Classify Different Fish Species Using Different CNN Models

Abstract- Identifying any fish type can be difficult for people who are not familiar with fish. Implementation of a fish classification machine learning model can become helpful in this scope. The purpose of this paper is to build such a fish classification machine learning model. With this classification model, people will be able to identify the class or type of fish even without much experience with fish. Different types of fish have different nutrition, vitamin, and fat content. Thus, this model can be helpful to ensure better nutrition intake as well. As we have to classify types of fish, we implemented a Convolutional Neural Network (CNN) with Keras along with a modified VGG16 transfer learning model. With the CNN model, the validation accuracy is 99.42%, and classification accuracy with the modified VGG16 is 99.56%. Our test accuracy, with the CNN model, accuracy is 94.74%, and classification accuracy with the VGG16 is 89.21%. The overall improvement is almost 1% better than the original paper which used the same dataset.

Introduction

The act of identifying fish species based on their features is called fish recognition [1]. Also, can be stated as a process in which targeted fish species are identified based on the similarities of images of representative specimens [2]. In simpler words, identifying fish species by extracting their features from their images is called fish recognition. Regardless of the difficulties, fish identification with image classification has a wide range of applications in the disciplines of fish resources research, popularization of fish knowledge, aquaculture processing, and the protection of rare fish species.

The Convolutional Neural Network (CNN or ConvNet) is a subtype of Neural Networks that is mainly used for applications in image and speech recognition. Its built-in convolutional layer reduces the high dimensionality of images without losing its information. That is why CNNs are especially suited for this use case.

Fish are a great source of low-fat high-quality protein, omega-3 fatty acids, and vitamins like D and B2 [3]. But not all fishes provide the same amount of nutrition. So, for a more normalized intake of nutrition consuming various types of fish can become healthy. However, there is various kind of living fish species in the world, more than 32,000 [4]. This makes the identification of fish an important subject. However, fish classification is more difficult than other object or image classification. The classification of marine life differs from that of general things such as cats, dogs, and flowers, which is more difficult due to the diversity of species and the physical similarities within classes, such as textures and shapes. Furthermore, due to light interference, the acquired fish images are frequently reflected too darkly, making image feature extraction difficult.

Regardless of the difficulties, fish identification with image classification has a wide range of applications in the disciplines of fish resources research, popularization of fish knowledge, aquaculture processing, and the protection of rare fish species. The creation of a comprehensive database of various fishes and the use of image classification methods to identify them can help not only to better exploit and protect fish resources but also to contribute to the development of marine fishery production, as well as have academic and economic value.

Nowadays object detection using machine learning has been used widely in various fields There are a lot of techniques used for image classification like SVM, K-Nearest Neighbor (KNN), K-means Clustering, Neural Network, etc. Among the neural network techniques, image classification with Convolutional Neural Network (CNN) is one of the most popular. The ability to affect multiple dimensions of an object's overall scale made image classification with CNN made it successful [5]. Image classification is widely used in face recognition, object recognition, and detecting any specified image. For our implementation, we used two CNN models. One is a pre-trained VGG16 model with transfer learning and the other one is our own CNN made from scratch using TensorFlow and Keras. VGG16 is a famous and widely used pre-trained model. Using two models can also give an insight into how the VGG16 model can perform a fish classification scenario.

Related Work

We found some papers about the works of image processing. They worked on different types of the images such as a flower, fish, tree, fruit, etc.

Oguzhan Ulucan Et al. [15] used SVM and KNN over the same dataset. They performed segmentation and extracted four features for classifying the fish species. They used CNN for extracting the features of the fish species; SVMs and K-Nearest Neighbor (KNN) with accuracy rates of 98.32% and 98.79% respectively, are applied for the classification task.

Fadzilah Siraj et al. [6] used the algorithm of Neural Networks (NN), Logistic Regression, and the method of this algorithm is SVM. The result of this paper is it can detect 95% of flowers from the dataset.

Dhian Satria Yudha Kartika el al. [7], used the K-means algorithm. And in this algorithm, they use the SVM and Naïve Bayes method. For the object separation, they used K-Means, and they used the Naïve Bayes method for comparison with SVM. They also used k-fold for cross-validation to get better accuracy. The resulting accuracy is 97% and it is using Hue, Saturation

Praba Hridayami et al. [8] created a model to detect fish, based on deep convolutional neural networks such as VGG16. This method is pre-trained with ImageNet via a transfer learning method. The fish dataset for this study consists of 50 species, each covered with 15 images, including 10 for training and 5 for testing. In this study, they trained the model on four different types of datasets: RGB color space images, Canny filter images, composite images, and composite images mixed with RGB images. The results show that the blended image of the image mixed with the RGB image training model has the highest true acceptance rate (GAR) value of 96.4%, followed by the RGB color space image training model with GAR of 92, 4% and the canny filter. Shown that the image continues. -The trained model with a GAR of 80.4% and the trained model with mixed images showed the lowest GAR of 75.6%.

