# A Study on Application of Artificial Neural Network and Genetic Algorithm in Pattern Recognition

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**Abstract**
Image processing is an emerging field and lots of research had been performed for the past few years. Image processing has various techniques which are image segmentation, enhancement, feature extraction, classification, restoration, image generation etc. pattern recognition is an important part of image processing system. The aim of this paper is to study the use of artificial neural network and genetic algorithm in pattern recognition. Artificial neural network helps in training process where as the selection of various parameters for pattern recognition can be done in an optimized way by the genetic algorithm.

**Keywords:** Pattern recognition, artificial neural network, genetic algorithm.

## 1. Introduction

A pattern is an arrangement of descriptors or features. It could be a human face, any image, speech signal, finger print, a hand written etc. A pattern class is a family of patterns that share common properties. Pattern classes are denoted $w_1$, $w_2$, $w_3$…, $w_n$ where n is the number of classes. Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, and make sound and reasonable decisions about the categories of the patterns. Pattern recognition by machine involves techniques for assigning pattern to their respective classes-automatically and with as little human intervention as possible. For recognizing an object the system must receive some information or features from that object. Based on these features the object is assigned with one of the possible classes. The classification can be easily done by using artificial neural network which provides a promising output. The aim of using genetic algorithm in pattern recognition is to select the parameters in an optimized way so to improve the quality of the output.

## 2. Pattern Recognition

Pattern recognition means identification of ideal object. In practice three common pattern arrangements used which are vectors (for quantitative descriptions), strings and trees (for structural descriptions). Recognition technique based on matching represent each class by a prototype pattern vector. An unknown pattern is assigned to the class to which it is closet in terms of a predefined metrics. The simplest approach is the minimum distance classifier which computes the distance between the unknown and each of the prototype vectors. It chooses the smallest distance to make a decision. The statistical properties of the pattern classes in a problem often are unknown or cannot be estimated. In practice, such decision-theoretic problems are best handled by methods that yield the required decision functions directly through training. The measuring and interpreting physical events, probability consideration become important in pattern recognition because of the randomness under which pattern classes normally are generated. It is possible to derive a classification approach that is optimal in the sense that, on average its use yields the lowest probability of committing classification errors.

The design of a pattern recognition system essentially involves the following three aspects:

- Data acquisition and preprocessing

- Data representation
- Decision making

The problem domain dictates the choice of sensor(s), preprocessing technique, representation scheme, and the decision making model. It is generally agreed that a well-defined and sufficiently constrained recognition problem (small intra-class variations and large interclass variations) will lead to a compact pattern representation and a simple decision making strategy. Learning from a set of examples (training set) is an important and desired attribute of most pattern recognition systems. The four best known approaches for pattern recognition are: 1) template matching, 2) statistical classification, 3) syntactic or structural matching, and 4) neural networks.
Pattern recognition is generally categorized according to the type of learning procedure used to generate the output value. Supervised learning assumes that a set of training data (the training set) has been provided, consisting of a set of instances that have been properly labeled by hand with the correct output. A learning procedure then generates a model that attempts to meet two sometimes conflicting objectives: Perform as well as possible on the training data, and generalize as well as possible to new data. An Unsupervised learning, on the other hand, assumes training data that has not been hand-labeled, and attempts to find inherent patterns in the data that can then be used to determine the correct output value for new data instances. A combination of the two that has recently been explored is semi-supervised learning, which uses a combination of labeled and unlabeled data (typically a small set of labeled data combined with a large amount of unlabeled data).

