Perceptron Networks and Applications

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- **Neural network architectures**
  - Fully connected networks
  - Layered networks
  - Acyclic networks
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  - Modular neural networks
- **Neural learning**
  - Correlation learning
  - Competitive learning
  - Feedback-based learning

Neural network architectures

▸ A single node is insufficient for many type of problems.

▸ Large number of nodes are frequently used.

▸ Different parts of the central nervous system are structured differently.

▸ **The cerebral cortex** consists of five to seven layers.

▸ The most processing is occurred in there.

▸ Each layer is supplying own outputs as input into the next layer.

Neural network architectures

▸ Each neuron is connected with many (not all) of the neighboring neurons within the same layer.

▸ Connections exist between cross layers.

▸ Connections may be excitatory (positive), inhibitory (negative), or irrelavent (almost zero).
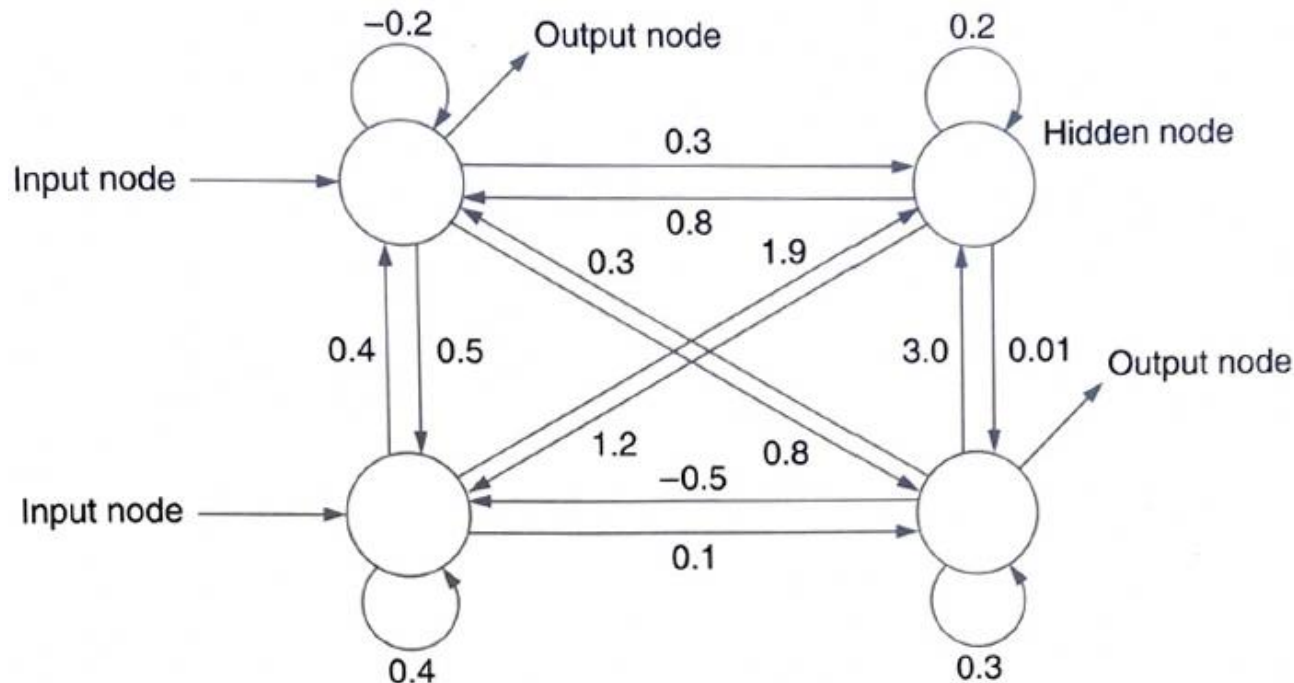
▸ Some of indirect self-excitatory occurs.

