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Multi-scale CNN Approach for Accurate Detection of Underwater Static Fish Image

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ABSTRACT

Recently, the identification and naming of fish species in underwater imagery processing has been in high demand. This is an essential activity for everyone, from biologists to scientists to fisherman. Humans' interests have recently expanded from the earth to the sky and the sea. Robots could be utilized to send mankind to explore the ocean and outer space, as well as for some dangerous professions that human beings are unlikely to perform. Humans have recently shifted their focus from land-based exploration to celestial exploration and the sea. Robots are used for the activities that pose a risk to mankind, like exploration of the seas and outer space. This research article provides a solution to underwater image detection techniques by using an appended transmission map, refinement method and deep learning approach. The features are deeply extracted by multi-scale CNN for attaining higher accuracy in detecting fish features from the input images with the help of segmentation process. Object recognition errors are minimized and it has been compared with other traditional processes. The overall performance metrics graph has been plotted for the proposed algorithm in the results and discussion section.

Keywords: Machine learning, Object detection

1. INTRODUCTION

It is no doubt that rivers, ponds, and lakes are overflowing with interesting themes. Evaluating images to determine the amount of fish and the general health of the environment

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may help to preserve underwater ecosystems and the natural environment. Most fish species are difficult to differentiate based on their external appearance since they are so similar [1]. If individuals rely on inaccurate information to differentiate between non-poisoned and poisoned fish, ordinary people will die as a result of their ignorance. A growing number of researchers have been drawn to the image recognition and classification due to the recent development in this research area. A huge amount of data is created by underwater images, and that data would need an inordinate amount of time and work for people to analyze and handle it [2-6]. The collection of variety of fishes in a single image has shown in the figure 1.

Figure 1 Collection of Underwater Fish Image

Saltwater fish and freshwater fish belong to two different fish categories. There are variations between saltwater and freshwater fish as far as their physiology, structural adaptability, and size are concerned [7]. Several freshwater environments may support freshwater fish. Many species can survive at a temperature of 24 degree Celsius (about 72 degree Fahrenheit), while others can tolerate the temperature ranging between 5 and 15 degree Celsius (59 to 59 degree Fahrenheit). Freshwater fish inhabit lakes, marshes, and shallow rivers with a water salinity of less than 0.05%. While saltwater fish may be found in a variety of settings, ranging from frigid Antarctica and the Arctic Ocean to the warm tropical seas, these environments don't offer similar opportunities [8].

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Coral reefs, mangroves, salt ponds, deep-sea, and seagrass beds provide excellent habitats for saltwater fish. Despite their small size, Filipino gobies have a population of over 100 million, making them the most common fish species in the Philippines. The white sturgeon, on the other hand, may weigh over 400 pounds and is one of the world's largest freshwater fish [9]. Freshwater fish include blueback, brook, cutthroat, and brown trout, cisco, charr, gar, mooneye, pike, trout (blueback, apache, and whitefish), and salmon. The salty water fish shape has shown in the figure 2.

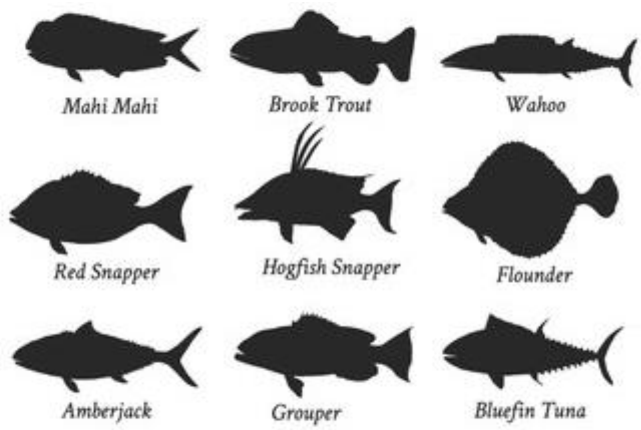

Figure 2 Shape based Salty Water Fish Images

Many places have a diverse variety of freshwater fish species. The saltwater fishes are as follows: Albacore, bluefish, eels, flounder, mackerel, cod, herring, marlin, shark, yellowtail, tuna, and snapper [10-12]. The imagery of fish has been detected in a variety of different environments, including the ocean. Image recognition has been attempted on many occasions, and so far, it has been proven unsuccessful due to the segmentation problems, distortion, and occlusion, as well as to object overlap in colored pictures. Some of the underwater fish input image has been shown in figure 3.