## 3. Review of Literature

For the past few years a lots of studies had been carried out on pattern recognition. In [1], authors proposed interactive voice response (IVR) with pattern recognition based on neural networks. In this case after entering the correct password the user is asked to input his voice sample which can be used to verify his voice. The addition of voice pattern recognition in the authentication process enhances the security. The results are promising based on false accept and false reject criteria having a quick response time. Here a Multilayer perceptron is used for feature matching. Authors in [2] used artificial neural network for face recognition. They evaluated the performance of the system by applying two photometric normalization techniques: Histogram equalization and Homomorphic filtering. The system produced promising results for face verification and face recognition.
In [3], the authors used artificial neural network for Electrocardiogram (ECG) pattern recognition. Four types of ECG patterns were chosen from the MIT-BIH database to be recognized, which includes normal sinus rhythms (N), premature ventricular contraction (PVC) and aterial premature beat (A) and left bundle branch block beat (L). Recognizing an ECG pattern is essentially the process of extracting and classifying ECG feature parameters which may be obtained either from the time domain or transform domain. In this method the performance of the neural networks was evaluated by the recognition sensitivities, the overall recognition accuracy and the number of neurons needed. The overall accuracy is defined as the ratio of the total number of beats recognized correctly to the total number of beats in the test phase.
In [4] authors applied artificial neural network approach for optical character recognition (OCR). A simple feed forward neural network model has been trained with different set of noisy data. The back propagation method was used for learning in neural network. The application includes postal code recognition, banking, reading devices for blind etc.

## 4. Artificial Neural Network

Artificial neural network (ANN) is an efficient information processing system which resembles in characteristics with a biological neural network. ANN possess large amount of highly interconnected processing elements called neurons, which usually operate in parallel and are configured in regular architectures. Each neuron is connected with other by a connection link. Each connection link is associated with weights which contain the information about the input signal. This information is used by the neuron net to solve a particular problem. ANN is characterized by their ability to learn, recall and generalize training patterns or data similar to that of a human brain. The computing world has a lot to gain from neural networks. Their ability to learn by example makes them very flexible and powerful. Furthermore there is no need to devise an algorithm in order to perform a specific task; i.e. there is no need to understand the internal mechanisms of that task. They are also very well suited for real time systems because of their fast response and computational times which are due to their parallel architecture. Neural networks, with their remarkable ability to derive meaning from complicated or

imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. It is characterized by the followings:

1. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3. Real time operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
4. Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

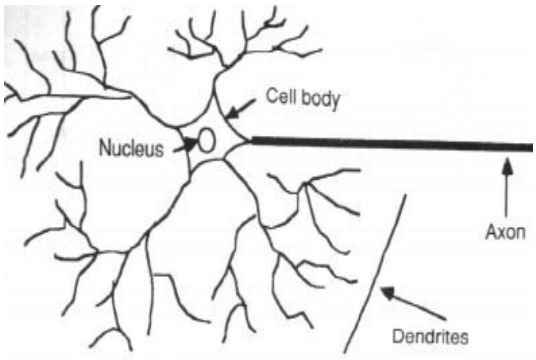



Fig .1 Structure of a neuron

**4.1 Model of an Artificial neuron**

Human brain can be viewed as a massive, highly interconnected network of simple processing elements called neurons. The behavior of a neuron can be captured by a simple model as shown in Fig. 2 where every component of the model bears a direct analogy to the actual constituents of a biological neuron and hence termed as artificial neuron. It is a model which forms the basis of artificial neural networks.

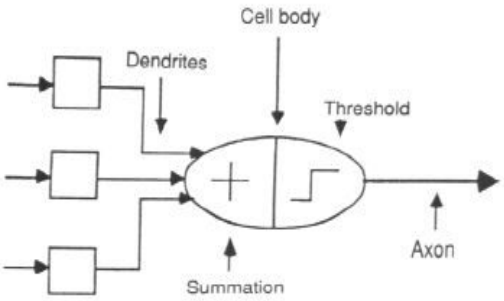



Fig. 2 Simple model of an artificial neural

The following figure represents structure of an artificial neural network which consists of three layers which are input layer, hidden layer and output layer. Input layer consists of all the inputs along with the weights associated to the neurons. The hidden layer used for computation and the output layer consists of the calculated output form the neurons.

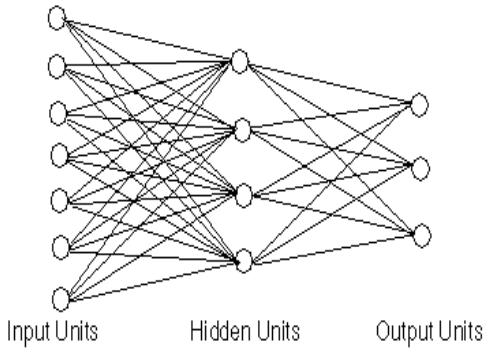



Fig.3 Diagram of ANN

**4.2Neural network in pattern recognition**

An important application of neural networks is pattern recognition. Pattern recognition can be implemented by using a feed-forward (figure 4) neural network that has been trained accordingly. During training, the network is trained to associate outputs with input patterns. When the network is used, it identifies the input pattern and tries to output the associated output pattern. The power of neural networks comes to life when a pattern that has no output associated with it, is given as an input. In this case, the network gives the output that corresponds to a taught input pattern that is least different from the given pattern.

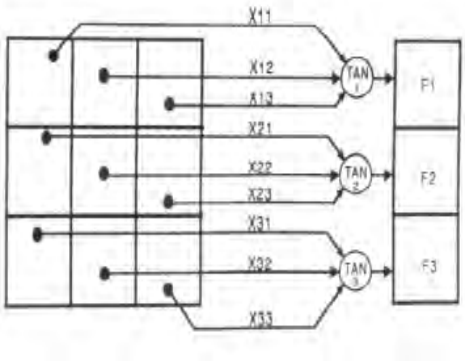



Fig. 4 Feed-forward neural network

Neural networks also contribute to other areas of research such as neurology and psychology. They are regularly used to model parts of living organisms and to investigate the internal mechanisms of the brain.

Example:
The network of figure 1 is trained to recognize the patterns T and H. The associated patterns are all black and all white respectively as shown below.


If we represent black squares with 0 and white squares with 1 then the truth tables for the 3 neurons after generalization are;

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| X11: | | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| X12: | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| X13: | | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| | | | | | | | | | |
| OUT: | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |

**Top neuron**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| X21: | | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| X22: | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| X23: | | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| | | | | | | | | | |
| OUT: | | 1 | 0/1 | 1 | 0/1 | 0/1 | 0 | 0/1 | 0 |

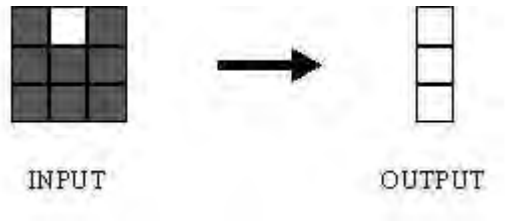
**Middle neuron**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| X21: | | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| X22: | | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| X23: | | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| | | | | | | | | | |
| OUT: | | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

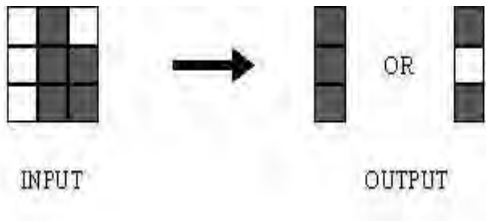
**Bottom neuron**

From the tables it can be seen the following associations can be extracted:


In this case, it is obvious that the output should be all blacks since the input pattern is almost the same as the 'T' pattern.




Here also, it is obvious that the output should be all whites since the input pattern is almost the same as the 'H' pattern.




Here, the top row is 2 errors away from the T and 3 from H. So the top output is black. The middle row is 1 error away from both T and H so the output is random. The bottom row is 1 error away from T and 2 away from H. Therefore the output is black. The total output of the network is still in favor of the T shape.

## 5. Genetic Algorithm

Genetic Algorithm (GA) is an optimization method that utilizes Darwinian criterion of population evolution for solving optimization problems based on natural selection. The process of natural selection is used to raise the effectiveness of group of possible solutions to meet an environment optimum [5]. GA is based on the principle of "Survival of the fittest". Holland proposed GA in the early seventies [6] as computer programs that mimic the natural evolutionary process. De Jong extended the GA to functional optimization [7] and a detailed mathematical model of a GA was presented by Goldberg in [8]. The GA has robustness that allows its structural functionality to be applied to many different search problems [8, 9]. Genetic algorithm belongs to the larger class of Evolutionary Algorithm (EA). Other algorithms in the same class include Evolutionary Strategies (ES), Evolutionary Programming (EP) and Genetic Programming (GP). A more striking difference between genetic algorithms and most of the traditional optimization methods is that GA uses a population of points at one time in contrast to the single point approach by traditional optimization methods.