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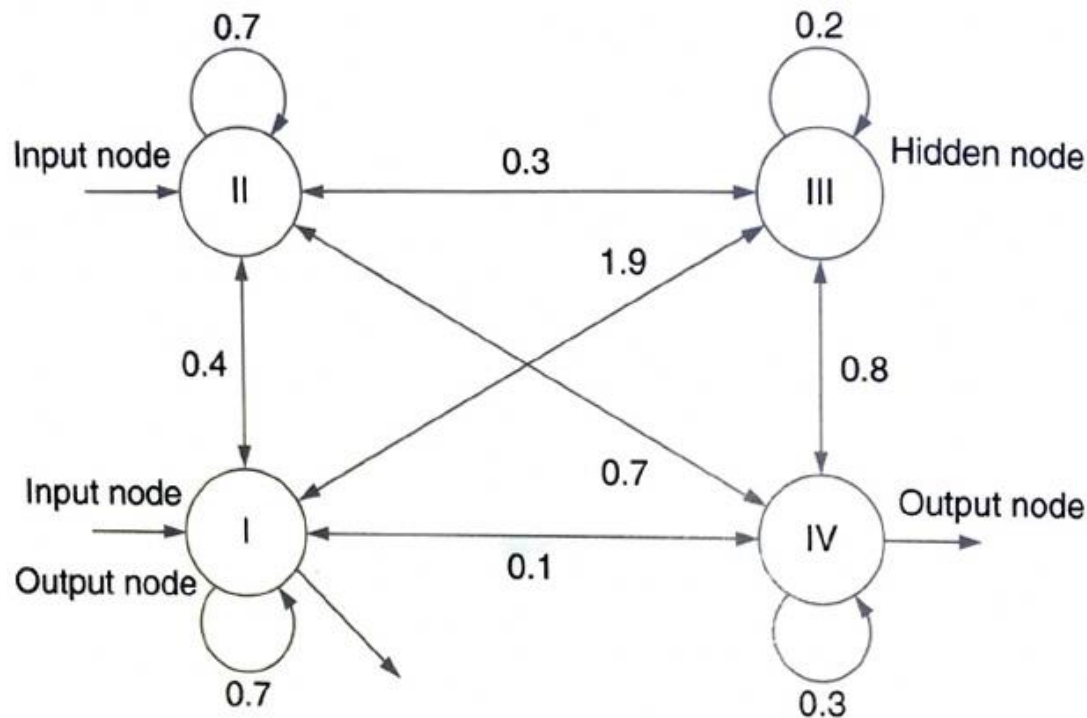
Neural network architectures

Fully connected networks

▸ Every node is connected to all other nodes.

▸ The most general neural net architecture.

▸ The connections may be asymmetric.

▸ It is seldom used due to the large number of connections.

▸ Fully connected networks are also biologically implausible.

Fully connected networks

▸ The connections may be symmetric (fully connected symmetric networks).

▸ It is seldom used due to the large number of parameters.

▸ Some nodes are inputs, and some nodes are outputs, all others are hidden nodes.

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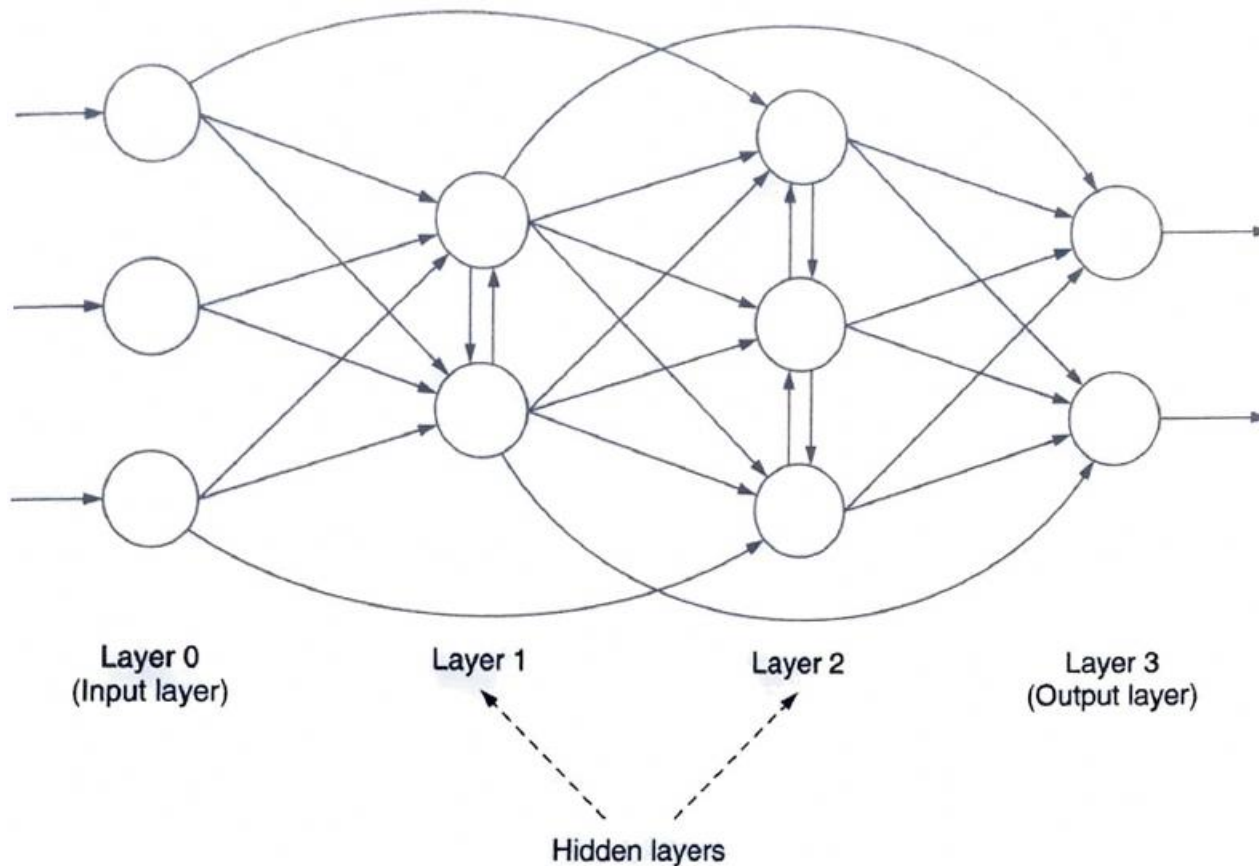 ▸ Feedback-based learning

Neural network architectures

Layered networks

‣ Nodes are partitioned into subsets called layers.

‣ No connections from layer j to layer k, if $j > k$.

‣ Input arrives at and is distributed to other nodes by each node of the "input layer" or "layer 0".

‣ No intra-layer connections among nodes in input and output layers.

‣ Connections may exist from any node in layer i to any node in layer j for $j > i$.

Neural network architectures

Layered networks

▸ Intra-layer connections may exist.

Layer 0
(Input layer)

Layer 1

Layer 2

Layer 3
(Output layer)

Hidden layers

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Neural network architectures

Acyclic networks

▸ A subclass of layered networks, **no intra-layer connections.**

▸ Connection may exist between nodes in layer i and in layer j, $(i < j)$.

▸ Computational process is simple.

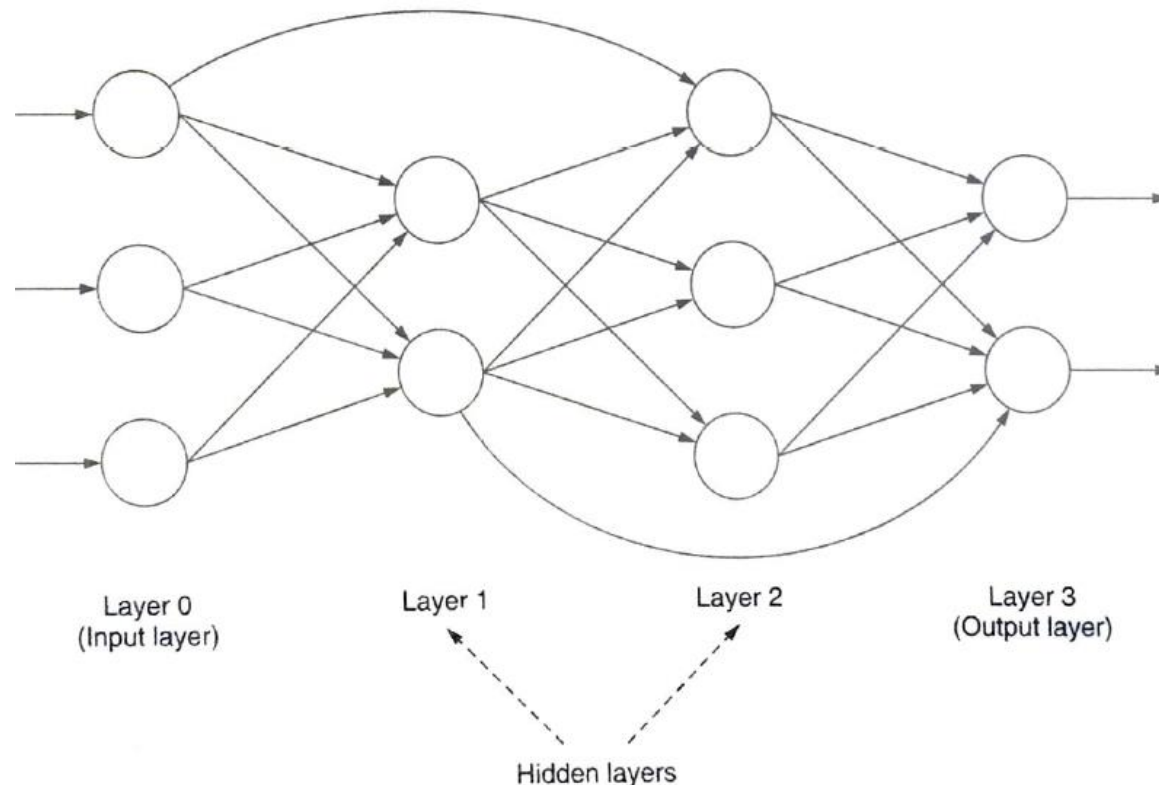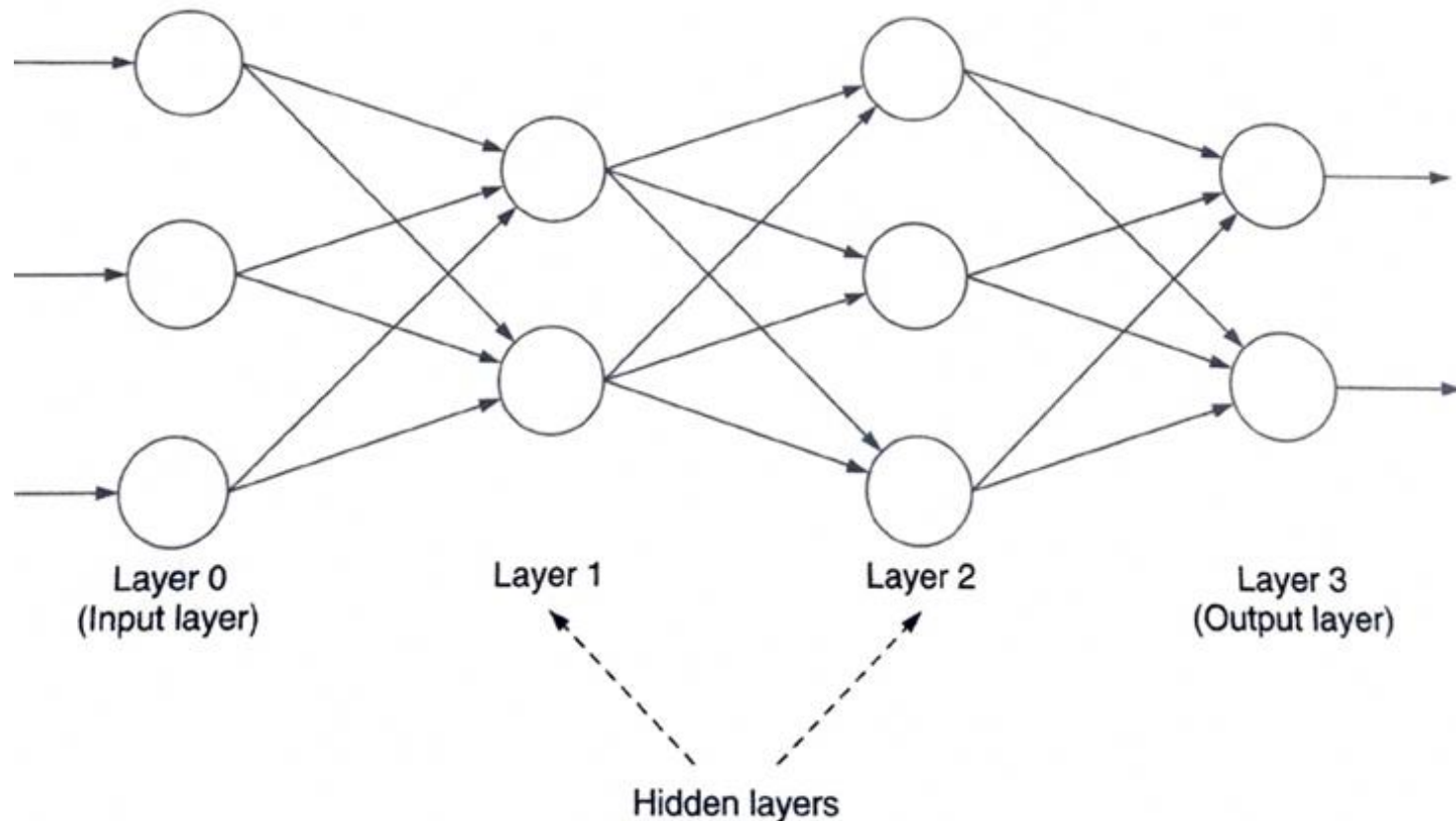Layer 0 (Input layer)   Layer 1   Layer 2   Layer 3 (Output layer)

Hidden layers

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Feedforward networks

▸ A subclass of acyclic networks, **no intra-layer connections.**

▸ Connection exists between nodes in layer i and in layer $(i + 1)$.

▸ Computational process is simpler than acyclic networks.

Layer 0 (Input layer)   Layer 1   Layer 2   Layer 3 (Output layer)

Hidden layers

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Neural network architectures

Modular neural networks

▸ Many problems are best solved using modular neural networks.

▸ Their architecture consists of several modules.

▸ Modularity allows the neural network developer to solve smaller tasks separately and combine them.
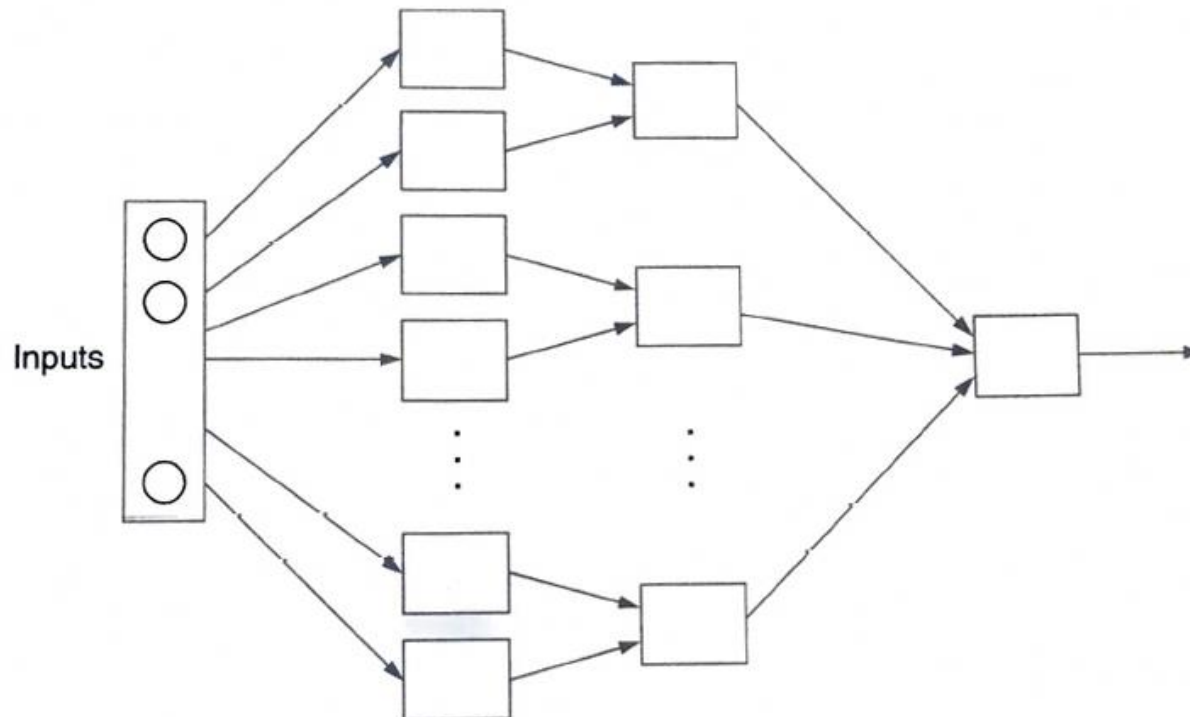
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Neural learning

▸ Neurons in an human's brain are hard wired.

▸ Humans learn as they grow.

▸ In artificial neural networks, learning refers to the method of modifying the weights of connections.

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Neural learning

Correlation learning

▸ Oldest and most widely known principles of biological learning mechanisms was described by Hebb (Hebbian learning, 1949).

▸ According to Hebb's rule, when an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes place in firing it.

▸ The strength of connections between neurons eventually comes to represent the correlation between their outputs.

▸ Weight modification rule for artificial neural networks can be stated as,

$$\Delta w_{i,j} = c\, x_i\, x_j$$

where c is constant value, x_i and x_j activation level of nodes.

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Neural learning

Competitive learning

▸ Different nodes compete to be winners with high levels of activity.

▸ The competitive process involves self-excitation and mutual inhibition among nodes.

▸ Finally, a single winner emerges.

▸ The connections between input nodes and the winner node are then modified.

▸ This process has been observed in biological systems.

▸ Different nodes may specialize in different subtasks.

▸ Two or more nodes accomplish a much bigger task.

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Neural learning

Feedback-based learning

▸ Humans learn based on feedback obtained from the environment.

▸ Each interaction with the environment can be viewed as measuring the performance of the system.

▸ In the neural networks, if increasing a particular weight leads to diminished performance or larger error, then that weight is decreased.

▸ The amount of change made at every step is very small.

▸ The network withstands some mistakes made by the teacher, feedback, or performance evaluation mechanism.

▸ The learning rate may vary for different networks.