Alien Fish Detection for Malaysia Waters Species Recognition using Convolutional Neural Network Algorithm

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Abstract: The fish population is getting less attention than other vertebrates. Alien fish is a group of fish that migrates from one country to another. Day by day, various local species in Malaysia waters are threatened by alien fishes such as *Cichla Ocellaris* and *Phractocephalus Hemioliopterus* that have bigger size and appetite. This group of fish threatens local species aggressively; eating all that fits their mouth and indirectly destroys some local species in their habitat. This causes negative effects such as altering existing natural surroundings and disturbing the balance of the ecosystem. Ichthyology Malaysia is aware of this issue and has raised concern for the nearly extinct species but still in the progress of research work. Therefore, the project aims to recognize foreign fish using the Convolutional Neural Network algorithm and to develop prototype for the recognition of fish species detection for conservation purpose. The process begins with collecting the dataset by downloading images of the fish. The images then need to be pre-processed by changing the name of files as well as the files format. After the dataset is ready to be used, the images are required to be resized into correct requirement before applying the Convolutional Neural Network Algorithm to perform the detection. We may see the accuracy obtained at the end and during the testing process somehow to be outperformed. The implementation of this idea is complex, yet it is possible as research and continuous studies to assist in environmental conservation especially for the local fish population to be saved from extinction.

Key words: *Alien fish detection, species recognition, Convolutional Neural Network (CNN)*

INTRODUCTION

Freshwater is the most crucial resource for humans and all other living creatures on earth. Insufficient of clean water makes us struggle to live healthily thus affecting the environment. Some organism can thrive on salty water, but the great majority of plants and mammals need fresh water to live. It is important to keep freshwater habitat in control to maintain and protect aquatic and riparian aquatic, protect and restore the natural water flow regimes and connectivity of waterways and much more. Inside biology classification, fish can be described in many phyla, classes, families, or genera. Any study of fishes either freshwater fish or saltwater fish is known as fisheries biology or in scientific name; *Ichthyologist*. Almost half of the habitat of fish in the world is in freshwater eco-system. Unfortunately, fish species in freshwater ecosystem gets a very little attention. It has never been in public's concern like other terrestrial and marine species. People overlooked at the potential of the freshwater ecosystem and did not realize changing inside the waters. The study of fish recognition is important for *Ichthyologist*. According to [1] fish recognition is valuable for fish counting, population assessments, detail of fish associations and monitoring the ecosystems. In addition, it is indispensable for accurate fish detection in order to be aware with fish practices for legal restriction; to identify threatened or endangered fish species. Moreover, [2] report on the article for the fish recognition studies contributes in the distribution of specific fish species, assists biologist to resolve issues such as food availability or the interaction between preys and predators and many more.

Previously, researchers have done their work on fish recognition, yet the accuracy is not high enough thus the result was a declined. Unlike mammal, fish is cold-blooded, therefore, fish do not maintain a constant internal body temperature and easily influenced by its environment. This sensitivity gives more effort to researcher to focus more to it. It is

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quite challenging since fish have morphological variety, such as colour, size, shape, body pattern and so on [3]. Considering all the situations, it is good to look forward on image recognition for fish in daily life for certain purpose.

Peacock Bass was originated from Amazon and Orinoco, while Redtail Catfish was from Venezuela, Brazil and Colombia. Both fish live in freshwater and it is difficult to find in Malaysia. However, some people imported this kind of fish as ornamental fish. Equivalent with Guppy and Goldfish, Peacock Bass and Redtail Catfish have their own unique shapes, colors and sizes which make people feel interested to keep it as ornamental fish.

Unfortunately, the size of the fish become bigger than expected and cannot be kept as pet. Thus, people tend to release the fish into the freshwater instead of having it as cuisine. The migrate fish; Peacock Bass and Redtail Catfish have an advantage where it can easily adapt to new environment. However, this condition initiates the local freshwater fish uncomfortably as being threatened. The endangered local fish population started to be harmed which leads to a decrease in number.

Fish recognition is the act of recognizing or identifying fish species based on their features. Therefore, this research proposed to develop an automated fish detection for Malaysia freshwater species recognition prototype based on the image of the fish greatly for conservation purpose of the local species.