Francis Jesmar P. Montalbo et al. [9] use CNN. They applied it to classify Verde Island fish species. They worked with three species of fish. They modified the VGG16 model, and they used Deep Convolutional Neural Network (DCNN). Their augmented images are filliped, rotated, cropped, zoomed, and sheared. Four additional FC layers are used to capture new features of the fish images. The accuracy of the model in this paper is 99%. In our VGG16 model, we used it differently from them. We apply seven-layer in our model.

Arindam Das et al. [10] use the algorithm of pre-trained VGG16. They applied inter-domain transfer learning. They also used Deep Convolutional Neural Network (DCNN). They worked on the RVL-CDOP document image dataset. The accuracy of the model in this paper is 92.21%.

Tsubasa Miyazono et al. [11] developed a technique to recognize the fish species with image processing. With their developed technique, the user can be able to identify the poisonous and non-poisonous fish before eating. Fish names and characteristics can also be checked by their developing detection system. For developing their detection model, they used the image normalization technique to resize the images. They used four featured points for annotating the images. By measuring the featured points, they created various channels for developing their CNN network. Then they used the CIFAR-10 network and AlexNet which are two well-known CNN architectures. These two networks are pre-training networks. After that, they collected 50 fish species to use as their dataset. They divided their dataset into four groups and applied 4-

fold cross-validation. With their dataset, they found an accuracy of 71.1% for one candidate and 91.4% for five candidates.

M. A. Iqbal et al. [12] created an automation and classification system for fish species. From their work, they helped marine biologists to have a better understanding of fish species and their habitat. They proposed a model which is based on Deep Convolutional Neural Networks. It uses a reduced version of the AlexNet model, which consists of four convolutional layers and two fully connected layers. Comparisons with other deep learning models such as AlexNet and VGGNet are shown in their model. Four parameters are considered: the number of convolution layers and the number of fully connected layers, the number of iterations to reach 100% accuracy in the training data, the stack size, and the dropout layer. The results show that the proposed and modified AlexNet model with fewer layers achieved a test accuracy of 90.48%, while the original AlexNet model achieved 86.65% compared to the untrained reference fish dataset.

System Architecture and Design

Our first model is a VGG16 transfer learning model. A learner's mastery of skill or knowledge in one context which enables them to use that same skill or context in another context can be taken as the cognitive practice of "Transfer" [13]. Similarly, for machine learning models, the pre-trained models such as VGG16 are trained with thousands of images, and with transfer learning, they can improve the performance of the model significantly. Making a CNN model from scratch has a risk of overfitting and poor performance due to various reasons like insufficient data, inappropriate parameters, etc.

In our implementation of the VGG16 Transfer learning model, we only changed the input layer and kept the imagenet weights and added some more dense and dropout layers to it.

