Real-Time Implementation of Object Detection Algorithm for Underwater Environment

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Abstract— An underwater environment where lighting and visibility are generally not controllable causes the underwater image of objects to be distorted as well as blurred most of the times. Therefore, the valuable information from such an image cannot be fully extracted for further processing. To solve the problems mentioned above and to improve the quality of underwater images, pre-processing of images is attracting tremendous interest [7]. This paper presents a new method based on bilateral transform along with Contrast equalization i.e., adaptive histogram equalization technique to preserve the edges of objects more effectively and efficiently. Bilateral transform is used for de-noising based on a soft threshold. SURF is used to extract the features. Qualitative analysis indicates that the proposed method exhibits better performance in enhancing the quality and retaining the edges of an image by cancelling neighbouring unwanted information [7].

Key words: Bilateral Filter, Pre-Processing, De-Noising, Image Processing, Adaptive Histogram Equalization, Contrast Equalization, SURF

I. INTRODUCTION

About 80 percent of the Earth's surface is filled with water. Thus, there is no scarcity of scope in underwater image processing as many resources exist underwater.

A. *The need for image pre-processing*

The major concern about underwater images is their quality. They are affected by different factors such as limited visibility range, low contrast, non-uniform lighting, blurring diminished colour and noise. These factors result in low contrast and colour attenuation. The underwater image processing area has received considerable attention. The light rays suffer from the scattering of light,

The absorption depends on the density and turbidity of the water. Studies have been conducted in this field, but most of them require a dedicated underwater imaging device. Although there are some computer vision methods for underwater image enhancement, the performances are still limited. To solve various problems mentioned above there is need of pre-processing of images which makes it less effective to noise. Various Automated underwater vehicles (AUV) and a wide range of application require underwater object detection for real-time application.

II. ALGORITHM FOR UNDERWATER IMAGE PROCESSING

Basic stepwise flow for underwater image processing to detect the desired objects includes:

1) Image Acquisition: Camera is the primary source of image acquisition. Input from the camera in an underwater environment should be of good quality for further processing to be easier. It is very challenging as different factor affects the quality of images.
2) Pre-processing: The main purpose of pre-processing is to suppress information that is irrelevant to the specific image processing task. Therefore pre-processing enhances the image features that are important. For our project, the acquired image is converted to the greyscale intensity image. The conversion takes place by eliminating the hue and saturation information while retaining the luminance. Image Enhancement and preserving the edges of an object are a crucial part of pre-processing. Bilateral Filter is used to enhance the image quality and contrast equalization using Adaptive Histogram Equalization is done for preserving the true edges.
3) Image Enhancement and Edge Preserving: Image enhancement and edge preservation can be done using different filters. There are some techniques which we have tested by taking reference from previously used filters for the underwater environment. Bilateral, Homomorphic and Median Filters are some of them.
4) Feature Extraction: Image matching or extracting the features from images for classification of the desired object is the main part of the object detection. Extracting the interesting points and features of an object are done with the feature extraction. We are considering fish as the desired detectable object in the underwater environment.
5) Classification: Classification of whether there is desired object of any redundant object is basically decided by the classifier in the computer vision by means of the extracted features and training of classifier accordingly.
6) Representation of detected object: Generally the representation of the detected object is known as Localisation. Localisation is highlighting the detected object to the human understanding.

III. ANALYSIS OF FILTERING TECHNIQUES

Image enhancement and edge preservation with maximum achievable speed and relatively high accuracy are the ideal parameters for selection of filters. So we have given the sample images to analyze the output of filters:

A. *Homomorphic Filter:*

The homomorphic filtering is used to correct non-uniform illumination to enhance contrast in an image. It is a frequency filtering method. Compared to other filtering techniques, it corrects non-uniform lighting and sharpens the image. The homomorphic filter is sometimes used for image enhancement [2]. It simultaneously compensates the brightness and contrast across all frames.

Homomorphic filter technique was applied to the single underwater low luminance image as shown in the fig. (1)

Fig. 1: Homomorphic Filter Result

From fig. (1), we can conclude that homomorphic filter does not give robust and adequate output for underwater images because when this filtered output was given to edge detectors, the interesting points from edges and various features were smoothened and hence feature extraction became tedious. Hence homomorphic filter did not give satisfactory results.

B. Median Filter

The median filter is a nonlinear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction filter is a typical pre-processing step used to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

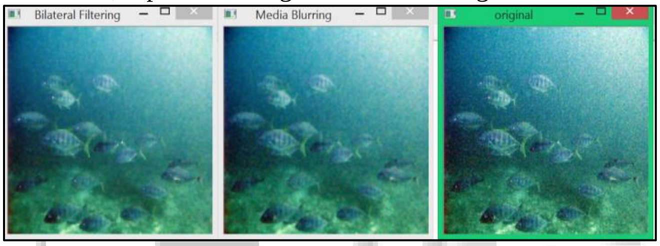

Fig. 2: Median Filter Result

As the Median Filter does not convert the images into greyscale, it processes rapidly relative to homomorphic filter but extra smoothening or blurring of images tends to lose some features and henceforth it turns to be unsatisfactory for our project. Background noise makes the images less sharp so the edges were getting blurred and also some features of fish like fin vanished. As result of this, we moved on to next filter.

C. Gaussian Filter

Gaussian filters are the only ones which are separable and at least to a lattice approximation circularly symmetric. They also overcome the other stated drawback of moving average filters because weights decay to zero. Gaussian filters have weights specified by the probability density function of a bivariate Gaussian, or Normal, distribution with variance.

As Linear filters do not preserve the edges it cannot be used in the underwater environment.

D. Bilateral Filter

A *bilateral filter* is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. Crucially, the weights depend not only on the Euclidean distance of pixels but also on the radiometric differences (e.g., range differences, such as colour intensity, depth distance, etc.). This preserves sharp edges [8].

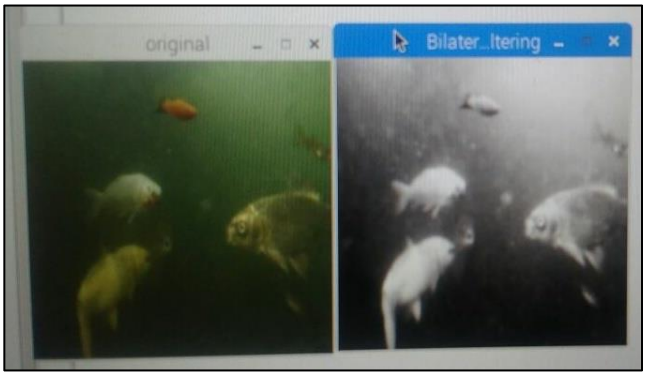

Fig. 3: Bilateral Filter Result

Fig 3 shows the result after applying the bilateral filter. From the timing analysis of the bilateral filter, it is found that it takes about 40.12 (ms) to process per frame till the application of the filter. Hence it is very fast as compared to other filters. So the results of Bilateral filter gives us the satisfactory results.

IV. Feature Extraction

Image matching by computer vision with high speed and accuracy is a major constraint in underwater image processing for different applications like AUVs

There are different feature extraction techniques:

A. SIFT

SIFT image features provide a set of features of an object that are not affected by many of the complications experienced in other methods, such as object scaling and rotation. The SIFT algorithm has four basic steps to aid the extraction of these features:

1) Scale-Space Extrema Detection: It is used to estimate scale-space extrema using the Difference of Gaussian (DoG).
2) Key-point Localization: A key point localization where the key point candidates are localized and refined by eliminating the low contrast points.
3) Orientation Assignment: A key point orientation assignment based on local image gradient.
4) Key-point Descriptor: A descriptor generator to compute the local image descriptor for each key point based on image gradient magnitude and orientation [9].

B. SURF

The SURF finds all the interesting points, and each described by a 64-dimension feature vector. When matching one image against another, very interesting point in one image must compare to every interesting point in the other. Images reported match if there are fair amount of matched interesting points. To use SURF in this project for target recognition, a database of images containing target is loaded at the beginning. Then for every query frame, the SURF feature is computed and compared to all the images in the database. A matched target is reported in the current frame for the best-matched database image. Except loading the database image at the beginning, all steps should run in real-time. There are two processes that potentially slow down SURF. The former has direct effect on the latter because if more features found, more comparisons have to be made when matching. There are two direct ways that can limit the number of features detected – lower the sensitivity of the detector and lower the resolution of the image. It is clear that both sacrifices the accuracy. Lower sensitivity means only strong features are detected, those strong features may not necessarily on the object; lower resolution of image kills the details straight away.

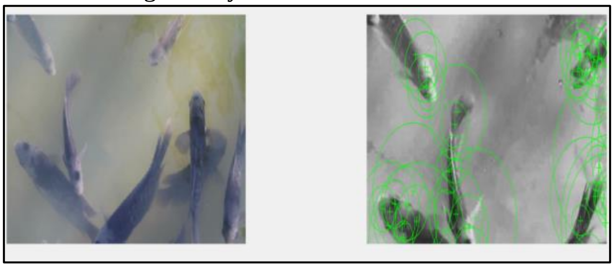

Fig. 4: SURF Feature extraction

V. CLASSIFICATION & LOCALIZATION

There are certain classifiers which classify extracted features of images. Among them are SVM and Bag-of features. SVM has more accuracy but requires more time on a platform like raspberry pi while bag of feature has less number of training set but has moderate accuracy with greater speed.

The localisation of the detected object is done by localizer by denoting the object in a rectangular box in real time.

VI. CONCLUSION

This Paper gives a survey of analysis of filters in the underwater environment and also effectively shows how Bilateral Filter gives the accurate results with very short processing time. The time required per frame till filtering process is 40.12 (ms). The approximate time with object detection using SURF feature extraction and SVM as a classifier with a localizer gives an output of 2 frames per second on the platform of raspberry pi and 10 frames per second on PCs.

As this paper mainly emphasises on the real-time object detection hence speed is the vital parameter as compared to accuracy. So as to fulfil the requirements in the underwater environment we conclude that bilateral filter with adaptive histogram equalisation and contrast equalisation by means of SURF as feature extractor and SVM classifier can give the desired output.

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