turbulent conditions.

d. *Performance of Proposed Method in Presence of Multiple Objects:*

Multiple moving object detection is good feature of any moving object detection algorithm. When there are multiple moving objects in the scene the algorithm must detect all the objects present in the frame. This experiment has been done to check the correctness of our proposed method in presence of multiple objects. Video 2 and 3 has been chosen. Video 2 consist of 3076 frames having frame width 704 and frame height 480.Frame rate of video 2 is 29frames/sec and video is in mp4 format. Video 3 consist of 9099 frames having frame width 704 and frame height 480.

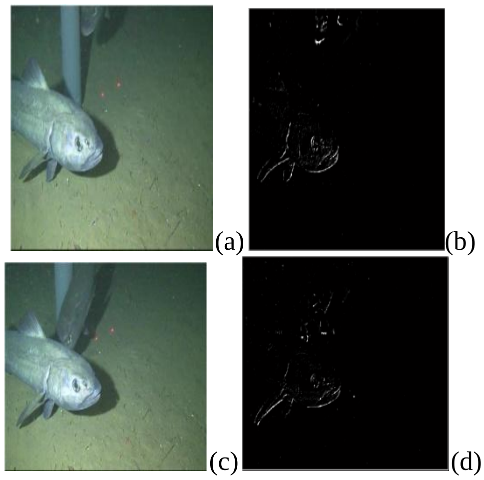


Figure 1: a) RGB representation and b) Detection Output of video 2, frame 266,c) RGB representation & d)) Detection Output of video 3, frame 305.

Frame rate of video 3 is 29frames/sec and is in mp4 format. For this purpose sample frames are chosen in which there are more than one or multiple objects are present .The method shall be able to detect all the objects present in the frame. Fig 4.9a) and 4.9b) shows presence of two fishes in two different frames Fig 4.9c) and 4.9d) shows the detection of both the fishes present in the frame.

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Proposed method detected all the objects present in the frame, thus successful in case of multiple objects.

e. **Performance of Proposed Method in case of False Detection:**

It is necessary for underwater detection algorithm to overcome false detection which are caused due to presence of moving water, mud etc. This experiment is done to check the performance of proposed in case of false detection. Most of the moving object detection algorithms do not detect true negatives. For this purpose sample frame is chosen in which there are lot of moving dust particles.

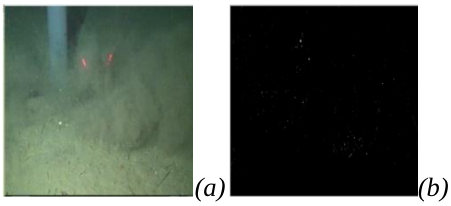


Figure 2: a)RGB representation and b)Detection Output of frame 441.

Video 2 and 3 has been chosen. Video 2 consist of 3076 frames having frame width 704 and frame height 480.Frame rate of video 2 is 29frames/sec and is in mp4 format. Video 3 consist of 9099 frames having frame width 704 and frame height 480.Frame rate of video 3 is 29frames/sec and video is in mp4 format. The method shall be able to perform efficiently in case of false detection also. Fig 4.10a) shows frame with lots of dust particles without any object in it. 4.10b) shows that our proposed algorithm doesn't pick dust particles as moving objects , thus showing that method was able to avoid false negatives as moving objects.

VI. COMPARISONS WITH ESTABLISHED APPROACHES

This section is devoted to compare output of Optical Flow and GMM over our proposed method .These are classic detection techniques which performs well in detecting moving objects There is very visible difference in detection results of these three algorithms.

GMM: The Gaussian mixture model (GMM) algorithm is based on a supposition that background is more regularly visible than the foreground, and background variance is little. It is background modeling technique which models the background to perform the background subtraction, It takes high computation time, thus not suitable for real time application.

Optical Flow : Optical Flow is the motion segmentation based technique to detect moving objects. It gives the displacement of image features in two consecutive images of one camera, and depends on the motion of the observer as well as the motion of the corresponding 3D point. Although this technique have good detection rate but fails considerably when it comes to detect true negatives.

