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A Substantial Deep Learning Approach for Classification of Local and Coastal Fish

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Abstract. Fish is a popular food all around the world Because of its excellent nutritional content. Furthermore, fish is low in fat and high in protein. The nutritional value of various fish varies. Fish are essential experimental animals in a variety of fields of biological and medical research. A solid foundation for understanding the more adaptable behavior of higher vertebrates has been established by research on fish. This article focused on the classification of two types of fish: local and coastal fish. This will aid in identifying fish, and this article will also provide knowledge of numerous fish species identifications, allowing researchers to study the nutritional value of fish. The local and coastal fish categories contain twelve different fish species: Catla, Cyprinus Carpio, Grass Carp, Mori, Rohu, Silver, Black Sea Sprat, Gilt Head Bream, Red Sea Bream, Horse Mackerel, Sea Bass, and Trout. Moreover, there are 13,176 fish shots in the dataset used in this article. In addition, to identify the species, fish are labeled with unique integer values. A deep learning based approach has been applied to classify the fish species in this article. A Convolutional Neural Network (CNN) technique has been used in this research work as CNN provides high-quality performance in the field of image segmentation. Hence, the proposed model achieves a satisfactory result of 98.33%.

Keywords: Computer Vision· Deep Learning· Image Processing· Machine Learning· Image Classification.

1 Introduction

Image segmentation is becoming a more popular study topic [2, 3, 8]. Researchers have worked on a variety of photographs to identify various objects, including human disease detection, animal and plant disease detection, flower recognition, fish detection, and so on. Because of the prominence of artificial intelligence, this research topic is quickly expanding. Furthermore, fish categorization is currently one of the most important research fields that leads academics to learn more about fish species and their significance [6].

This article examines several research gaps that should be filled in order to absorb the knowledge of fish and its nutritional worth so that biologists and the

general public can get sufficient proficiency and add adequate nutritional value to their diets. This article noted that some work on local fish classification has been done in a number of countries [2–4]. Despite this, there is a scarcity of coastal fish classification study. Coastal fish, on the other hand, have a nutritional advantage over local fish because they are raised in the sea.

Furthermore, the classification of both local and coastal fish is the topic of this article [4, 7]. The focus of this study is on the identification of six common local fish in Bangladesh. The coastal fish dataset, on the other hand, included six different types of fish. Furthermore, our aim is to take a raw snapshot of data and supplement it using our own augmentation technique, resulting in a new dataset. This paper discusses a complex enhancement procedure that yielded a total of 13,176 pictures. Another goal of this study is to collect a wide range of data in order to train the proposed model. Following that, this study used our enhanced dataset to train our proposed model, which performed admirably. However, this article will address the following research question regarding fish classification:

- Why is data augmentation necessary?
- What can be the output of before and after augmentation?
- How does CNN perform for image classification?

We have demonstrated an inclusion and exclusion criteria in fig 1 which indicates that some dataset building research work, fish species classification based work and survey in this field to understand the present situation of this field have been selected for this research purpose.

The rest of the article is structured as follows: some literature works have been illustrated in section 2. Section 3 defines the methodology part consist of data preprocessing, augmentation and the implementation of proposed model. section 4 evaluates the performance of the model and finally section 5 concludes the final outcome.

2 Literature Review

Having a good deal of nutritious value, fish plays a vital role in a human food diet. As fish is the source of high-quality protein, it is important to have knowledge of fish. For this reason, the domain of fish classification research and finding other nutritious values is becoming popular day by day. Many people don't recognize fish [4] along with the nutritional value of fish in Bangladesh. Consequently, some work has been done for fish classification and its dataset. In article [5], researchers prepared a dataset consisting of six local fish species where they constructed their dataset by the fishes i.e. Catla, Cyprinus Carpio, Grass Carp, Mori, Rohu, Silver [4, 5]. The name of their dataset is Fish-Pak: an image dataset of 6 different fish species encapsulated by a single camera. Their dataset contains 915 images. As Convolutional Neural Network is familiar for image processing, this approach is used in the article [4]. Here, CNN achieves a satisfactory result with 88.96% accuracy. On the other hand, Machine Learning-based approaches

