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

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Abstract— Pattern Recognition is a mature but exciting and fast developing field, which underpins developments in cognate fields such as computer vision, image processing, text and document analysis and neural networks. It is closely akin to machine learning, and also finds applications in fast emerging areas such as biometrics, bioinformatics, multimedia data analysis and most recently data science. Image processing is also an emerging field and lots of research had been performed for the past few years. 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, Artificial Neuron, Neural Network in Pattern Recognition.

I. 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 w1, w2, w3…, wn 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.

II. PATTERN RECOGNITION

Pattern recognition is a branch of machine learning that focuses on the recognition of patterns and regularities in data, although it is in some cases considered to be nearly synonymous with machine learning. Pattern recognition systems are in many cases trained from labelled "training" data (supervised learning), but when no labelled data are available other algorithms can be used to discover previously unknown patterns (unsupervised learning). 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 pre-processing
- Data representation
- Decision making

The problem domain dictates the choice of sensor(s), pre-processing 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 labelled 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-labelled, 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 labelled and unlabeled data (typically a small set of labelled data combined with a large amount of unlabeled data).

III. ARTIFICIAL NEURAL NETWOKS

Artificial neural network (ANN) are computing system arouse by the biological neural network. It can also be termed as connectionist system since it is a set of approaches in the field of Artificial Intelligence (AI), cognitive psychology, neuroscience, cognitive science and philosophy of minds that replicates mental and behavioural phenomenon as the emergent process of interconnected network of simple units called neurons. It has the ability to learn, recall and generalize training patterns or data similar to that of a human brain. Their ability to learn by example makes them very flexible and powerful. It does not require any task-specific programming. The original goal of the neural network approach was to solve problems in the same way that a human brain would. Over time, attention focused on matching specific mental abilities, leading to deviations from biology such as back propagation, or passing information in the reverse direction and adjusting the network to reflect that information. Neural networks have been used on a variety of tasks, including computer vision, speech recognition, machine translation, social network filtering, playing board and video games, medical diagnosis and in many other domains.

A trained neural network can be thought of as a "specialist" 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.

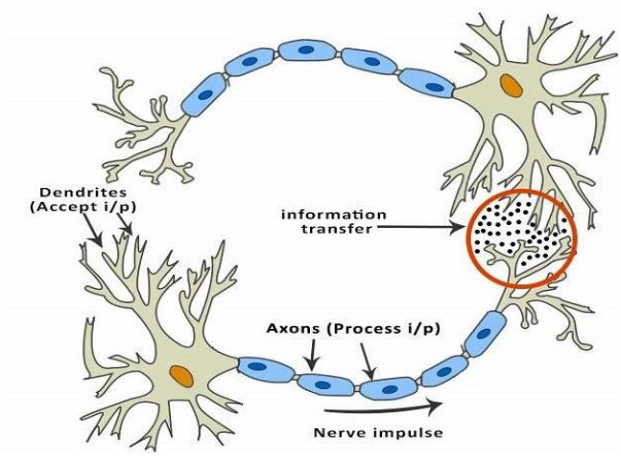

Fig .1 Structure of a neuron

III. 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.

IV. ARTIFICIAL NEURON

Neural network is made up of small interconnected nodes called neurons. Each node processes a small part of task. Most common type of neural network is a multilayered preceptron It's a model which forms the basis of artificial neural network.

