

Neural networks

Artificial intelligence

- store knowledge, apply knowledge to solve problem, acquire new knowledge
- Representation
 - Language to store knowledge
 - Easy to understand by human
 - Declarative: static collection of facts
 - Procedural: embodied in executable code
- Reasoning
 - Ability to solve problems
 - Problem solving is searching problem
 - Use observation to make improvements on knowledge base
- Learning
 - Inductive: patterns and rules are determined from raw data and experience
 - Deductive: rules are used to determine facts
- Comparison to neural network
 - Processing: AI sequential, NN parallel
 - Level of explanation: AI builds symbolic representations, NN parallel distributed processing models
 - Representational structure: AI linguistic structure NN has problems in structure

Benefits

- Nonlinearity
- Input-Output mapping
- Adaptivity
- Evidential Response
- Contextual Information
- Fault Tolerance
- VLSI Implementability
- Uniformity of Analysis and Design
- Neurobiological Analogy

Human brain as neural network

- Stimulus -> receptors <=> neural net (brain) <=> effectors -> response
- Neural events in millisecond range (relatively slow)
- Efficient because highly parallel

A Neuron

- Information processing unit
- Three basic elements
 - synapses
 - adder
 - activation function
 - Threshold function
 - Piecewise-Linear function
 - Sigmoid function (most common)
- A bias may also be part (can also be part of the weights)
- It is also possible to have a stochastic model for a neuron

Knowledge representation

- Knowledge = stored information used to interpret, predict and respond to outside world
- Known world state (prior information)
- Observation of the world
- Knowledge of the world
 - Similar input should produce similar representations (euclidian distance)
- Four rules
 - Items of separate classes should give widely different representations
 - An important feature should have a lot of neurons
 - Prior information should be built into the neural network

Architectures

- One input and one output layer
 - No feedback
 - Acyclic
- Single-layer feedforward
- One or more hidden layers
 - Typically input from previous layer and output to next
 - fully connected = every node is connected to every other node in the adjacent layer
- Multilayer feedforward

Feedback

- Output of an element influences the input of an element
- Networks with feedback are called recurrent networks
- $A/(1-AB)$ is closed-loop operator
- AB is open-loop operator
- unit delay operator z^{-1} (delays output by one time unit)
 - If $|w| < 1$ then system is stable (convergent)
 - if $|w| > 1$ then system is unstable (divergent)
 - if $|w| = 1$ the divergence is linear, else exponential

Directed graphs

- Network of directed links and nodes
- Node has signal
- A link originates in a node and terminates in a node and has a transfer function
- A signal flows only in the direction of the link
- A node sums up all incoming signals
- The signal of a node is transmitted to each outgoing link