Figure 3 Input Images

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It will be hard to determine which fish belong to which group if we cannot estimate the percentage of all fish species in the sea. With its orientation steps, feature variation, image quality, and fish size, we can categorize and name the fish.

2. ORGANIZATION OF THE RESEARCH

The rest of this research paper is organized as follows: section 3 provides related works about underwater image fish detection techniques. Section 4 explains the proposed framework for automatic fish detection. Section 5 discusses about the detection results with the proposed algorithm. The conclusion and future tasks will be discussed in the final section.

3. PRELIMINARIES

The researchers LeCun et al recognize the utilization of deep designs like multilayer deep neural networks; it is possible to extract task-dependent characteristics even when the input pictures vary. Deep convolutional neural networks (CNNs) are extensively employed in computer vision issues, including object identification and face recognition [13].

Hsiao et al. have recently used motion-based fish recognition in videos. Moving foreground items are segmented from the backdrop by the use of background modelling [14].

The average detection accuracy was achieved by four submarine films with a high fluctuation of brightness, significant backdrop motion, dynamic textures, and rich backgrounds. The GMM and KDE methods for fish detection are now regarded as state-of-the-art by Spampinato et al. [15].

Palazzo et al have proposed a similar idea for recognizing the color and texture characteristics of fish from the video frames with covariance modeling of the background and foreground [16].

This novel image denoising filter developed by Chen et al. include a conventional median filter with additional parameters to detect noise and convert the original pixel value to a newer median [17]. The results of Kocak et al. were filtered by using a median filter to eliminate noise. The RGB color level stretching integrates the overall quality of the images. In the event of images with little noise, the ambient light may be acquired via the dark channel [18].

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Bilateral filtering was used by Zhang et al. for images with a lot of noise. The outcomes are positive but the processing time is very long [19]. The generalized Anscombe transformation has an inverse known as the Mäkitalo transformation, and the two are equal because of their respective roles in providing correct denoising outcomes [20].

In other words, Soble's technique for categorizing freshwater fish in Indonesia is presented by Rosina et al. They tested their approach with 200 freshwater photos of 10 distinct species. Additional methods are required, such as the use of texture or color, and content-based techniques to improve the model's accuracy. Recent research has suggested a DL method that combines the Dense Neural Network (DNN) and Spatial Pyramid Pooling (SPP). This is accomplished by first using the SPP with the DenseNet feature of the DNN before applying the Spatial Pyramid Pooling (SPP) [21, 22].

Research Gap

In the traditional motion detection and image classification techniques, the contribution of this study is to solve the primary difficulty encountered by such methods. To avoid misunderstandings, these deep learning modules are taught to focus on the essential information present in the data. In situations where the ambient conditions are ever-changing, like underwater recordings of fish, this method is particularly beneficial. Our innovation comes in the suggested hybrid setup that combines multi-scale with CNN and optical flow to mine important motion information and enhances it with deep CNNs of various filtering approaches [23-25]. We have developed a proposed framework to overcome this problem and it is shown in figure 4.

4. PROPOSED FRAMEWORK

The MS-CNN method is suitable for enhancing the features of underwater fish images at higher resolution with the various scales of filtering. The proposed algorithm, CNN, is used to crop the transmission map of the image for the structural model. We are using a transmission map and refinement for enhancing the fish images, which is shown in figure 2.