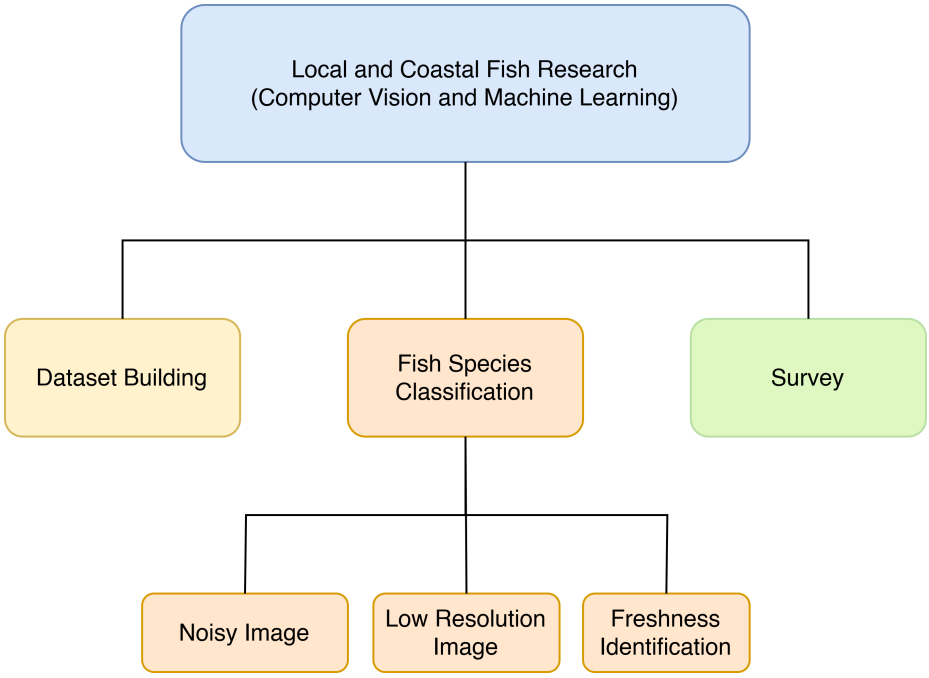

Fig. 1. Visualization of inclusion criteria

have been applied in the article [2] such as Support Vector Machine (SVM), k-nearest neighbors (KNN), and Ensemble methods where SVM gave the highest accuracy of 94.20%.

Oguzhan Ulucan et al. have also used Support Vector Machine [7] to detect nine sea fish species. Their dataset contains 1000 images of fish. They used Bag of Words (BoF) and CNNsF with their SVM model and got 81.55%, and 93.25% accuracy for BoF and CNNsF respectively. However, few of them used Naive Bayesian fusion-based deep learning [6] for fish classification. They used two datasets named FishPak and BYU. The volume of their dataset is 273 and 630 for FishPak and BYU respectively. They classified 6 fish from the FishPak dataset and 4 fish from the BYU dataset. Using the transfer learning approach, AlexNet is trained for each fish segmentation. They got an accuracy of 98.64% for the FishPak dataset, and 98.94% for the BYU dataset. Fish identification along with fish freshness determination has been done on paper [3]. They categorized three fish species for instance milkfish, round scad, and tilapia. Their dataset contains 800 images and they labeled the freshness of fish into five levels.

Convolutional Neural Network (CNN) is one of the most widely used models for image classification. There are three types of layers used in CNN which have the multiple convolutional filters working and scanning the complete feature matrix and carry out the dimensionality reduction. This enables CNN to be a

very apt and fit network for image classifications and processing [1]. In article [13], CNN achieved a remarkable validation accuracy of 90% and 92% respectively where the networks derived from the VGGNet. On the contrary, Deep CNN has been used in the context of noise in images where the training model synthesizes more data with random noise, in the article [10]. Dhruv Rathi et al. [1] have worked on classifying underwater fish species from the dataset containing 27,142 images. They have classified the fish species based on 21 classes with the CNN and Deep Learning models and their model gave an accuracy of 96.29% which showed an improvement from the previous proposed classification models.

