I. INTRODUCTION

This chapter contains the preliminary and introductory section of the study. This includes from the background of the study to the research methodology. This chapter briefly explains the main points of the title topic and problem and why is it selected.

1.1. Background of the Study

Artificial intelligence (AI) currently is one of the leading areas in computer science in which it dominates lots of solving problems in the real world [1]. There are lots of areas in Artificial Intelligence but one that is interesting is Neural Networks [2]. Neural networks are structures that can be “trained” to recognize patterns in inputs. It is trained on how inputs relate to the expected output. This is called as Supervised Learning [3]. Among the various types of neural networks, one of these is a modular neural network. This type of neural network emphasizes on using modules. These modules are considered to represent a single action or event. Every module is a single neural network and does can be trained simultaneously or separately from other modules.

One of the branches of machine learning is pattern recognition. It focuses on the recognition of patterns and regularities in data. Pattern recognition systems are in many cases trained from labeled "training" data (supervised learning) [4]. Pattern recognition is the ability to detect arrangements of characteristics or data that yield information about a given system or data set [5].

Various techniques are used to extract out the pattern, usually with the use of machine learning, as well as data mining and knowledge discovery in database (KDD). [6]. Neural network is also considered as one method in pattern recognition. It is under the classification algorithms (predicting categorical nonparametric labels) and regression 2

algorithms (predicting real-value labels) [7]. The pattern in mind are usually images and abstract sequences. But the pattern in this research is how data shows relevance on a given time period or how it cycles to come up with a pattern itself. Examples of this kind of pattern recognition is speech recognition, traffic analysis and control, stock exchange forecast and classification of rocks [8].
The important thing in pattern recognition is the data to be used as the basis for the recognition of such. Almost everything is used with data, and this includes agriculture and environmental studies. One area in environmental studies or field is the study of crop distribution. A crop is a plant or animal product that can be grown and harvested extensively for profit or subsistence. Crop may refer either to the harvested parts or to the harvest in a more refined state. Most crops are cultivated in agriculture or aquaculture [9]. There are several factors leading to the growth of a plant or crop, and mostly deal with the environment and how does the specie interact with it. Depending on these factors does the crop propagate. Some of these factors are temperature, humidity, soil composition, the growing season, altitude and even rainfall [10].
Lanao del Sur is one of the provinces in ARMM. According to various online government sources, the province is rich in agriculture. The land area dedicated for this is 140,111 hectares [11]. If you are to visit the farmers' guide map website which is the National Color-Coded Guide Map, it is observed that the province area is indeed rich. The website gives color coded map, and it is seen that in most crops the area will be lit green [12]. This means that these most crops are suitable for growth. Among these crops are rice, corn and banana. 3

In most cases, crops can grow in the same area. This is where crop rotation comes in. Growth and yield changes depending on external factors on the environment. Some plants thrive on hotter temperature and some might not be able to survive. If data science is going to be used with this, a table leading to growth rate in areas and time can be made. A pattern can be found. This is where crop rotation comes in. Crop rotation is the systematic planting of different crops in a particular order over several years in the same growing space. This process helps maintain nutrients in the soil, reduce soil erosion, and prevents plant diseases and pests [13]. Going back to the information about Lanao del Sur, it is observed that there are several different crops growing in the same area [11][12]. If patters are extracted from this, it should be feasible to do so. Crops growth depends actually not just on the environmental factors but also to some soil nutrients. Crops absorb nutrients from what other crops release on the soil. Using that, crops are planted on a sequence and from that, a pattern can be extracted.

There are various studies concerning with the application of computing in crops. Some of them are trying to give predictive analysis on crop yields. But most of them are using data mining techniques, just like the study by Ms. Nasrin Fathima from India. Her study is agricultural crop pattern using data mining techniques. In the abstract of her study, it is written that she wants to discover various knowledge in farming, particularly crop pattern [14]. Other studies also were found, in which it has the same goal, but the approach is a bit different. Most of these studies are trying to predict crop yield. There are two papers made with this goal and performed well. One of this study is by Ms. Dahikar in which her study is about a neural network approach in predicting crop yield using various parameters [15]. 4

It was mentioned [10] that environmental and soil composition affect the growth, yield and even the sequence or the crop rotational pattern. From this, a pattern recognition process is performed to determine the crop rotation using a neural network to understand how these environmental and soil factors affects the cyclic pattern in planting common crops such as maize or corn, rice, cassava and banana. The use of a modular neural network is employed as such because the study is dealing with at least two potential targets and many parameters to be used. This study formally proposed a modular feedforward-backpropagation neural network to model the patterns of the selected crops in different locations around Lanao del Sur.

1.2. Statement of the Problem

A modular feedforward-backpropagation neural network has a significance impact in determining or predicting the cyclic pattern in planting maize or corn, rice, cassava and banana on the Lanao del Sur province considering the environmental and soil factors affecting it.

1.3. Main Objective

The main objective of this study is to design a modular feedforward-backpropagation neural network to model cyclic patterns in planting the selected crops which are maize or corn, rice, cassava and banana within the Lanao del Sur boundaries.

1.4. Specific Objectives

1.4.1. Gather and study the data that are used in this study which is the large dataset given about the growth of crops across the years in the Lanao del Sur area; study if there are recurring patterns that can be observed; analyze the selected neural network

type to be used which is modular type network and understand further about it; study about feedforwarding and backpropagating in neural network; study about the significance of modular neural networks over the usual artificial neural networks

1.4.2. Determine the input parameters and the predictors to be used from the dataset that will be included in the model.

1.4.3. Design and implement a modular neural network model based on the requirements gathered and the parameters determined; train and test the neural network made

1.4.4. Evaluate the performance of the modular neural network model by comparison with other reconfigurations.

1.5. Scope and Limitation of the Study

This study focused only on the potential impact of modular neural networks in the field of agriculture and its advantage over the normal ANN and data mining techniques. Among the various environmental factors from the dataset, a selection was made. Factors that were considered are temperature, soil composition and location. The reason why a selection among the factors are done is to avoid a vague training process for the model. The crops that are selected for the study is maize (corn), rice, cassava and banana.

The data that were used is only limited to the given data which supervises only the area around Lanao del Sur.

1.6. Significance of the Study

In the area of the field neural network, this study adds more emphasis on the use of a modular neural network instead of relying on a single network. This study used several factors, and it has more than one task that can be considered. From this, a modular neural network was used.

Also, it is said that pattern recognition is a main part of the study, and this term is a relative application of artificial intelligence that involves data mining and machine learning [6]. Rather than using knowledge discovery in database, a neural network is utilized. Another significance that is considered since pattern recognition mostly uses data mining, rather than neural networks.

Even though the study is all about theories and the science behind it, the application is still to be considered. End users will be receiving benefits from this, specifically statisticians and professionals on agriculture. Despite these statisticians and professionals that are educated to perform analysis on crops and agronomy, this study can give assistance to them to support and compare their analysis. It takes a lot of time to tabulate heaps of data and to perform a prediction and pattern recognition, it will take a long time to come up with a computation to do so. And so, with the help of artificial intelligence and neural networks, this will be easier now. With an absence of these professionals, this also can serve as a perfect tool for farmers to use to help with their tasks in agriculture. If this is used, this can help some new farmers understand their land, and even some young agriculture professionals. 7

1.7. Research Methodology

1.7.1. Data Collection

1.7.1.1. Gathering of Data

As any good experiments there are, data is the most important part and so, must be obtained properly. The data was obtained from a reliable source which will be given by an accomplice of the researcher, which is Prof. Mero of the College of Forestry. Prof. Danilo Mero is a professor IV at the College of Forestry and Environmental Studies. His expertise is on forest governance. This obtainable source, according to him, consists of all the necessary information and data used, consisting of several environmental factors. The data will only compromise of the four selected crops, which are maize (corn), rice, cassava, banana and coconut.

1.7.1.2. Selecting the Parameters and Predictors

Once the primary data were obtained properly as needed, proper classification of attributes and predictors was made. The input parameters are selected from the given data set will in turn are the predictors used during the training process and the actual prediction. There are lots of factors affecting the growth of a crop, but among these factors, a selection was made. These prior selections are dependent of the neural network model. It is considered temperature, and soil composition as part for these factors. Also, the location and crops are also part of the predictors or parameters. Not all environmental factors mentioned by Sir Mero were used because correlation between potential input values should be prioritized to reduce redundancy and some variables have small predictive power or none at all. But since this is a trial-and-error process, there were changes on the factors or

variables selected on the run during the conducting procedures depending on a situation that will arise.

1.7.2. Data Preprocessing

1.7.2.1. Cleaning and Formatting the Data

Retrieving the data doesn't mean it can be used immediately on the neural network. It must be properly processed so that it will be fitting for the network. From the retrieved and raw data, it became a pre-processed data. Also, the identified predictors/variables were used as basis for the data. The data gathered are formatted in a way that the machine can understand efficiently. For example, if the names of the crops are considered as one of the variables, instead of using the string of the name, the use of integers or numbers were employed. Basically, the identifications of the crops are now in numerical format. Another thing considered is adjusting some of the data values depending on its factor. Like in temperature, instead of Fahrenheit, Celsius is utilized. Adjusting or formatting the data doesn't mean the values are changed. This is just to consider how will it fit with network architecture. Basic normalization of data was also considered.

1.7.2.2. Selecting the Dataset for the Training and Testing

The experiment will come in two phases, the training part and then the actual prediction. This is where a baseline segregating the two parts was set, which is the training and testing dataset. The training part will rely on the training data that is taken from a much former years and then the testing will be done on the latter or the most recent one. 9

Figure 1.1. Selecting the Dataset for the Training and Testing

1.7.3. Neural Network Designing and Building

1.7.3.1. Designing a Structure for the Neural Network

Neural networks have many types to choose from, but each of it has different uses and where it is applicable more. Instead of using a single neural network, it is decided to use two of them. The output from the first neural network is needed as input at the second neural network. Even though the second neural network needed data made from the first one, it doesn't mean it is connected as a bigger neural network model. Both neural network structure are trained simultaneously either on a single machine with the memory and process speed allocated properly to avoid lags and computer hiccups, or just use two machines for better performance.

The first neural network has the predictors (or inputs) set to the environmental factors affecting plant growth but excluding the soil parameters. The reason for this is that the soil composition is used on the second network. The first network has the output set to the first crop that will grow on a given time period. So basically, what the first neural network is doing is trying to predict what crops will grow as the first one in a given area in a given time period using the factors. Now, for the second network, it uses this first crop as a predictor together with soil

composition. It is because according to crop rotation, crops grow by absorbing the needed nutrients from soil, and at the same time it releases other nutrients to the same soil. Here, it can be determined what crops will next grow by using the pre-determined soil and first crop as basis. With this, the output from the second neural network will be a pattern or sequence of crops, ranging from 3-4 crops in order. The proposed design is at the figure below but changes will apply throughout the run of the experiments. This neural network architecture design is efficient in accommodating more than one task.

Figure 1.2. A Two Neural Network Structure

In this part also contains what arithmetic computations needed for the activation functions and the bias and weight selection of the perceptrons to be used in the model. 11

1.7.3.2. Building the Neural Network

After designing a structure for the neural network, building should always come next. Using the variables identified, and the design made, the structure is built accordingly. This is a crucial part of the study since all evaluations made will be circulating around the structure of the neural network. Building the neural network will start the experiments of this study, as such, after building, the whole neural network must be finalized as well.

1.7.4. Training and Testing

1.7.4.1. Training

This step here is the most crucial part. For the study to be proven good, the training stage must properly execute. So, from the pool of data from the first batch, the neural network structure was trained to analyze each streams of data. Specifically, this is the part where the model learns how the factors, which are the predictors or the input parameters, affects the target variable, the crops and the pattern found. Any mishaps and errors should be clearly solved. Process here relies on repetitions to reduce the marginal error and obtain higher accuracy.

Since the structure or design of the network is modular, and it has two networks, different data is used in each network. The first neural network uses environmental factors as the input parameters, and the output is the first crop that grows at a given time period. On the second neural network, inputs are the first crops that will grow and some soil factors like nutrients composition. Since this is a modular design, during the training process, both neural networks are trained simultaneously for speed and to reduce stress during evaluating training error. 12

1.7.4.2. Testing

After making the necessary things to be done during the training process, it should be tested before calling it a success. So, in here, the testing part is done on the second batch of data. Using a mini system, or a simple program using the trained structure of the neural network, prediction was made using the second batch of data. Training and testing will always be done in accordance to any error, and this will be kept doing back-and-forth training and testing.

On the training part, both the two networks are trained simultaneously. For the first part, the testing is done simultaneously. This validates the neural networks capabilities. After doing simultaneous testing, the whole neural network system is tested, as a modular one. It is re-configured so that it is a series of network. The first neural network is connected to the second. The output from the first one goes directly as input on the second network. The output from the second network is the one to be tested and evaluated.

1.7.4.3. Reconfiguring using the error and loss from Training and Testing

A neural network can be designed and configured depending on what you are trying to achieve. And so, there are many configurations, like what mathematical functions to be used, the layout of the structure or the layer, the variables to be used and many more. From here, the structure's strength and weakness is evaluated.

Using the loss from the training and the error factor from the testing, the neural network design is reconfigured, possibly changing the parameters and hyperparameters of the network. After achieving a set threshold, the best configuration is made.