Combination of Neural Network and its Applications, Genetic Algorithms
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Abstract:
Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts. Genetic algorithms are a randomized heuristic search strategy. The typical candidate representation is a binary string. This string can be thought of as the genetic code of a candidate thus the term “genetic algorithm”.

Keywords: Neural network, Genetic algorithm.

I. INTRODUCTION:
The scope of this teaching package is to make a brief induction to Artificial Neural Networks (ANNs) for people who have no previous knowledge of them. We first make a brief introduction to models of networks, for then describing in general terms ANNs. The user should know algebra and the handling of functions and vectors. Differential calculus is recommendable, but not necessary. The contents of this package should be understood by people with high school education. It would be useful for people who are just curious about what are ANNs, or for people who want to become familiar with them, so when they study them more fully, they will already have clear notions of ANNs.

II. NETWORKS:
One efficient way of solving complex problems is following the lemma “divide and conquer”. A complex system may be decomposed into simpler elements, in order to be able to understand it. Also simple elements may be gathered to produce a complex system. Networks are one approach for achieving this. There are a large number of different types of networks, but they all are characterized by the following components: a set of nodes, and connections between nodes. The nodes can be seen as computational units. They receive inputs, and process them to obtain an output. This processing might be very simple or quite complex. The connections determine the information flow between nodes. They can be unidirectional, when the information flows only in one sense, and bidirectional, when the information flows in either sense. The interactions of nodes though the connections lead to a global behavior of the network, which cannot be observed in the elements of the network. This global behaviour is said to be emergent. This means that the abilities of the network supercede the ones of its elements, making networks a very powerful tool.

III. NEURAL NETWORKS:
An Artificial Neural Network is an interconnected group of artificial neurons that uses mathematical model for information processing based on connectionist approach to computation. It is an information processing paradigm that is inspired by biological nervous systems. ANN is a machine learning approach inspired by the way in which the brain performs a particular learning task. Neuron in artificial neural networks tend to have fewer connections than biological neurons. Each neuron in ANN receives a no. of inputs. An activation function is applied to these inputs which results in output value of neuron (activation level of neuron).Neural network by parallel architecture of human or animal brains. Neuron N/w comprises of many units which work in parallel these units individually are simple units but together they are used to performed complex task .In neuron N/w are simple processing element and high degree of interaction between them.

The Neuron:
• The neuron is the basic information processing unit of a NN. It consists of:
1. A set of synapses or connecting links, each link characterized by a weight:
   \[ w_f, w_2, w_3, \ldots, w_m \]

2. An adder function (linear combiner) which computes the weighted sum of the inputs:
   \[ u = \sum_{j=1}^{m} w_j x_j \]

3. Activation function (squashing function) for limiting the amplitude of the output of the neuron.
   \[ y = \varphi(u + b) \]

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**Figure 2. an Artificial Neuron**

**History of neural network:**
- **1943:** McCulloch and Pitts introduced Neural Network
- **1949:** First learning rule for neuron network
- **1969:** Minsky and Papert published paper of perceptron limitation that leads to depth of artificial neuron network
- **1980:** Re-Emergence of ANN as multilayer N/W.

**Biological neuron network:**
It is used to study human brain itself to process information. In the human brain, a neuron collects signals from others through a host of fine structures called dendrites. The neuron sends out spikes of electrical activity through a long, thin stand known as an axon. At the end of branch, a structure called a synapse (converts the activity from axon into electrical effects), when a neuron receives excitatory input that is sufficient large compared with its inhibitory input, it sends a spike of electrical activity down its axon. Learning occurs by changing the effectiveness of the synapse so that the influence of one neuron on another changes.

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**Figure 3. how the brain learns**

**Types of neural network:** There are three different types of neural network:

**Feed forward Neural Network:** The feedforward neural networks are the first and simplest type of artificial neural networks. In this type, the information moves in only one direction, forward, from the input nodes, through the hidden nodes and to the output nodes. There are no cycles or loops in the network.

**Single-Layer Perceptron:** Single layer consists of a single layer of output nodes; the inputs are fed directly to the outputs via series of weights. The sum of the products of the weights and the inputs is calculated in each node, and if the value is some threshold the neuron fires and takes the activated value; otherwise it takes the neuron fires and takes the deactivated value. Neurons with this kind of activation function are also called McCulloch-Pitts neurons or threshold neurons. A perceptron can be created using any values for the activated and deactivated states as long as the threshold value lies between the two. Input layer of Output Source node layer

**Multi-layer perceptron:** Multilayer network consists of multiple layers of computational units, usually interconnected in a feed-forward. Each neuron in one layer has directed connections to neurons of subsequent layer. In Multilayer feed-forward neural network, there are hidden layers between input and output layers. Hidden nodes do not directly receive inputs nor send outputs to external environment. The output of layer is transmitted to the input of nodes in other layers through weighted links.
Applications of Neural Networks:

- **Aerospace**: Autopilot aircrafts, aircraft fault detection.
- **Automotive**: Automobile guidance systems.
- **Military**: Weapon orientation and steering, target tracking, object discrimination, facial recognition, signal/image identification.
- **Electronics**: Code sequence prediction, IC chip layout, chip failure analysis, machine vision, voice synthesis.
- **Financial**: Real estate appraisal, loan advisor, mortgage screening, corporate bond rating, portfolio trading program, corporate financial analysis, currency value prediction, document readers, credit application evaluators.
- **Industrial**: Manufacturing process control, product design and analysis, quality inspection systems, welding quality analysis, paper quality prediction, chemical product design analysis, dynamic modeling of chemical process systems, machine maintenance analysis, project bidding, planning, and management.
- **Medical**: Cancer cell analysis, EEG and ECG analysis, prosthetic design, transplant time optimizer.
- **Speech**: Speech recognition, speech classification, text to speech conversion.
- **Telecommunications**: Image and data compression, automated information services, real-time spoken language translation.
- **Transportation**: Truck Brake system diagnosis, vehicle scheduling, routing systems.
- **Software**: Pattern Recognition in facial recognition, optical character recognition, etc.
- **Time Series Prediction**: ANNs are used to make predictions on stocks and natural calamities.
- **Signal Processing**: Neural networks can be trained to process an audio signal and filter it appropriately in the hearing aids.
- **Control**: ANNs are often used to make steering decisions of physical vehicles.
- **Anomaly Detection**: As ANNs are expert at recognizing patterns, they can also be trained to generate an output when something unusual occurs that misfits the pattern.

Genetic Algorithm: Genetic Algorithm is search based optimization technique or heuristic search strategy based on the principles of **Genetics and Natural Selection**. It is used to find optimal or near-optimal solutions to difficult problems which otherwise would take a lifetime to solve. It is used to, many large-scale combinational mathematical programming problems such as large scale scheduling problems, solved optimization problems, in research, and in machine learning. Genetic algorithm is subset of much larger branch of computational known as **Evolutionary Computation**. GAs was developed by John Holland and his students and colleagues at the University of Michigan, most notably David E.Goldberg and has since been tried on various optimization problems with a high degree of success. Genetic algorithm is processed on natural selection that belongs to the larger class of evaluation algorithm’s. GA are commonly used to generate high quality solutions to optimization and search problems depending on operators such as crossover, mutation and selection. Genetic algorithm starts from population of randomly generated individual and is an iterative process, with a population in each iterative process, with a population in each iteration called generation. In each generation the fitness function is evaluated, the fitness is value of the objective is selected from the current population and combine to form a new generation. The algorithm terminates when eithera maximum no of generation has been reached for the population.

**Principles of Genetic Algorithm:**

1. **Heredity**: There must be a process in place by which children receives the property of their parents.
2. **Variation**: There must be a variety present in population.
3. **Selection**: There must be a mechanism by which some members of a population of the opportunity to there parents and pass their genetic information and some do not .It is referred as survival to the fittest.

**Basic Structure of GA**:

![Basic structure of GA](image-url)
A pseudo-code for GA:

GA()
Initialize population
Find fitness of population
While (termination criteria is reached) Do
    Parent selection
    Crossover with probability p(c)
    Mutation with probability p (m)
    Decode and fitness calculation
    Survivor selection
    Find best
Return best

Steps in Genetic algorithm:

1. Create a random population of ‘N’ elements. It is also called Setup function.
2. Draw Function:
   a. Calculate fitness for ‘N’ elements

Fitness is the mathematical function to determine which member of population are lightly to be selected to pass its genetic information to the next generation. Fitness function is the key factor of genetic algorithm.

   b. Reproduction/Selection
      (i). Pick two parents
      (ii). Make a new element with crossover or mutation.

Operators in Genetic Algorithm: Genetic operators used in genetic algorithm maintain genetic diversity. Genetic diversity or variation is necessity for the process of evolution.

1. Reproduction (or selection)
2. Crossover (or Recombination); and
3. Mutation.

1. Reproduction or Selection: Reproduction is usually the first operator applied on population. From the population the chromosomes are selected to be parent to crossover and produce offspring. The problem is how to select these chromosomes? According to Darwin’s evolution theory “survival of the fittest”—the best one should survive and create new offspring. The reproduction operators are also called section operators. Selection means extract a subset of genes from an existing population, according to any definition of quality, every gene has a meaning, so one can derive from the gene a kind of quality measurement called fitness function. Following this quality, selection can be performed. Fitness function picks the optimality of a solution a particular solution may rank against all other solutions.

2. Crossover: the crossover operator is analogous to reproduction and the biological crossover. In this more than one parent is selected and one or more offsprings are produced using the genetic material of the parents. Crossover is usually applied in a GA with a high probability.

Crossover operators: In this section we will discuss some of the most popularly used crossover operators. It is to be noted at these crossovers operators are very generic and GA designer might choose to implement a problem specific crossover operator as well.

The crossover operators are of many types:

a. One point crossover:
b. Multi point crossover:
c. Uniform crossover:

A. One point Crossover: In this one point crossover, a random crossover point is selected and the tails of its two parents are swapped to get new offspring.

\[ P_1 = 1 \, 0 \, 1 \, 0 \, 0 \, 1 \, 0 \Rightarrow O_1 = 1 \, 0 \, 1 \, 0 \, 0 \, 1 \, 0 \]

\[ P_2 = 0 \, 1 \, 1 \, 0 \, 0 \, 1 \Rightarrow O_2 = 0 \, 1 \, 1 \, 0 \, 1 \, 1 \]

B. Multi point Crossover: Mutipoint cross over is a generalization of the one point crossover wherein alternating segments are swapped to get new offspring.

\[ P_1 = 0 \, 1 \, 2 \, 3 \, 4 \, 5 \, 6 \Rightarrow O_2 = 0 \, 1 \, 9 \, 4 \, 5 \, 6 \, 5 \]

\[ P_2 = 5 \, 8 \, 9 \, 2 \, 3 \, 5 \Rightarrow O_3 = 5 \, 8 \, 2 \, 3 \, 2 \, 3 \, 5 \]

C. Uniform Crossover: In uniform Crossover we do not divide the chromosome into segments, rather the treat each gene separately them. In this we essentially flip a coin for each chromosome to decide whether or not it will be included in offspring. We can also bias the coin to one parent, to have more genetic material in the child from that parent.

\[ P_1 = 0 \, 1 \, 2 \, 3 \, 4 \, 5 \, 6 \, 7 \, 8 \, 9 \Rightarrow O_1 = 5 \, 1 \, 9 \, 4 \, 4 \, 5 \, 5 \, 7 \, 8 \, 9 \]

\[ P_2 = 5 \, 8 \, 9 \, 4 \, 3 \, 5 \, 7 \, 5 \, 8 \Rightarrow O_2 = 0 \, 8 \, 2 \, 3 \, 2 \, 3 \, 6 \, 7 \, 8 \]

3. Mutation: if we have enough variation in population before child if finished we apply mutation. Mutation may be defined as small random tweak in chromosome to get a new solution. It is used to maintain and introduce diversity in the genetic population and is usually applied with a low probability-p (m). If the probability is very high the GA gets reduced to a random search.

Mutation operators are of many types:

1. Bit flip Mutation
2. Random re setting
3. Swap Mutation

1. Bit flip Mutation: In Bit flip Mutation, we select one or more random bit and flip them. This is used for binary in encoded GAs.

\[ P_1 = 0 \, 0 \, 1 \, 0 \, 1 \, 0 \, 0 \, 1 \, 0 \Rightarrow O_1 = 0 \, 0 \, 1 \, 0 \, 1 \, 0 \, 0 \, 1 \, 0 \]

2. Random re setting: Random resetting is an extension of the bit slip for the integer representation. In this random value from the set of permissible values is assigned to a randomly chosen gene.

3. Swap mutation: In Swap Mutation, we select two position on the chromosome at random, and interchange the value. This is common in permutation based encoding.
IV. CONCLUSIONS:

Artificial neural network are widely spread and used in every day services, products and application. All though modern software product enable relatively easy handing with ANN. In the introduction of ANN, we briefly described artificial neurons of neural network and their transformation from single artificial neurons to complete ANN. We described types (single, multiple) and its applications of neural network and we also described genetic algorithm and its operators (selection, mutation, and crossover).

V. REFERENCES:


