FISH RECOGNITION SYSTEM

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DECLARATION

I declare that this thesis entitled “FISH RECOGNITION SYSTEM is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	24 May 2019

APPROVAL

I hereby declare that I have checked this report entitled "FISH RECOGNITION SYSTEM" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATIONS

To my beloved mother and father

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Praise to God that with His will and His bless, I am able to finish my Final Year Project. I am extremely fortunate to have many support and guidance from many people around me to ensure the success and the final outcome of this project. Firstly, I would like to express my deepest appreciation to my parents and my whole family for supporting me all this time. I would not have been able to go this far without them. Their kind cooperation and encouragement help me a lot in the completion of this project.

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ABSTRACT

Recognition is defined as the ability to detect and identify object into their respective classes. Nowadays there are a lot of different recognition system methods that can be used to identify an object. An example of recognition system that can be implemented is a system that can be used to recognize fish. A development of fish recognition system is crucial to maintain the sustainability of fish ecosystem for future generations. This is because researcher will have to measure its population by recognizing each type of fish species. In order to recognize fish and classify them according to its species, there are several methods that have been proposed by previous researcher. Hence, for this research, several methods of fish recognition system was studied to find the most accurate and user friendly to be used as the main system. The chosen system then will be developed to classify several fish according to its species.

ABSTRAK

Pengiktirafan ditakrifkan sebagai keupayaan untuk mengesan dan mengenal pasti objek dalam kelas masing-masing. Pada masa kini terdapat banyak kaedah pengenalan sistem yang berbeza yang boleh digunakan untuk mengenal pasti objek. Satu contoh sistem pengiktirafan yang boleh dilaksanakan adalah sistem yang boleh digunakan untuk mengenali ikan. Pengembangan sistem pengiktirafan ikan adalah penting untuk mengekalkan kelestarian ekosistem ikan untuk generasi akan datang. Ini kerana penyelidik perlu mengukur populasi mereka dengan mengenali setiap jenis spesies ikan. Untuk mengenali ikan dan mengklasifikasikannya mengikut spesiesnya, terdapat beberapa kaedah yang telah dicadangkan oleh penyelidik terdahulu. Oleh itu, untuk kajian ini, beberapa kaedah sistem pengenalan ikan dikaji untuk mencari yang paling tepat dan mesra pengguna untuk digunakan sebagai sistem utama. Sistem yang dipilih kemudiannya akan dibangunkan untuk mengklasifikasikan beberapa ikan mengikut spesiesnya.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The main field of this research is regarding recognition system, specifically on the recognition system of fish species. This chapter will discuss on the analysis of the background for recognition system by covering the research background, motivation, problem statement, objectives and the scope that will be used for the research.

1.2 Research Background

Recognition is defined as the ability to detect and identify objects into their respective classes[1]. Recognition system has been applied in various fields to help in the area of environment or ecological research where it can help scientist to identify and classify certain types of species or specimens. Whereas in manufacturing industries, where multiple goods can be produced using a single manufacturing line, recognition system can be used to classify objects such as food and beverages according to its specific requirement such as sizes, types, colors or shapes for packaging.

Previously, the researches done on the recognition system mostly are focused on the objects on the land. However, for the last 30 years the growth of research on the underwater-based technology has undergone a fast development. This is because it was prompted by the first United Nation Conference on Environment and Development or also known as The Earth Summit held in 1992 at Rio de Janeiro, Brazil that acknowledged the lack of information within the ocean[2]. This is proven due to the facts that most part of the oceans is still unexplored. Thus, greatly increase the demand for the system that can recognize underwater object.

1.3 Problem Statement and Motivation

Sustainability of fish ecosystem is very important especially for our future generation to ensure that our food supply does not run out. In order to decide the current status of fish population, researchers are required to manually go to the fish habitat to obtain data and manually do the recognition of the fishes. However, methods used by researchers to investigate fish sustainability is quite invasive. For example, casting nets into the sea will disrupt the balance of the ecosystem. Other example of method used by researcher involves the use of camera by recording an underwater video and then manually calculates the fish species. The researchers mean of obtaining data to ensure the sustainability of the fish is very time consuming and troublesome.

By having a fish recognition system, recognition of a fish species can be done efficiently with less effort without any harmful side effect as it could be used to help researchers such as scientist or marine biologist to improve the process or procedure on obtaining the data on the sustainability of fish species.

1.4 Objectives

The main objective is as follows:

- To develop a fish recognition system that can classify adult reef-associated fish.

1.5 Scope

The scopes of the researches are as follows:

i) 4 types of adult reef-associated fish are used to obtain result from fish4knowledge dataset[3]:

- *Dascyllus Reticulatus*
- *Plectroglyphidodon Dickii*
- *Chromis Chrysura*
- *Amphiprion Clarkia*

ii) Horizontal orientation of fish images for recognition process

iii) Implementation technique by using MATLAB software

1.6 Conclusion

This chapter has presented on the importance of the fish recognition system to ensure the stability of the fish sustainability as food supply for the current and future generation. The next chapters will cover about the previous research that has been done regarding the method for recognition of fish and the most suitable method for fish recognition will be chosen.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter consists of researches regarding fish recognition system where different approach is used to identify fish and is follow by the theoretical section on the selected method for the project.

2.2 Support Vector Machine Approach.

The Support Vector Machine (SVM) is define as a type of classifier that can classify, regress, or other tasks in a highly dimensional space by building a hyper planes[4]. A hyper plane that has the biggest separation to the training-data point of any class shows a good difference because by having a bigger margin the percentage of making a mistake for the classifier is smaller[5]. according to research paper by Diego Mushfieldt, Mehrdad Ghaziasgar, and James Connan[4] that describe the basic for a flexible system that can be used to recognize different type of fish species and demonstrate the data instantly to the user, segmentation of the needed fish with a novel pre-processing procedure is used. A classification method using SVM is employed to identify 20 fish based on its shape and color. In 11 out of the 20 fish, the experimentation result proved the system was 100% in accuracy while 17 of the 20 fish score the accuracy of above 70%. The whole system consists of three main components which is segmentation, training and recognition using an SVM, and Figure 2.1 shows an example of the result.

Figure 2.1 Example of Result

The usage of SVM was also applied in the research paper by H. Qin, X. Li, J. Liang, Y. Peng, and C. Zhang[7], who have implemented the DeepFish-SVM-aug-scale method for classification. According to this research, live fish recognition framework based on a simple cascaded deep network that was fed to SVM classifier is comparable with a carefully designed and tuned deep Convolutional Neural Network architecture. Underwater fish dataset image that was shown in Figure 2.2 was acquired from truth dataset made by the Fish4Knowledge project[3].

A linear SVM layer was adopted instead of commonly used Softmax layer because it is the most effective and has the least falsely classified fish as shown in Figure 2.3 because out of 3908 test images, only 53 fish are falsely classified as a different result of test images. This system is considered effective as it can achieve the accuracy of 98.64%.

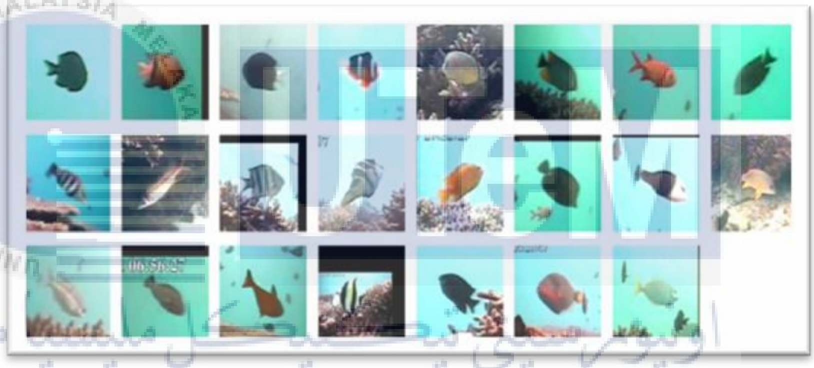

Figure 2.2 Dataset Used

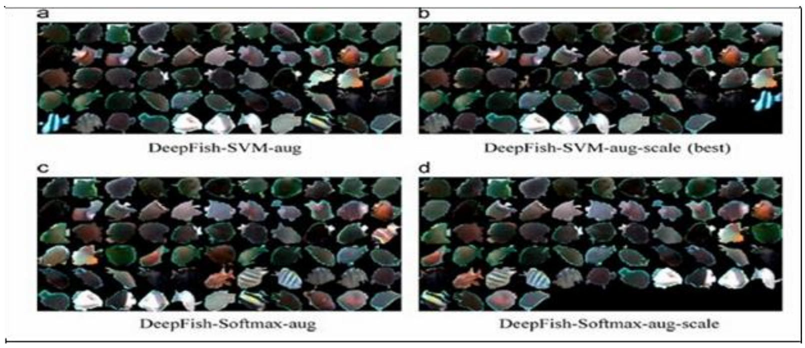

Figure 2.3 Falsely Classified Image

2.3 Template Matching Based Approach

Template matching is a technique that is able to do computerized processing for finding small parts of an image that can coordinate with a template image[6]. Template matching based approach is one of a method that can be used for classification of image by comparing two images thoroughly. The images used will show extracted part of edge point and the distance transform in the model image with another query image.

According to the research paper by Rova Andrew, Mori Greg, and Dill Lawrence M. that classify two fish species which is the Striped Trumpeter and Western Butterfish that is shown in Figure 2.4, this method can be part of a system that classified fish species automatically[7]. The method applied in this technique uses deformable template matching to align template images and query images. A deformable template matching was used so that it can align template images and query images to improve classifier that is based on texture that are precise to pixel alignment. However, the final classification to decide the output uses SVM as classifier. Each query image is warped to the striped trumpeter template and western butterfish template. Experimental results based on the table 2.1 shows the superiority of using deformable template matching over raw SVM texture based classification[7].

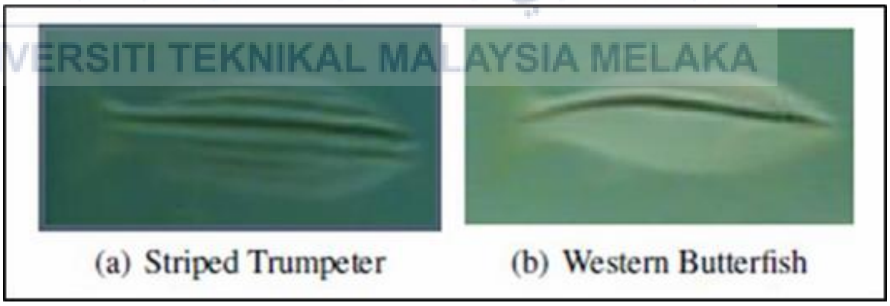

Figure 2.4 Type of Fish Used

Table 2.1 Result of Classification

SVM Kernel	Unwarped	Warped
Linear	84%	90%
Polynomial	81%	86%

2.4 Artificial Neural Network

An Artificial Neural Network is an interconnected processing information that make a decision from a specific problem given[8]. The processing information of an ANN is based on the way that a human nervous system work such as brain to create the resemblance of a brain neuron because just like human, it is a system that learned something from an example given[9].

2.4.1 Multilayer Perceptron Network (MLP)

MLP network is a class of feed forward artificial neural network that is made up of more than a single perceptron that is connected to one another as pictured in Figure 2.5. It is made up of three levels which is inlet level for signal receiving, hidden level for computational engine, and outlet level for decision making. Even with a single layer of hidden level, the systems are able to approximate any continuous function[10].

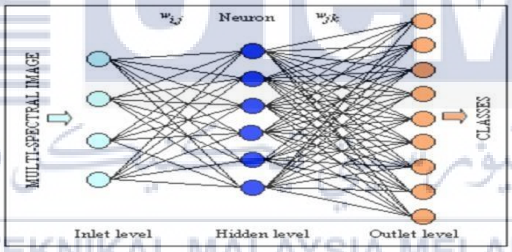

Figure 2.5 MLP Network structure

According to the research paper done by Eiji Morimoto, Yuichiro Taira, and Makoto Nakamura, a fish recognition system can be developed by employing neural networks that could learn to differentiate and classify fish species using references point[11]. References point was extracted from images of the body texture of the fish by using truss protocol as shown in Figure 2.6. In order to assemble the dataset used for network inputs, the truss lengths between reference points according to the total body length are used. The specified fish species that was used for the identification was D. Macrophthalmus. For the learning process, each signal for the specified species was labeled as 1 while the other species was 0. Figure 2.7 shows the learning results of the method that proved its effectiveness because almost all of the specified D. Macrophthalmus species is 1 and the other species is 0.

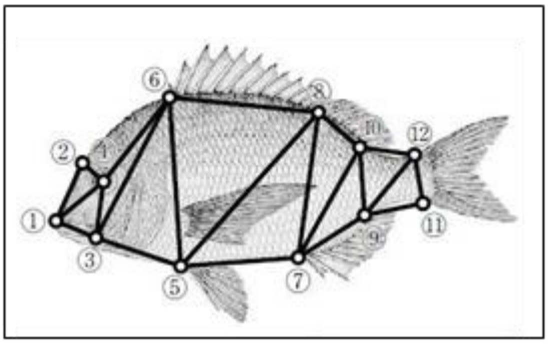

Figure 2.6 Landmark and Trusses[11]

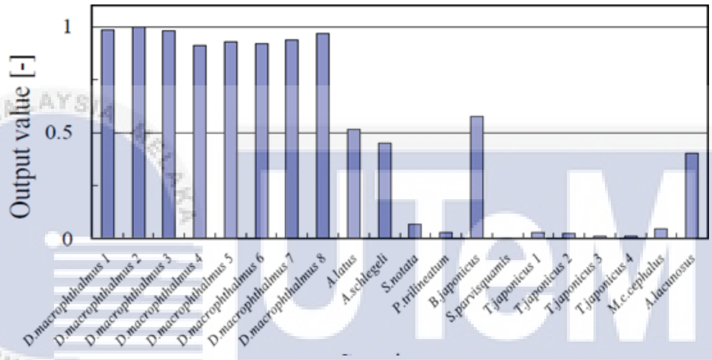

Figure 2.7 Learning Result[11]

Moreover, methods of fish recognition by using multilayer perceptron neural network are also done by Purti Singh and Deepti Pandey[12]. In their research, shape of the fish is an essential visual characteristic and is the key features used to illustrate the content of the image. The fish features that was approach are the size, shape, color, and its geometrical parameters. Based on the results, the recognition system that also include the training and testing processes of all fish shows accurate classification result that achieve 97.4%.

2.4.2 Convolutional Neural Network (CNN)

A CNN is also a class of feed forward artificial neural network that is commonly used for the analysis of image visualization. Compared to the neural networks that its neuron is fully connected with each layer, CNN will only consider the closest neurons in a given range[13]. This is possible because pixel information from an image will be extracted in a specific block size

Lecun et.al was the first person to propose the convolutional neural network algorithm to be used to recognize documents and created solutions to classify single digits, strings of digits and zip codes respectively[14]. The architecture of CNN was pictured in Figure 2.8.

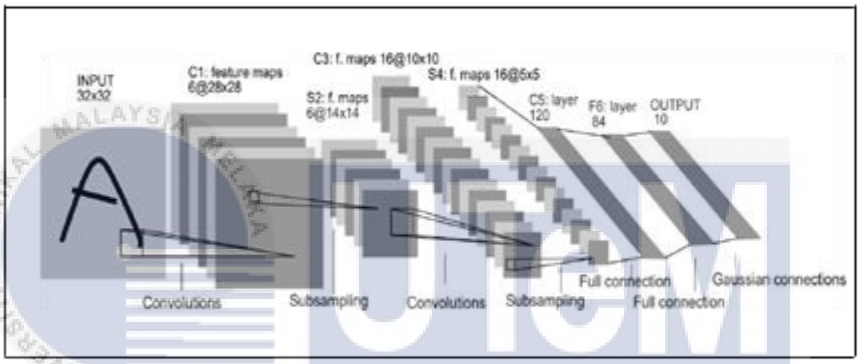

Figure 2.8 CNN Architecture

The usage of convolutional neural network is applied by M. Alsmadi et. Al [15] for fish recognition of four type of different species. The input test data was trained into the CNN model to get the recognition results. The training samples are regularized and adjusted to a uniform size and use batch approach in the training process to randomly select the training samples, preventing the adverse effects of poor data in the training process. By using the back-propagation algorithm for each small batch, the weight was updated. The training process was stopped when it reaches a certain number of iterations or the error reaches the threshold.

Convolutional neural network was also used by Minsung Sung, Son Cheol Yu, and Girdhar Yogesh[16]. The based technique of this method adopts the concept of You Only Look Once (YOLO) network algorithm for the recognition of fish in real time. Since object detection that is based on CNN algorithm have been improved in the recent years, main objectives for researchers nowadays are to improve accuracy and processing speed. Hence, YOLO was introduced by Redmon Joseph, et al. [17].

The usual classical method of fish recognition detects identical characteristic such as its features of shape or a pattern of color. To improve the precision of the system, seabed images are trained to be classified as a non-fish object because most fish has its skin texture identical to the seabed for defense mechanism. It is then labeled as „negative‟ to prevent the system from recognizing seabed as a fish. The same method was used to other underwater non-fish objects and labeled as „negative‟. The network was trained efficiently by using grid search to optimized the hyper-parameters that is made up of value of momentum, number of epoch, mini batch size, and learning rate. Figure 2.9 shows an example of fish recognition by implementation of YOLO and CNN algorithm.

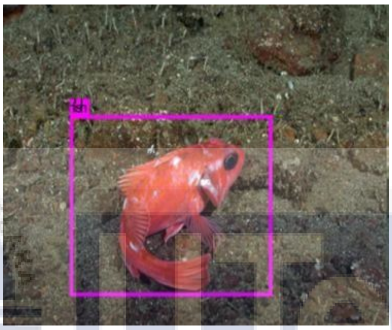

Figure 2.9 Detected Fish in Seabed

CNN algorithm was also implemented by Alex Krizhevsky et. Al with their publication paper entitled "ImageNet Classification with Deep Convolutional Neural Networks" [18]. The architecture for AlexNet is shown at figured 2.10 and was named after its first author, Alex Krizhevsky. AlexNet was abundantly greater than the earlier CNNs used for computer vision tasks such as Yann LeCun's LeNet paper in 1998[14].

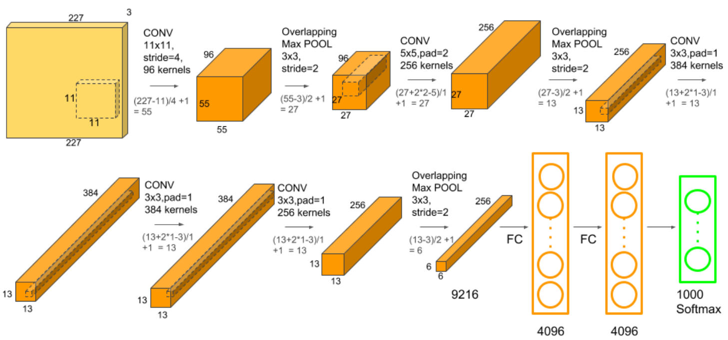

Figure 2.10 AlexNet Architecture [19]

2.4.2.1 Working Principle

A CNN can produce the desired outputs by taking an input image and passing through the system layers. The system can have tens or several layers, with each layer figuring out how to distinguish between the variations features of a picture. Filters are connected to each training image at various resolutions, and the yield of each convolved image is utilized as the input to the following layer. Figure 3.5.1 shows a CNN architecture that are fully connected layers that flattened the matrix to a one-dimensional matrix, representing the merging of feature maps. The final outputs are produced when the feature maps are merged into fully connected layers after convolving and activation functions and implementation of pooling by a specified number of layers that have been done.

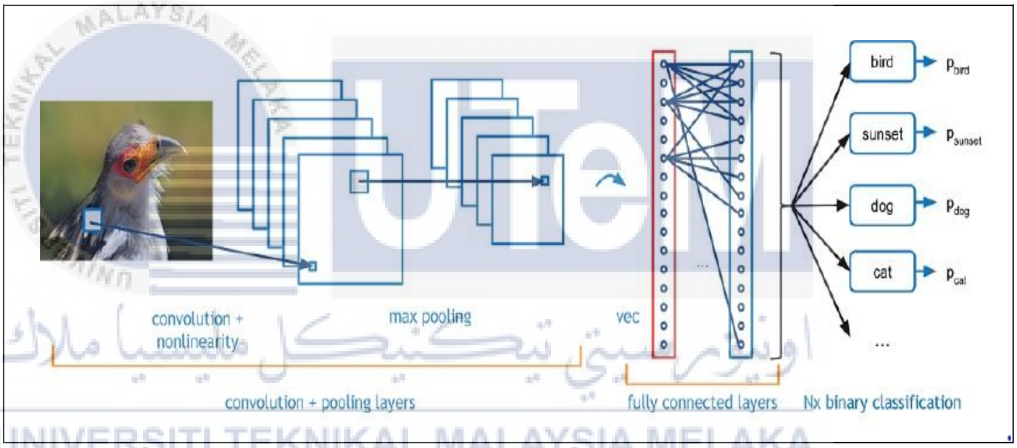

Figure 2.11 Convolutional Neural Network

Convolutional neural network basically works by reducing the number of connections. According to Aghdam and Heravi`s example from "Guide to Convolutional Neural Networks"[20], when the number of grayscale pixel input is 16×16 = 1024 neurons, and the neural network has a hidden layer of 7200 neurons, will gives a total of 1024×7200 = 7372800 connections. The image`s pixel is grouped together in a 5×5 grid, and the neurons in the hidden layer are grouped into 50 sets of 12×12 blocks. After weight sharing is implement to the hidden layer, neurons are grouped into (5×5) × 50 = 1250 connections, which is a 99.98% reduction of connections. The input image is known as filters while the regions of the input images that the filters are applied to are known as the receptive fields.

Convolving is a process when the filter is applied to the receptive field. The output produce is known as feature map. Illustration of convolving process is shown in Figure 2.12. During convolving, the unit’s number that a filter can slide is possible by striding. It can be specified in both x and y direction of the matrix. One stride is used by default, allowing for a more detailed feature maps even if it is causing overlap between strides. Border pixels may be left out as result of selection of filter size

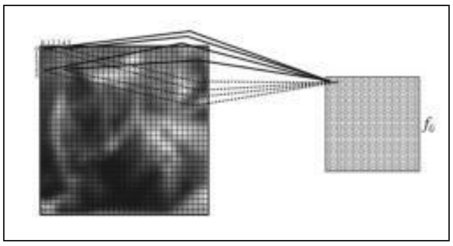

Figure 2.12 Convolving Process

Potential important features may be excluded during striding but can be resolved by the means of zero-paddling that added zeros around the image as shown in Figure 2.13. The most common input is 3-dimensional because images mostly use the RGB-scale, which has one value each for red, green and blue. The number 3 in the dimension size 3 indicates that it is an RGB image.

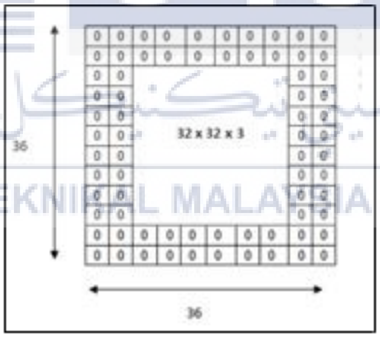

Figure 2.13 Zero Padding

2.5 Convolutional Neural Network as a Method for Fish Recognition System

From the experiments that was demonstrated by previous researcher, Convolutional Neural Network was chosen as the main method to be used for fish recognition system since it can learn a high level of features along with the classifier that uses multiple layer architecture at the same time. It is also chosen because of its performance and robustness. After the learning process of the high-level features, it will have a better performance than generic low-level features, making it more efficient for recognition. Moreover, Convolutional Neural Network is very useful because it is vastly used in deep learning since it directly learned important features and has no need for manual elimination of feature extraction. Result produce are also a state-of-the-art recognition result. It is also a flexible method as it can be used to train a network that is built from scratch and from a pre-trained model[21].

2.5.1 Training From Scratch

One of the methods to build a CNN architecture were by building it from scratch. Development of a convolutional neural network system from scratch required a set of image data to be used for training and testing. Basically, using MATLAB to train a network from scratch involves data access that was usually downloaded from the internet. The network layers are then configured and created to be trained. Table 2.2 shows the most commonly option used for the training of the network.

Table 2.2 Commonly Used Training Option

Training Options	Description	Example of Functions Used
Plot of training progress	Mini-batch loss and accuracy plots are show	("Plots","training progress")
Max epochs	full pass of the training algorithm over the whole sets of training	("MaxEpoch")
Mini-batch size	A mini batch is a subset of the training data set that is processed simultaneously	("MiniBatchSize")

2.5.2 Transfer Learning

Deep learning is a type of machine learning that operate human like tasks such as speech recognition, image identification, or decision making[22]. A CNN is a practical machine learning approach from the sector of deep learning. CNNs are trained using various type of numerous images. From those various type, CNNs can learn the characteristic illustrations of a wide range of images.

Transfer learning is also known as a reuse pretrained network, this refers to the process of using the weights from pre-trained networks on a large dataset. This is because the pre-trained networks have already learned how to identify lower level features such as edges, lines, curves, and many others. Training of a CNN model can also be trained from a model that has already been trained and it is much faster than training from scratch because it uses image that has already been learned for robust extraction information of image as a starting point for new task learning. Figure 2.15 shows the flow of CNN structure made from pre-trained network.

With the convolutional layers which are frequently the most computationally time-consuming parts of the process, the use of these weights helps the network to converge to an excellent score faster than training from scratch. In this project, we use AlexNet [18], then modified its final layer to recognize different classes of fish as shown in Figure 2.14.

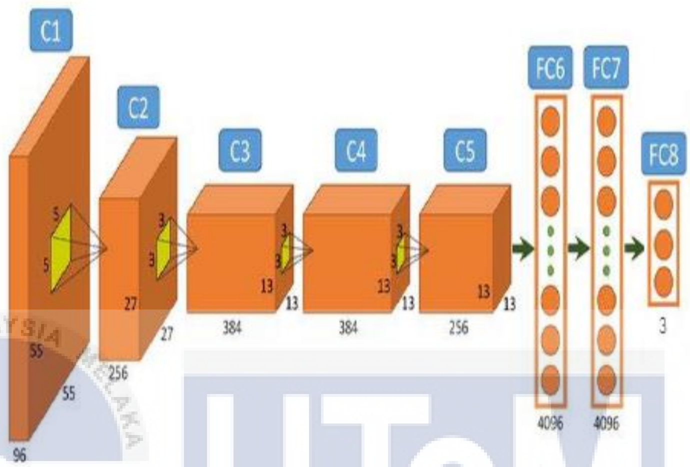

Figure 2.14 AlexNet Architecture[23]

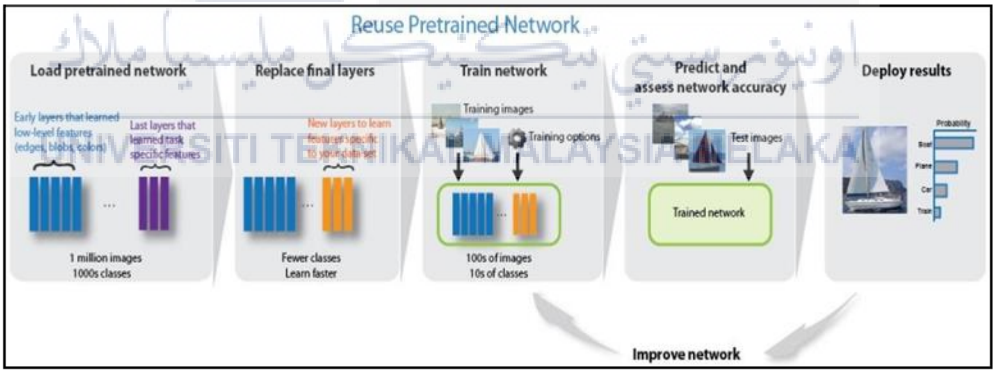

Figure 2.15 Pre-Trained Network[21]

2.5.3 Training From Scratch versus Transfer Learning

Training from scratch and transfer learning are the two most commonly used approaches for deep learning to build a convolutional neural network. Both methods have their own benefits and can be used for different deep learning tasks.

Developing and training a model from scratch works better for very specific tasks for which preexisting models cannot be used. This method is recommended to be used when there is no access to a pretrained model for a text analysis task. The disadvantages of this method are it usually requires a large amount of data to produce accurate results. For example, when text needs to be verified and many data samples are available.

Transfer learning is useful for tasks such object recognition, for which a variety of popular pretrained models, such as AlexNet and GoogLeNet, can be used as a starting point. For example, a botany project needs flowers to be classified. However, with limited available data, AlexNet can be used by transferring weights and layers which can classify it into 1000 different images categories by replacing the final classification layer.

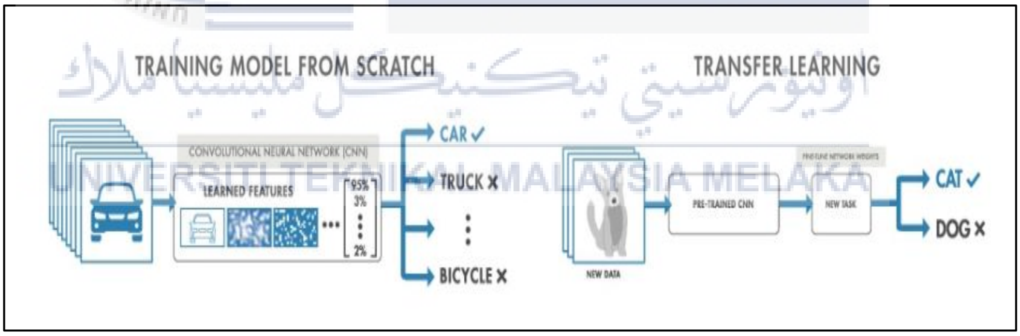

Figure 2.16 Comparison between two method[24]

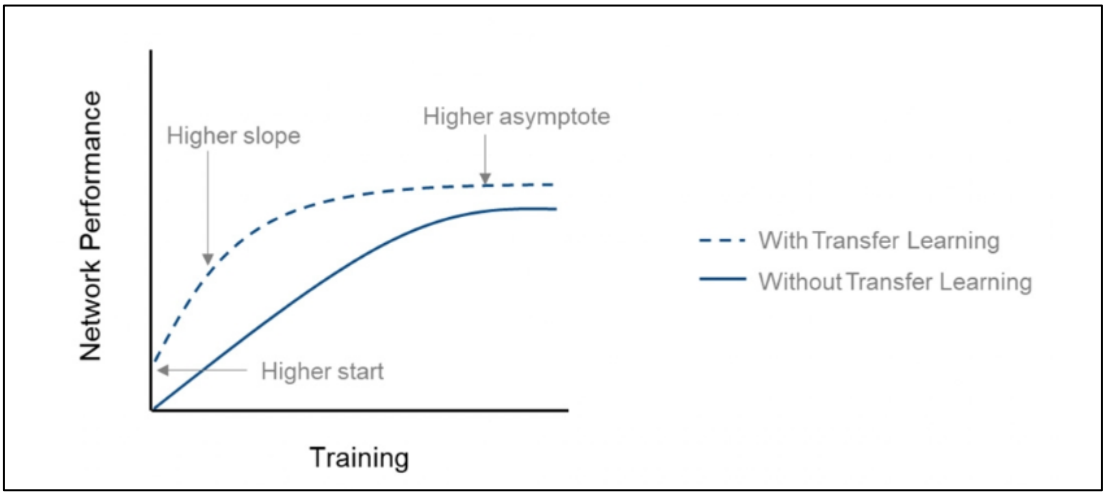

Figure 2.17 Network Performance[24]

2.6 Conclusion

Based on the information obtain from previous research, convolutional neural network has a better accuracy compared to other methods that was studied. Template matching approach and method that is based on support vector machine that was proposed is quite difficult to execute and extraction of the most appropriate image features was complex. Hence, implementation of CNN method that was chosen as the main method for recognition of fish will be discuss in the next chapter of this research. For this project, implementation of CNN that uses transfer learning from AlexNet architecture method was used as the main method instead of the training from scratch method.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presented the proposed solution to the problem statement. A Convolutional Neural Network method based on transfer learning from AlexNet was chosen as the solution for this project. The process flow of the project starts with studying the journal that is related with the research to be done and understanding it to be able to further analyze the project. The research on fish recognition system and on Convolutional Neural Network can be implemented on MATLAB software.

3.2 Overall Project Flow

This thesis presents a new and integrated analytical approach to estimate proposed methodology. The overall flow of this research is as shown in Figure 3.1. The total flow of the project is divided into two parts. For the first past, the project is started with the research done on the background of the project. Previous research regarding the fish recognition system was done by doing literature review in order to identify the most suitable method. The second part will apply the knowledge gain from the previous research and implementation of data will be done by using MATLAB software. The result will be analyzed and discussed to come up with the conclusion of the research.

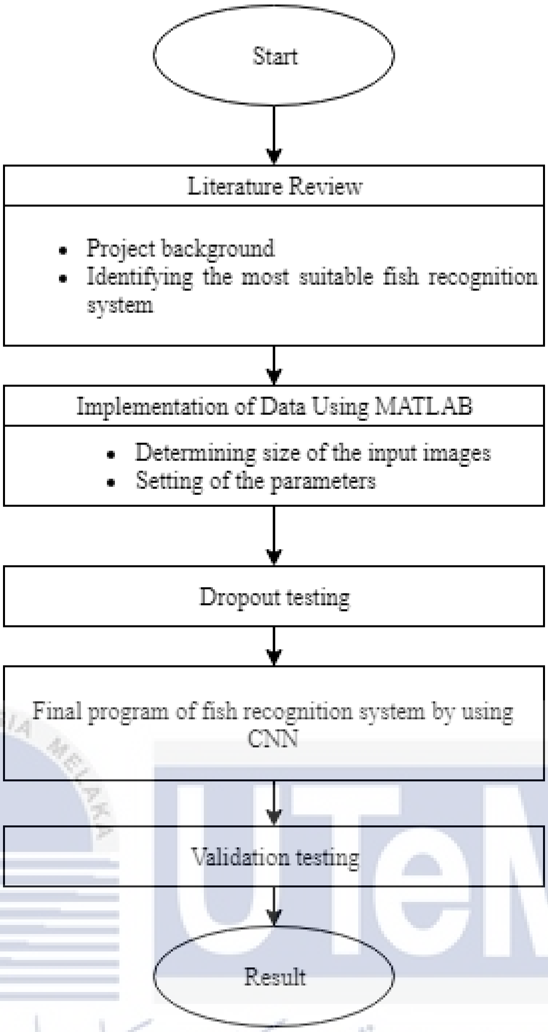

Figure 3.1 Overall Project Flow

3.3 Training Phase

The first phase of the recognition system is illustrated in Figure 3.2. In this phase, input images will be trained by the means of CNN method. The trained CNN model then will be used for the identification of the testing images

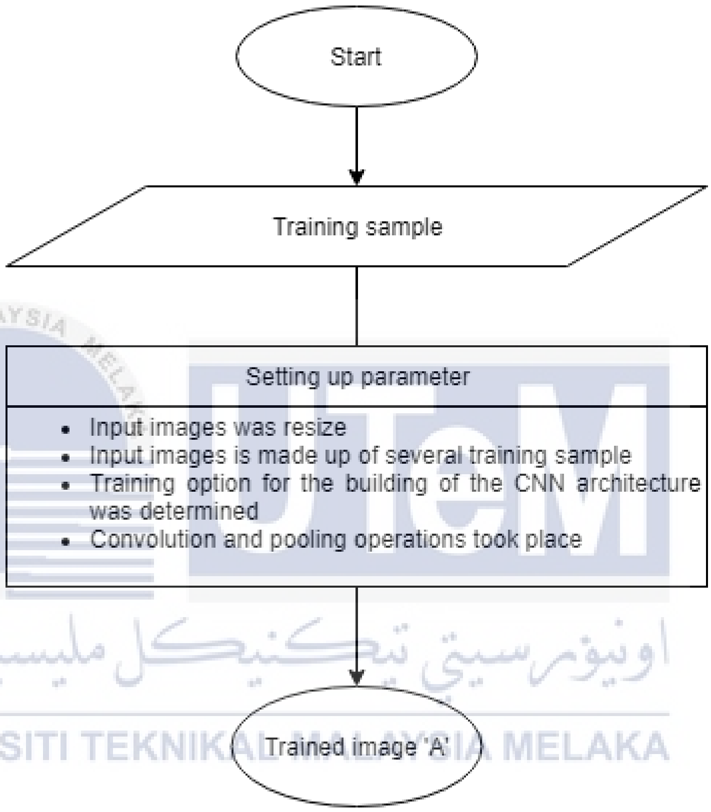

Figure 3.2 First Stage of CNN Implementation

3.4 Testing Phase

The second phase of the recognition system is illustrated in Figure 3.3. In this phase, input images will be tested by the means of CNN method. The trained CNN model then will be used for the identification of the testing images. Other than that, a small experiment was also conducted in the terms of dropout testing to determine the best dropout used for accuracy of the network.