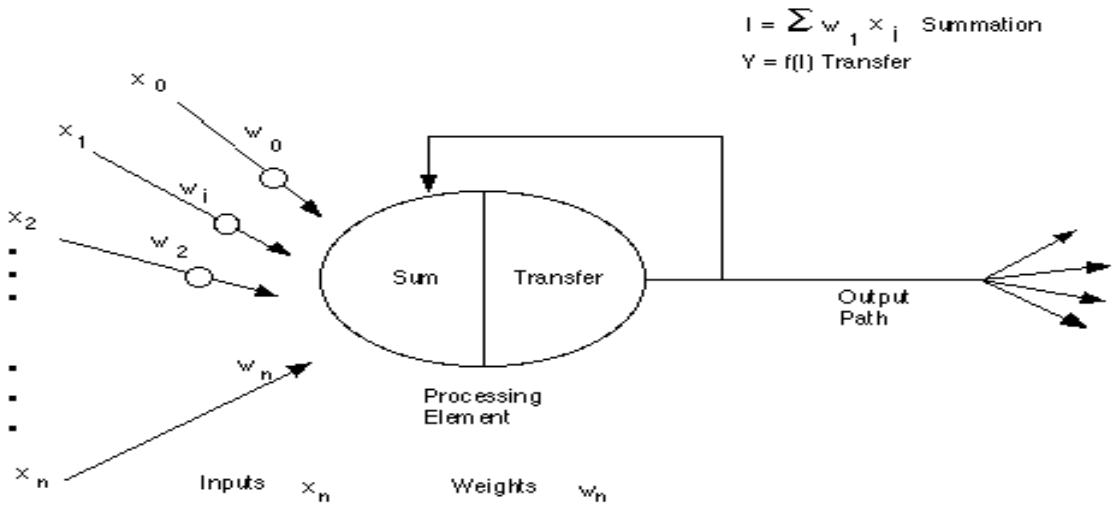

Fig. 2 Simple model of an Artificial Neuron

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 from the neurons.

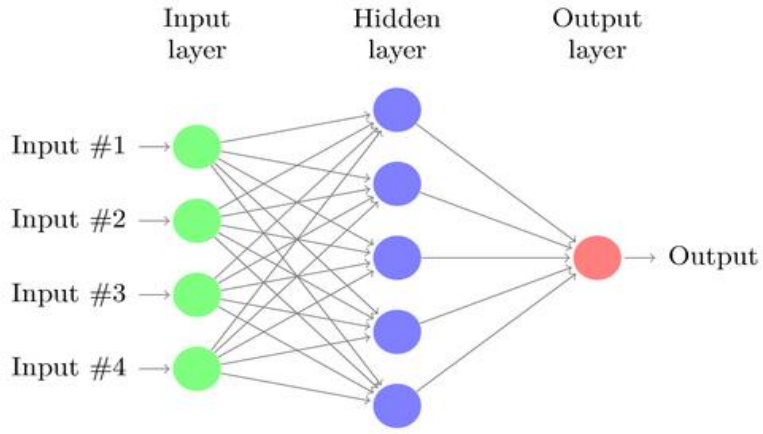

Fig.3 Diagram of ANN

V. 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.

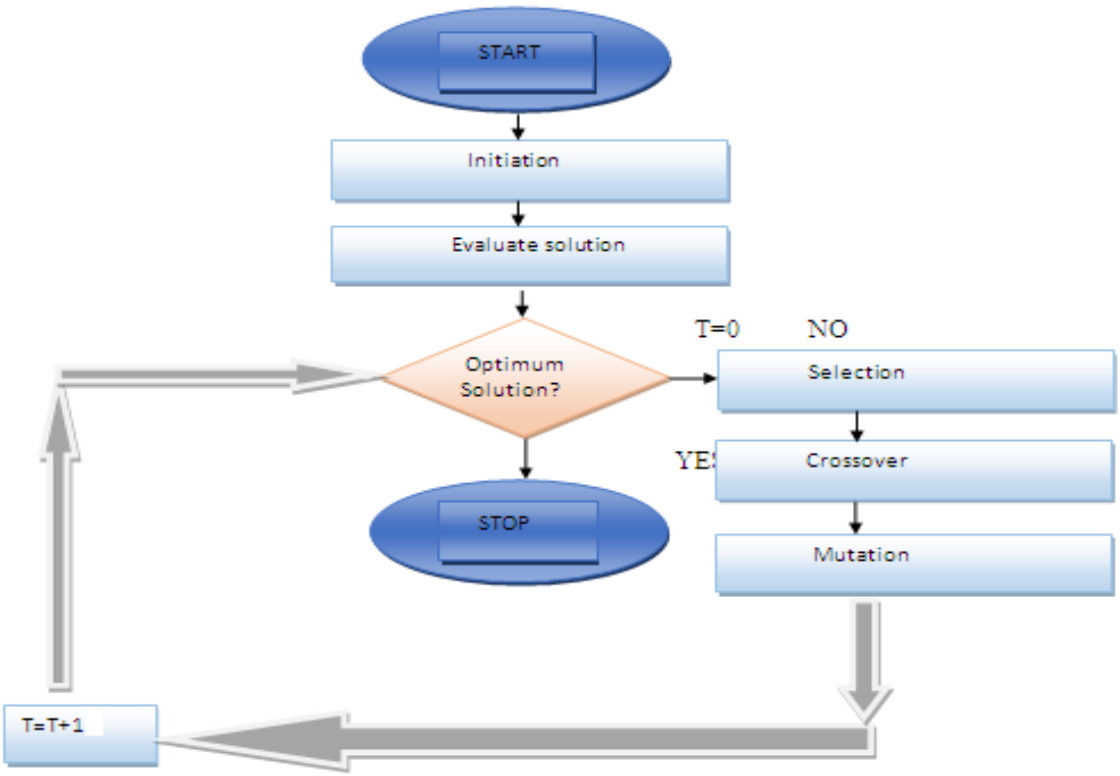

Fig. 3: A Basic flow of Genetic Algorithm

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
Genetic Algorithm procedure

```
Function sga ( )
      {
Initialize population;
Calculate fitness function;

While (fitness value! =termination criteria)
            {
             Selection;
             Crossover;
             Mutation;
             Calculate fitness function;
              }
      }
```

GA operators and parameters:

➢ **Selection:**

The primary objective of selection operator is to emphasize the good solutions and eliminate the bad solutions in a population while keeping the population size constant. "Select the best, discard the rest"

➢ **Crossover:**

In genetic algorithms, crossover is a genetic operator used to vary the programming of a chromosome or chromosomes from one generation to the next. It is analogous to reproduction and biological crossover, upon which genetic algorithms are based. Crossover is a process of taking more than one parent solution and producing a child solution from them. There are methods for selection of the chromosomes.

➢ **Mutation:**

It is agenetic operator used to maintain genetic diversity from one generation of a population of genetic algorithm chromosomes to the next. It is analogous to biological mutation. Mutation alters one or more gene values in a chromosome from its initial state. In mutation, the solution may change entirely from the previous solution. Hence GA can come to a better solution by using mutation. Mutation occurs during evolution according to a user-definable mutation probability. This probability should be set low. If it is set too high, the search will turn into a primitive random search. The classic example of a mutation operator involves a probability that an arbitrary bit in a genetic sequence will be changed from its original state.

One of the mutation types:

Bit string mutation

The mutation of bit strings ensue through bit flips at random positions.

Example:

1 0 1 0 0 1 0

↓

1 0 1 0 1 1 0

The probability of a mutation of a bit is 1/L, where L is the length of the binary vector. Thus, a mutation rate of 1per mutation and individual selected for mutation is reached.

VI. NEURAL 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.

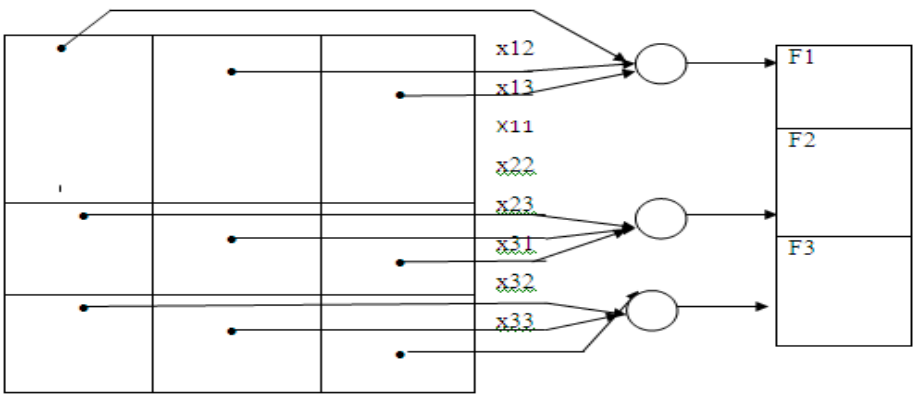

Fig. 4 Feed-forward neural network

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.

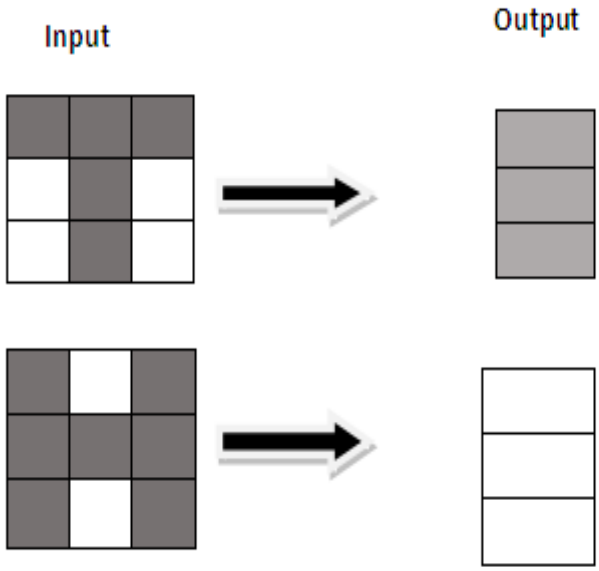

Fig. 5 Pattern Recognition of different Alphabets

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

Top neuron:

X11:	0	0	0	0	1	1	1	1
X12:	0	0	1	1	0	0	1	0
X13:	0	1	0	1	0	1	0	1
Z								
Output:	0	0	1	1	0	0	1	1

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
Output:	1	0/1	1	0/1	0/1	0	0/1	0

Bottom neuron:

X31:	0	0	0	0	1	1	1	1
X32:	0	0	1	1	0	0	1	1
X33:	0	1	0	1	0	1	0	1
Output:	1	0	1	1	0	0	1	0

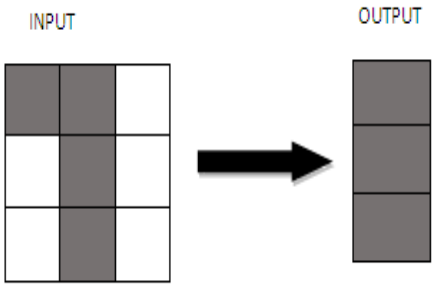

Fig. 6: A: Different types of pattern of Alphabetic shapes

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.

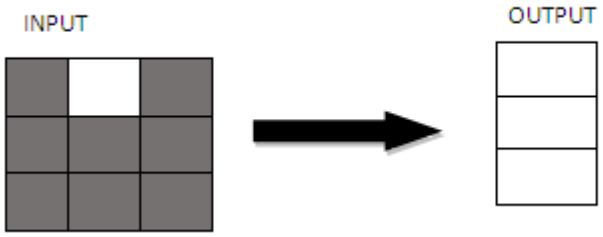

Fig. 6: B: Different types of pattern of Alphabetic shapes

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

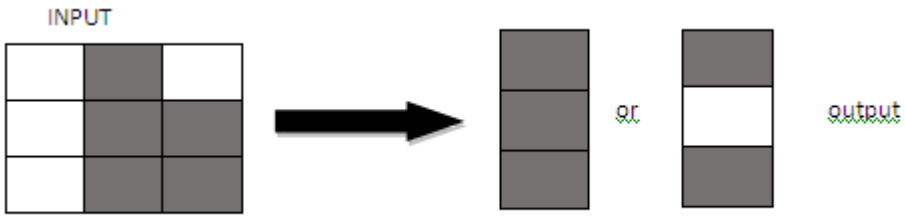

Fig. 6: C: Different types of pattern of Alphabetic shapes

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.

VII. CONCLUSION

The computing world has lot to gain from neural networks. Their ability to learn by examples makes them very flexible and powerful. 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. Finally we would like to state even though

neural networks have a huge potential we will only get the best of them when they were integrated with Artificial Intelligence (AI), fuzzy logic and related subjects.

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