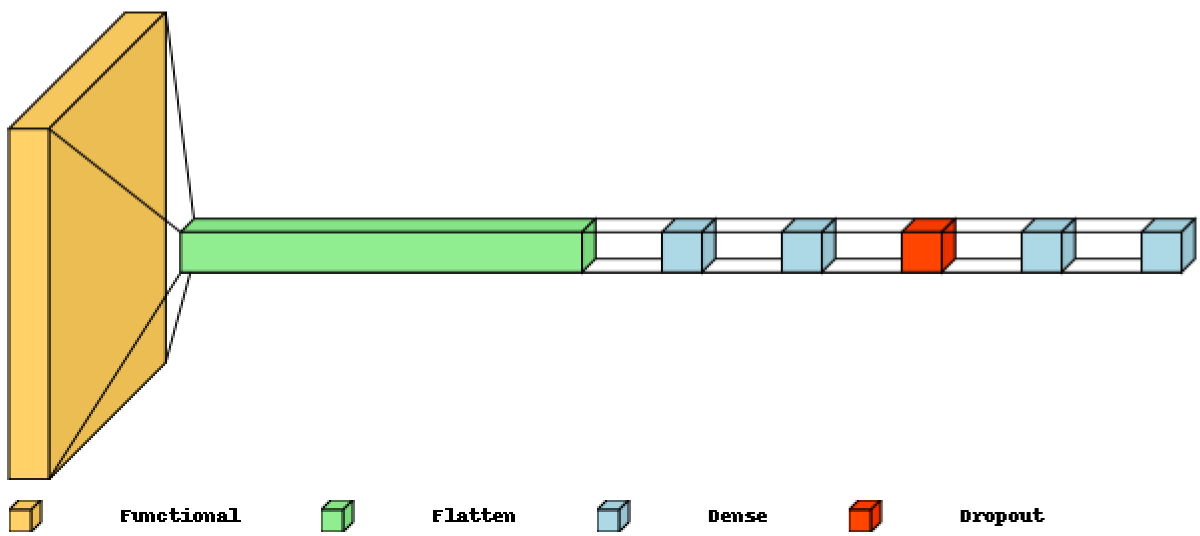

Figure 1(a): Layers of the VGG16 transfer learning model Graphical view

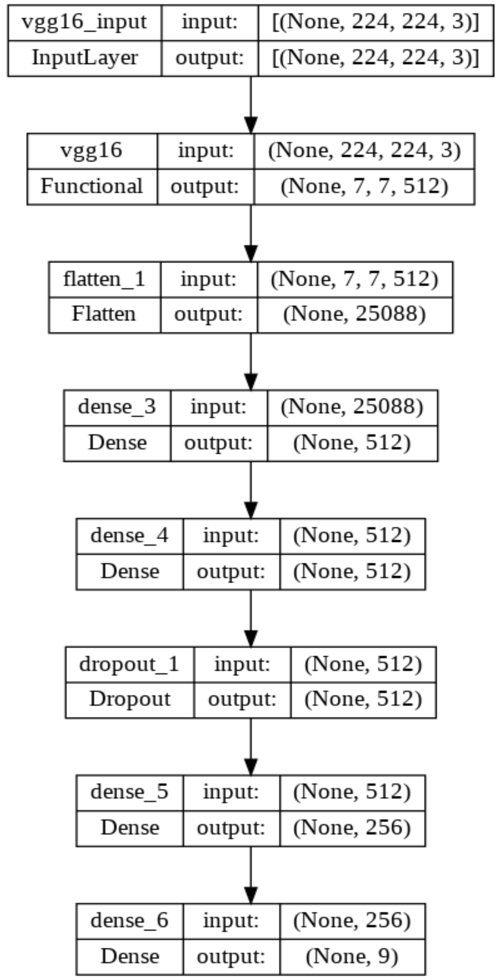

Figure 1(b): Layers of the VGG16 transfer learning model

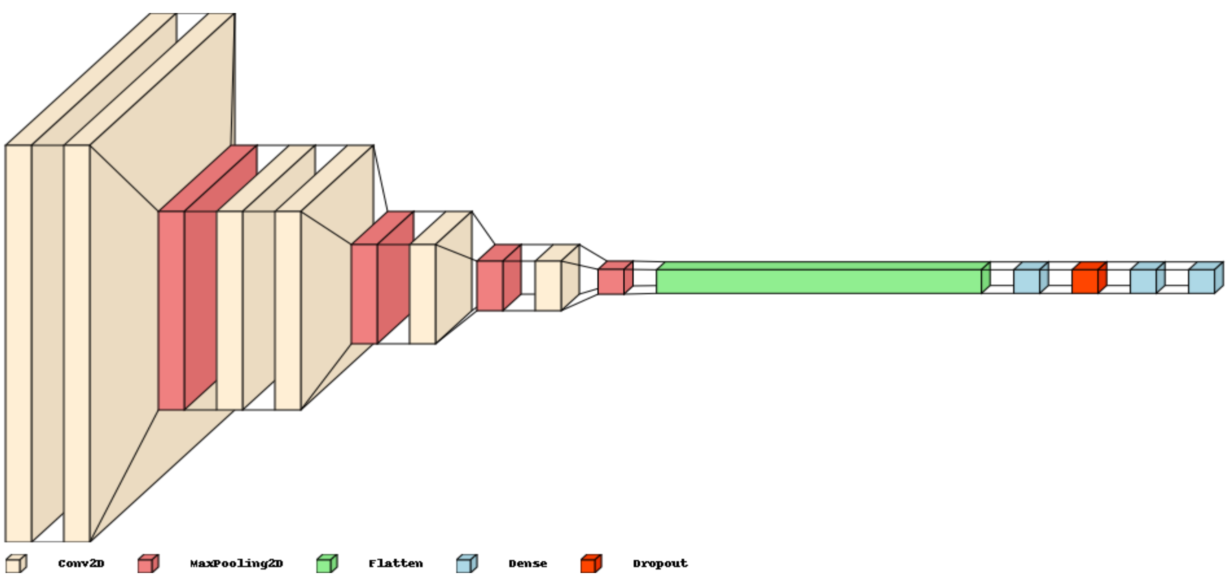

Figure 2(a): Layers of the VGG16 transfer learning model Graphical view

For the other model, we made our own Convolutional Neural Network (CNN) model for fish detection with TensorFlow and Keras. The final five layers of the model are kept similar to what we used for VGG16. So, the other layers such as Convolutional blocks (Conv2d), max-pooling layer (MaxPooling2D) will be the ones to create the difference of performance between the two models.