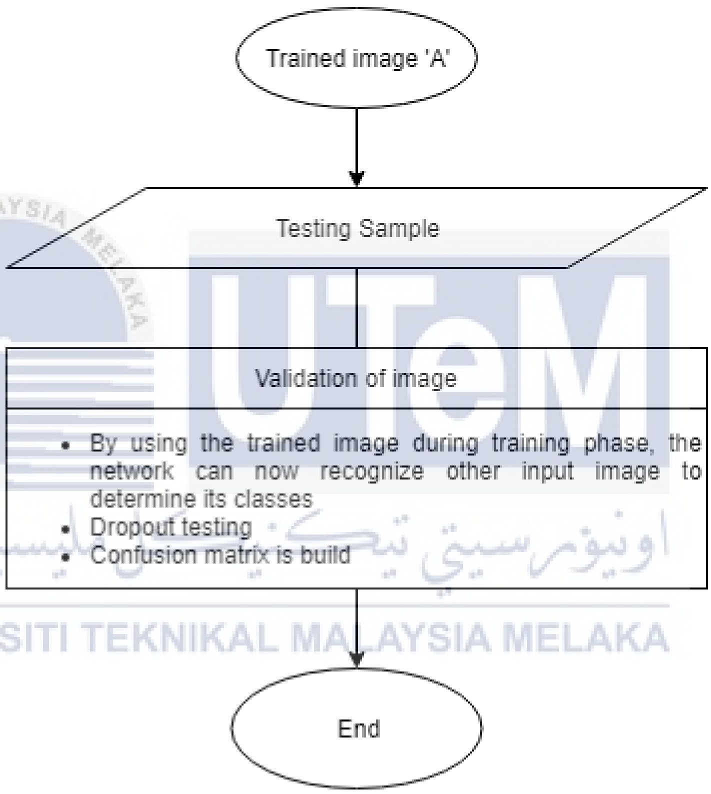

Figure 3.3 Second Stage of CNN Implementation

3.5 Dataset

The dataset used are taken from the Fish4Knowledge dataset [3]. The dataset consists of 23 types of fish species. However, only 4 of them are used for recognition process to simplify the data analysis. The fish data is obtained from the web page created by Phoenix X. Huang, Bastiaan B. Boom and Robert B. Fisher. Specifically, this fish dataset is acquired from a live video [15]. The difference of quantity of each fish is relatively big and causing the data collection to be imbalance. For example, species *Dascyllus Reticulatus* have a vast number of samples while species *Neoglyphidodon Nigroris* only have a small number of samples. Figure 3.4 shows the distribution of the datasets that can be found at the Fish4Knowledge web page while in Appendix B shows the distribution detail of the fish from the dataset.

Figure 3.4 Fish4Knowledge Dataset

3.5.1 Configuration

The specific configurations for the project are described in this subsection.

- The images are re-sized to 227x227 pixels, because all images need to have the same dimensions for the CNN to work to be applied to the input images.
- 2772 images for training, 1188 images for testing.
- One run of 10 epochs.
- Batch size of 21

3.5.2 Dropout

In order to prevent overfitting during dataset training, a dropout of 50% was applied between the two last fully connected layers of the AlexNet to create variation in the dataset. Overfitting is a term used when a network has trained the architecture with too much detail until it negatively affects the network. Values of dropout was then been tested at 10%, 50%, and 80% as shown in Figure 3.5, Figure 3.6, and Figure 3.7 respectively. As the dropout with 10% and 50% have almost identical graphs, the one with 80% dropout converges at a slightly lower training accuracy compare to the other two. This shows that higher dropout rate gives out more information that will be lost during training since forward and backpropagation is done only on the remaining neurons after applying dropout. Dropout values of 10% and 50% give an accuracy on the testing set of 99.57% and 99.85% respectively. The losses on the testing set for both 10% and 50% are almost identical, with 50% dropout having a loss of slightly less than the 10% dropout while dropout of 80% gives a testing accuracy of 99.11%. These factors led to 50% dropout being the one implemented in the final solution.

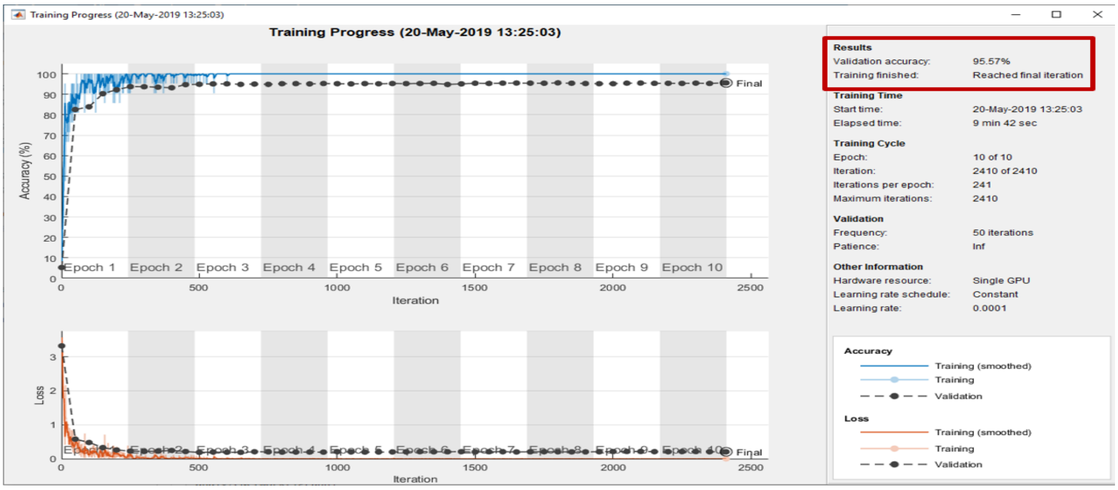

Figure 3.5 Dropout at 10%

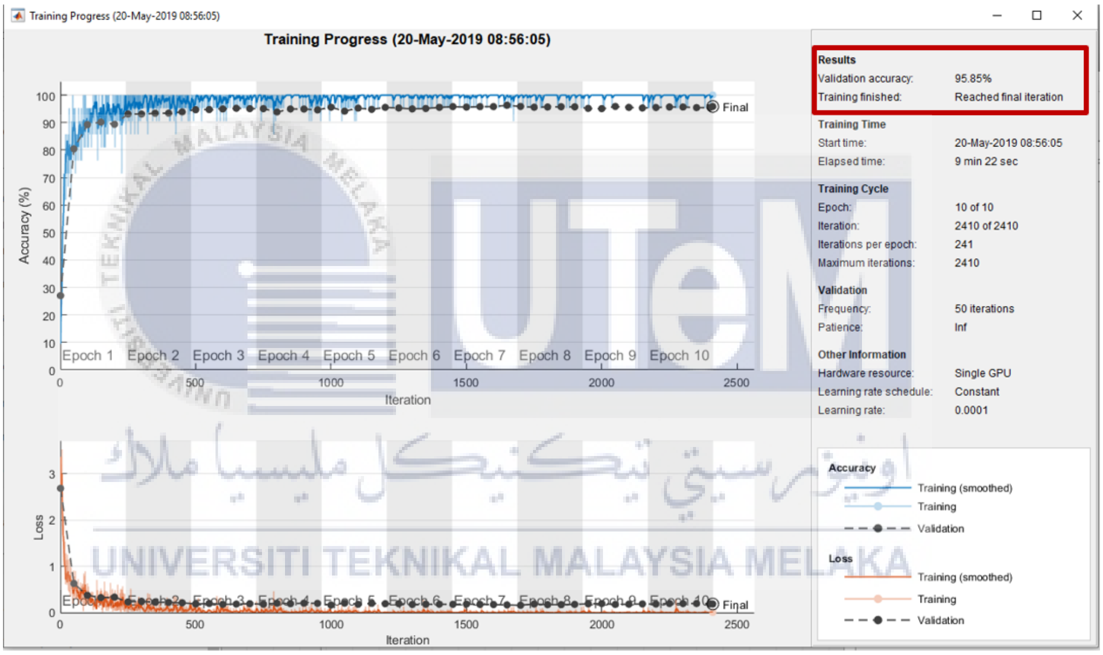

Figure 3.6 Dropout at 50%

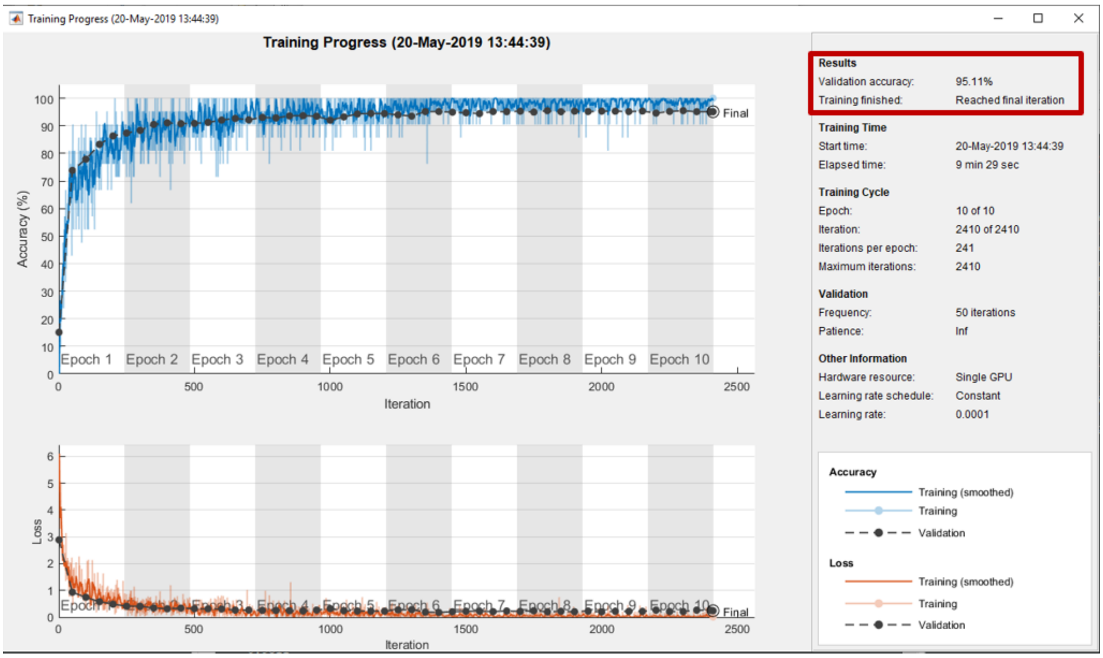

Figure 3.7 Dropout at 80%

3.5.3 Developing CNN AlexNet Architecture

In order to determine the superior method between training from scratch and transfer learning that is going to be used to build a CNN network, two different CNN architecture was built to make a quick comparison between the two by using the same set of input images. It is found that transfer learning has a better accuracy of network despite having a smaller number of input images. Hence, the final result will be based on the transfer learning method.Table 3.1 shows the accuracy comparison between the methods while Figure 3.8 and Figure 3.9 shows the output given from both method.

Table 3.1 Accuracy Comparison

Train from scratch		**Transfer learning**
20s	Time to train	22s
1000/class	Training image	100/class
95%	Overall accuracy	98.2%

```
Command Window
>> trainfromscratch
Training on single GPU.
Initializing image normalization.
|========================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |   Accuracy   |     Loss     |      Rate       |
|========================================================================================|
|       1 |           1 |       00:00:01 |       26.56% |       1.3866 |          0.0010 |
|       1 |          50 |       00:00:03 |       81.25% |       0.5574 |          0.0010 |
|       2 |         100 |       00:00:04 |       90.63% |       0.2521 |          0.0010 |
|       3 |         150 |       00:00:06 |       93.75% |       0.1764 |          0.0010 |
|       4 |         200 |       00:00:08 |       89.06% |       0.3523 |          0.0010 |
|       5 |         250 |       00:00:09 |       98.44% |       0.1378 |          0.0010 |
|       5 |         300 |       00:00:11 |       98.44% |       0.0442 |          0.0010 |
|       6 |         350 |       00:00:12 |       95.31% |       0.0898 |          0.0010 |
|       7 |         400 |       00:00:14 |       98.44% |       0.0757 |          0.0010 |
|       8 |         450 |       00:00:15 |      100.00% |       0.0188 |          0.0010 |
|       9 |         500 |       00:00:17 |       98.44% |       0.0583 |          0.0001 |
|       9 |         550 |       00:00:18 |      100.00% |       0.0179 |          0.0001 |
|      10 |         600 |       00:00:19 |      100.00% |       0.0194 |          0.0001 |
|      10 |         620 |       00:00:20 |      100.00% |       0.0123 |          0.0001 |
|========================================================================================|
>> testingfromscratch

ans =

    0.9500
```

Figure 3.8 Training from Scratch

```
Command Window
Training on single GPU.
Initializing image normalization.
|========================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |   Accuracy   |     Loss     |      Rate       |
|========================================================================================|
|       1 |           1 |       00:00:00 |       35.94% |       1.3750 |          0.0010 |
|       9 |          50 |       00:00:19 |      100.00% |       0.0131 |          0.0010 |
|      10 |          60 |       00:00:22 |      100.00% |       0.0062 |          0.0010 |
|========================================================================================|

ans =

    0.9816

>>
```

Figure 3.9 Transfer Learning

3.5.3.1 Training Parameters

This project uses a total of 3960 images of fishes that was obtained from Fish4Knowledge datasets. Each species' data was split into 70:30 for training and validation set significantly. The number of fish's images of each species used is 990. The AlexNet is a transfer learning architecture which was modified with MATLAB by importing into deep network designer toolbox as illustrated in Figure 3.10 to be used to identify each class of the fish species as shown in Figure 3.11 and Figure 3.12. The network consists of 25 layers and has five convolutional layers with three fully connected layer for each species. The input to the first convolutional layer is 227x227x3 because the image size is 227x227 pixels and the 3 channels represent the RGB color scheme. Mini batch size is set to 21 for faster and a whole convergence [23]. Maximum epoch is set to be at 10 epochs with a total of 1320 iteration. The validation frequency is set at 50 per iteration.

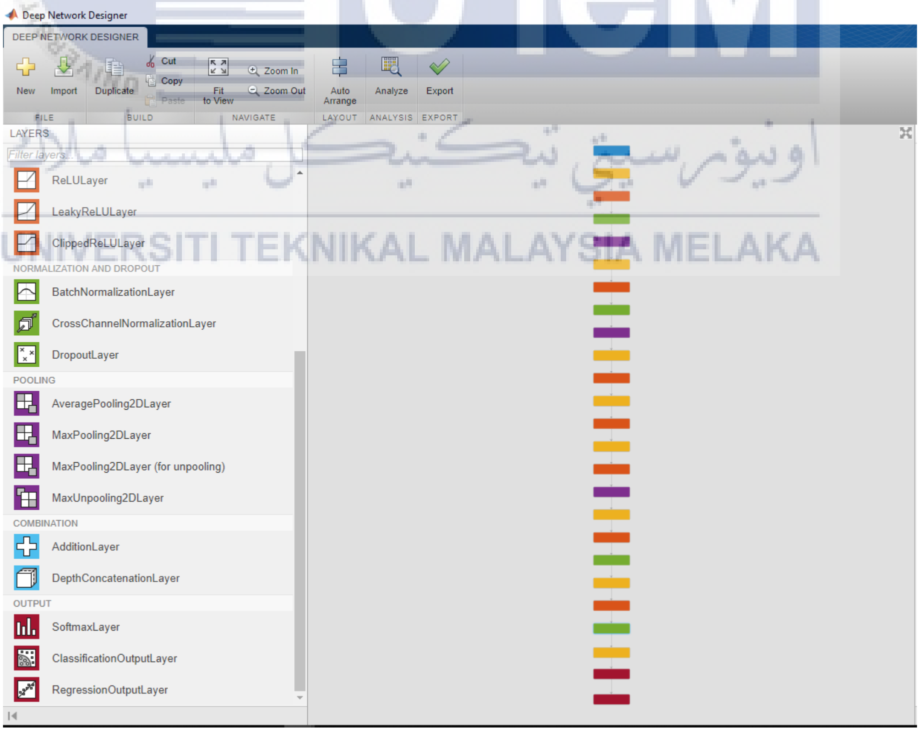

Figure 3.10 Deep Network Designer

ANALYSIS RESULT				
	NAME	TYPE	ACTIVATIONS	LEARNABLES
1	data	Image Input	227×227×3	-
2	conv1	Convolution	55×55×96	Weights 11×11×3×96 Bias 1×1×96
3	relu1	ReLU	55×55×96	-
4	norm1	Cross Channel Nor...	55×55×96	-
5	pool1	Max Pooling	27×27×96	-
6	conv2	Convolution	27×27×256	Weights 5×5×48×256 Bias 1×1×256
7	relu2	ReLU	27×27×256	-
8	norm2	Cross Channel Nor...	27×27×256	-
9	pool2	Max Pooling	13×13×256	-
10	conv3	Convolution	13×13×384	Weights 3×3×256×384 Bias 1×1×384
11	relu3	ReLU	13×13×384	-
12	conv4	Convolution	13×13×384	Weights 3×3×192×384 Bias 1×1×384
13	relu4	ReLU	13×13×384	-
14	conv5	Convolution	13×13×256	Weights 3×3×192×256 Bias 1×1×256
15	relu5	ReLU	13×13×256	-
16	pool5	Max Pooling	6×6×256	-
17	fc6	Fully Connected	1×1×4096	Weights 4096×9216 Bias 4096×1
18	relu6	ReLU	1×1×4096	-
19	drop6	Dropout	1×1×4096	-
20	fc7	Fully Connected	1×1×4096	Weights 4096×4096 Bias 4096×1
21	relu7	ReLU	1×1×4096	-
22	drop7	Dropout	1×1×4096	-
23	fc	Fully Connected	1×1×4	Weights 4×4096 Bias 4×1
24	prob	Softmax	1×1×4	-
25	classoutput	Classification Output	-	-

Figure 3.11 Network Analysis

```
Command Window

  25x1 Layer array with layers:

     1   'data'     Image Input                   227x227x3 images with 'zerocenter' normalization
     2   'conv1'    Convolution                   96 11x11x3 convolutions with stride [4  4] and padding [0  0  0  0]
     3   'relu1'    ReLU                          ReLU
     4   'norm1'    Cross Channel Normalization   cross channel normalization with 5 channels per element
     5   'pool1'    Max Pooling                   3x3 max pooling with stride [2  2] and padding [0  0  0  0]
     6   'conv2'    Convolution                   256 5x5x48 convolutions with stride [1  1] and padding [2  2  2  2]
     7   'relu2'    ReLU                          ReLU
     8   'norm2'    Cross Channel Normalization   cross channel normalization with 5 channels per element
     9   'pool2'    Max Pooling                   3x3 max pooling with stride [2  2] and padding [0  0  0  0]
    10   'conv3'    Convolution                   384 3x3x256 convolutions with stride [1  1] and padding [1  1  1  1]
    11   'relu3'    ReLU                          ReLU
    12   'conv4'    Convolution                   384 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
    13   'relu4'    ReLU                          ReLU
    14   'conv5'    Convolution                   256 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
    15   'relu5'    ReLU                          ReLU
    16   'pool5'    Max Pooling                   3x3 max pooling with stride [2  2] and padding [0  0  0  0]
    17   'fc6'      Fully Connected               4096 fully connected layer
    18   'relu6'    ReLU                          ReLU
    19   'drop6'    Dropout                       50% dropout
    20   'fc7'      Fully Connected               4096 fully connected layer
    21   'relu7'    ReLU                          ReLU
    22   'drop7'    Dropout                       50% dropout
    23   'fc8'      Fully Connected               1000 fully connected layer
    24   'prob'     Softmax                       softmax
    25   'output'   Classification Output         crossentropyex with 'tench' and 999 other classes
```

