Abstract: - Glaucoma is an eye disease where the increased fluid pressure in the eye reduces the blood supply to the nerves of the retina, causing the photoreceptors to die. If the pressure remains too high for too long, the visual field of the patient will deteriorate and the patient will eventually go blind. There are two main types of glaucoma in Asian patients, namely, the open-angle glaucoma and the angle-closure glaucoma. This work aims to determine if a characteristic pattern exist in the visual field pattern of the two types of glaucoma patients. Several structures of a feed-forward multi-layer perceptron network were used to investigate the relationship. The results obtained were at an average correct classification rate of 70.5% and a false classification rate of 34.6%, which indicates that there is some characteristic pattern in the two types of glaucoma.

Key-Words: - Glaucoma, Visual Field Pattern, Pattern Classification, Neural Networks

1 Introduction
Glaucoma is a group of diseases that have common features [10]. These can include high intraocular pressure (IOP), damage to the optic nerve, and visual field loss. Glaucoma usually occurs in both eyes, but extra fluid pressure often starts to build up in one eye first. This damage may cause gradual visual changes and then visual field loss. The early visual changes are very small and usually do not affect the central vision. Instead, parts of the peripheral vision are affected first which may not be noticed at first.

Currently, a medical eye specialist uses the following three tests [12, 13] to indicate the possibility of glaucoma:
- Measurement of the Intraocular pressure (IOP)
- Appearance of the optic nerve (using an ophthalmoscope)
- Visual field analysis (using the Humphrey system)

For a patient to be diagnosed with glaucoma, the results of the above three tests must be negative. All the above-mentioned tests are expensive and time-consuming. If a system can be developed to assist eye specialists in the detection and diagnosis of the different types of glaucoma, this would mean great savings in time and resources.

There are different types of glaucoma. The two main types are open-angle glaucoma and angle closure glaucoma [11]. The open angle glaucoma is the most common form of glaucoma, accounting for about 90% of glaucoma cases in the US. The angle-closure glaucoma is less common and it occurs mostly in farsighted, elderly people. In this research, we attempt to determine whether a unique pattern exists in the visual field pattern of different types of glaucoma. If a unique pattern can be detected, a potential system could be developed to assist medical practitioners to conduct test on patients for glaucoma and diagnose them based on an analysis of the test results before consulting the doctor.

2 Pattern Classification Techniques
There are several pattern classification techniques that can be used to investigate the existence of a pattern in visual field patterns. Classification typically involves two steps: first the system is trained on a set of data and next, it is used to classify a new set of unclassified cases. We will look at each of them briefly:

2.1 Bayesian Classifier
The Bayesian classifier [4] is one of the oldest methods to perform supervised classification. A Bayesian classifier is trained by approximating the class-conditional probabilistic density function (PDFs). Each PDF indicates the frequency of occurrence of samples in the feature space. Hence, an unknown sample is basically classified into a class with the highest value of the PDF. The
advantage of this technique is that not much training is needed and a large data set will not be necessary. However, when problems are of greater dimensionality, the technique tends to fail or produce unsatisfactory results (curse of dimensionality).

2.2 Linear Discriminant Analysis
Linear Discriminant Analysis is based on forming a weighted sum of the values of variables for each of the units in the sample to compute a score for each unit [4], the computed score will be used to classify the data. This method aims to find a way to calculate scores such that the percentage of misclassified cases will be minimized. However, it has a problem in finding a set of weights such that the within-class variance will be very small while the between-class variance will be very large. In some situation, it has the disadvantage that it cannot achieve complete separation [4].

2.3 Artificial Neural Network
Artificial neural networks [1, 2] are methods of computation and information processing that takes advantage of advanced technology. Mimicking the processes found in biological neurons, artificial neural networks are used to predict and learn from a given set of data. Neural Networks are more robust at data analysis than statistical methods because of their ability to handle small variations of parameters and noise. However, artificial neural networks are usually more complicated due to the large number of parameters or weights [3, 5]. Besides, artificial neural network needs to be trained in order to classify and a large amount of data is required to achieve high accuracy of classification [6].

