International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

# Underwater Biofouling Detection Using Image Processing And Neural Network

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***ABSTRACT : India has a total coastline of 7516.6 km which consists of mainland and coastal land. Marine transportation plays a vital role in the economy from the origin of human civilization by promoting national and international trading among different countries. Important marine transports are passenger transportation, national defence, fishing, resource extraction, and navigational service. There are many different living organisms present in marine water that almost boggles the mind. From microscopic bacteria to gigantic whales, marine organisms come in all shapes, sizes, features, textures and colours in different levels of water to undersea. Bio fouling on the ship surface happens due to flora and fauna present in the sea water. The control of bio fouling on hull of the ship surface is a challenging and a worthy task for the marine transportation. Detecting the bio fouling in the early stage will improve the hull performance by taking remedial actions to remove it immediately. So many researches gave solution to this problem in a wide manner. In this research it is done by the detection of bio fouling using image processing technique embedded with Artificial Intelligence.***

***Keywords: Bio fouling, Image processing, Hull, Artificial Intelligence.***

## 1. INTRODUCTION

Early civilization developed in the banks of river. Since from olden days people use water transportation rather than other modes for communication. The technology advancement makes communication worldwide and sea water mode plays a vital role for the economic growth of the country. Ships and Submarines are mostly used for transportation and defence purposes. Since the costly sophisticated ships and marines travels and docked in the salt water, growth of marine organisms on the hull create bio fouling on the surfaces hence pull down its efficiency. It is due to adherence of bio-foulants present in marine water which will also increase the frictional resistance thereby requires increased power to maintain the speed of the ships and submarines. Detecting the underwater hull surface marine waterborne organisms growth and growing period is indeterministic. The ultimate effect of the organism growth makes the system to fail when it is not properly removed. This research focused on detecting the bio fouling presence and its depth on the lateral surface of the ships and submarines using image processing and neural network.

## 2. LITERATURE REVIEW

S.Gollasch[1] et.al focussed on vector of species introduced in Northern sea. Study performed to assess the importance of ballast water, tank sediment and hull fouling as transport vectors for fauna into the North Sea. In this method after sampling of the first ship it was realized that a high number of species were transported in the fouling communities of ship's hull. Since the sampling method for different parts of ship are different it was done on qualitatively.

In the study it was found that most of non-native barnacles found occurred at higher frequencies. Sediment samples are collected at various locations by climbing down to the bottom. Living organism species are detected in the bio fouling samples and the species were classified.

Michael O'Byrne[2] et.al proposed a contemporary deep encoder–decoder network, termed as SegNet, to train 2500 annotated synthetic images of size 960 × 540 pixels and the images were rendered in a virtual underwater condition and its corresponding ground truth image is taken. Training is done on synthetic imagery and SegNet is applied on real time images. The segmentation is further refined using Iterative based Support Vector Machine post processing method. It reaches an accuracy of 94% when tested on subsea videos.

C. S. Chin[3] et.al proposed a system that utilizes custom based transfer learning approach and deep convolutional neural network (CNN) to perform the image recognition on the image with fouling. System classifies the detected fouling species and the density of fouling on the surface using Convolutional Neural Network. Database of 10 categories and 1825 images are utilized for Transfer learning approach using Google's Inception V3 model with Softmax at the output layer. The system recognizes and detect the fouling with better accuracy. The fouling image is uploaded to Google Drive cloud storage easily and subsequently used for image recognition via wireless mobile network.

Pei-Fang Wang [4] et.al proposed an algorithm that includes three parts: image production, feature extraction, and neural network classifiers. Raw images reflecting various fouling conditions that exists. On the raw images sub-sampling is performed and a total of 360 sub-image samples were generated and divided into two datasets, one with 300 samples for training and the other 60 samples for testing of a Self-Organizing Map (SOM) neural network. 32 feature variables are extracted from the image using statistical method of SGLDM and utilized for training the SOM neural network. Training the images using these method gave the prediction of 100%.

Cheng Siong Chin[5] et.al proposed a system which incorporates Haar cascade detection with DSLR high resolution camera module in a waterproof enclosure to detect fouling in real-time. The portable low cost system designed to detect fouls automatically from the images of barnacles that were taken from Singapore's coast- line to train the Haar cascade classifier. The experimental results show that the system can detect the type of barnacle with a reasonable accuracy. By monitoring the fouling condition on the ship hull, the ship owners can plan docking schedules and routes to reduce fouling activity and enables money saving for maintenance and docking time. 4000 negative images from the internet sources are obtained and the negative images are comparatively larger than positive images to allow superimposing of these pictures. By superimposing negative and positive images a total of 25 vector files were generated. Merging of these vector files will create the vector file for Haar cascade training and the accuracy of the fouling detection can be performed automatically in a shorter time frame with Haar classifier.

Valery Grishkin[6] et al. proposed traditional methods for bio fouling detection based on image processing techniques where images were taken in visible and near infrared spectrum.

Under pre-processing all images are converted to a selected shooting point, and the background is removed and the feature vector is built from combinations of formal vegetation indices. Type of biological contaminants is recognized by a pre-trained classifier based on SVM method with RBF kernel. Training is done using a set of labelled feature vector where the labelling of images is done by experts. They analyses the image and marks it in the areas relevant to the specific type of fouling, as well as areas pertaining to the material of the object.

Markings are made that includes only one type of contamination or material of the object which corresponds to the traditional procedure for taking biological samples on a real object. From the marked area, the average value of the feature vector of a given type of biological fouling or objects material is calculated. Finally a set of feature vectors is formed which is used for training the classifier. Later classifier training was carried out from the several training series of images of real objects, on the surface of which there were different types of bio-contamination that includes images of the same object, received in the summer and autumn in the morning, afternoon and evening at different levels of natural illumination.

Classifier training is carried out using the cross validation technique following SVM kernels for training linear kernel, polynomial kernel, sigmoid kernel and an RBF-based kernel Of these kernels, RBF kernel and sigmoid kernel gives the best results.

The performance of the classifier with RBF kernel is 3 times higher than the classifier with a sigmoid kernel hence it was chosen for further recognition.

## 3. PROPOSED SYSTEM

The disadvantage of the existing system is overcome in the proposed system. In this paper, we proposed that the image can be enhanced using the Gaussian filter. Second, the segmentation is done using Fuzzy C-means for partitioning the image into multiple segments to identify the mass easily and features are extracted using DWT(Discrete Wavelet Transform). Further species has been analysed and classified using CNN classifier. CNN delivers a unique solution since the optimality problem is convex. This is an advantage compared to neural networks, which have multiple solutions associated with local minima and for this reason it may not be robust over different samples.

### 3.1 Preprocessing

The input image given to the system can be obtained in any lighting condition or by using high resolution to take under water images. Hence it is necessary for pre-processing. Pre-processing includes the image resizing contrast and brightness adjustment This is done in order to compensate for the non-uniform illumination in the image. This is done by image processing techniques like gamma correction. Gaussian filter is used to remove the noise in the images and reduces details for processing. It has better performance in frequency domain by averaging the neighboring pixels. The general expression for Gaussian filter is given in equation (1) where it depends on standard deviation of Gaussian distribution. Gaussian filter can be applied for image processing.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-i\frac{x^2+y^2}{2\sigma 2}} \quad ..........(1)$$

Images are collected from in-water surveying with different levels of fouling for training and testing the neural network. Around 4000 images are used for testing and 500 images for testing. Fig No.2 block diagram describes the flow of process and is explained in the further steps.

Fig No.1 Images showing presence of biofouling in the ship hull

Table No.1 Number of samples with different level of fouling

3.2 Image Segmentation

| CLASS | TEST SET | TRAIN SET | DESCRIPTION |
|---|---|---|---|
| Images with Level of fouling 0 | 800 | 50 | No fouling organisms, but biofilm or slime may be present |
| Images with Level of fouling 1 | 2000 | 210 | Fouling organisms (e.g. barnacles, mussels, seaweed or tubeworms) found |
| Images with Level of fouling 2 | 2200 | 250 | Variety of large number of fouling organisms present |

Clustering is the method of segregating the similar data by considering the relationship of objects. It allocates the feature vectors into N clusters and every cluster has its center. Fuzzy C-Mean clustering (FCM) is widely used when compared to other various kinds of fuzzy clustering methods. FCM utilizes reciprocal distance to determine fuzzy weights whose input are known number of clusters, N. The mean position of every member of a cluster is identified and it is segregated based on that to form a class of object. Segmentation is performed on the optimum weight of the feature vector over all clusters.