Figure 3.12 Network Architecture

3.5.3.2 Testing and Validation

The network can also be tested by using an outside data using function 'imread' which was not used in the training and validation set as shown in Figure 3.13 and Figure 3.14

```
addpath 'C:\Users\Megat Izzul Iman\Desktop\Fish\newgambo\orange clownfish'
I = imread('_98263962_clownfish.jpg');
fish_type = classify(netTransfer,I)
```

Figure 3.13 Testing Outside Data

```
fish_type =

  categorical

     Amphiprion clarkii
```

Figure 3.14 Outside Data Output

3.6 Conclusion

This chapter presents the proposed methodology in order to develop a new, effective project. Based on the method used that was demonstrated in this chapter, the convolutional neural network architectures that is based on transfer learning of AlexNet have been built by using the dataset from the Fish4Knowledge website. The result for the developed system is shown in the next chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter provided the display of result for the research on fish recognition system and on Convolutional Neural Network that was implemented in the MATLAB software. This chapter will compare and discuss the CNN used based on the configurations made prior to the which has been defined in the previous chapter.

4.2 AlexNet Transfer Learning

The result of the project shows the output of training data and testing data that was used for fish recognition system by the means of AlexNet Convolutional Neural Network. The recognition system was built by transfer learning using MATLAB software This project uses a total of 7230 images of fishes that was obtained from Fish4Knowledge datasets. Each species’ data was split into 70:30 for training and validation set significantly.

4.2.1 Training Data Output

As shown in Figure 4.1, the training process of the dataset is being carried out. The network achieves a validation accuracy of 99.16% and took almost 5 minutes to complete the training with the total of 1320 iteration.

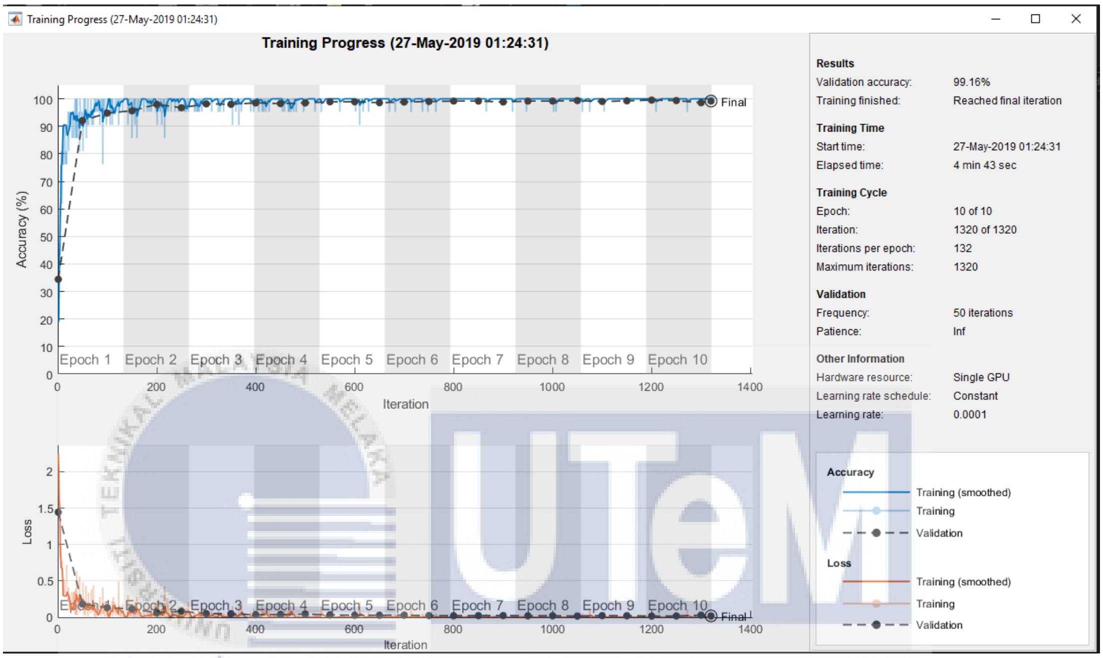

Figure 4.1 Training Process

4.2.2 Testing Data Output

Figure 4.2 shows the output result of the experiment the percentage beside the fish species name is the probability of accuracy for that specific output image. The coding used for this experiment shows that the output images were randomly classified when the system is executed, and the coding is inserted at the appendix section. Figure 4.3 shows the confusion matrix of the network with 99.2% accuracy with 0.8% probability of getting an incorrect data. Based on the confusion matrix, all 297 images of tested *Amphiprion Clarkii* are correctly classified due to its colour that is different from all other tested images. *Chromis Chrysura* have 2 wrongly classified images as *Plectroglyphidodon Dickii*. *Dascyllus Reticulatus* have 3 mistakenly classified images as *Chromis Chrysura* while 5 images of *Plectroglyphidodon Dickii* was wrongly classified as *Chromis Chrysura* and *Dascyllus Reticulatus* and 3 of them are *Dascyllus Reticulatus.*