LITERATURE REVIEWS

Malaysia is geographically surrounded by oceans. One of the oceans is South China Sea. [4] stated that at least 3,365 species of marines come from the South China Sea. They further explain that the South China Sea lies at the tropical zone of the Western Pacific Ocean and both oceans are popular with higher productivity as it is richer in plants and other livings. In [4] thesis, they provided all 276 genera and 108 families including the taxonomy of 441 coloured photographs. Bony fish is a part of the clade that includes a vast majority of fish species and all tetrapod. Figure 1 shows the example physical anatomy of a fish.
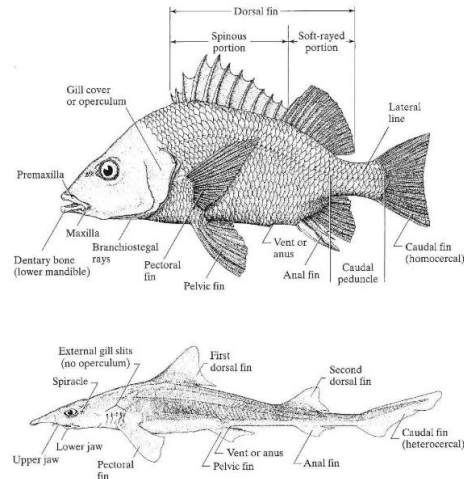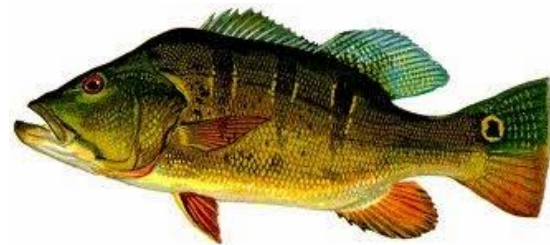

Figure 1 The physical anatomy of fish [5]

Figure **Error! No text of specified style in document.** Peacock Bass fish

Table 1 The collection name of Peacock Bass

English/Common Name	Butterfly Peacock Bass
Malay Name	Ikan Raja
Scientific Name	*Cichla Ocellaris*

Table **Error! No text of specified style in document.** The Classification of Peacock Bass

Kingdom	*Animalia*
Phylum	*Chordata*
Class	*Actinopterygii*
Order	*Perciformes*
Family	*Cichlidae*
Genus	*Cichla*
Species	*Cichla Ocellaris*

Details on two types of fish which are *Cichla Ocellaris* (Ikan Raja) in figure 2 and *Phractocephalus Hermioliopterus* (Ikan Keli Merah) in figure 3 are observed. Details on description, name and classification of the fish is in table 1, table 2, table 3 and table 4.

Figure 3 Redtail Catfish

Table 1 The collection name of Redtail Catfish

English/Common Name	redtail catfish, pirarara, South American Red Tailed Fish
Malay Name	Ikan Keli Merah
Scientific Name	*Phractocephalus Hermioliopterus*

Table 2 The classification of Redtail Catfish

Kingdom	*Animalia*
Phylum	*Chordata*
Class	*Teleostei*
Order	*Siluriformes*
Family	*Pimelodidae*
Genus	*Phractocephalus*
Species	*Phractocephalus Hermioliopterus*

CONVOLUTIONAL NEURAL NETWORK

In recent year, Convolutional Neural Network (CNN) that is used in classification and recognition becoming higher in accuracy and support the GPU [2]. According to [6] when CNN is used as classifier, the approaches already report that it has high accuracy for natural scene text detection and recognition. They also state that the capability of CNN in learning high-level meaningful features and semantic representation for visual recognition using an architecture of multi-layer features to be convolutional.

The combination of several CNNs into a multi-column deep neural network produces more positive result in recognition rate compared to the single CNN [3]. Moreover, during CDAR 2011 offline Chinese Character Recognition Competition, they won the first place. The eye is the image of dataset that was collected, and the brain is the CNN algorithm where prediction on the image is produced. Furthermore, the speed and accuracy in recognition can be improved by modifying the architecture of CNN algorithm; there are four convolutional layers and each of them consist of

different window sizes [7]. Every CNN consists of multiple convolutional layers, subsampling layers and fully connected layers [8]. Figure 4 illustrated the example layer in CNN.
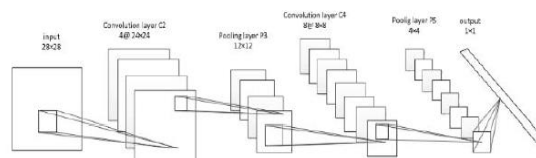

Figure 4 The example layer in CNN

METHODOLOGY

Prototype design begins with collecting images of *Cichla Ocellaris* (Ikan Raja) and *Phractocephalus Hermioliopterus* (Ikan Keli Merah) through web browser. The name of fish is searched on google image and downloaded via google extension; Fatkun. The images are stored in the folder according to the searched name of the fish. Unfortunately, the format of the images are in combination of *.jpg* and *.png* type images. Training process becomes smooth with the same image format and simple naming image. XnConvert is the software used to change the file format and standardize the name of images by renaming the images file. All image files were converted into .jpg format. The process is repeated with different species of fish. The amount of *Cichla Ocellaris* that was used as dataset were 689 while *Phractocephalus Hermioliopterus* were 649.

The Convolutional Neural Network consists of several specially designed layers to be desired relative to other image classification algorithms. The algorithm learned by using filters and applying it to the images. The overall architecture of CNN consists of an input layer, hidden layer(s) and an output layer. The hidden layer may include, Convolutional, Activation, Pooling, Dropout, Dense and other layer. The importance of hidden layer(s) in CNN algorithm is to decide on which hyper parameter that involves in the architecture and this condition is affecting the accuracy of the entire process of accuracy. First, import Conv2D, MaxPooling2D, Dense, Flatten and Dropout before they are used as a parameter.

Keras model comes into two forms, either Functional API or sequential. Most of the deep learning networks were built using sequential model. Functional API allows the build of more complicated architecture while sequential model allows the easily stack sequential layers of the network in order to begin with the input until output.

Conv2d layer where the Convolutional neural network concept was applied. Filter was used to show number of output channel. The conv2D layer was different for each layer. Since this research is using three layers, 16,32, and 64 as for filter output channel. The kernel is usually used to refer to the kernel trick, a method of using a linear classifier to solve a non-linear problem.

During the filtering process, sometimes the filter does not fit perfectly the input of the images. So, there is option either pad the picture with the zeros (zero padding) or drop the part of the images where the filter cannot do for it. This process is also called valid padding where it only keep the valid part to run the process. Same padding in CNN, the output of the same width and height is compared to the input. The input layer may come in many different sizes of width and height, to standardize the image, this layer is using 'same' in padding. Through this convolutional layer, it reduces the number of weights needed that depend on the kernel size instead of the variety of input size.

The correct activation function selection is a crucial part in order to get the output of the node and basically it can be divided into two, which are linear or non-linear. Almost all the Convolutional Neural Network or deep learning model used ReLU as activation function to get the positive value. ReLU stands for Rectified Linear Units for a non-linear operation. It is important to have ReLU to introduce the non-linearity in convolutional network. In real world, data is needed to process convolutional network to learn the non-negativity linear values. Instead of ReLU, tanh or sigmoid can be used to process non-linear function. However, for most of the data, researchers used ReLu since the performances of ReLU is better than the other two.

Pooling is where the system reduces the number of parameters when the images are too large. In pooling, there are several types inside such as max pooling, average pooling and sum pooling. Maxpooling2d or Max pooling takes the largest element from the rectified feature map. The average pooling takes the largest element while sum pooling sums of all the elements in the feature map. After completed one layer of CNN, repeat with 2 more layers in CNN using different filter on 32 and 64. The more layer of CNN, the higher the accuracy result.

Visible layer or dropout purposely to hide the neuron in network model on input. Dropout may increase the accuracy by forcing a neural network to randomly disable some neurons in the learning phase. The rate for dropout used is 50% as a weight constraint on those layers. Flatten work as operation on tensor reshapes the tensor to have a shape that is

equal to the number of elements contained in the tensor. Dense layer or fully connected layer neural network is a linear operation on the layer input vector connected to every output by a weight. Before output layer, Softmax layer makes sure the output has same number of nodes. It is suitable to use when there are multiple of classifications. Figure 5 illustrated the model summary of CNN.

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_4 (Conv2D)            (None, 64, 64, 16)        208
_____
max_pooling2d_4 (MaxPooling2 (None, 32, 32, 16)        0
_____
conv2d_5 (Conv2D)            (None, 32, 32, 32)        2080
_____
max_pooling2d_5 (MaxPooling2 (None, 16, 16, 32)        0
_____
conv2d_6 (Conv2D)            (None, 16, 16, 64)        8256
_____
max_pooling2d_6 (MaxPooling2 (None, 8, 8, 64)          0
_____
dropout_3 (Dropout)          (None, 8, 8, 64)          0
_____
flatten_2 (Flatten)          (None, 4096)              0
_____
dense_3 (Dense)              (None, 32)                131104
_____
dropout_4 (Dropout)          (None, 32)                0
_____
dense_4 (Dense)              (None, 2)                 66
=================================================================
Total params: 141,714
Trainable params: 141,714
Non-trainable params: 0
```

Figure 5 The model of summary of CNN

Batch size is referring to the size of dataset that is thrown to the model at a time, depending to the memory in the computer. High performance of the specification of computer may input many models all once. The resize size must be same when loading the dataset at previous step. Epoch is passing the full dataset multiple times to the same neural network. When the number of epoch increases, the more the times of weight are changed in neural network and may lead curves underfitting to optimal and optimal to overfitting. Different datasets have different number of epochs. This research is using 100 times of epoch. When it comes to total number of training examples in single batch, it means the batch size. So, for alien fish detection, 100 dataset was trained in simultaneous times. Training dataset consists of 1027 images and validation consists of 267 images for both species.

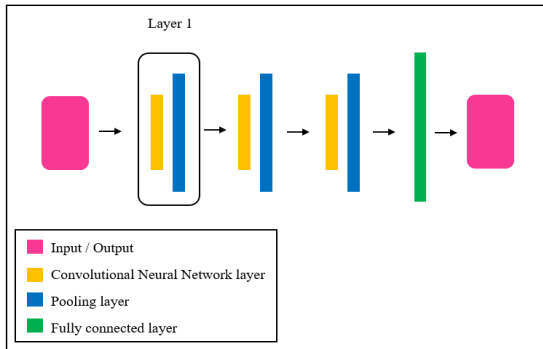**Applied CNN Architecture**

Figure 6 CNN Architecture

The process starts with an input/output and continue with first layer of CNN. The first layer consists of filter =16, kernel size = 2, padding = same and activation= ReLU. The application is the same for second layer and third layer of CNN, but the value of filter may be different. The filter on second layer of CNN is 32 and third layer is 64. It then proceeds with fully connected layer and lastly the result of output.

RESULT AND DISCUSSION

The number of data in the dataset will enhance the value of the accuracy. In this research, the training is performed on 80% of randomly dataset and the remaining 20% of dataset is used for validation process. Surprisingly, the recognition accuracy achieved is around 100 % for 100 epochs. The result on the accuracy against epoch figure 7 and training and validation as figure 8. The result for testing is illustrated in figure 9.
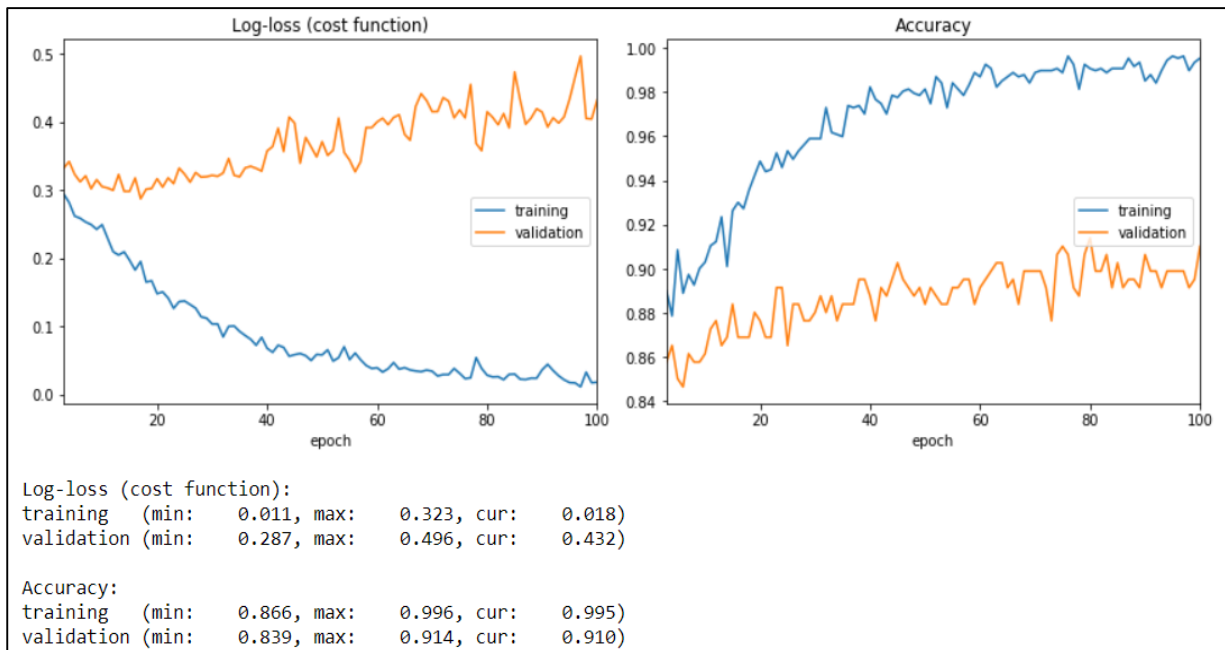

Figure 7 The loss and accuracy of training against validation

Figure 8 The result of training and validation accuracy

