Machine Intelligence
Module-5
Neuro Genetic Systems

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Neuro Genetic Systems: Introduction

- Neuro-Genetic Systems are a combination of artificial neural *networks* and genetic algorithms.

- Two such hybrid systems are
- 1. Neuro-Genetic System for weight determination of multi layer feed forward networks.
- 2. A technique that artificially evolves neural network topologies using Genetic Algorithms.

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- Weights are usually determined through backpropagation learning method.
- In backpropagation of errors the interconnection weights are randomly initialized during network design.
- Recall how with backpropagation, network tries to optimize the weights.
- During training, the actual output is compared with the actual output and the error, if any, is backpropagated for adjustments of interconnection weights.
- The error is calculated as

$$E = \frac{1}{2}\sum_i (TO_i - O_i)^2,$$

where TO_i is the target output and O_i is the actual output at the i^{th} output unit.

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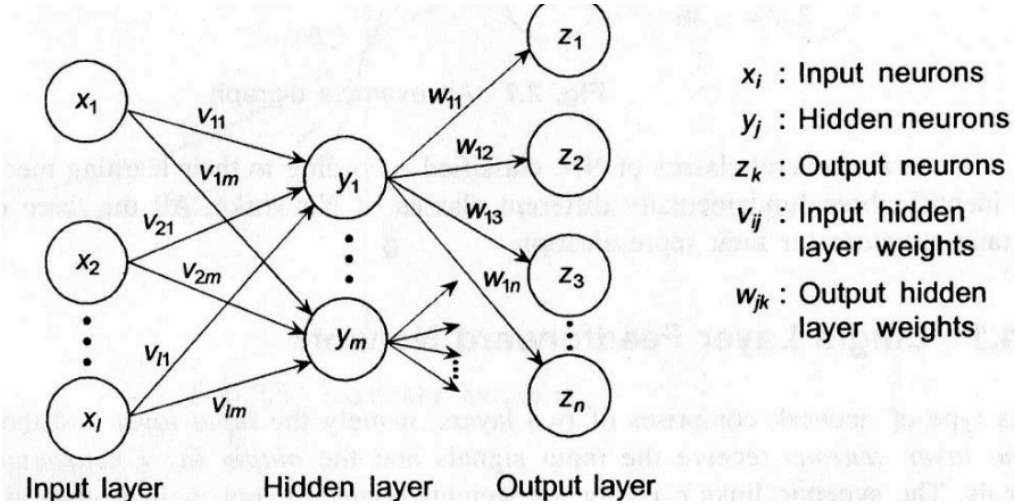

Image source:https://www.semanticscholar.org/paper/A-Survey-on-Backpropagation-Algorithms-for-Neural-Vora-Yagnik

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- During backpropagation of the error, the network adjusts its weights to return better results in the next iteration.
- This error back propagation follows a gradient descent rule and therefore is vulnerable to the problem of settling down at local minima.
- Another limitation of the gradient descent technique is that it is slow since the number of iterations needed to properly train the network is usually considerably high.

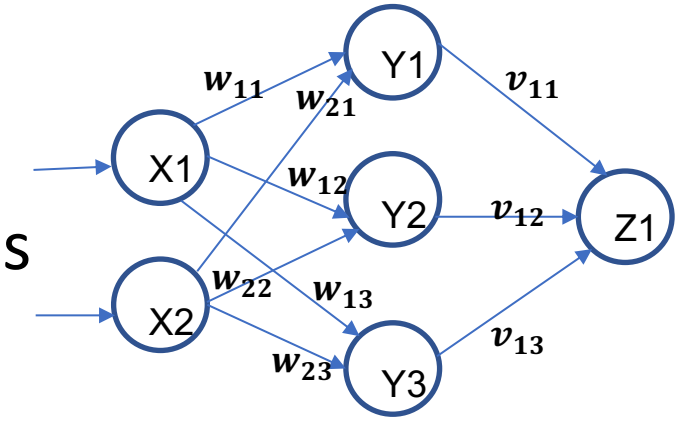
Wt. determination of Multilayered N/w using GA

- Consider a single hidden layer network having
  - $m+n+r$ number of nodes.
  - Total no. of interconnecting weights in the network would be (mn+rn)
- Represent each weight by a gene, so a chromosome will be having

  $(mn+rn)$ number of genes.
- Structure of gene: $d_1 d_2 d_3 d_4 d_5$ (representing an interconnection weight)
  - Where d's are digits
  - d_1 is used to determine the sign
  - $d_2 d_3 d_4 d_5$, the interconnection weights '+' or '-' depending on whether d_1 is even or odd.
- The magnitude is obtained by dividing $d_2 d_3 d_4 d_5$ by 100
- A chromosome is then a linear array of (m+r) nx5 digits.

Wt. determination of Multilayered N/w using GA

- Consider a 2-3-1 multi-layer network.
- The weights between the input layer and the hidden layer are $w_{11}\ w_{12}\ w_{13}\ w_{21}\ w_{22}\ and\ w_{23}$.
- And between the hidden layer and the output layer are $v_{11}\ v_{21}\ v_{31}$.
- Therefore a chromosome for this network corresponds to an arrangement of weights as given by:



w_{11}	w_{12}	w_{13}	w_{21}	w_{22}	w_{23}	v_{11}	v_{12}	v_{13}

-

Wt. determination of Multilayered N/w using GA

- In the present case, the chromosome is an array of
  (2+1) x 3 x 5 = 45 digits.

- For instance, let 143459076543210765430456713509246809478562589 be a chromosome.

- The mapping between the chromosome , weights and interconnections as shown below

14345	90765	43210	76543	04567	13509	24680	94785	62589
-43.45	-07.65	+32.10	-65.43	+45.67	-35.09	+46.80	-47.85	+25.89
w_{151}	w_{112}	w_{113}	w_{251}	w_{222}	w_{233}	w_{151}	w_{112}	w_{113}

Wt. determination of Multilayered N/w using GA

- The initial population consists of a set of randomly generated chromosomes .
- Fitness is measured in terms of the error term $E = \frac{1}{2}\sum_i (TO_i - AO_i)^2$.
- In order to compute the error, a chromosome is mapped to its corresponding BPN net .
- The network is then tested by applying the input of a test pair and computing the actual output for the said input .
- This actual output when compared with the target output in $E = \frac{1}{2}\sum_i (TO_i - AO_i)^2$ gives the error for that training pair .

Wt. determination of Multilayered N/w using GA

- The same is computed for every training pair and the average is considered for fitness calculation .
- Since the aim is to minimize the error whereas A is a maximization process, we cannot directly use the error E as fitness measure .
- An obvious way is to take the reciprocal of E as the fitness

$$F = \frac{1}{E}$$

- the rest of the process is usual GA .
- It may be noted that the GA – based learning of multilayer nets does not involve any backpropagation of error.
- The journey towards the *minimum error multilayer network is now controlled by the GA* instead of the backpropagation learning method process.

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THANK YOU

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