A typical genetic algorithm requires:

1. A genetic representation of the solution domain.
2. A fitness function to evaluate the solution domain.

Once these functions are defined GA proceeds to initialize a population of solution randomly, then it is improved by repeated application of GA operators like selection, crossover and mutation.

### 5.1 Search Space

The space for all possible feasible solutions is called search space. Each solution can be marked by its value of the fitness of the problem. Looking for the solution means looking for extrema (either maximum or minimum) in search space. The search space can be known by the time of solving a problem and we generate other points as the process of finding the solution continues. (Shown in fig. 1)

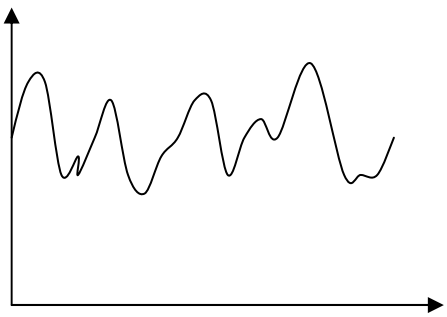


Fig. 5 Examples of search space

### 5.2 Genetic Algorithm Methodology

In a Genetic Algorithm, a population of strings called chromosomes which encode candidate solutions to an optimization problem evolves toward better solutions. The evolution usually starts from a population

of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (crossover and mutation) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached. A GA is based on a sequence of actions that can be represented by the figure.1 (Goldberg, 1989).

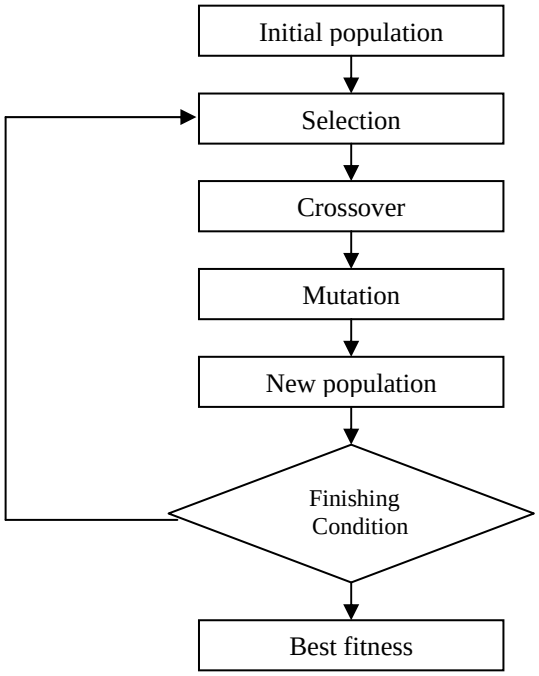



Fig. 6 Basic flow of GA

**5.3 Genetic Algorithm procedure**
Genetic Algorithm consists of the following steps:

**Step1**: Choose the initial population of individuals
**Step2**: Evaluate the fitness of each individual in that population
**Step3**: Repeat on this generation until termination (time limit, sufficient fitness achieved etc.):

- Select the best-fit individuals for reproduction.
- Breed new individuals through crossover and mutation operations to give birth to offspring
- Evaluate the individual fitness of new individuals
- Replace least-fit population with new individuals

GA involves the following steps while selecting the parameters for pattern recognition

- Definition of objective function
- Definition and implementation of genetic representation
- Definition and implementation of genetic operators

## 6. Conclusion

Artificial neural network and Genetic algorithms has various advantages. Neural network show a promising result in pattern recognition and also in the training process. Genetic algorithm is an unbiased optimization algorithm which makes parameter selection in an optimized way so as to obtain the global optimum.

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