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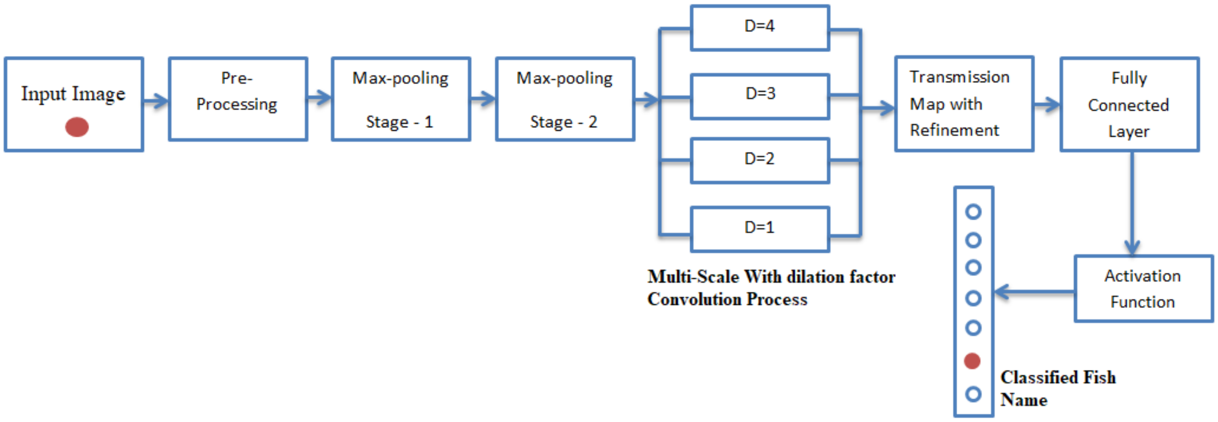

Figure 4 Multi Scale CNN Method for Accurate Fish Name Classification

Step 1:

The transmission map is implemented in the proposed system to obtain better visual of images. This RGB color channel may be used to divide the intensity of the color in the input images. This can be achieved by multi task as follows;

$$F_m(x) = 1 - \zeta \frac{x_i}{A}$$

Where, "A" is Constant value to adjust the lighting effects.

Step 2:

The training for the multi scale parameters are learned by this following formula;

$$MS = \{(x_i, y_i)\}_{i=1}^{N}$$

Where,

$x_i is\ training\ image\ patch\ y_i = output\ set\ of\ tuple$

Step 3:

$F_{refined}(x) = a_k F_k + b_k$

This "a" and "b" are linear co-efficient to transmit the refined transmission maps. This refining of the transmission map function can be defogged the images during reconstruction of the output image.

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Step 4:

The various scale networks are formed by AlexNet, which contains 5 convolution layers that lead to convolution operation. After 2 max-pooling layers are designed, 2 fully connected layers are constructed in the framework. The feature maps extract the fine features of fish from the entire image. The fully connected layers collect the missing image features.

Step 5:

The stochastic gradient descent approach training in the scale1 and 2.

Step 6:

This multi-scale work makes a free-handle filtering process for higher resolution with various specific threshold values. Concatenated feature maps are refined in the third layer in the proposed model, which provides better resolution of the input fish images.

Step 7:

The refined smooth function in the local arguments,

$$F_{img}(x_i, y_i) = \frac{1}{N}\sum_{i} F_{ref}(x_i, y_i)$$

This final construction is used to sample the positive values in the optimal parameters by stochastic gradient descent.

5. RESULTS & DISCUSSION

The proposed MS-CNN method is examined with the Fish4knowlegdet dataset to find the performance measures. The Fish4knowlegdet dataset was used in comparing the performance of the proposed model. The experimental setup and thus it is reported scores, which are identical in both the Fish4knowlegdet dataset and our experiment. Overall, we outperform all other systems, even those using multi-scale approaches, in almost all environmental circumstances [26].

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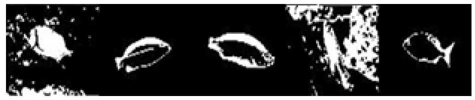
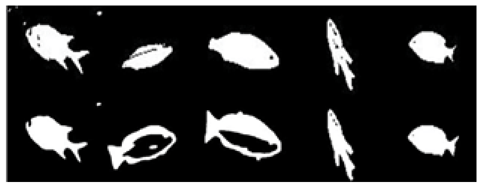
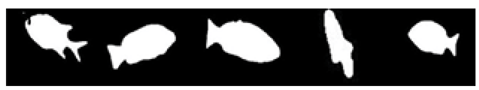
Results obtained segmentation process



Results obtained after SVM classifier



Results obtained by pre-trained CNN



Results obtained by our proposed algorithm

Figure 5 Results Obtained from Various Methods

Assigned dimensions of 256*256 of the pre-processed image; this activity is dependent on the width of the segmented fish image size from the given input image, once it is computed. For training and testing purposes, an algorithm has been presented to divide the datasets into 80% and 20% to get perfect accuracy. This 20% division is allotted for testing and validation for strong object detection. We are attempting to implement our method to see whether it is feasible. The fish species are identified correctly with our proposed model as follows; myrispristis, Lutjanus vitta, scolopsis monogramma, assessor randalli, and kyphosis cinerascens.

As shown in Figure 3, the raw input image for testing is obtained. Also, these results are shown in figure 5.

Table 1 Overall proposed model performance metrics

S.No	Methods	Recall	Precision	Accuracy	Classification Success rate	Object Recognition Error
1	Single Classifier SVM	68.98%	74.53%	82.45%	90.78%	0.129
2	Pre-trained CNN	86.34%	90%	84%	94.34%	0.021
3	Proposed Multi Scale CNN framework	93.5%	94.67%	96.99%	98.25%	0.001

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The proposed multi-scale CNN has achieved fewer object recognition errors when compared to other processes. These computed results are tabulated in Table 1. Besides, figure 6 shows the graphical version of the tabulated values.

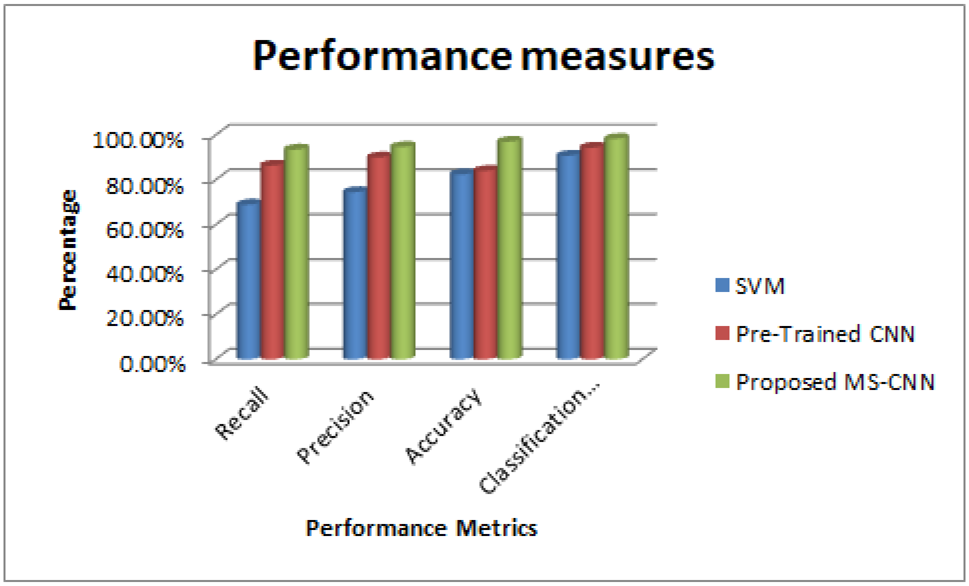

Figure 6 Overall Performance Measures of Proposed Framework

Table 1 offers an overview on the utility of our solution via a side-by-side comparison of benchmark methods, including ones seen in still and video images, which are often utilized for static based object identification [27]. The formulas are written here as follows;

8

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

The accuracy, precision and recall are calculated and tabulated in the table 1.

6. CONCLUSION

Thus the proposed MS-CNN method is used to detect the fish object detection by leveraging higher accuracy than other algorithms. The combination of transmission map and

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refinement is well suited with a multi-scale CNN algorithm. This research work will assist and support fisheries experts, who rely on automated methods to identify, classify, name, and monitor fish species. We also want to implement a multi-scale deep architecture with various other algorithms to equip and optimize the proposed algorithm with cleaned datasets and with more rigorous mathematical modeling, which can analyze video sequences in real-time. For efficient fish image identification, of the proposed system will be more appropriate because it is capable of both classifying the motion of fish and detecting them [28-30].

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