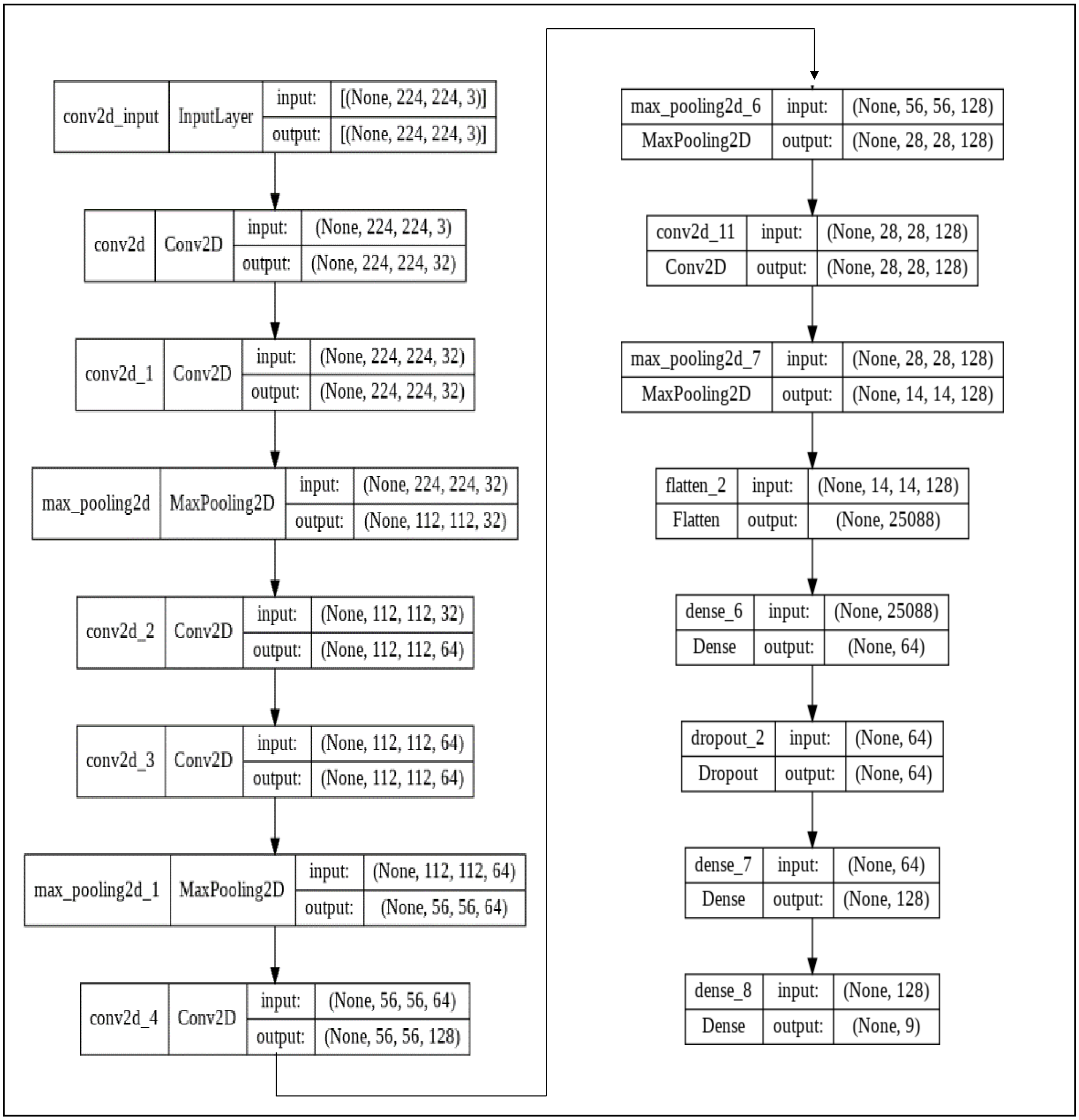

Figure 2(b): Layers in the Data Augmentation Model

Dataset Description

Out Dataset is taken from Kaggle on large scale fish dataset [14]. This dataset contains 9000 images of 9 different seafood types collected from a supermarket in Izmir, Turkey for a university-industry collaboration project at Izmir University of Economics, and this work was published in ASYU 2020. The dataset includes gilt head bream, red sea bream, sea bass, red mullet, horse mackerel, black sea sprat, striped, red mullet, trout, shrimp image samples. The dataset also contains 380 images of 9 fish category for testing.

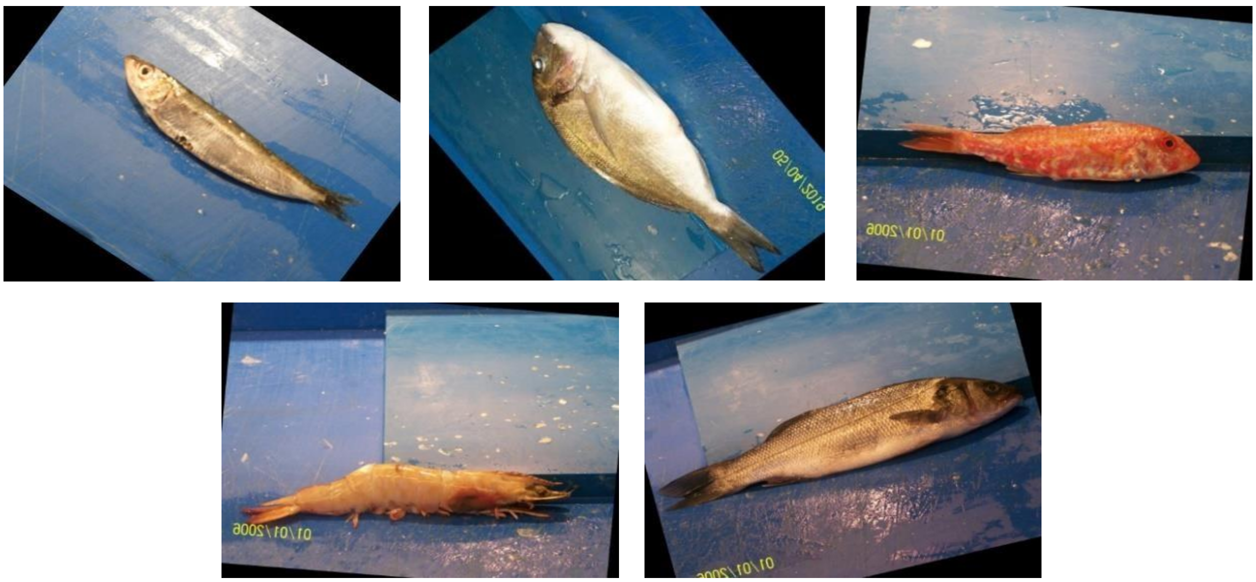

Figure 3: Dataset Sample

Data Preprocessing

First, we split the data (images) for training and validation purposes in a 75:25 ratio. 75% of the images were randomly selected for training and the rest were for validation. After the splitting, we had 750 pictures for each 9 fish classification folders (total 6750 images) as training data and 250 pictures for each 9 fish classification folders (total 2250 images) as validation data. For preprocessing of the images, we used the ImageDataGenerator function of the Keras image preprocessing library. Using the function, we rescaled the images by 1/255 of their original scale. Random horizontal flipping was enabled. A random zoom range of 0.4 and random rotation of 30° was used. We resized all the images to 224×224 pixels.

Fish Classification

In VGG16 the topmost layer or input layer is removed for transfer learning. The rest of the layers are kept. Six more layers consisting of a Flatten layer, a Dropout layer, and four Dense layers. These layers extract information from the provided images.

On the other approach, for the CNN model, the topmost or input layer is a Conv2D layer. Then few more layers consisting of Conv2D, MaxPooling2D, Flatten, Dense, and Dropout are used. These layers extract information from the provided images.

Implementation and Experimental Result

Experimental Setup

Windows Operating system- We have conducted all the experiments in a Windows operating system in this project. The system configuration used in this project, Intel(R), Core (TM) i5-8250U, CPU limit: 1.60GHz 1.80 GHz, Installed RAM capacity: 16.0 GB. The system type is a 64-bit operating system, and the processor is an x64-based processor.

Google Colab- Google Colab is a powerful python coding tool offering Zero configuration, Free accessed GPUs, and Easy sharing. Colab is a platform provided by Google to write codes in python with all the libraries. The platform offers more GPU power to run heavy models. We have used Google's collab services for our implementation as it supports TensorFlow and Keras APIs. Also, as our dataset is very large with 9000 images, the GPU runtime of the Collaboratory was an ideal option for the implementations.

Implementation

A stepwise approach to our implementation:

1. Make a training and validation directory
2. Split dataset into train and validation by 75:25 ratio
3. Preprocess images
4. Modify pre-trained model/Build CNN model
5. Train the model with a batch size of 32 and 25 epochs
6. Save the best model
7. Load weights of the best model
8. Evaluate the model using a test dataset

Performance Evaluation

Comparison values are of the best models of the VGG16 transfer learning model and CNN from the scratch model. For ease, the VGG16 transfer learning model is mentioned as VGG16 and the CNN that we built is mentioned as CNN.

Training and Validation Accuracy:

	VGG16	CNN	Original Paper
Training:	98.06	95.59	98.01
Validation:	99.56	99.42	98.79

Table 1: VGG16 vs CNN training and validation accuracy

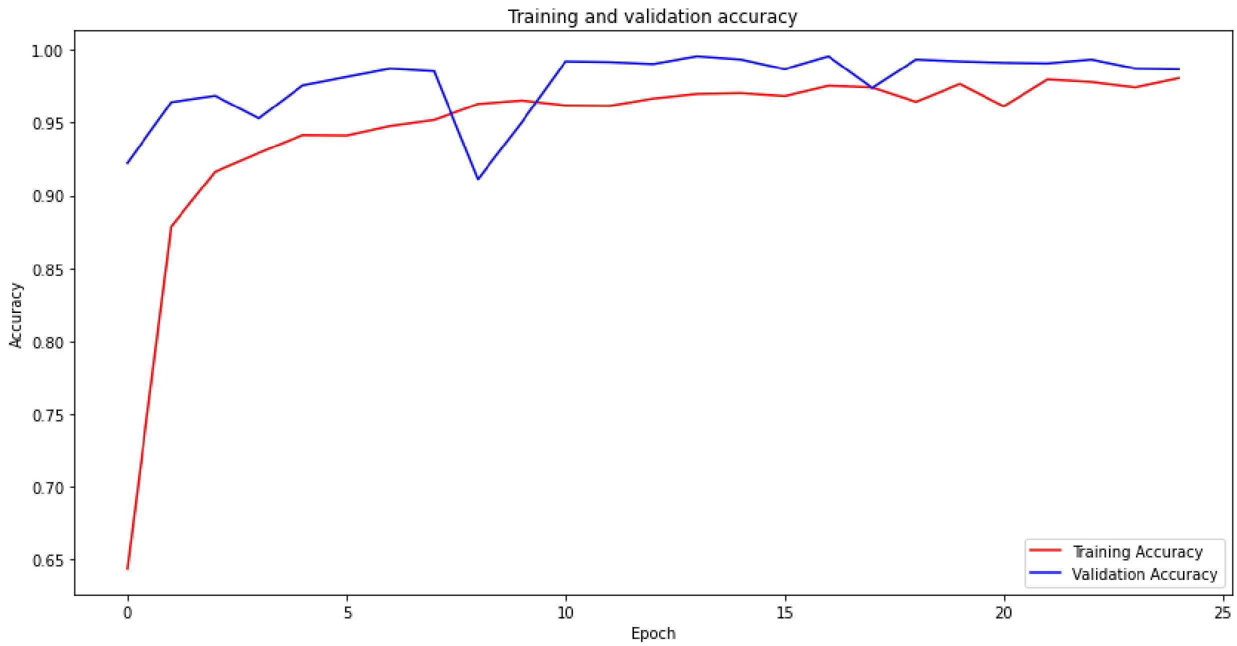

Figure 4: Training and Validation Accuracy plot for VGG16 model

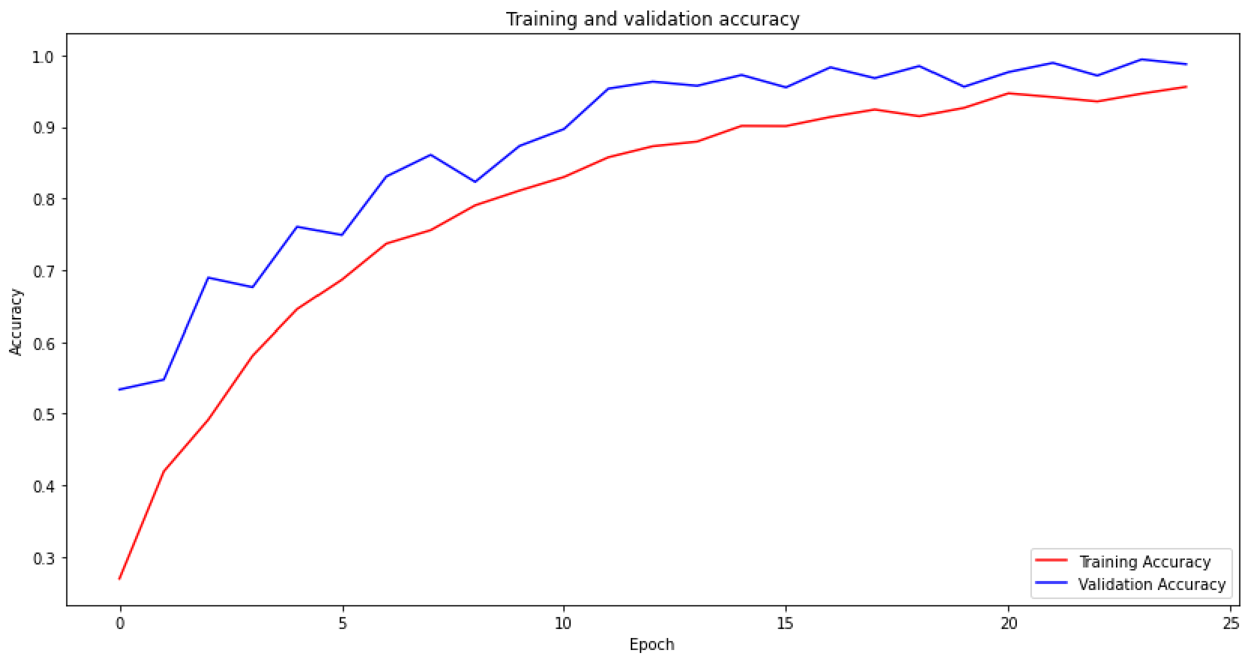

Figure 5: Training and Validation Accuracy plot for CNN model

From the above table, we see that the VGG16 training and validation accuracy for the VGG16 model is better. However, the validation scores are close and there is not a significant difference between the scores though training accuracy has almost 3% difference.

Training and Validation Loss:

	VGG16	CNN
Training:	05.67	13.04
Validation:	05.01	03.19

Table 2: VGG16 vs CNN training and validation loss

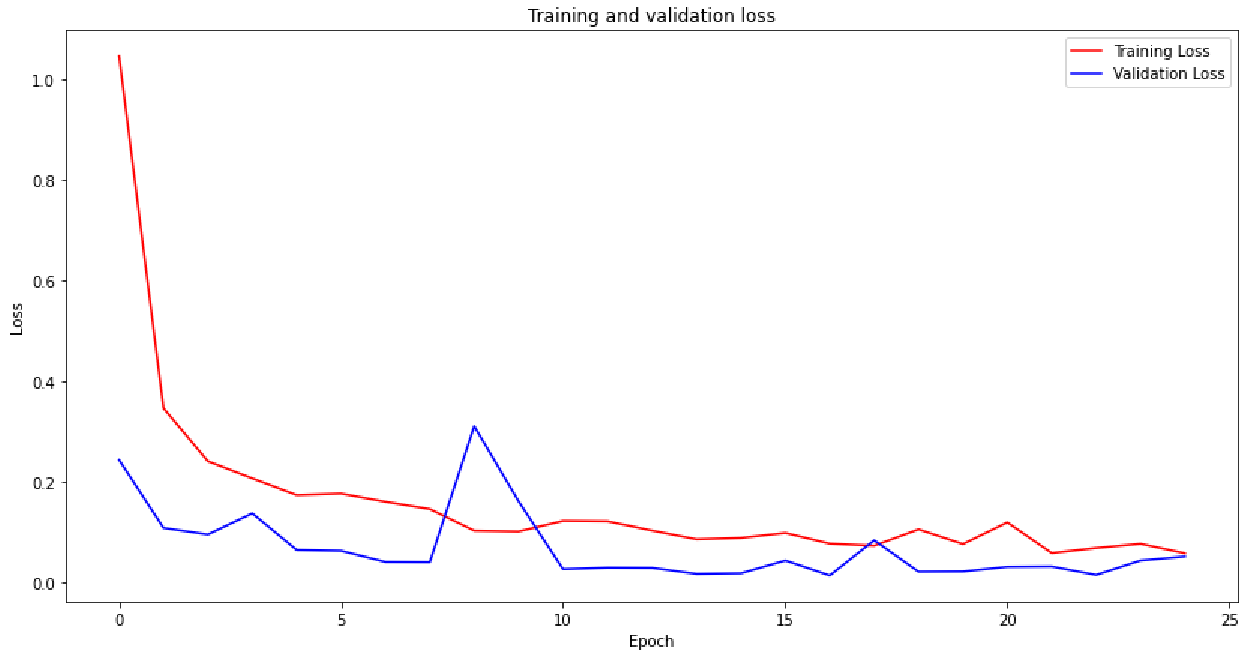

Figure 6: Training and Validation Loss plot for VGG16 model

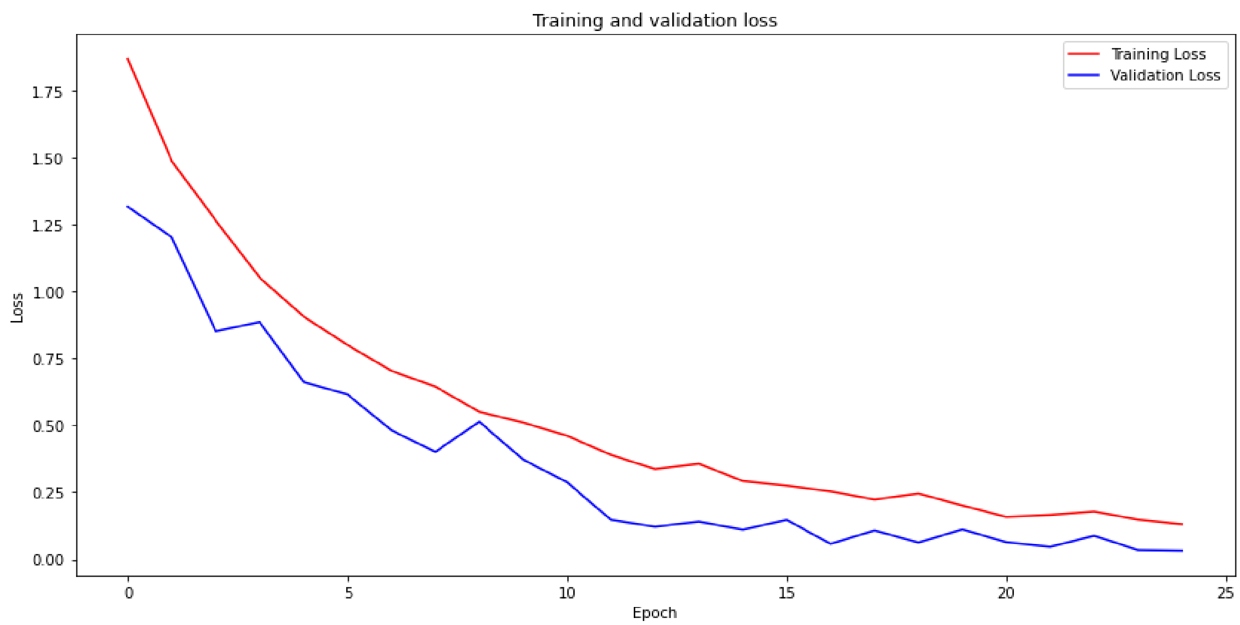

Figure 7: Training and Validation Loss plot for CNN model

Unlike the accuracy, in the loss of training and validation, we see a significant difference between the two models. The validation loss of the VGG16 model is higher than CNN model and the training loss is quite lower than the CNN model.

To evaluate the models, we used a test dataset that contained 380 images of 9 class using Keras's built-in model evaluation methods.

	VGG16	**CNN**	**Original Paper**
Accuracy:	93.68	94.74	88.69
Loss:	0.2193	0.1783	----

Table 3: VGG16 vs CNN Model evaluation accuracy and loss

Though the VGG16 model performed quite close to the CNN model in terms of training and validation loss even better in validation accuracy, the evaluation accuracy of the model is not very impressive. The model has accuracy 93% whereas the CNN achieved nearly 95%. The loss in VGG16 was significantly higher than the CNN model as well. On the other hand, our implemented models performed significantly better than that of the original paper [15].

5 Conclusion

In this project, we used transfer learning to classify fishes based on the modified VGG16 CNN model. We also implemented our data augmentation CNN model from scratch with Keras. The data augmentation process performs various image transformations such as zooming, rotation, flipping, etc. to create variation in images to decrease the chances of overfitting. We used 9000 images of 9 classes for training and validation.

The expected outcome was that the modified VGG16 model would perform significantly better than the CNN model built from scratch. However, that wasn't the scenario. The transfer learning model performed almost as well, but not better than the CNN model that was built from the scratch. Regardless of this, both models can identify various fish species with acceptable accuracy. Such models can help in the automatic identification of fishes from aquaculture to household with appropriate integration or implementation with software applications.

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