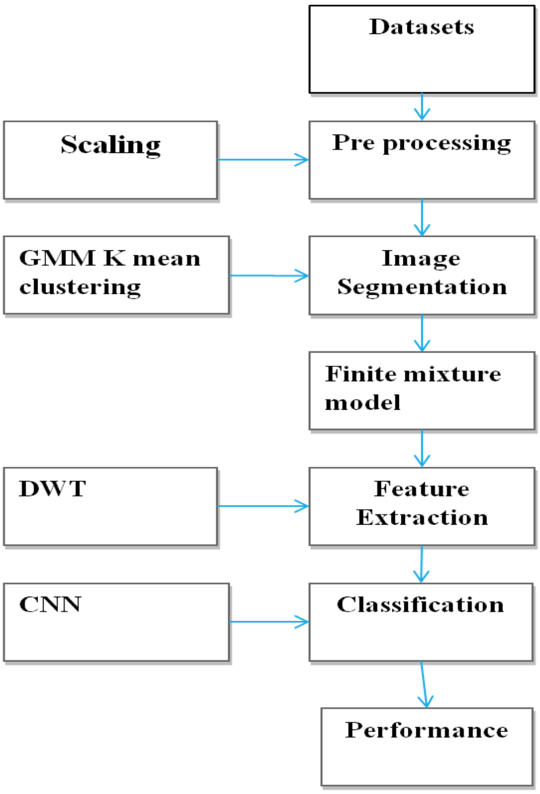


Fig No.2 Block Diagram

### 3.3 Feature Extraction

Features selection and extraction plays a vital role in object detection Feature selection prior to classification[11]remove irrelevant and redundant features to improve classification accuracy. In this approach, a feature extraction method based on discrete wavelet transform (DWT) is proposed. Some useful features along with the approximation coefficients of DWT selected by the maximum modulus method are used as features and the data is rearranged by giving a threshold to the wavelet coefficient using DWT and then calculates the approximate value of the raw data after applying an inverse function to the transformed data. After that feature selection method is applied to the selected feature at the same approximation value.

### 3.4 CNN Algorithm

Biofouling includes algae, bryozoans, vertebrates and be different colors like magenta, yellow, red, green, cyan, blue. A Convolutional Neural Network (CNN) is a deep learning algorithm that can detects, recognize and classify features from the images for computer vision. It is designed to analyze visual inputs and perform tasks such as image classification, segmentation and object detection, using Artificial Intelligence. CNN's can also be used for deep learning applications in marine images.

There are two main parts to a CNN: A convolution tool that differentiates the various features of the image for analysis. The output layer is a fully connected layer that uses the output of the convolution layer to predict the best description for the image. The neurons within a CNN are split into a three-dimensional structure, which transfer information to different layers of neuron analyzes a small region or feature of the image. CNN's use the predictions obtained

International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

from different layers to produce a final output that presents a vector of probability scores to represent the likelihood that a specific feature belongs to a certain class.

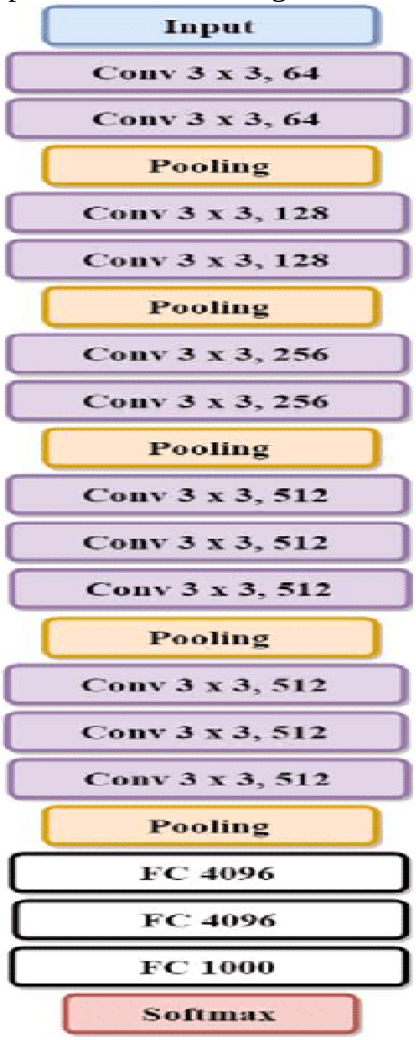


Fig No.3 CNN architecture

A CNN is different layered structure which creates a feature map to predict the class probabilities for each feature by applying a filter that scans the whole image. It predicts few pixels at a time.

Pooling layer (downsampling)-scales down the amount of information that a layer generated for each feature and maintains the most essential information (the process of the convolutional and pooling layers usually repeats several times).

Fully connected input layer-"flattens" the outputs to 1D vector which was generated by previous layers that can be used as an input for the next layer.

The architecture of a CNN is a key factor in determining its output performance and efficiency for the images that feed in. The way in which the layers which transfer information are structured, will often affect the speed and accuracy with which it can perform various tasks. The layer parameters use the learnable kernels and are usually small in spatial dimensionality, but spreads along the entirety of the depth of the input. When the data enters as a input to the convolutional layer, the layer convolves each filter across the spatial dimensionality of the input and produces a 2D activation map. Convolutional layers are also able to significantly reduce the complexity of the model through the optimisation of its output. These are optimised through three hyper parameters, the depth, the stride and setting zero-padding.

Zero-padding pads the border of the input, and is an effective method to give further control as to the dimensionality of the output volumes. It is also important to understand that through using these techniques, we will alter the spatial dimensionality of the convolutional layers output. To calculate this, you can make use of the following formula:

$(V - R) + 2Z\ S + 1$………(2)

Where V represents the input volume size (height×width×depth), R the receptive field size, Z is the amount of zero padding set and S refers to the stride. Result has to be calculated result using the equation(2) and if it is not equal to a whole integer then the stride has been incorrectly set, as the neurons will be unable to fit neatly across the given input.

## 4. RESULTS AND DISCUSSIONS

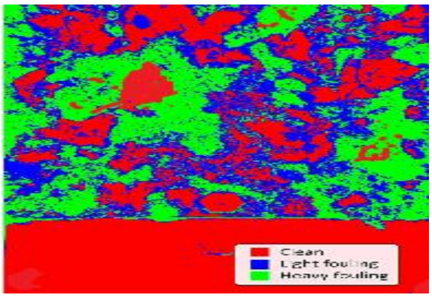


Fig No.4 Shows presence of level of fouling

Nearly 5000 images from the in-water surveying is pre-processed and segmented. From the segmented images feature extracted and it is given as input to the neural network. The network is trained in the ration of 80:20 with the training set of data with different levels of fouling as listed in table no.1. As the extracted features are given as input to the neural network, it passes through different hidden layers of the neural network. Trainable parameters vary with the layers as it goes through finally it is given as input to the softmax layer. Classification is based on the presence of level of bio-fouling in the ship hull thereby the ship movement performance is measured. It is encountered that if level of biofouling in the ship hull is more, then it is to be removed as the movement of ship hull is decreased. So the level of houling is found by the presence of biotic presence stick to the hull. If the neural network is trained with images containing different levels of houling, from the feature vectors extracted from the training data it learns about the different biotic organism's texture and color. As it learns and classify at the softmax layer the comparison of performance metrics are shown in fig no.5,6,7 Accuracy of finding the level of fouling is better in CNN which is slightly greater than Support Vector Machine.

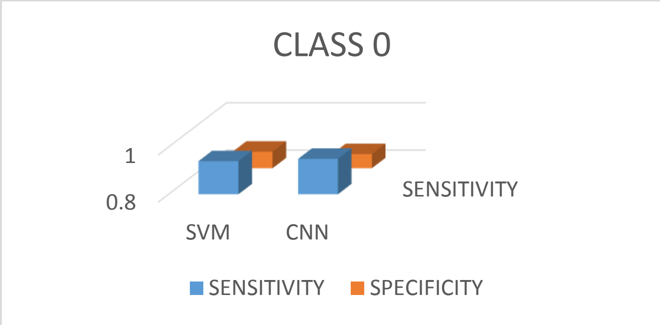


Fig No.5 Shows presence of class 0 fouling

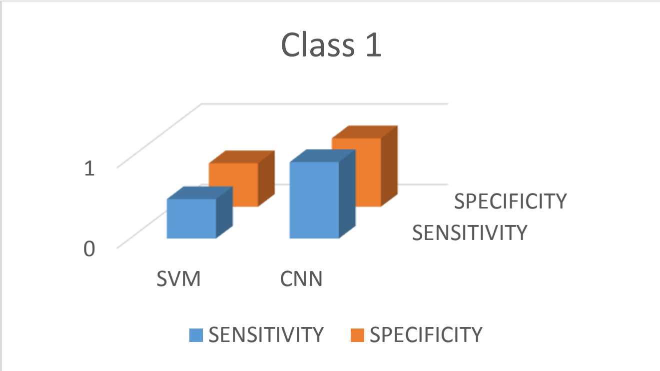


Fig No.6 Shows presence of class 1 fouling

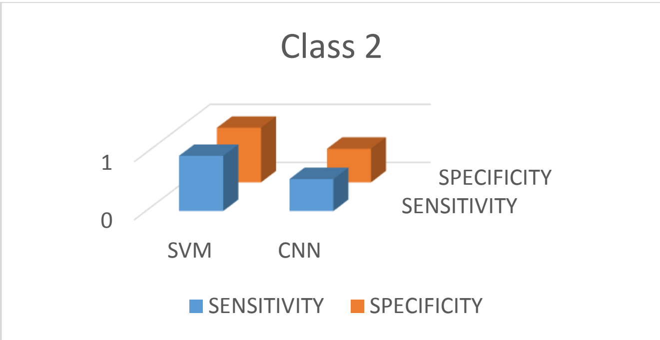


Fig No.7 Shows presence of class 2 fouling

## 5. CONCLUSION

As from different research review papers on bio fouling the detection and identification of marine bio fouling organisms over the hull of the ships and submarine is possible with different techniques. From that identification it is inferred that recognition is cost effective and efficient from the images taken through camera. So it is possible to use Convolutional Neural Network to train the network with input images taken from the standard dataset. Training and testing can be done with more than 5000 samples of different intensity of images. It is concluded that CNN performance metrics is better than SVM.

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