A. *A Visual Comparison of the Detection Output by the Proposed Method and Other Techniques I.E. GMM and Optical Flow:*

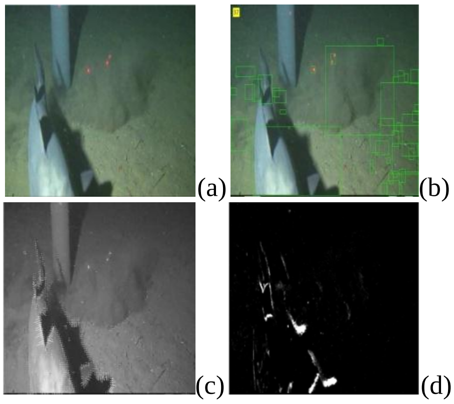


Figure 4.1: Detection Results of Different Algorithm (Video 1)

Fig 4.11 shows a) ORIGINAL RGB frame b)Detection output of GMM c) Detection output of optical flow d) Detection Output of proposed method It can be seen visually that GMM shows noise as detected objects ,thus failing considerably while showing true Video 2 and 3 has been chosen to analyze the performance. Video 2 consist of 3076 frames having frame width 704 and frame height 480.Frame rate of video 2 is 29frames/sec and video is in mp4 format. Video 3 consist of 9099 frames having frame width 704 and frame height 480.Frame rate of video 3 is 29frames/sec and is in mp4 format. negatives . Detection Output of optical flow shows that it captures shadows as detected output, which also is true negative .Proposed method captures only fish and do not show noise as detected object.

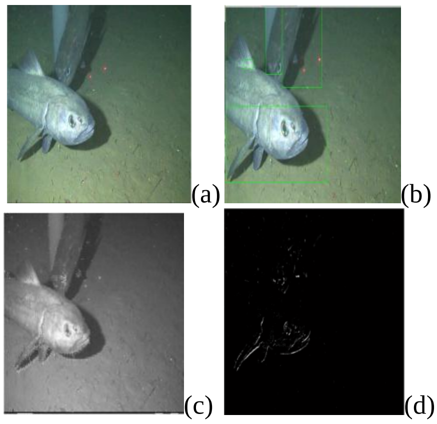
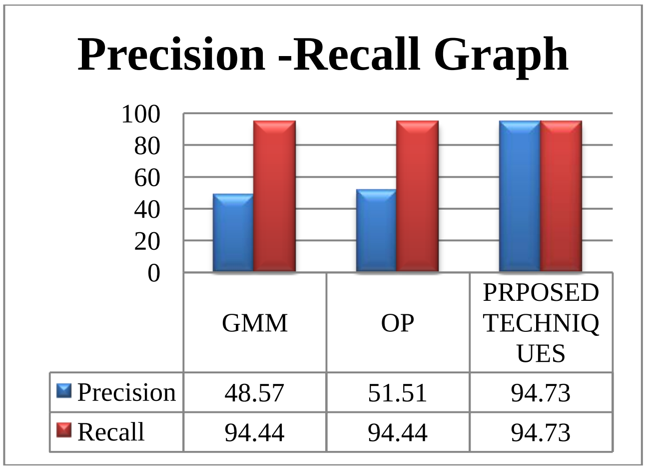


Figure 4.2: Detection Results Of Different Algorithm(Video 5)

Fig 4.12 shows that though all these algorithms do well in detecting underwater moving object detection but the result deteriorates considerably in GMM and optical flow as compared to our proposed method in case of detecting true negatives .In case of GMM it can be seen that lot of negatives have been shown as detected objects. Optical flow show shadows as detected objects while proposed method do well in detecting true positives as well as true negative

Quantitative Comparison of Proposed method with GMM and Optical Flow

SN 0	PARAMETERS	GMM	OP	PROPOSED ALGORITHM
1.	True Positive	17	17	18
2.	True Negative	1	2	18
3.	False Positive	18	18	1
4.	False Negative	1	1	1
5.	TPR	94.44%	94.44%	94.73%
6.	FPR	94.73%	88.88%	05.8%
7.	Precision	48.57%	51.51%	94.73%
8.	Recall	94.44%	94.44%	94.73%
9.	Accuracy	48.64%	52.77%	94.44%SS



VII. CONCLUSION

This work has proposed novel technique for underwater moving object detection method.
The technique is based on temporal information to generate the motion saliency map to detect moving objects. This method also suppress the noise present in the background. Morphological operators are used to suppress the noise.. The proposed method does not require user interaction or parameter tuning as most of the preceding works did. Different experiments in versatile conditions are performed. The experimental results show that proposed schemes can detect underwater moving objects with high accuracy and robustness. To check the performance of proposed method it is compared with well established moving object techniques i.e. GMM and Optical flow Proposed method outperforms the above methods visually as well as quantitatively. Proposed Method can be used for underwater applications like military, marine sciences etc.

FUTURE WORK

The proposed algorithm is based on the frame difference while there are consecutive serried moving objects coming through the scene they will exit negative interaction on each other. Complete or correct boundary detection is still an issue that could be explored for further research. Suitable method for detecting Obscured object could also be devised.

Noise level can also be suppressed to enhance detection of objects. Adaptive version of the proposed method can be made, so that it can adapt to different noise levels automatically. Work can be done to deal with interactions of consecutive moving objects. The work can be done to plot complete boundaries of object. Another extension is to use the proposed approach for some consumer video applications

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