```
Predicting ...............................
1/1 [==============================] - 0s 2ms/step
[[6.176793e-06 9.999938e-01]]
1
redtail_catfish
The predicted Animal is a redtail_catfish with accuracy =    0.9999938
```

Figure 9 Sample result from testing

CONCLUSIONS

Development of prototype on alien fish detection for Malaysia freshwater species recognition consists of many processes to be performed. In this research, the objective of recognizing the alien fish using Convolutional Neural Network algorithm is carried out.

This research was run for 100 epochs. The number of *Cichla Ocellaris* species that are used as dataset were 689 while *Phractocephalus Hermioliopterus* were 649.

The system achieved an accuracy of 100% in the detection and is said to be outperformed. Thus, it is expected to benefit people in recognizing the exact species of fish using images for good intention such as studies, research purpose, conservative of extinction species and as protection from aggressive fish species towards ecosystem.

REFERENCES

[1] Ogunlana, S. O., Olabode, O., Oluwadare, S. A. A., & Iwasokun, G. B. (2015b). Fish Classification Using Support Vector Machine. African Journal of Computing & ICT African Journal of Computing & ICT Reference Format: Afr J. of Comp & ICTs, 8(2), 75–82.

[2] Ding, G., Song, Y., Guo, J., Feng, C., … G. L.-O., & 2017, undefined. (n.d.). Fish recognition using convolutional neural network. Ieeexplore.Ieee.Org.

[3] Zhong, Z., Jin, L., & Feng, Z. (2015). Multi-font printed Chinese character recognition using multi-pooling convolutional neural network. Proceedings of the International Conference on Document Analysis and Recognition, ICDAR, 2015–Novem, 96–100.

[4] Matsunuma, Mizuki & Motomura, Hiroyuki & Matsuura, Keiichi & M Shazili, Noor Azhar & Ambak, M.. (2011). Fishes of Terengganu, East Coast of Malay Peninsular, Malaysia.

[5] Anatomy.pdf. (n.d.).

[6] Ali, A., Pickering, M., & Shafi, K. (2018). Urdu Natural Scene Character Recognition using Convolutional Neural Networks. 2018 IEEE 2nd International Workshop on Arabic and Derived Script Analysis and Recognition (ASAR), 29–34. https://doi.org/10.1109/ASAR.2018.8480202

[7] Rao, G. A., Syamala, K., Kishore, P. V. V, & Sastry, A. S. C. S. (2018). Deep Convolutional Neural Networks for Sign Language Recognition, 194–197.

[8] stanford.edu. (2018). Convolutional Neural Network, 247–251.