AlexNet is used for deep CNN for classifying 6 fish species from the dataset of 1334 images and their proposed model customized layered AlexNet achieved 90% testing accuracy in the article [11]. Moreover, In the article [15], brown trout (Salmo trutta) and European grayling (Thymallus thymallus) images extracted from videos for classification without prior pre-processing and the high accuracy of above 99% showing the dominance of AlexNet. On the other hand, VGG16 Network also gave an immersive result on the article [14], their model achieved 99% of accuracy for three different fish species from a small dataset of 530 images.

Moreover, surveys on fish classification techniques are also a part of gathering knowledge about fish. The study on preprocessing methods features extraction techniques and classifiers from recent works have also been done in this domain [8, 12]. After studying the preprocessing methods, feature extractions and classification techniques, a fish classification architecture was proposed by [8]. They also showed the dataset available in this domain and their description. Another article made a review on recent advances in machine vision technology for fish classification [12]. They represented an overview of machine vision models applied in the field of fish classification. They produced an elaborate description of this field and discussed the advantages of applied techniques.

3 Methodology

This article has worked on classifying the local and coastal fish species and evaluating the proposed model on these data. The functionality of the whole process regarding this research is illustrated in fig 2. However, a CPU of AMD Ryzen 7 3700X 8-Core Processor 3.59 GHz has been used for data augmentation and model implementation in this study. Accordingly, the RAM size of this hardware is 16GB and GPU is NVIDIA 1660 Super 6GB. For coding, implementation jupyter notebook has been used in this article.

3.1 Dataset

This article has worked on two different fish datasets: Local fish and coastal fish. The name of the local fish dataset is "Fish-Pak: Fish Species Dataset from

[1] https://medium.datadriveninvestor.com/why-are-convolutional-neural-networks-good-for-image-classification-146ec6e865e8

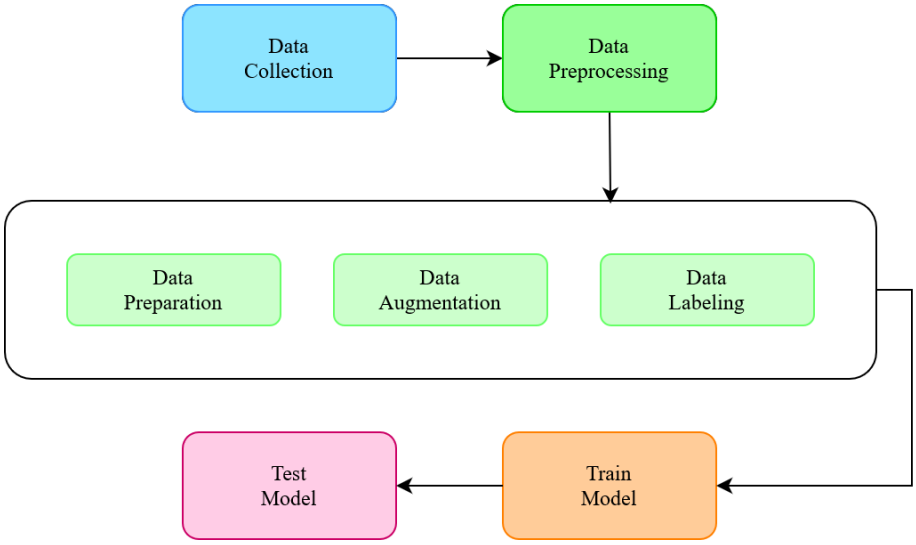

Fig. 2. Workflow Diagram

Pakistan for Visual Features Based Classification" [6] and the coastal fish dataset name is "A Large Scale Fish Dataset" [8]. There are 915 images in the local fish dataset where the images contained the body, head, and scale of a fish. But this article selected only body part images as we will train our model by the full image of each fish species. We selected 269 full-body images in the local fish dataset and the ratio of the images was 3:2. This dataset contains six species of fish for instance Catla, Cyprinus Carpio, Grass Carp, Mori, Rohu, and Silver. On the other hand, the coastal fish dataset contains 9 different fish species collected from a supermarket in Izmir, Turkey. The dataset includes gilt head bream, red sea bream, sea bass, red mullet, horse mackerel, black sea sprat, striped red mullet, trout, and shrimp image samples. From these species, we selected only six species as our local fish has six fish species. We have selected black sea sprat, gilt head bream, red sea bream, horse mackerel, sea bass, and trout. The reason behind choosing these species is these fish species look similar to the local fish we have selected. This will help to evaluate our proposed model more accurately. In addition, there are 280 images in the coastal fish dataset after selecting the several six species and the image ratio was 4:3. The number of images for each species of fish is represented in Table 1 and Table 2.

3.2 Data Preprocessing

Data Preparation There are some discrepancies in the data. Since two distinct datasets have been taken to evaluate the proposed model in this research work. The pictures in the dataset had diverse aspect ratios. So, this difficulty must be

Table 1. Number of Data (images) for Local fishes

Fish Name	Number of images
Catla	18
Cyprinus Carpio	50
Grass Carp	11
Mori	70
Rohu	73
Silver	47

Table 2. Number of Data (images) for Coastal fishes

Fish Name	Number of images
Black Sea Sprat	50
Gilt Head Bream	50
Horse Mackerel	50
Red Sea Bream	50
Sea Bass	50
Trout	30

addressed in order to obtain effective results. As a consequence, all of the data has been reduced to 100 by 100 pixels in order to keep the same aspect ratio.

Additionally, an RGB image is made up of pixels, each of which has three numeric values that correlate to the color intensity. And the range of the numeric values is 0 to 255. Thus, all of the features have been separated into 255 to assist speed up the learning process by reducing the scatteredness.

Fig. 3. Sample Images for Local Fish (Rohu)

Fig. 4. Sample Images for Coastal Fish (Sea Bass)

Data Augmentation This article used augmentation to turn one image into 24 images. This artificial data augmentation resulted in a dataset with 6,456 images for local fish and 6,720 images for coastal fish. As a result, data augmentation has produced a total of 13,176 images. The following is the augmentation procedure: Rotate images at positive 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°, 165°, and flip each image horizontally.

Data Labeling To label each of the fish species in the dataset, this article employed unique integer values. The fishes are designated by 12 integer values such as 0-11. There are 12 fish species in the local and coastal fish taxonomy. Table 3 lists the fish species that have been labeled:

Table 3. Corresponding Labels of Different Classes

Fish Name	Label
Catla	0
Cyprinus Carpio	1
Grass Carp	2
Mori	3
Rohu	4
Silver	5
Black Sea Sprat	6
Gilt Head Bream	7
Horse Mackerel	8
Red Sea Bream	9
Sea Bass	10
Trout	11

3.3 Proposed Model

Convolutional Neural network (CNN) is very familiar in the field of Deep Learning as it performs very well for image segmentation [4]. This article classifies 12 different fish species where six species are local fish and the rest of the part is coastal fish. As there are two datasets that have been used, this article combines these two datasets to build a new one. After combining them, the whole dataset contains 13,176 data.

The dataset was split by 80:20 to train the data and we trained the dataset on several multilayer convolutional neural networks. There were two dense layers and a flatten layer that performed best. Different filters for different layers were used where the first layer had 64 layers, second layer had 128 and third had 256 layers. To implement the model, 3x3 size was used for each convolutional kernel size and there was an activation function called "relu". And the maxpooling layer has the pool size of 2x2.

Flatten layer was used to feed the data into dense layers. There were 128 hidden units in the first dense layer, 64 hidden units in the second layer and

12 hidden units in the output layer which denoted the number of labels or the number of fish species. Softmax activation function was used in the output layer. In addition, this article used 20% dropout after every layer to avoid the overfitting problem. However, the flatten layer and the output layer were not used dropouts. In "adam" optimizer 0.001 value was set for learning rate. An illustration of our CNN model is shown in figure 5. This proposed model has got 98.33% accuracy on testing dataset.

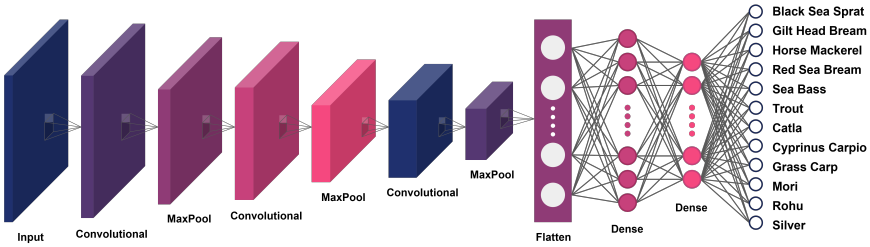

Fig. 5. Convolutional Neural Network model architecture.

4 Performance Evaluation

This article has made a comparison between the proposed model and the other existing model's performance based on the volume of the dataset and the number of classes they have dealt with. The table below shows the circumstances as well.

Table 4. Performance Evaluation of Different Existing Works with Proposed Model

Method	Dataset Volume	No of Classes	Classifier	Accuracy
Israt Sharmin et al.	180	6	SVM	94.20%
Shumaiya Akter Shammi et al.	4575	6	CNN	88.96%
Abinaya N.S. et al.	273 (FishPak), 630 (BYU)	6, 4	Naive Bayes	98.64%, 98.94%
Oguzhan Ulucan et al.	1000	9	SVM	93.2%
Adamu Ali-Gombe et al.	3777	8	Deep CNN	N/A
Muhammad Ather Iqbal et al.	1334	6	Deep CNN	90.48%
B. S. Rekha et al.	3777	8	CNN	92%
Francis Jesmar P. Montalbo et al.	530	3	CNN (VGG16)	99%
Thitinun Pengying et al.	9220	2	CNN	99%
Proposed Method	**13,176**	**12**	**CNN**	**98.33%**

The suggested model clearly outperformed the other existing techniques, as shown in Table 4. Furthermore, certain approaches 6, 14, 15 produced findings that are almost identical to our proposed method. However, the size of the

dataset and the number of classes are not comparable to our study. This article contains a large number of class variations 12, when most only have 2-6 class variations. However, when compared to other datasets, the volume of this article's dataset is quite large. This post has used a unique augmentation approach to help increase the number of data as well as the image quality.

Table 5. Comparison of performance before and after augmentation

Before Augmentation	After Augmentation
Data structure is inconsistent for which model cannot learn properly from these variable size of data.	Data is properly organized and structured that enhances the learning capability of model.
Performance is significantly poor: 40.91% accuracy	Performance is satisfactory: 98.33 %

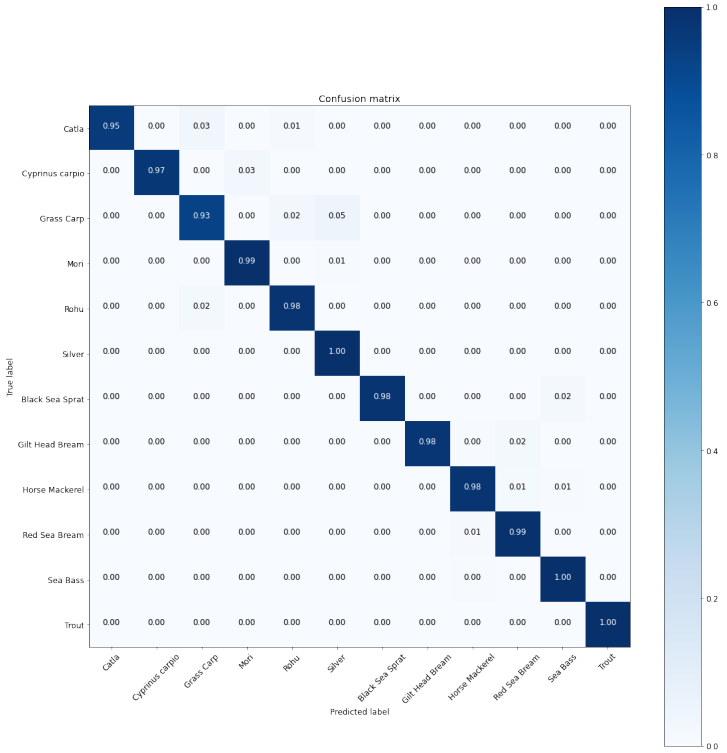

Fig. 6. Convolutional Neural Network Confusion Matrix

This article have examined the result before and after augmentation. Before augmentation of data, the result was too poor. 40.91% accuracy was achieved before the augmentation of data. Because, data were inconsistent before augmentation and the model cannot learn properly from the huge number of inconsistent data. On the other hand, augmentation is necessary to prepare the variation of data. This article have done this variation with several types of angular position of the data that helps to create the variation and helps model to learn the features. The confusion matrix, as well as the train and validation of the model's performance, have previously been shown in the methodology part, which determines the satisfactory performance.

Performance visualization of our proposed model and the performance before augmentation is shown in figure 6 by confusion matrix. Accordingly, the accuracy and loss during the training and validation phase has been given in fig 7.

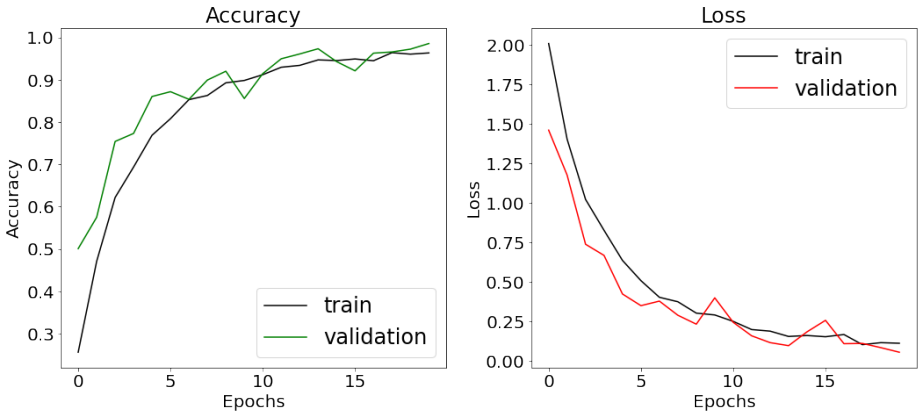

Fig. 7. Accuracy and Loss during the training and validation phase

The accuracy and loss during the training and validation phase has been given in fig 7.

5 Conclusion

This article has attempted to create a wide variety of fish species datasets, which has been done well in this study. Local fish species and coastal fish species are represented in two categories of fish photographs gathered from various sources. There are six fish species in each group. All of the fish shots were preprocessed and scaled to the same ratio using excellent preprocessing techniques. Multiple representations of fish have been created using a rich augmentation technique. Finally, to obtain a successful outcome, a convolutional neural network-based technique was used. Using the proposed model, this article has a 98.33 % accuracy, which is highly satisfactory.

References

1. D. Rathi, S. Jain and S. Indu, "Underwater Fish Species Classification using Convolutional Neural Network and Deep Learning," 2017 Ninth International Conference on Advances in Pattern Recognition (ICAPR), 2017, pp. 1-6, doi: 10.1109/ICAPR.2017.8593044.
2. Sharmin, Israt & Islam, Nuzhat & Jahan, Israt & Joye, Tasnem & Rahman, Riazur & Habib, Md. (2019). Machine vision based local fish recognition. SN Applied Sciences. 1. 10.1007/s42452-019-1568-z.
3. Navotas, Ian & Santos, Charisse & Balderrama, Earl John & Candido, Francia Emmanuelle & Villacanas, Aloysius John & Velasco, Jessica. (2018). Fish identification and freshness classification through image processing using artificial neural network. Journal of Engineering and Applied Sciences. 13. 4912-4922.
4. S. A. Shammi, S. Das, M. Hasan and S. R. Haider Noori, "FishNet: Fish Classification using Convolutional Neural Network," 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT), 2021, pp. 1-5, doi: 10.1109/ICCCNT51525.2021.9579550.
5. Shah, Syed Zakir Hussain ; Rauf, Hafiz Tayyab; lali, IkramUllah; Bukhari, Syed Ahmad Chan; Khalid, Malik Shahzaib; Farooq, Muhammad ; Fatima, Mahroze (2019), "Fish-Pak: Fish Species Dataset from Pakistan for Visual Features Based Classification", Mendeley Data, V3, doi: 10.17632/n3ydw29sbz.3.
6. Abinaya N.S., Susan D., Rakesh Kumar S., Naive Bayesian fusion based deep learning networks for multisegmented classification of fishes in aquaculture industries, Ecological Informatics, Volume 61, 2021, 101248, ISSN 1574-9541, https://doi.org/10.1016/j.ecoinf.2021.101248.
7. O. Ulucan, D. Karakaya and M. Turkan, "A Large-Scale Dataset for Fish Segmentation and Classification," 2020 Innovations in Intelligent Systems and Applications Conference (ASYU), 2020, pp. 1-5, doi: 10.1109/ASYU50717.2020.9259867.
8. Mutasem K. Alsmadi, Ibrahim Almarashdeh, A survey on fish classification techniques, Journal of King Saud University - Computer and Information Sciences, Volume 34, Issue 5, 2022, Pages 1625-1638, ISSN 1319-1578, https://doi.org/10.1016/j.jksuci.2020.07.005.
9. M. N. Rachmatullah and I. Supriana, "Low Resolution Image Fish Classification Using Convolutional Neural Network," 2018 5th International Conference on Advanced Informatics: Concept Theory and Applications (ICAICTA), 2018, pp. 78-83, doi: 10.1109/ICAICTA.2018.8541313.
10. ali-gombe, Adamu Elyan, Eyad Jayne, Chrisina. (2017). Fish Classification in Context of Noisy Images. 216-226. 10.1007/978-3-319-65172-9_19.
11. Hussain, Muhammad Ather Iqbal Wang, Zhi-Jie Ali, Zain Riaz, Shazia. (2021). Automatic Fish Species Classification Using Deep Convolutional Neural Networks. Wireless Personal Communications. 116. 10.1007/s11277-019-06634-1.
12. Daoliang Li, Qi Wang, Xin Li, Meilin Niu, He Wang, Chunhong Liu, Recent advances of machine vision technology in fish classification, ICES Journal of Marine Science, Volume 79, Issue 2, March 2022, Pages 263–284, https://doi.org/10.1093/icesjms/fsab264
13. B S, Rekha G N, Dr. Srinivasan Reddy, Sravan Kakwani, Divyanshu Bhattad, Niraj. (2020). Fish Detection and Classification Using Convolutional Neural Networks. 10.1007/978-3-030-37218-7_128.
14. F. J. P. Montalbo and A. A. Hernandez, "Classification of Fish Species with Augmented Data using Deep Convolutional Neural Network," 2019 IEEE 9th Inter-

national Conference on System Engineering and Technology (ICSET), 2019, pp. 396-401, doi: 10.1109/ICSEngT.2019.8906433.
15. T. Pengying, M. Pedersen, J. Y. Hardeberg and J. Museth, "Underwater Fish Classification of Trout and Grayling," 2019 15th International Conference on Signal-Image Technology Internet-Based Systems (SITIS), 2019, pp. 268-273, doi: 10.1109/SITIS.2019.00052.