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Estimating Fish Population Using Artificial Neural Network

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Abstract— Fish is a marine life that brings many benefits to people all over the world. Apart from being major protein consumption, it is also a commodity that helps boost the economy of a country that depends highly on the fisheries sector, particularly developing countries. Year after year, the declination of fish populations has delayed most of the fishing activities and endangering food security and sustainability efforts. In this study, it focuses on efforts to sustain fish populations optimally by using an artificial neural network. The method used is mark and recapture technique simulated in MATLAB software. As the result, the system produces a graph that indicates a simulation of fish population and how many fish lived in certain area.

Keyword: neural network, fish population, fisheries, developing countries, food sustainability.

I. Introduction

Fish is a potential source of protein and is needed by humans because protein is the largest component after water contained in the fish meat. The high content of protein and water content in the body of the fish is a good medium to replace other protein sources such as chicken, beef, egg and others. Fish also becomes the high value commodity as it provides valuable foreign exchange earnings to the country. It has been reported that in 2013, fish accounted for about 17% of the global population's intake of animal protein and 6.7% of all protein consumed. Fish is also providing to more than 3.1 billion people with almost 20% of their average per capita intake of animal protein. [1].

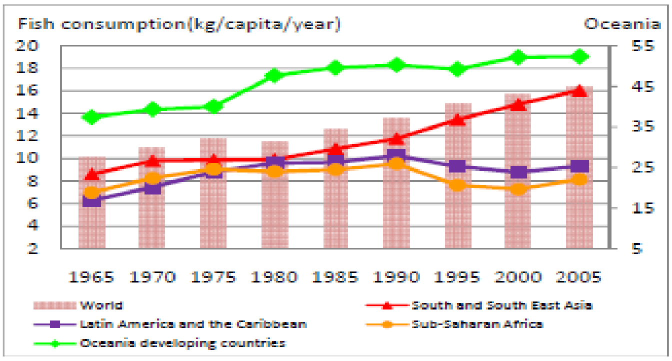

FIGURE 1.1: *Changes in per capita fish consumption different developing regions of the world.*

In every region, the amount of fish consumption varies each other. Based on the Figure 1.1 regarding changes in per capita fish consumption (estimated by the per capita food fish availability) between 1965 and 2005 for different developing regions of the world. Year 2005 shows an increased value upon global fish consumption with the amount of 16.4 kg per capita per year than in 1965 with the average of 10.1 kg [2]. This confirms the facts that fish consumption are relatively increasing in most countries around the world except in Latin America and the Caribbean, and sub-Sahara Africa where fish consumption on that region are the lowest in the world due to four decades of stagnancy.

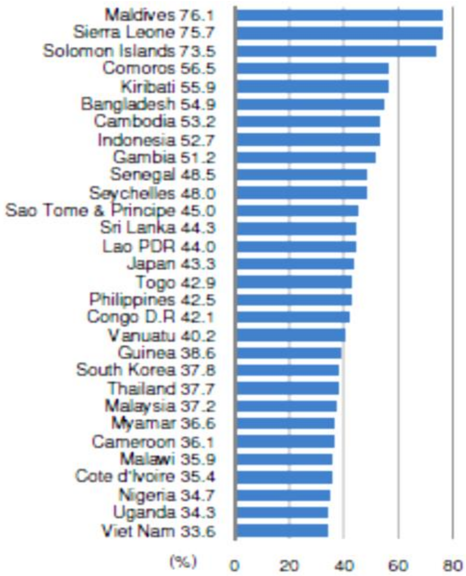

FIGURE 1.2: *Fish protein / animal protein consumption.*

In spite of that, fish still plays an important role in many African, Asia and Oceania countries. In most countries, more than 1/3 of the total animal protein supply belongs to fish based on the calculation from the FAO food balance sheets [2]. 30 countries have fulfilled the criteria and 22 of them are categorized as low-income food-deficit countries (LIFDC) in 2009. It means that a 73% majority of countries are poor and food deficient and that explains their high dependency to fish as an important source of animal protein (see Figure 1.2).

II. RELATED WORKS

A. Definition of Neural Network

Artificial neural network is one of the artificial applications that mimic the human brain, which has always tried to simulate the learning process of the human brain [3]. Neural network is implemented using the help of a computer program capable of resolving a number of the calculation process during the learning process.

Artificial neural networks have a lot of neurons scattered throughout parts. Each of these neurons grouped into several layers and has relationships with one another.

The layer of artificial neural network consists of several parts:

a) Input layer - This layer is the place where all the initial weight is inserted (initialization input) which is further processed to be sent to the layers above.

b) Hidden layer - This layer is located between the input layer and output layer. At this layer, the weight received from the input layer is processed further and is sent to the output layer.

c) Output layer - This layer is the last layer in the network architecture, in which the output value from the network is produced. The actual output values are compared with the output value of neural network itself, to determine whether the network is in accordance with the desired results or not.

B. Methods for Fish Counting via Artificial Neural Network

i) Back-propagation Network

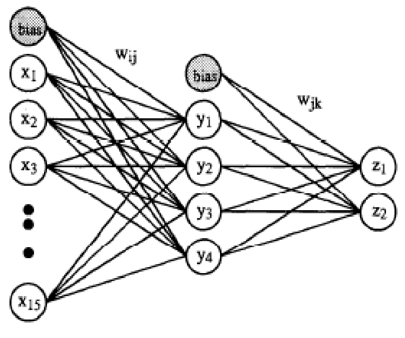

FIGURE 1.3*: Example of a feed-forward network with 15 input units, 4 hidden units and 2 output units*

Back-propagation network is a feed-forward network containing numbers of input nodes which require a particular input pattern to activate it and channel into a layer of 'hidden' nodes which in turn enabling a layer of output nodes for activation, whose response we take as being the output of the network as seen in Figure 1.3, which in return gave the result in an input-output mapping [4]. The back-propagation algorithm makes an adjustment to the connections between nodes in proportion to some measure of the contribution on each node to the global network root mean square error (RMS). As the network is exposed to the training data repeatedly, the adjustments are also carried out iteratively.

ii) Fuzzy Artificial Neural Network

Fuzzy pattern match scheme is part of the artificial neural network [5]. To apply it for fish counting, fuzzy artificial neural network is integrated with digital picture via intelligent window. This network consists of Layer 0 and Layer 1, where Layer 0 determine which one would be solid box (more than 50%) or an empty box (less than 50%) while Layer 1 responsible for pattern matching.

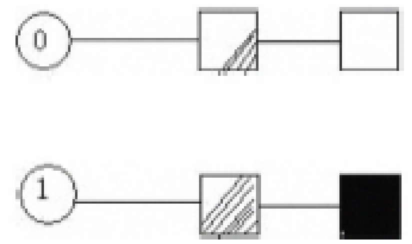

FIGURE 1.4*: Layer 0 node*

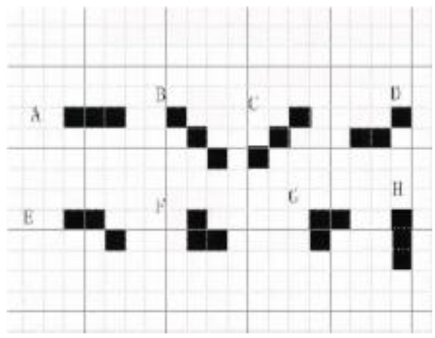

FIGURE 1.5*: Layer 1 node*

iii) Mark and Recapture Using Probabilistic Neural Network

Mark and recapture is a method generally used for estimating animal's population size. It is done by marking a subset of the population so that it is distinguishable from the unmarked members of the population. From the population, they made a subsequent sample and identify the marked and unmarked individuals and finally they draw the inference on the population [6].

The general process for estimating a fish population using the mark and recapture method entails:

a) Collecting a sample of fish of the target species from a discrete section of stream during an initial "marking run".
b) Giving fish identifying marks, such as a tag or temporary fin clip.
c) Tabulating data by species and size.
d) Releasing fish in good condition back into the same area.
e) Allowing at least 1 day for marked fish to recover and become mixed in the population.
f) Collecting a random sample of fish during a subsequent "recapture run".
g) Noting the ratio of marked to unmarked fish by species and size (e.g., inch group).

h) Calculating for each combination of species and size group (to compensate for gear selectivity) an estimate of abundance by a Petersen equation.
i) Summing the size group estimates by species to obtain an estimate of the total population within the size range actually sampled.

There has been an experiment on measuring the active web pages on a sub-universe of the world wide web, such as a search engine's directory, at any given point in time using mark and recapture and applied with probabilistic neural network which capable of classifying web pages under a specific taxonomy [7].

The idea of this experiment is that the web page is considered as animals living in every corner of the web and other specific types of web pages. Similar to animals, each web page is captured, marked and then released on several trapping periods. If a marked web page is captured on a subsequent trapping period, it is considered as recaptured. After that, with the assistance of probabilistic neural network, the researcher are now able estimate the total population size using statistical models and their estimators based on the number of marked web pages that are recaptured.

III. TESTING

The estimating process is implemented using MATLAB software. MATLAB is a high-performance multi-paradigm numerical computing language used for many purposes, such as, mathematical and computing process, development of algorithm and so on. This software is a perfect platform for generating neural network whose function is to make prediction and estimation.

The system will be introduced with "Mark and Recapture" method as the formula for the system to simulate an environment of using artificial neural network to estimate fish population. To generate the simulation within the system, several attributes need to be set. These attributes work as a catalyst to render a digitized environment of a certain territorial waters filled with several amount of fish populated there.

The attributes are as follow:

A	= Total population area.
a	= Size of the plot.
nbar	= Average number of fish per plot.
N_est	= Population size.
s	= Number of plot used.
ni	= Number of fish counted in each plot.

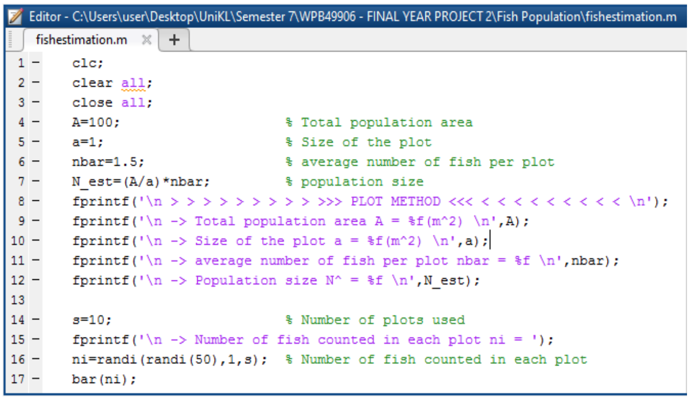

***FIGURE 1.7**: Sets of attributes*

After assigning the attributes, the remaining part is to generate neural network by using the calculation from mark and recapture method, specifically from Bailey's modification of Petersen model. The formulas are:

$$V[\hat{N}] = \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} = \frac{\hat{N}^2(C-R)}{(C+1)(R+2)}$$

where

N	= Population estimate
M	= Number of fish initially marked and released
C	= Number of fish collected in second period
R	= Number of recaptures found in C

Please refer to Figure 1.6, Figure 1.7 and Figure 1.8 for the coding and test data in MATLAB format.

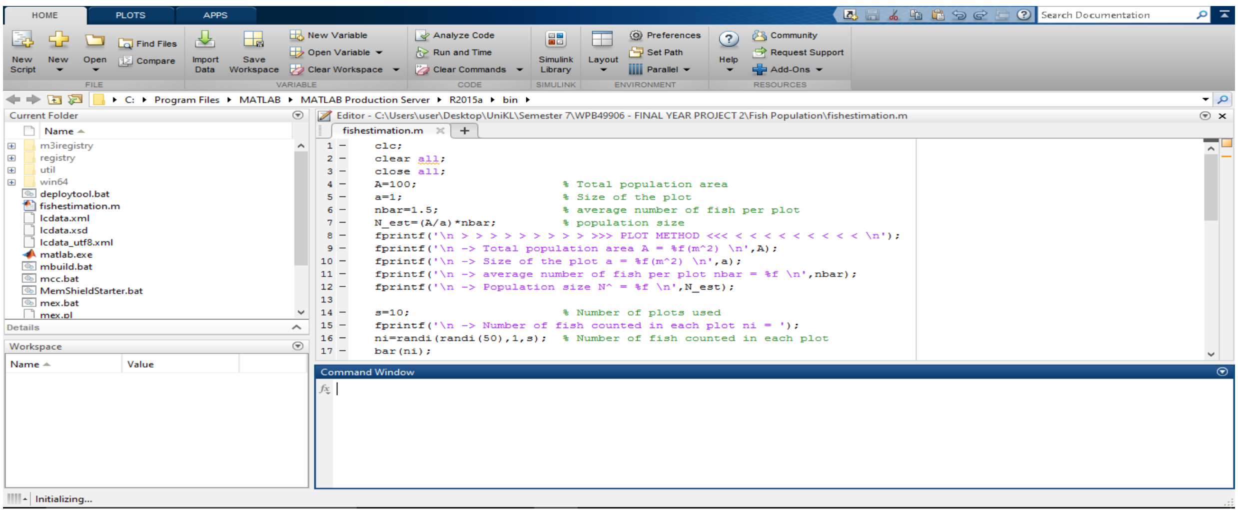

***FIGURE 1.6**: MATLAB interface*

```
fprintf('\n > > > > > > > > > >>> Mark and Recapture - Peterson Method <<< < < < < < < < < < \n');
M=550;     % Number of fish initially marked and released
C=500;     % Number of fish collected in second period
R=157;     % Number of recaptures found in C
N_cap=(M*(C+1))/(R+1);
fprintf('\n -> Number of fish initially marked and released M = %f \n',M);
fprintf('\n -> Number of fish collected in second period C = %f \n',C);
fprintf('\n -> Number of recaptures found in "C" R = %f \n',R);
fprintf('\n -> Population size N^ = %f \n',N_cap);
V=((M^2)*(C+1)*(C-R))/(((R+1)^2)*(R+2));
fprintf('\n -> Variance of Mark and Recapture method V(N^) = %f \n',V);
MR1=N_cap-1.96*sqrt(V);
MR2=N_cap+1.96*sqrt(V);
fprintf('\n -> 95 percent confidence interval of Mark and Recapture method is from %f to %f \n\n',MR1,MR2);
```

***FIGURE 1.8**: Mark and recapture - Petersen method*

IV. RESULT

When the attributes and the formulas has taken its place, all the input will be processed and compiled by the neural network and at the end of the process, the result will appear as below:

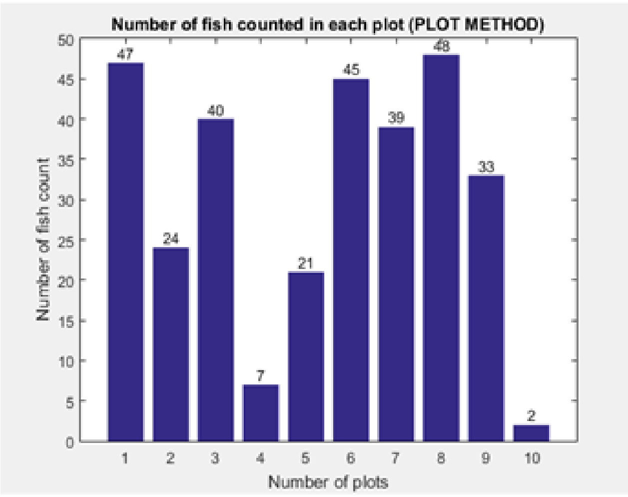

***FIGURE 1.9**: Result from the estimation*

The result shows a set of bar graph for the number of fish counted in each plot. Number of plots indicates segmented area within the territorial waters and each segmented area has a number of fish living in each area. Based on the result above, it explains how the MATLAB were able to create a simulation of waters area and use neural network formula to estimate the number of fish population. The estimation result can be altered depending on what type of data used and other additional information.

V. CONCLUSION

"Estimating Fish Population Using Artificial Neural Network" is an interesting project because the project does not only allow us to learn more about artificial neural network, but the main purpose is to solve the issue on the sustainability of fish stock by applying neural network. Many researchers have proved that this concept can be applied in most sector including fisheries.

The one thing that makes neural network unique is its capability to estimate certain event or scenario projected based on the collective data given to it. This capability makes artificial neural network a better solution to assist fisheries sector to maintain and sustain fish population. For example, in the coming event of dry season, fisheries sector can obtain the data from the weather center and use neural network to project estimation on how many of fish could survive during dry season in certain territorial waters so that they can establish preliminary action to sustain fish stock. For future improvement, there are few suggestions:

a) Make it as an application or web-based by installing neural network application such as MATLAB inside the application or website.
b) If by application or web-based, ensure that the process is less complex and more understandable so that the user knows how to operate the system.
c) Interactive design is advised to make sure the system is attractive and gives positive impact to the user.

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