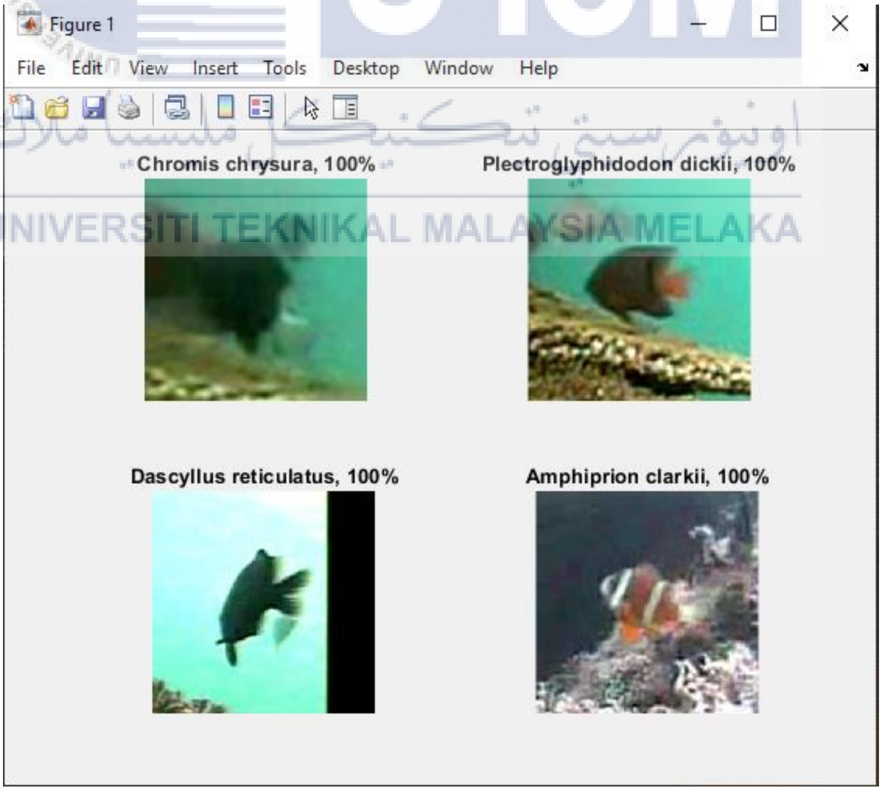

Figure 4.2 Sample of Fishes output

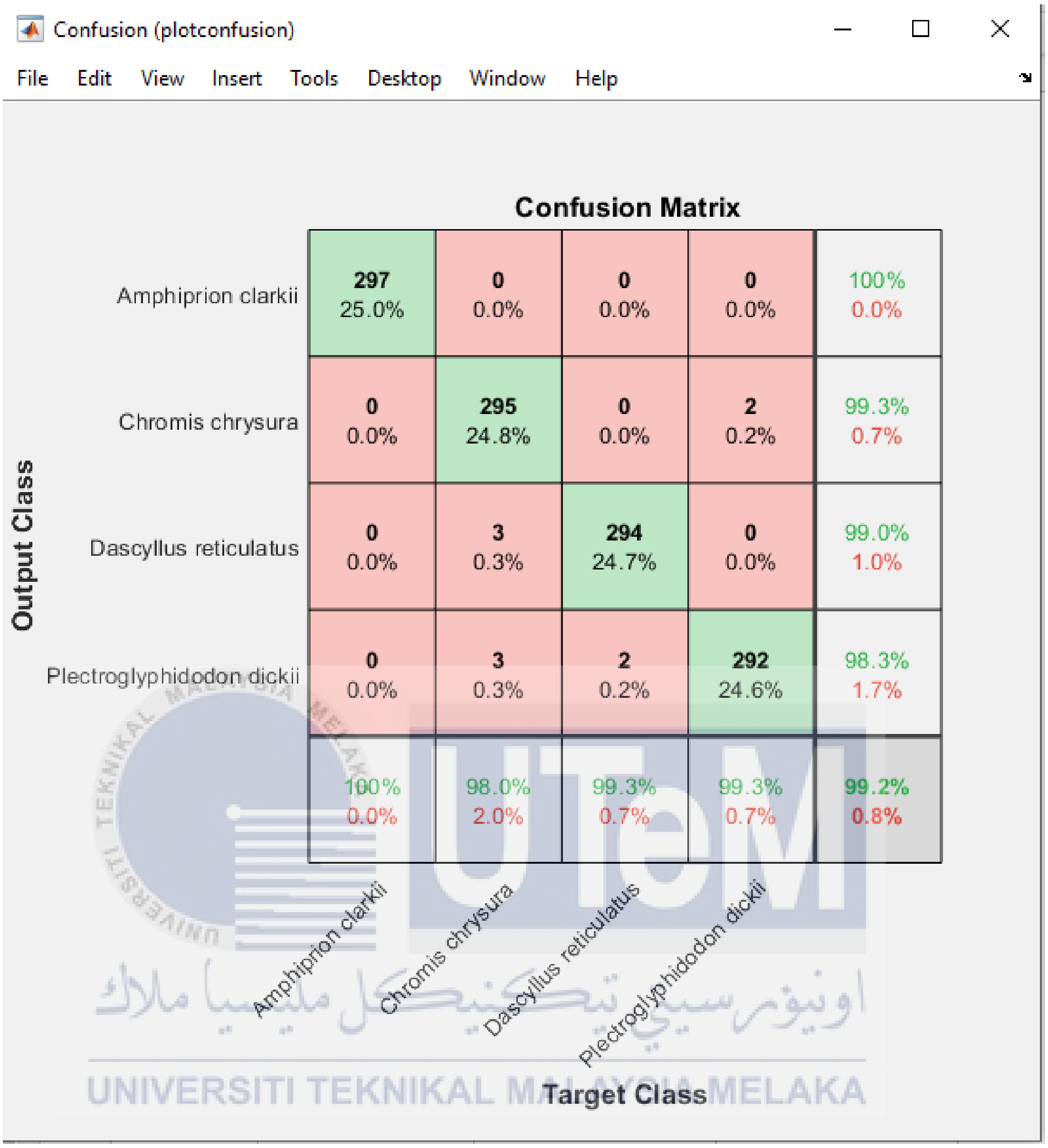

Figure 4.3 Confusion Matrix of the Network

4.3 Conclusion

Based on the early results shown, it is known that the architecture used for the CNN was effective for the recognition of fish by using the input dataset of fish images to get the output for the training and testing sets. The system that was built from scratch by using MATLAB empowers the framework to dissect and extract significant highlights from a picture, making it feasible for users to just recognize the sort of fish species from the information picture.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the results shown, it is known that the architecture used for the CNN was effective for the recognition of fish by using the input dataset of fish images to get the output for the training and testing sets. The system that was built from scratch by using MATLAB required a lot of data, however, transfer learning with AlexNet architecture was able to recognize images of fish with higher accuracy. This will enable users to empower the framework to dissect and extract significant highlights from a picture, making it feasible for them to just recognize the sort of fish species from the information picture. By having a fish recognition system, recognition of a fish species can be done efficiently with less effort without any harmful side effect as it could be used to help researchers such as scientist or marine biologist to improve the process or procedure on obtaining the data on the sustainability of fish species

5.2 Recommendation

In the future, hopefully this system of fish recognition could be implemented in various other sector of artificial intelligent. Artificial intelligent from convolutional neural network should be applied to do many task that are too difficult for human beings.

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APPENDICES

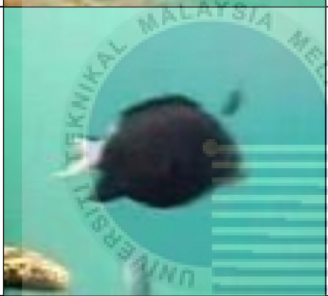
A.Coding Used

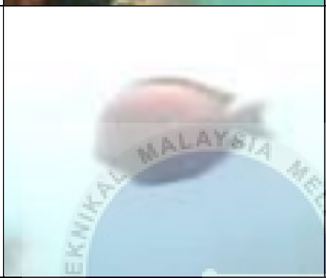
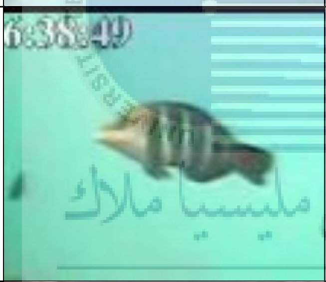
```
categories = {'Amphiprion clarkia','Chromis chrysura',
    'Dascyllus reticulatus','Plectroglyphidodon dickii'};
rootFolder = 'F:\cit10\Fish\Train';
imds = imageDatastore(fullfile(rootFolder, categories), ...
    'LabelSource', 'foldernames');

varSize = 32;
conv1 = convolution2dLayer(5,varSize,'Padding',2,'BiasLearnRateFactor',2);
conv1.Weights = gpuArray(single(randn([5 5 3 varSize])*0.0001));
fc1 = fullyConnectedLayer(64,'BiasLearnRateFactor',2);
fc1.Weights = gpuArray(single(randn([64 576])*0.1));
fc2 = fullyConnectedLayer(4,'BiasLearnRateFactor',2);
fc2.Weights = gpuArray(single(randn([4 64])*0.1));
layers = [
    imageInputLayer([varSize varSize 3]);
    conv1;
    maxPooling2dLayer(3,'Stride',2);
    reluLayer();
    convolution2dLayer(5,32,'Padding',2,'BiasLearnRateFactor',2);
    reluLayer();
    averagePooling2dLayer(3,'Stride',2);

    convolution2dLayer(5,64,'Padding',2,'BiasLearnRateFactor',2);
    reluLayer();
    averagePooling2dLayer(3,'Stride',2);
    reluLayer();
    fc2;
    softmaxLayer()
    classificationLayer()];
opts = trainingOptions('sgdm', ...
    'InitialLearnRate', 0.001, ...
    'LearnRateSchedule', 'piecewise', ...
    'LearnRateDropFactor', 0.1, ...
    'LearnRateDropPeriod', 8, ...
    'L2Regularization', 0.004, ...
    'MaxEpochs', 10, ...
    'MiniBatchSize', 100, ...
    'Verbose', true);
[net, info] = trainNetwork(imds, layers, opts);
rootFolder = 'F:\cit10\Fish\Test';
imds_test = imageDatastore(fullfile(rootFolder, categories), ...
    'LabelSource', 'foldernames');
labels = classify(net, imds_test);
ii = randi(4000);
im = imread(imds_test.Files{ii});
imshow(im);
if labels(ii) == imds_test.Labels(ii)
   colorText = 'g';
else
    colorText = 'r';
```

```
    end
    title(char(labels(ii)),'Color',colorText);
    confMat = confusionmat(imds_test.Labels, labels);
    confMat = confMat./sum(confMat,2);
    mean(diag(confMat))
```

```
net = alexnet
deepNetworkDesigner

categories = {'Dascyllus reticulatus','Plectroglyphidodon dickii','Chromis chrysura','Amphiprion clarkii'};
rootFolder = 'C:\Users\Megat Izzul Iman\Desktop\fish4knowledge227';
imds = imageDatastore(fullfile(rootFolder, categories), ...
    'LabelSource', 'foldernames');
[imdsTrain,imdsValidation] = splitEachLabel(imds,0.7);
augimdsTrain = augmentedImageDatastore([227 227],imdsTrain);
augimdsValidation = augmentedImageDatastore([227 227],imdsValidation);
options = trainingOptions('sgdm', ...
    'MiniBatchSize',21, ...
    'MaxEpochs',1, ...
    'Shuffle','every-epoch', ...
    'InitialLearnRate',1e-4, ...
    'ValidationData',imdsValidation, ...
    'ValidationFrequency',50, ...
    'Verbose',false, ...
    'Plots','training-progress');
netTransfer = trainNetwork(imdsTrain,lgraph_1,options);
[YPred,probs] = classify(netTransfer,imdsValidation);
accuracy = mean(YPred == imdsValidation.Labels)
idx = randperm(numel(imdsValidation.Files),4);
figure
for i = 1:4
    subplot(2,2,i)
    I = readimage(imdsValidation,idx(i));
    imshow(I)
    label = YPred(idx(i));
    title(string(label) + ", " + num2str(100*max(probs(idx(i),:)),3) + "%");
end
```

B. Details of Fish4Knowledge Dataset

No.	Fish Image	Species	Number of Image
1.		*Dascyllus reticulatus*	990
2.		*Plectroglyphidodon dickii*	990
3.		*Chromis chrysura*	990
4.		*Amphiprion clarkii*	990
5.		*Chaetodon lunulatus*	990

6		*Chaetodon trifascialis*	180
7		*Myripristis kuntee*	450
8		*Acanthurus nigrofuscus*	210
9		*Hemigymnus fasciatus*	240
10		*Neoniphon sammara*	300
11		*Abudefduf vaigiensis*	90

12		*Canthigaster valentini*	150
13		*Pomacentrus moluccensis*	180
14		*Zebrasoma scopas*	90
15		*Hemigymnus melapterus*	30
16		*Lutjanus fulvus*	180

17		*Scolopsis bilineata*	30
18		*Scaridae*	60
19		*Pempheris vanicolensis*	30
20		*Balistapus undulatus*	30
21		*Siganus fuscescens*	30

C.Gantt Chart

	Final Year Project 1														Semester Break					Final Year Project 2													
Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Title Registration																																	
Literature Review																																	
Implementation of Data Using MATLAB																																	
CNN Architecture Training and Testing																																	
Result and Discussion																																	