Glossary

Accuracy: The measurement (or a prediction) error that is repeatable from trial to trial. Accuracy is limited by systematic (repeatable) errors.

Action Potential: Electric signal propagated over long distances by excitable cells (e.g., nervous and muscular ones); it is characterized by an all-or-none reversal of the membrane potential in which the inside of the cell temporarily becomes positive with regards to the outside; it has a threshold and it is conducted without decrement. It is also known as nerve impulse.

Activation Function: The time-varying value that is the output of a neuron.

Adaptive Learning Rate: A learning rate that is adjusted according to an algorithm during the training to minimise training time.

Aggregate: It is the inert filler material in concrete that permits good physical properties at a low cost.

Apoptosis: Form of programmed cell death caused by the activation of endogenous molecules leading to the fragmentation of DNA.

Architecture: A description of the number of layers in an artificial neural network, the activation function of each neuron, the number of neurons per layer, and the connections between layers.

Artificial Intelligence (AI): Artificial intelligence is most often defined as "the ability of a computer to perform activities that are normally thought to require intelligence." As science, AI is often branched into several lines of research based on the methods used to achieve the "intelligence," including expert systems, fuzzy logic, and artificial neural networks.

Artificial Neural Network (ANN): An artificial neural network is an information-processing system that is based on generalizations of human cognition or neural biology and are electronic or computational models based on the neural structure of the brain. The brain basically learns from experience. There are two main types of ANN, the first one with only feedforward connections is called feedforward ANN, and the second one with arbitrary connections without any direction, are often called recurrent ANN (RANN). The most common type of ANN consists on different layers, with some neurons on each of them connected with feedforward connections and trained with the backpropagation algorithm.

Astrocyte (Astroglia): A star-shaped cell, especially a neuroglial cell of nervous tissue that supports the neurons.

Autocorrelation: A signal correlated with itself. It is useful because the Fourier transform of the autocorrelation is the power spectrum of the original signal.

Autonomic nervous system: Part of the vertebrate nervous system that regulates involuntary action, such as the intestines, heart, and glands. It is divided into the sympathetic nervous system and the parasympathetic nervous system.

Axon: The usually long process of a nerve fiber that generally conducts neuron impulses away from the body of the nerve cell.

Backpropagation (Generalised Delta-Rule): A learning rule in which weights and biases are adjusted by error-derivate (delta) vectors backpropagated through the network. Backpropagation is commonly applied to feedforward multilayer networks. Sometimes this rule is called the generalized delta rule.

Basis Functions: The set of waveforms used by decomposition. For instance, the basic functions for the Fourier decomposition are unity amplitude sine and cosine waves.

Bayesian Framework: Assumes that the weights and biases of the network are random variables with specified distributions.

Bias: A neuron parameter summed with the neuron's weighted inputs and passed through the neuron's transfer function to generate the neuron's output.

Bias Vector: A column vector of bias values for a layer of neurons.

Blood-Brain Barrier (BBB): A physiological mechanism that alters the permeability of brain capillaries, so that some substances, such as certain drugs, are prevented from entering brain tissue, while other substances are allowed to enter freely.

Bond: A debt instrument that pays a set amount of interest on a regular basis. The amount of debt is known as the principal, and the compensation given to lenders for making such funds available is typically in the form of interest payments. There are three major types of bonds: corporate, government, and municipal. A corporate bond with a low credit rating is called a high-yield or junk bond.

Bond Rating: An assessment of the likelihood that a bond issuer will pay the interest on its debt on time. Bond ratings are assigned by independent agencies, such as Moody's Investors Service and Standard & Poor's. Ratings range from AAA or Aaa (highest) to D (in default). Bonds rated below B are not investment grade and are called high-yield or junk bonds. Since the likelihood of default is greater on such bonds, issues are forced to pay higher interest rates to attract investors.

Cell Body (Soma): The portion of a nerve cell that contains the nucleus but does not incorporate the dendrites or axon.

Cement: It is a kiln-dried and finely pulverized mixture of natural earth materials used as a bonding ingredient in concrete.

Central Nervous System: The portion of the vertebrate nervous system consisting of the brain and spinal cord.

Cepstrum: A rearrangement of "spectrum." Used in homomorphic processing to describe the spectrum when the time and frequency domains are switched.

Civil Engineering: A broad field of engineering that deals with the planning, construction, and maintenance of fixed structures, or public works, as they related to earth, water, or civilization and their processes. Most civil engineering today deals with roads, structures, water supply, sewer, flood control, or traffic.

Classification: An association of an input vector with a particular target vector.

Clustering: Clustering algorithms find groups of items that are similar. For example, clustering could be used by an insurance company to group customers according to income, age, types of policies purchased, and prior claims experience. It divides a set of data so that records with similar content are in the same group, and groups are as different as possible from each other. Since the categories are unspecified, this is sometimes referred to as unsupervised learning.

Competitive Layer: A layer of neurons in which only the neuron with maximum net input has an output of 1 and all other neurons have an output of 0. Neurons compete with each other for the right to respond to a given input vector.

Competitive Learning: The unsupervised training of a competitive layer with the *instar* rule or Kohonen rule. Individual neurons learn to become feature detectors. After training, the layer categorizes input vectors among its neurons.

Competitive Transfer Function: Accepts a net input vector for a layer and returns neuron outputs of 0 for all neurons except for the "winner," the neuron associated with the most positive element of the net input n.

Concrete: It is a mass of sand, gravel, crushed rock, or other aggregate bonded together by a hardened paste of hydraulic cement and water.

Conjugate Gradient Algorithm: In the conjugate gradient algorithms, a search is performed along conjugate directions, which produces generally faster convergence than a search along the steepest descent directions.

Connection: A one-way link between neurons in a network.

Connection weight: The weight of a link between two neurons in a network. The weight determines the effect that one neuron has on another.

Connectivity: The interaction level within a system, the structure of the weights in a neural network, or the relative number of edges in a graph.

Cortex: Outer layer of grey matter that covers the surface of each cerebral hemisphere.

Credit rating: A credit rating is an assessment by a third party of the creditworthiness of an issuer of financial securities. It tells investors the likelihood of default, or non-payment, of the issuer financial obligations.

Crossover: Genetic process by which two chromosomes paired up exchange a distal portion of their DNA.

Data clustering: A common technique for data analysis, which is used in many fields, including machine learning, data mining, pattern recognition, image analysis, bioinformatics, and search engines.

Data mining – Knowledge discovery in databases (KDD): An information extraction activity whose goal is to discover hidden facts contained in databases. Using a combination of machine learning, statistical analysis, modeling techniques, and data-base technology, data mining finds patterns and relationships of the data and infers rules that allow the prediction of future results. Typical applications include market segmentation, customer profiling, fraud detection, evaluation of retail promotions, and credit risk analysis.

Decision boundary: A line, determined by the weight and the bias vector, for which the net input n is zero.

Decomposition: The process of breaking a signal into two or more additive components. Often it is referred specifically to the *forward Fourier transform*, breaking a signal into sinusoids.

Delta vector: The delta vector for an ANN layer is the derivate of the network's output error with respect to that layer's net input vector.

Dendrite: Short fiber that conducts information toward the cell body of the neuron.

Distance function: A particular way of calculating distance, such as the Euclidean distance between two vectors.

Epoch: The presentation of the set of training (input and/or target) vectors to an ANN and the calculation of new weights and biases. Note that training vectors can be presented one at a time or all together in a batch.

Error ratio: A training parameter used with adaptive learning rate and momentum training of backpropagation ANNs.

Error vector: The difference between an ANN's output vector in response to an input vector and an associated target output vector.

Evolutionary Computation (EC): Encompasses methods of simulating evolution on a computer. The term represents an effort bring together researchers who have been working in closely related fields but following different paradigms.

Expert Systems: A branch of artificial intelligence, expert systems use a complex hierarchy of rules to perform "intelligent tasks" based on available data. Examples include disease diagnosis and financial analysis.

False Negative: One of four possible outcomes of a target detection trial. The target is present, but incorrectly indicated to be not present.

False Positive: One of four possible outcomes of a target detection trial. The target is not present, but incorrectly indicated to be present.

Feedback Network: An ANN with connections from a layer's output to that layer's input. The feedback connection can be direct or by pass several layers.

Feedforward Network: A layered ANN in which each layer only receives inputs from previous layers.

Forecasting: Making predictions about future performance on the basis of historical and current conditions data.

Function Approximation: The task performed by an ANN trained to respond to inputs with an approximation of a desired function.

Fuzzy Logic: A branch of artificial intelligence, whereas most computer systems use boolean logic where everything is made with 1 and 0, true and false, fuzzy logic uses "partial truth." This helps in dealing with some human concepts, such as the meaning of natural language (this 84% certainly means X) and quantification (someone who is 190 centimeters tall is 70% certainly "tall," someone who is 210 centimeters is by all measures 100% certainly tall).

Generalisation: A measure of how well an ANN can respond to new input information on which it has not been trained but which is related in some way to the training patterns. An ability to generalise is crucial to the decision-making ability of the ANN. An attribute of an ANN whose output for a new input vector tends to be close to outputs for similar input vectors in its training set.

Genetic Algorithm (GA): An algorithm used to find approximate solutions to difficult-to-solve problems through the application of the principles of evolutionary biology to computer science.

Genetic Programming (GP): A type of programming that uses the same properties of natural selection found in biological evolution. The general idea behind genetic programming is to start with a collections of functions and randomly combine them into programs; then run the programs and see which gives the best results; Keep the best ones (natural selection), mutate some of the others, and test the new generation; repeat this process until a clear best program emerges.

Gland: Organ that produces a secretion for use elsewhere in the body or in a body cavity or to be eliminated by the body.

Glia: Supporting tissue that surrounds and supports neurons in the central nervous system; glial and neural cells together compose the tissue of the central nervous system. Also named neuroglia, glial cells do not conduct electrical impulses, unlike neurons.

Global Minimum: The lowest value of a function over the entire range of its input parameters. Gradient descent methods adjust weights and biases in order to find the global minimum of error for an ANN.

Gradient Descent: The process of making changes to weights and biases, where the changes are proportional to the derivatives of the ANN error with respect to those weights and biases. This is done to minimise the ANN error.

Hebb Learning Rule: Historically, the first proposed learning rule for neurons. Weights are adjusted proportional to the product of the outputs of pre- and post-weight neurons.

Hebbian Learning: ANNs process that strengthens the association between two simultaneously active neurons.

Hidden Layer: A layer of an ANN that is not the ANN input or output.

Hopfield ANN: A particular example of an ANN capable of storing and recalling memories or patterns. All nodes in the ANN feed signals to all others.

Hydrology: Is the study of the occurrence, distribution, and movement of water on, in, and above the earth.

Immune System: Integrated body system of organs, tissues, cells, and cell products such as antibodies that differentiates self from no self and neutralises potentially pathogenic micro-organisms or substances.

Initialisation: The process of setting the network weights and biases to their original values.

Input Layer: A layer of neurons that receive inputs directly from outside the ANN.

Input Space: The range of all possible input vectors.

Input Vector: A vector of inputs presented to the ANN.

Input Weights: The weights connecting ANN inputs to the input layer.

Intrusion Detection System (IDS): A software tool used to detect unauthorised access to a computer system or network. This may take the form of attacks by skilled malicious hackers or Script kiddies using automated tools.

Kohonen Learning Rule: A learning rule that trains selected neuron's weight vectors to take on the values of the current input vector, in Kohonen ANN.

Layer: A group of neurons that have a specific function and are processed as a whole. The most common example is in a feedforward ANN that has an input layer, an output layer, and one or more hidden layers.

Layer Diagram: An ANN architecture figure showing the layers and the weight matrices connecting them. Each layer's transfer function is indicated with a symbol. Sizes of input, output, bias, and weight matrices are shown. Individual neurons and connections are not shown.

Layer Weights: The weights connecting layers to other layers. Such weights need to have non-zero delays if they form a recurrent connection.

Learning Algorithms (Supervised, Unsupervised): An adaptation process whereby synapses, weights of ANNs, classifiers strengths, or some other set of adjustable parameters is automatically modified so that some objective is more readily achieved. The backpropagation and bucket brigade algorithms are two types of learning processes.

Learning Rate: A training parameter that controls the size of weight and bias changes during the ANN training process.

Learning Rule: The algorithm used for modifying the connection weights in response to training patterns while training is being carried out.

Local Minimum: The minimum of a function over a limited range of input values. A local minimum may not be the global minimum.

Mean Squared Error (MSE) Function: The performance function that calculates the average squared error between the ANN outputs and the target outputs.

MK System: The standard classification system, the Morgan-Keenan (MK) system was developed in the 1940s and, because photographic film was used, depended on a small region in the blue part of the stellar spectrum for classification. For the last 20 years, astronomers have relied on electronic detectors, which are more sensitive in the red regions of the spectrum.

Momentum: A technique often used to make it less likely for a backpropagation ANN to get caught in a shallow minima.

Momentum Constant: A training parameter that controls how much "momentum" is used.

Multi-Layer Perceptron (MLP): A type of feedforward ANN that is an extension of the perceptron in that it has at least one hidden layer of neurons. Layers are updated by starting at the inputs and ending with the outputs. Each neuron computes a weighted sum of the incoming signals, to yield a net input, and passes this value through its sigmoidal activation function to yield the neuron's activation value. Unlike the perceptron, an MLP can solve linearly inseparable problems.

Mutation: Genetic operation that makes a change of a gene of a chromosome of an organism resulting in the creation of a new individual not found in the parental type.

Natural Selection: Process in nature by which, according to Darwin's Theory of Evolution, only the organism most adapted to their environment tend to survive and transmit their genetic characteristics in increasing numbers to succeeding generations while those less adapted tend to be eliminated.

Neighborhood: A group of neurons within a specified distance of a particular neuron.

Nervous System: The specialized coordinating system of cells, tissues, and organs that endows animals with sensation and volition. In vertebrates, it is often divided into two systems: the central (brain and spinal cord), and the peripheral (somatic and autonomic nervous system).

Neuroglia: Network of branched cells and fibers that support the tissue of the central nervous system. It is also called glia.

Neuron: A simple computational unit that performs a weighted sum on incoming signals, adds a threshold or bias term to this value to yield a net input, and maps this last value through an activation function to compute its own activation. Some neurons, such as those found in feedback or Hopfield networks, will retain a portion of their previous activation.

Neurotransmitters: A group of substances that are released on excitation from the axon terminal of a presynaptic neuron of the central or peripheral nervous system and travel across the synaptic cleft to either excite or inhibit the target cell. Among the many substances that have the properties of a neurotransmitter are acetylcholine, noradrenaline, adrenaline, dopamine, glycine, glutamic acid, enkephalins, endorphins, and serotonin.

Organism: Individual form of life, such as a plant, animal, bacterium, protist, or fungus; a body made up of organs, organelles, or other parts that work together to carry on the various processes of life.

Output Layer: A layer whose output is passed to the world outside the ANN.

Output Vector: The output of an ANN. Each element of the output vector is the output of a neuron.

Outstar Learning Rule: A learning rule that trains a neuron's output weight vector to take on the values of the current output vector of the post-weight layer. Changes in the weights are proportional to the neuron's output.

Overfitting: A case in which the error on the training set is driven to a very small value, but when new data is presented to the ANN, the error is large.

Pathology: Study of the nature of disease and its causes, processes, development, and consequences; anatomic or functional manifestation of a disease.

Pattern Association: The task performed by an ANN trained to respond with the correct output vector for each presented input vector.

Pattern Recognition: The task performed by an ANN trained to respond when an input vector close to a learned vector is presented. The network "recognizes" the input as one of the original target vectors. This can be carried out by the ANN even in the presence of noise or when some data is missing.

Perceptron: An ANN capable of simple pattern recognition and classification tasks. It is composed of two layers where signals only pass forward from nodes in the input layer to nodes in the output layer. There are no connections within a layer. This ANN is often trained with the perceptron learning rule.

Perceptron Learning Rule: A learning rule for training single-layer hard-limit ANN. It is guaranteed to result in a perfectly functioning ANN in finite time, given that the ANN is capable of doing so.

Performance: The behavior of an ANN.

Performance Function: Commonly, the mean squared error (MSE) of the ANN outputs.

Phenotype: The physical or biochemical expression of an individuals' genotype; observable expressed traits, such as eye and skin color.

Phylogenetic Learning: Learning process that takes place over millions of years, as species evolve governed by natural selection. It is here that the abilities to perceive the most important features of the world around us — at our own scales of size and time — and to survive in it, are selected for and perfected.

Physiology: Study of the functions of living organisms and their parts.

Pitch: Human perception of the fundamental frequency of a continuous tone.

Principal Component Analysis (PCA): Orthogonalize the components of ANN input vectors. This procedure also can reduce the dimension of the input vectors by eliminating redundant components.

Radial Basis Network: An ANN that can be designed directly by fitting special response elements where they will do the most good.

Receptor: Cell surface molecule that binds specifically to particular proteins or peptides.

Resilient Backpropagation: A training algorithm that eliminates the harmful effect of having a small slope at the extreme ends of the sigmoid, "squashing" transfer functions.

Rheology/Rheological Behaviour: It is the science of the deformation and flow of matter, and the emphasis on flow means that it is concerned with the relationships between stress, strain, rate of strain, and time.

Rough Set Theory (RST): Can be approached as an extension of the Classical Set Theory, for use when representing incomplete knowledge. Rough sets can be considered sets with fuzzy boundaries sets that cannot be precisely characterized using the available set of attributes

Scaled Conjugate Gradient Algorithm: Avoids the time-consuming line search of the standard conjugate gradient algorithm, for the training process of an ANN.

Self-Organizing: An ANN is called self-organizing if it is capable of changing its connections so as to produce useful responses for input patterns without the instruction of a smart teacher.

Sigmoid Function: A function that is often used as an activation function in an ANN.

Slump Test: The slump test is the most well-known and widely used test method to characterize the workability of fresh concrete. The apparatus consists of a mold in the shape of a frustum of a cone. The mold is filled with concrete. The slump cone mold is lifted vertically upward and the change in height of the concrete is measured.

Soma: The neuron cell body that contains the nucleus.

Spectral Analysis: In astronomy, the study of the composition and structure of bodies via spectroscopy.

Spectrum: A graph or plot of intensity versus wavelength or frequency.

Spread Constant: The distance an input vector must be from a neuron's weight vector to produce an output of 0.5.

Stem Cell: Cell that gives rise to a lineage of cells. Particularly, used to describe the most primitive cells in the bone marrow from which all the various types of blood cells are derived.

Stimulus: A factor that can be detected by a receptor, which in turn produces a response.

Sum-Squared Error: The sum of squared differences between the ANN targets and actual outputs for a given input vector or set of vectors.

Supervised Learning: A learning process in which changes in an ANN's weights and biases are due to the intervention of any external teacher. The teacher typically provides output targets.

Synapse: Space in which a signal passes from one neuron to another.

Target Vector: The desired output vector for a given input vector.

Test Vectors: A set of input vectors (not used directly in training) that is used to test the trained ANN.

Threshold: A quantity added to (or subtracted from) the weighted sum of inputs into a neuron, which forms the neuron's net input. Intuitively, the net input (or bias) is proportional to the amount that the incoming neural activations must exceed in order to activate a neuron.

Timbre: The human perception of harmonics in sound.

Time Series: A series of measurements taken at consecutive points in time. Data mining products which handle time series incorporate time-related operators such as moving average.

Tissue: Organization of differentiated cells of a similar type. There are four basic types of tissue: muscle, nerve, epidermal, and connective.

Topology Functions: Ways to arrange the neurons in a grid, box, hexagonal, or random topology.

Training: A procedure where an ANN is adjusted to do a particular job. Commonly viewed as an "off-line" job, as opposed to an adjustment made during each time interval as is done in adaptive training.

Training Set: An ANN is trained using a training set. A training set comprises information about the problem to be solved as input.

Training Vector: An input and/or target vector used to train an ANN.

Trait: Genetically determined characteristic or condition.

Tuning Phase: Period of self-organizing feature maps (SOFM) training during which weights are expected to spread out relatively evenly over the input space while retaining their topological order found during the ordering phase.

Unsupervised Learning: A learning process in which changes in an ANN's weights and biases are not due to the intervention of any external teacher. Commonly, changes are a function of the current ANN input vectors, output vectors, and previous weights and biases.

Update: Make a change in weights and biases. The update can occur after presentation of a single input vector or after accumulating changes over several input vectors.

Validation Vectors: A set of input vectors (not used directly in training) that is used to monitor training progress so as to keep the ANN from overfitting.

Voiced: Human speech sound that originates as pulses of air passing the vocal cords. Vowels are an example of voiced sounds.

Weight: In an ANN, the strength of a synapse (or connection) between two neurons. Weights may be positive (excitatory) or negative (inhibitory). The thresholds of a neuron also are considered weights, since they undergo adaptation by a learning algorithm.

Weight Function: Weight functions apply weights to an input to get weighted inputs as specified by a particular function.

Weight Matrix: A matrix containing connection weights from a layer's inputs to its neurons. The element w_{ij} of a weight matrix W refers to the connection strength from neuron j to neuron i.

Weighted Input Vector: The result of applying a weight to a layer's input, whether it is an ANN input or the output of another layer.

Workability: ACI defines workability as "that property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated, and finished." Workability is affected by every component of concrete and essentially every condition under which concrete is made. A list of factors includes the properties and the amount of the cement; grading, shape, angularity, and surface texture of fine and coarse aggregates; proportion of aggregates; amount of air entrained; type and amount of pozzolan; types and amounts of chemical admixtures; temperature of the concrete; mixing time and method; and time since water and cement made contact.