3 Implementation and Results
In our research we have chosen to use the multi-layer perceptron (MLP) network to perform the classification. The MLP network is a universal function approximator [7] and theoretically, it is possible to teach anything learnable to this network. The execution speed is also among the fastest of all models currently in use. So if real-time processing is needed, this network may be the only practical choice [8, 9].

We implemented the feed-forward multi-layer perceptron network with 54 input nodes (corresponding to the 54 data points of the Humphrey Full Threshold Visual Field Test). We vary the number of hidden nodes from 10 to 50 and record the network performance corresponding to each. Our data set consists of 238 left eye Humphrey field data (112 angle closure and 136 open angle) and 224 right eye Humphrey field data (116 angle closure and 98 open angle). The patients are at various stages of glaucoma and have an age ranging from young adults of around 21 years old to retirees of more than 60 years old.

To examine whether a pattern exists in the visual field data, we randomly take sub-groups of the left eye visual field data for training, and use the remaining left eye visual field data for testing. For example, in one group we may use 50 left-eye angle closure glaucoma data and 50 left-eye open angle glaucoma data for training and we pooled the remaining left eye data (62 angle-closure glaucoma and 76 open angle glaucoma) to form a test set of 138 visual field data. The results are shown in Fig. 1.

![Different Sizes Of Training Set](image)

**Fig. 1. Performance vs No. of Training Data.**

The results indicate a >50% positive detection both the angle-closure and open-angle glaucoma patients. This is a positive indication that there exists a pattern in the visual field data of the two types of glaucoma. As the training data size increases, the positive detection increases and the false detection decreases. This result is consistent with the existence of a pattern because a larger training set should reinforce the learned pattern in the artificial neural network.

We vary the structure of the neural network by adding more nodes in the hidden layer. We also vary the Output Error Tolerance and the Training Rate Coefficient to study its impact on the network. The results are shown in figures 2 to 4:
The results showed that although we vary the various parameters in the neural network, we are still able to achieve an average detection of 70.5% and a false detection of 34.6% for angle-closure glaucoma; and an average detection of 65.4% and a false detection of 29.5% for open-angle glaucoma. These figures indicate that there is indeed some distinguishing pattern in the visual field data that may be used to separate the two types of glaucoma.

In an attempt to produce more accurate classification, we increase the training data by flipping the right-eye visual field data over to the left. This is a valid procedure because if a patient is diagnosed to have a certain type of glaucoma in one eye, then the other eye must either be normal or it must have the same type of glaucoma [2]. The process of visual field loss is also the same and will therefore give rise to a symmetrical visual field pattern.

By flipping the right-eye data over to the left, we now have a larger data set of which we use 94 angle-closure data and 117 open angle data for training, and use the remaining 251 (134 angle-closure and 117 open-angle glaucoma) for testing. The results are shown in figure 5.

The results show that although there is no improvement in the detection of angle-closure glaucoma, there is an improvement in the detection of open-angle glaucoma rate from 66% to 73%. This further reinforces the existence of a pattern in the two types of glaucoma.

4 Conclusion and Future Work

In this research, we have investigated the application of pattern recognition techniques, namely, Artificial Neural Network algorithms to the classification of Glaucoma patients. The results have shown a positive indication that a pattern does exist in the visual field data of the two main types of glaucoma patients.

The detection rates (of about 70%) are still considered low for medical diagnosis purposes. This is due to the relatively small data set for the number
of degrees of freedom in the neural network. However, this seemingly small data set is the cumulative effort of several researchers and technicians over a period of two years. Further glaucoma field data set is being collected to build a larger data set for future improvement to the system.

The next step is to build an automated system that will harness this information to pre-diagnose glaucoma patients so as to reduce the load on the medical practitioner. The system is, of course, targeted to assist and not to replace the medical practitioner in their diagnosis.

References: