VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR 440010
DEPARTMENT OF MECHANICAL ENGINEERING

PRESENTATION ON

ARTIFICIAL NEURAL NETWORKS

SUBMITTED TO:
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Artificial Neural Networks

Introduction

What are Neural Networks?

- An artificial neural network is a biologically inspired computational model that consists of processing elements (neurons) and connections between them, as well as of training and recall algorithms.
- The network is usually implemented using electronic components or simulated in software on a digital computer.
- Neural Networks attempt to bring computers a little closer to the brain's capabilities by imitating certain aspects of information processing in the brain, in a highly simplified way.

The Brain vs A Computer

	Brain	**Computer**
Processing Elements	10^{10} neurons	10^{8} transistors
Element Size	10^{-6} m	10^{-6} m
Energy Use	30 W	30 W (CPU)
Processing Speed	10^{2} Hz	10^{12} Hz
Style Of Computation	Parallel, Distributed	Serial, Centralized
Energetic Efficiency	10^{-16} joules/opn/sec	10^{-6} joules/opn/sec
Fault Tolerant	Yes	No
Learns	Yes	A little

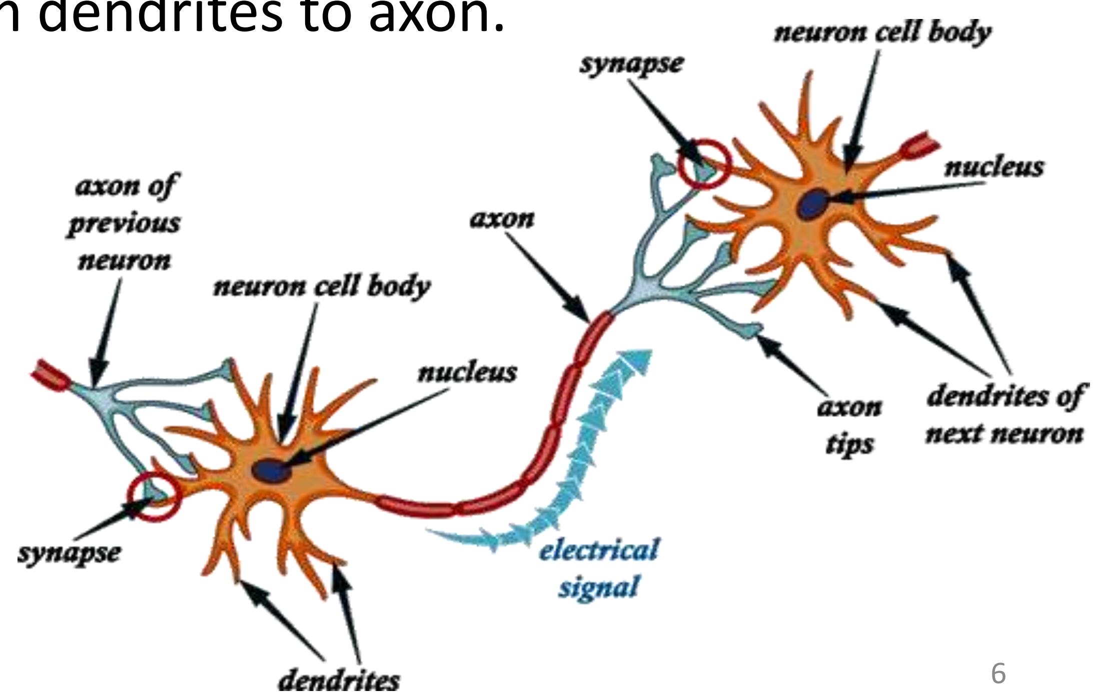
Characteristics of a Biological Brain

- Massively parallel, distributed information processing
- High degree of connectivity among basic units
- Connections get reorganized based on experience
- Performance degrades gracefully if some units are removed (i.e. some nerve cells die)
- Learning is constant and usually unsupervised
- Learning is based only on local information

Introduction

The Biological Brain

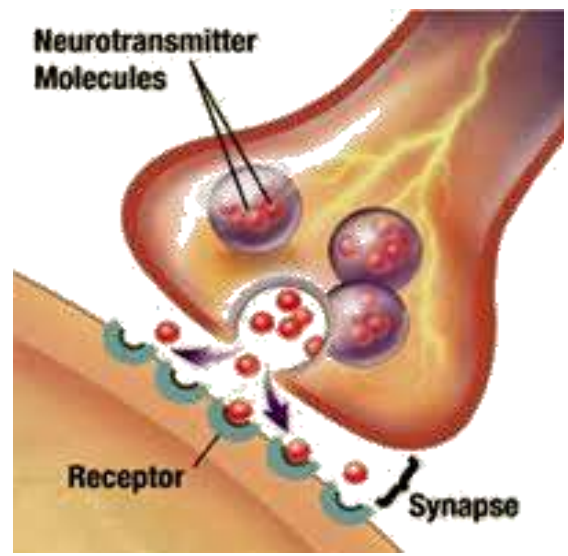
- **Neurons:** Fundamental information-processing units of the brain.
- Neurons contain **axons** (the transmission lines) and **dendrites**, (the receptive zones).
- Electrical signal flows from dendrites to axon.



Introduction

The Biological Brain

- **Synapses** are elementary structural and functional units that mediate the interactions between neurons.
- Synapse converts a presynaptic electrical signal into a chemical signal and then back into a postsynaptic electrical signal.
- During the early stage of development (first two years from birth), about 1 million synapses are formed per second.
- In an adult's brain, a neuron is connected to around 10,000 other neurons by synapses.



Introduction

Evolution of Neural Networks

- 1911 - Ramon y Cajal introduced the idea of neurons as structural constituents of the brain
- 1943 - McCulloch and Pitts apply Boolean algebra to nerve net behaviour
- 1948 - Donald Hebb postulates qualitative mechanism for learning at cellular level in brains
- 1957 - Rosenblatt develops ‘*perceptron*’ neurocomputer
- Between 1960’s & 1980’s - Almost no research in ANN
- Middle 80's - John Hopfield revives ANN
- Today - ANN one of the most active current areas of research

Characteristics of Neural Networks

- **Universal Regression Systems** - Modeling of a system with an unknown input-output relationship
- **Learning** - Network with "no knowledge“ can be trained with set of paired input-output data to give desired outputs for known inputs.
- **Generalization** - Produce best output according to learned examples if a different vector is input into network.
- **Adaptivity** - Adapt response to changes in surrounding environment

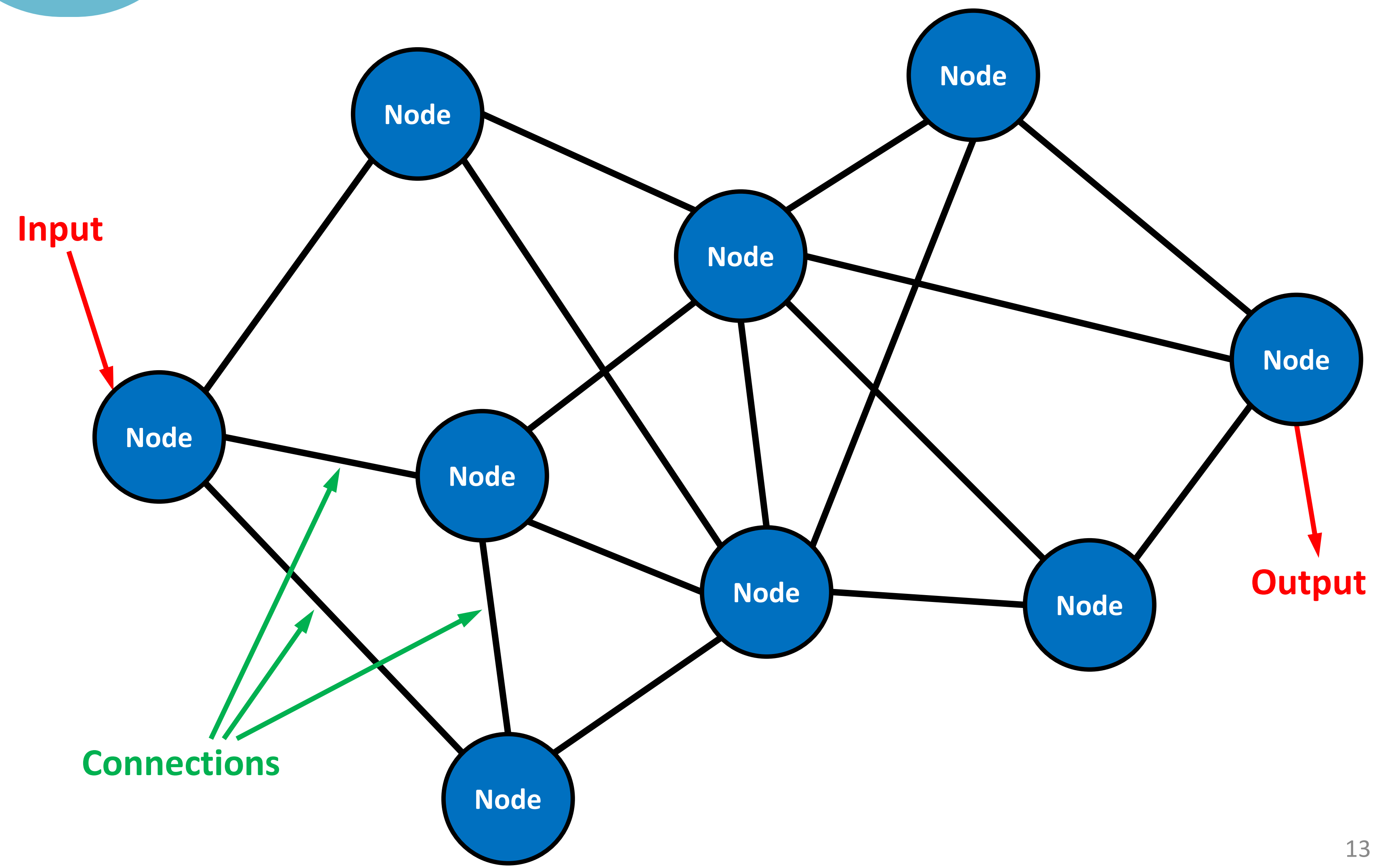
Characteristics of Neural Networks

- **Nonlinearity** - Cope with nonlinear data and environment
- **Massive parallel processing** - Many neurons fire simultaneously during data processing
- **Fault Tolerance** - Good response even if input data is slightly incorrect
- **Robustness** - Whole system can still perform well even if some neurons "go wrong"

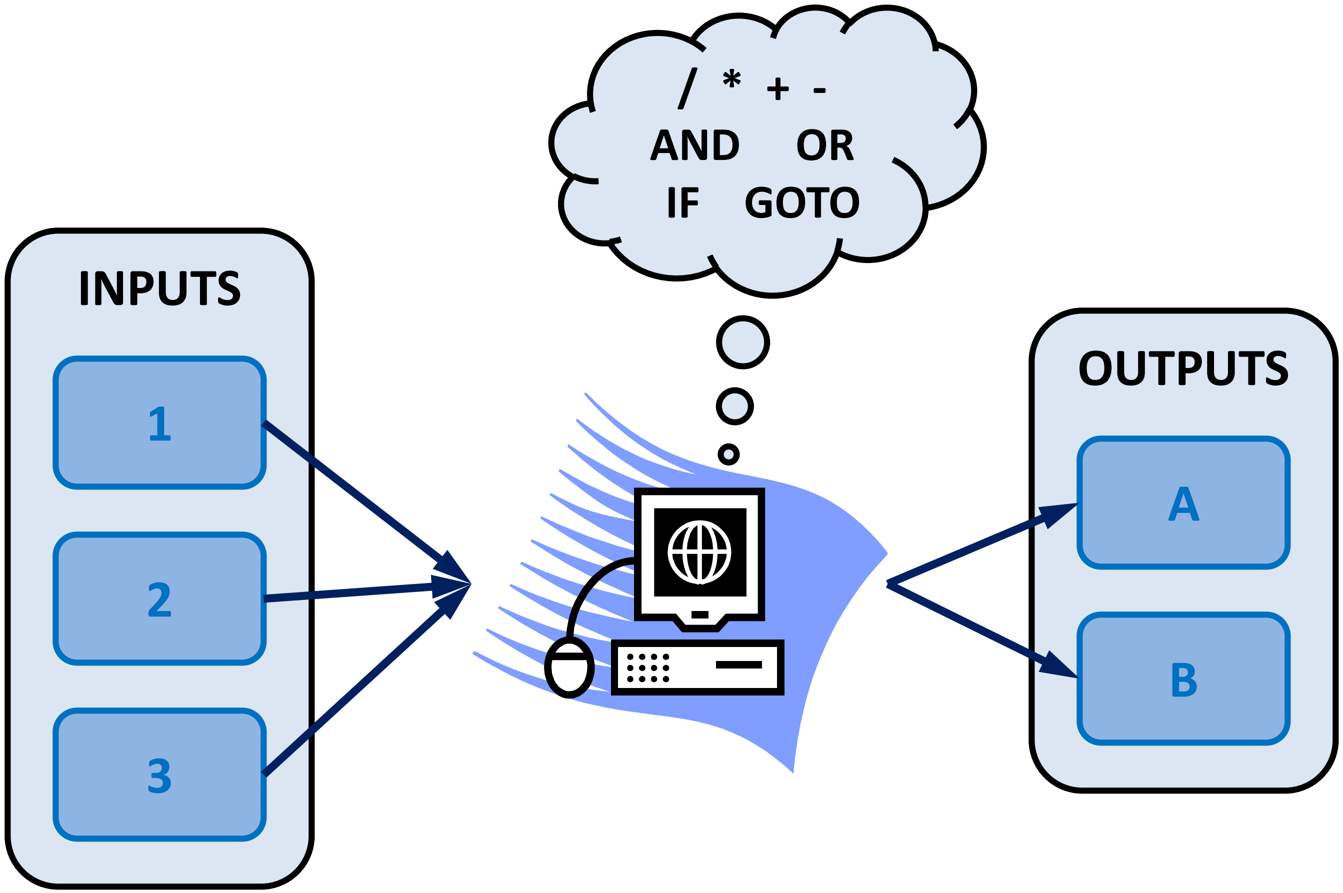
Artificial Neural Networks

Neural Networks Modeling

Representation of Neural Networks

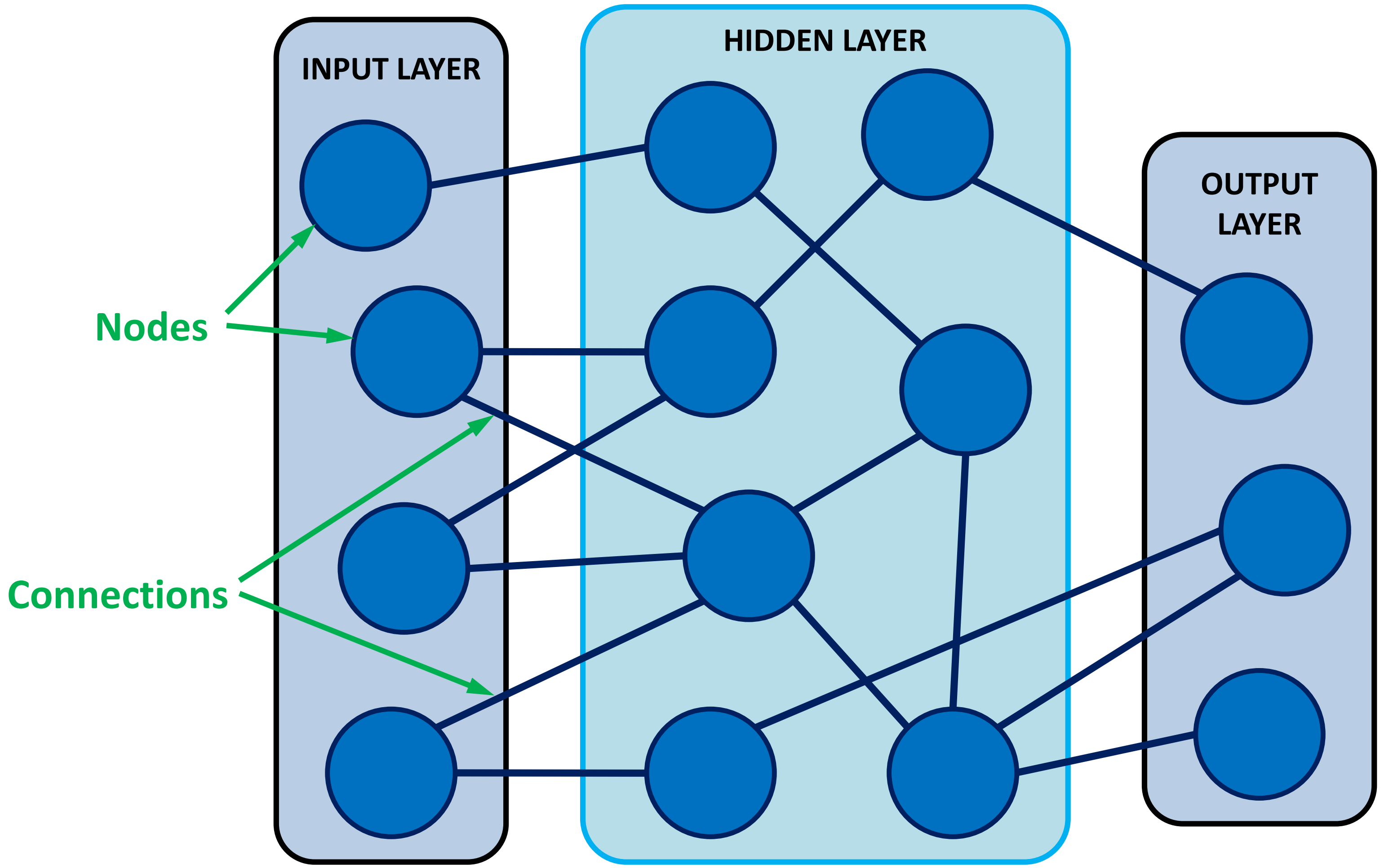


Conventional Computer Model



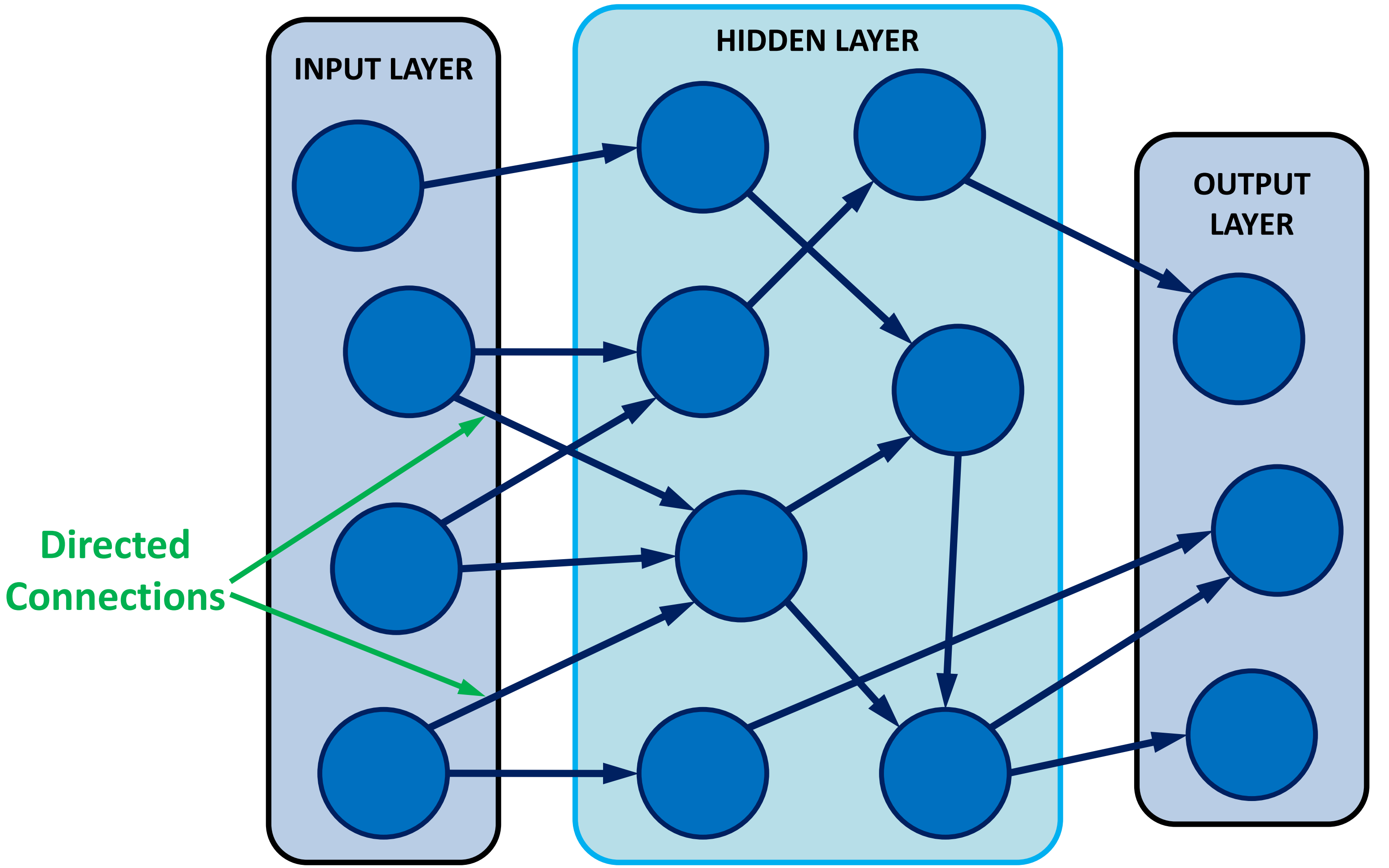
Neural Networks Modeling

Neural Network As A Computer Model



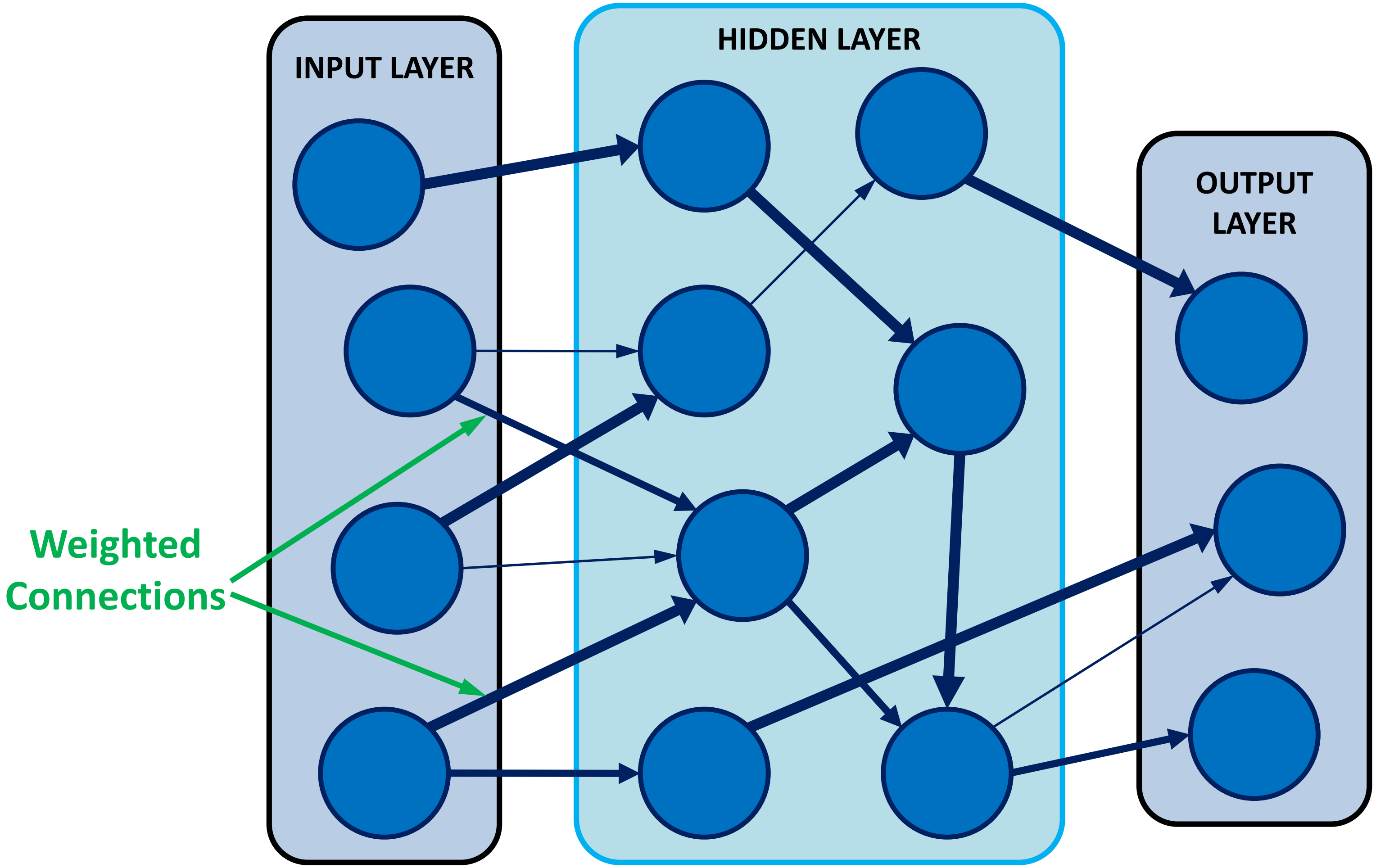
Neural Networks Modeling

Neural Network As A Computer Model

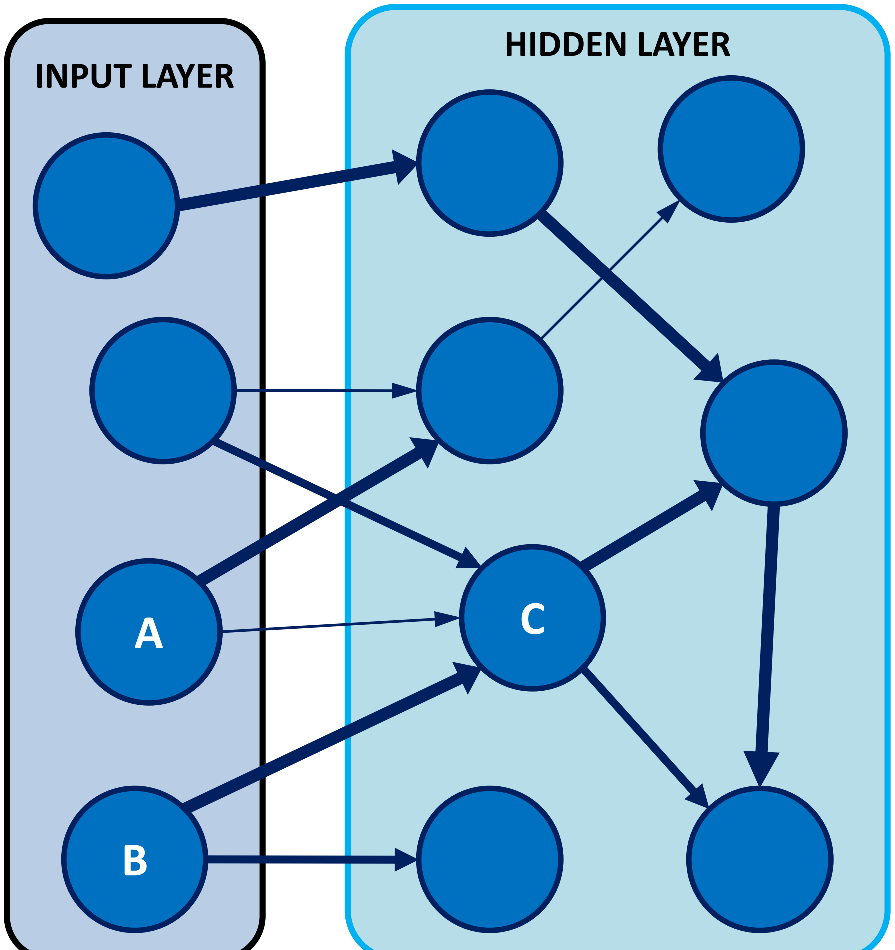


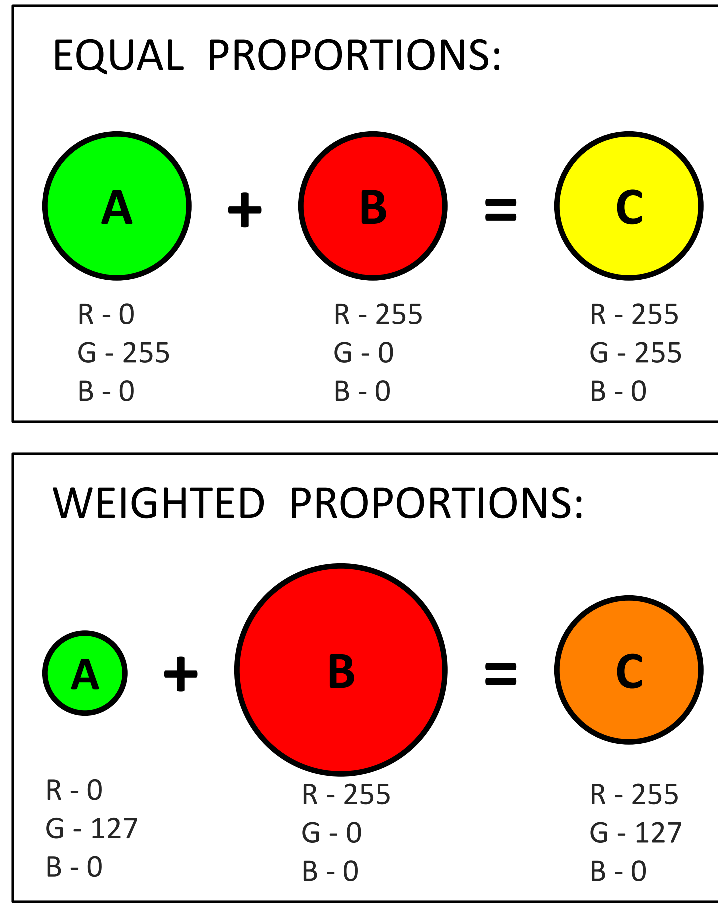
Neural Networks Modeling

Neural Network As A Computer Model

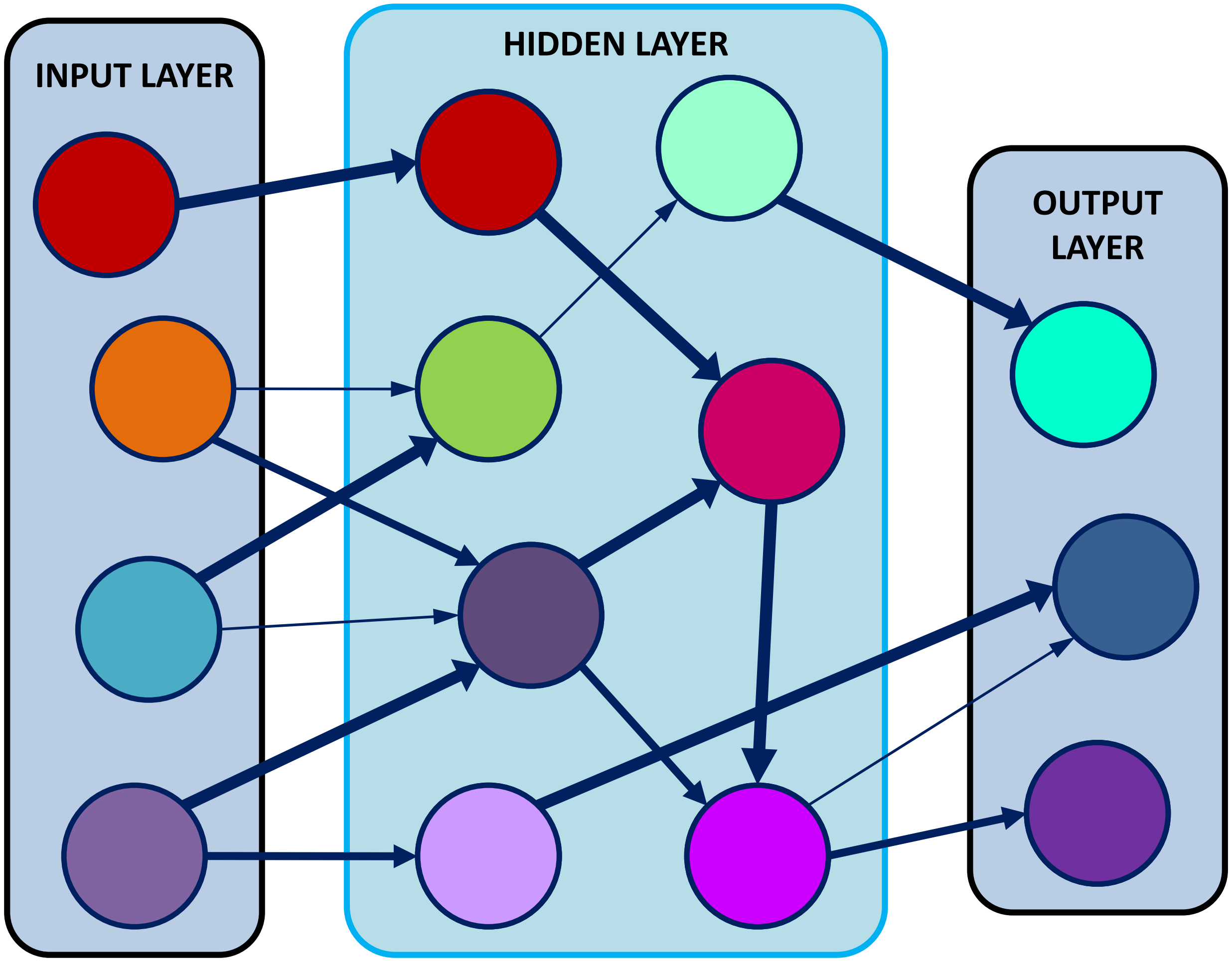


Effect of Weighted Connections

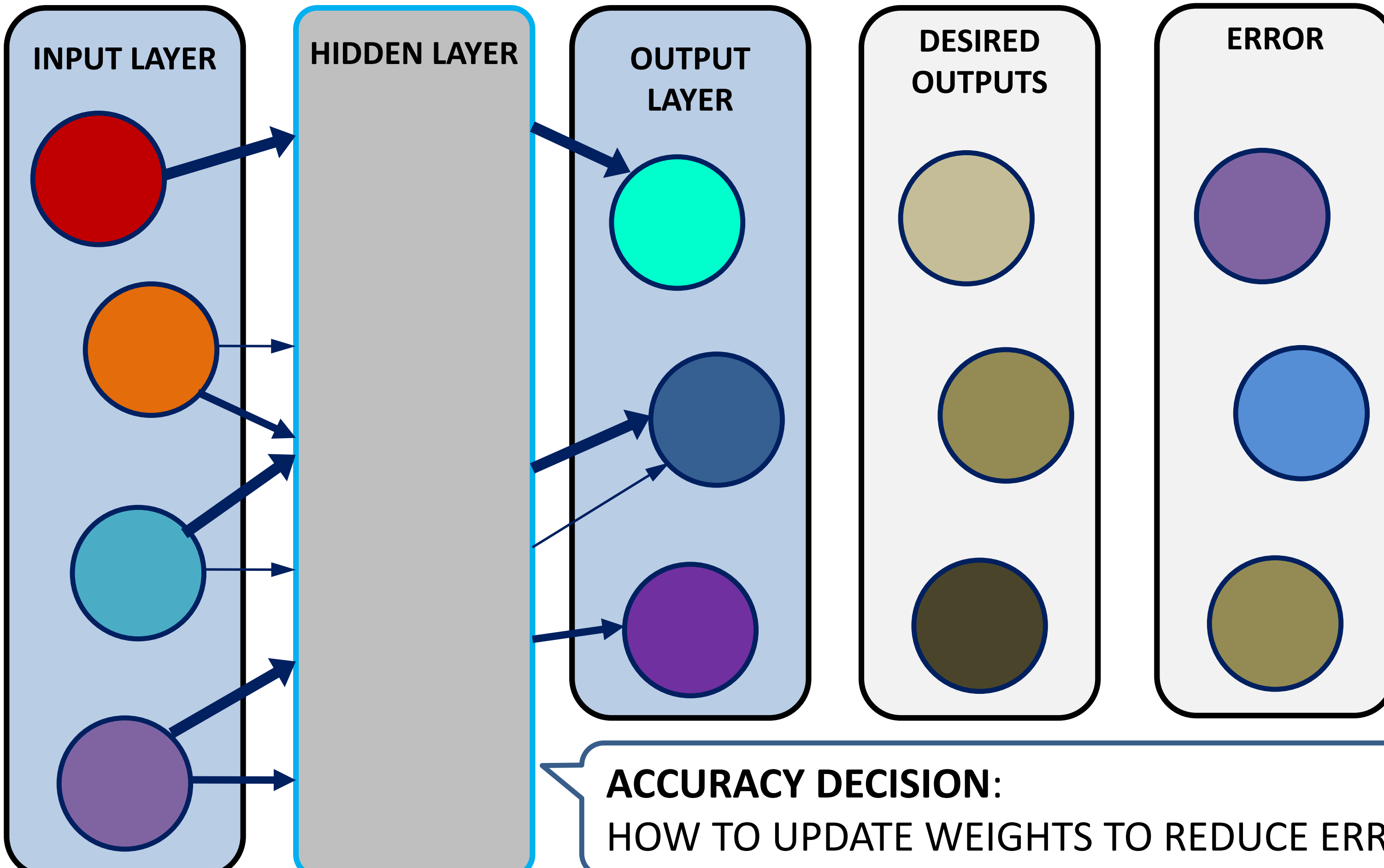




Example of Weighted Connections



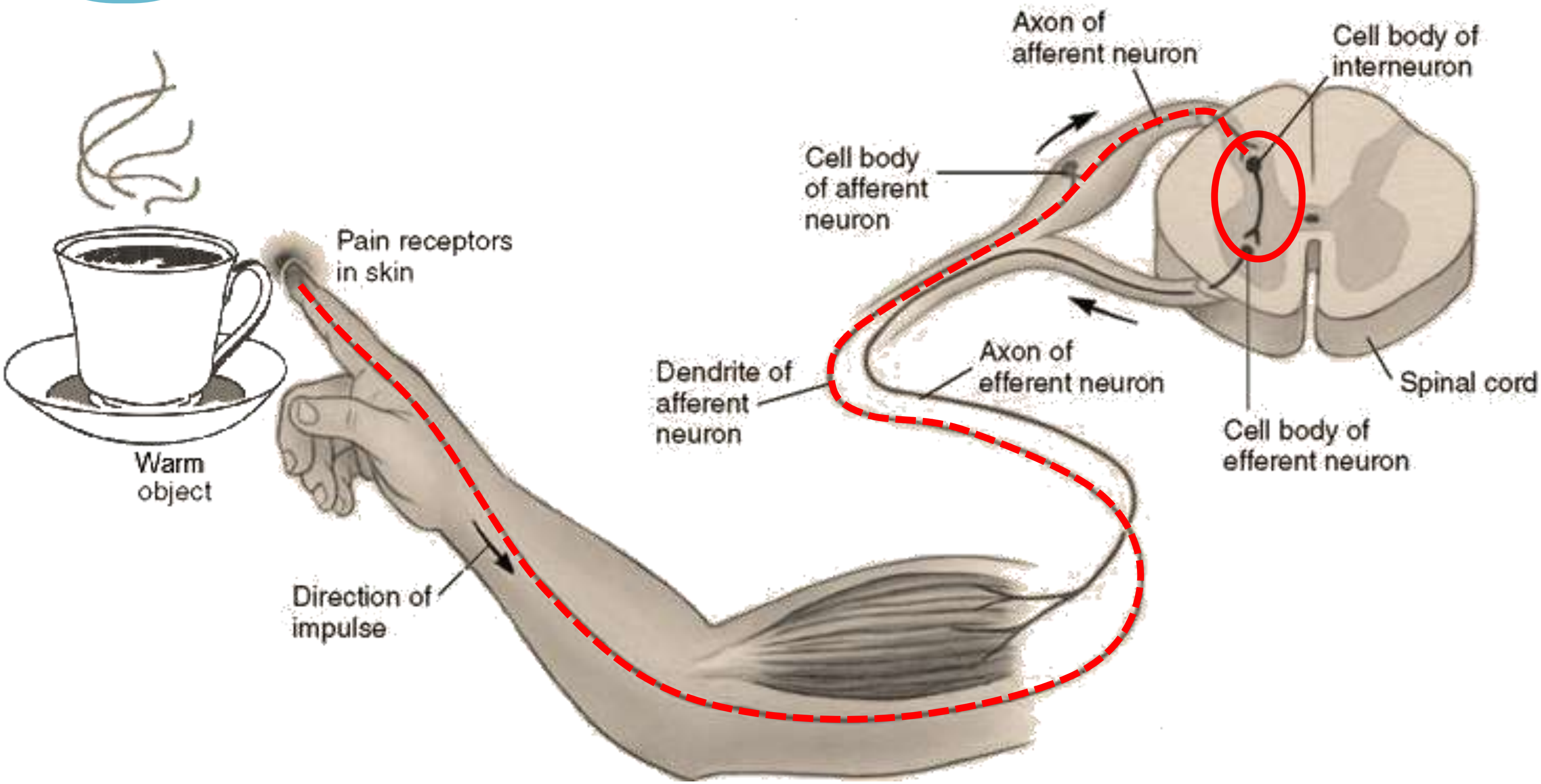
Decision Making in Neural Networks



ACCURACY DECISION:
HOW TO UPDATE WEIGHTS TO REDUCE ERROR?

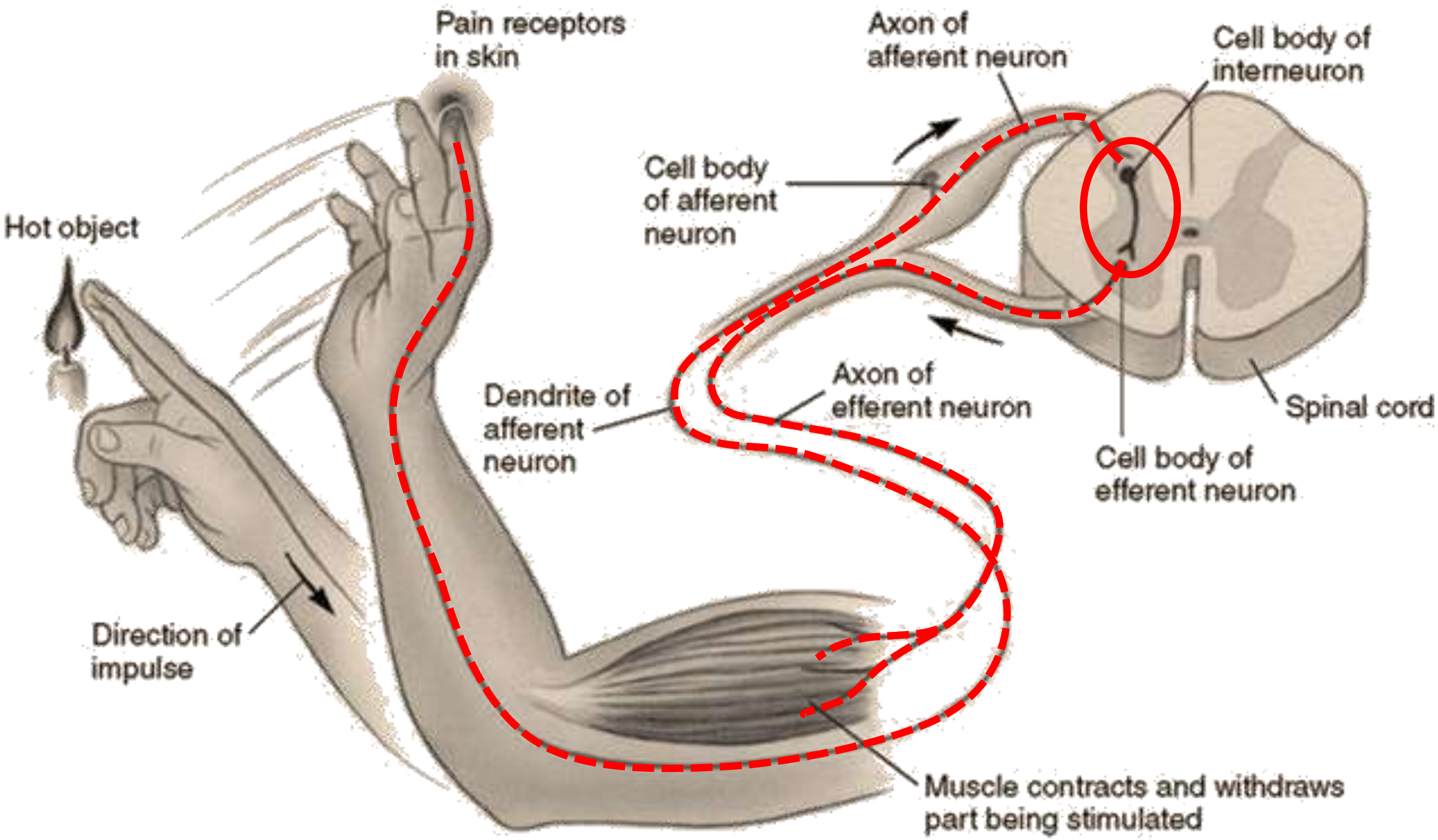
Introduction

Thresholding in Biological Neural Network

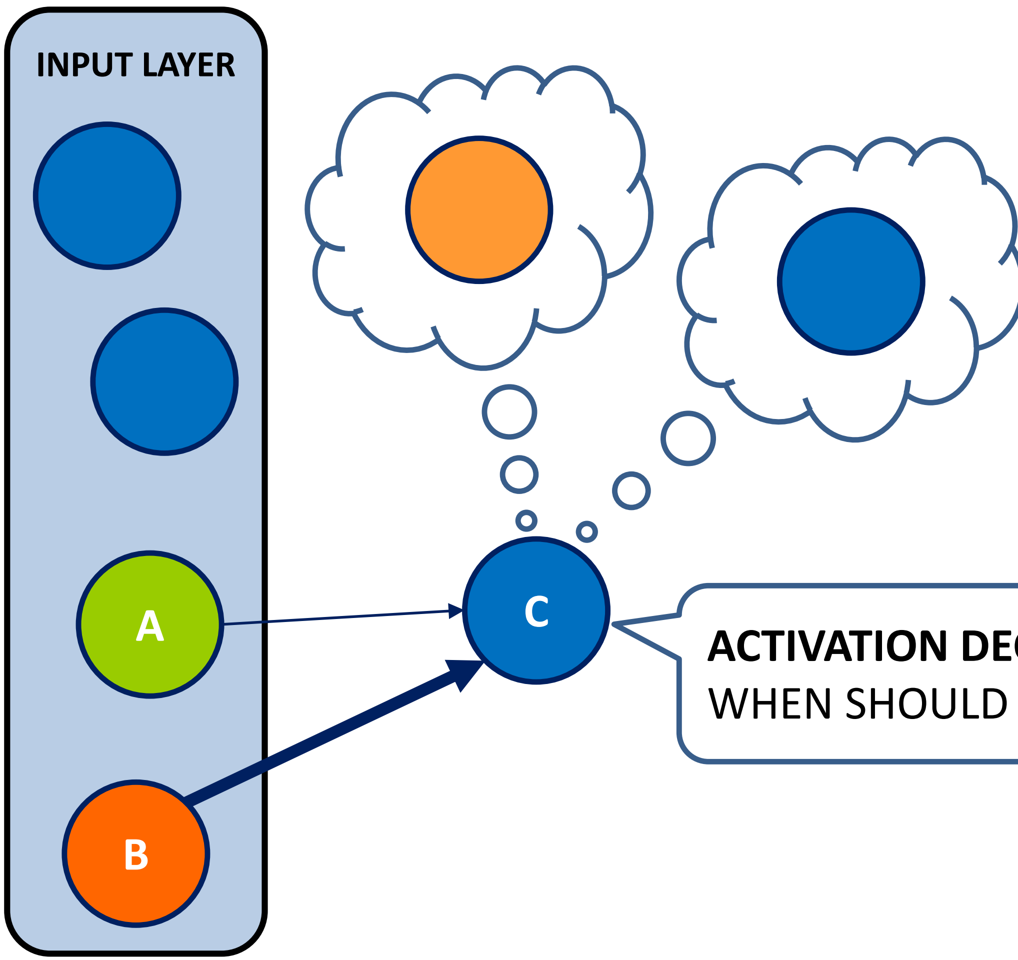


Introduction

Reflex Action in Biological Neural Network



Decision Making in Neural Networks



ACTIVATION DECISION:
WHEN SHOULD THE NODE FIRE ITS OUTPUT?

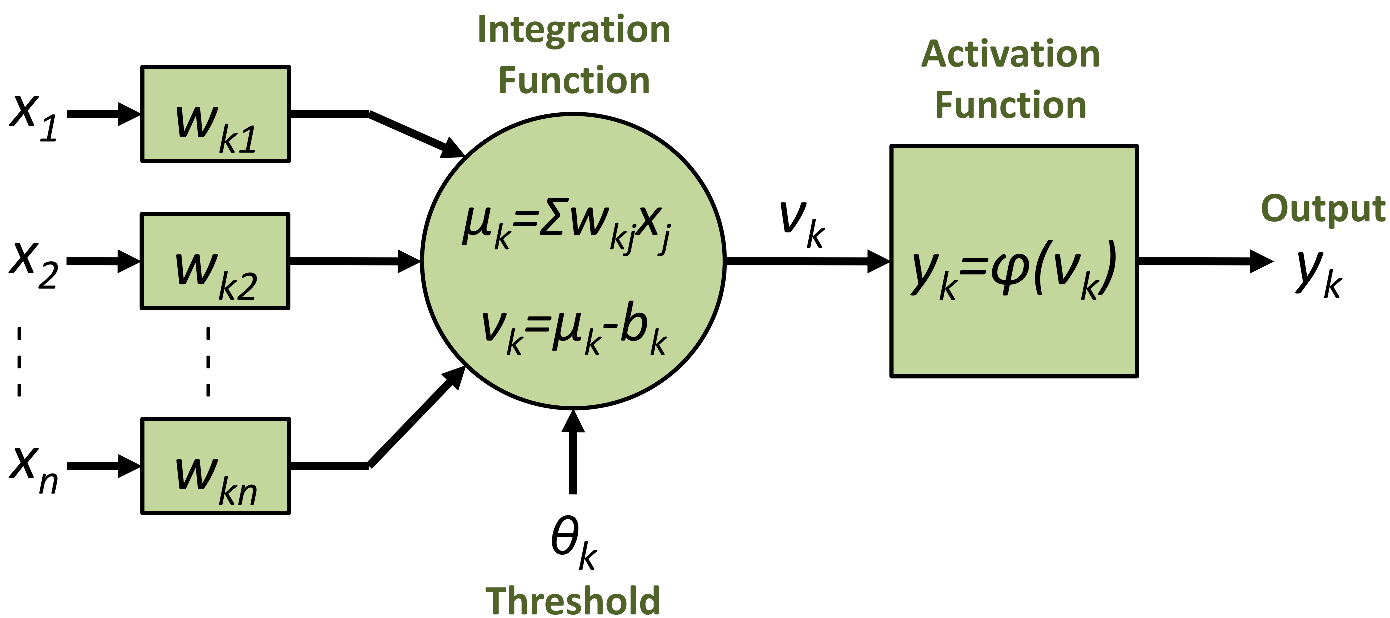
Neural Networks Modeling Aspects

- Fundamental issues in modeling of an artificial neural network:
  - How to assign weights to the connections?
  - How to determine the neuron output threshold?

- Major steps in modeling an artificial neural network:
  - Model a single neuron
  - Establish a pattern of neuron interconnectivity
  - Implement a learning mechanism

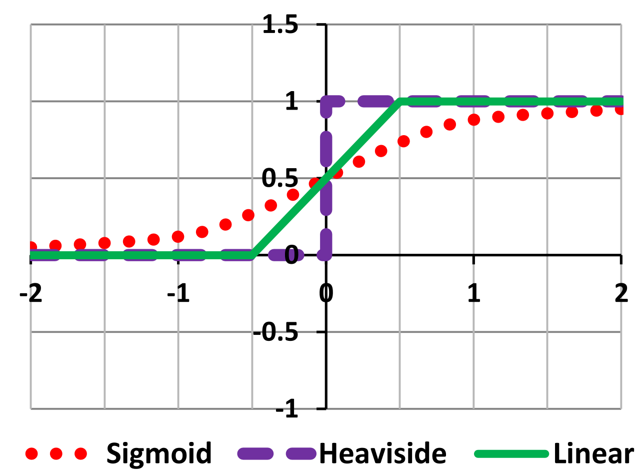
Modeling an Artificial Neuron

- **Perceptron Model**: Developed by Rosenblatt in 1957.
- Other neuron models are adaptations of perceptron model

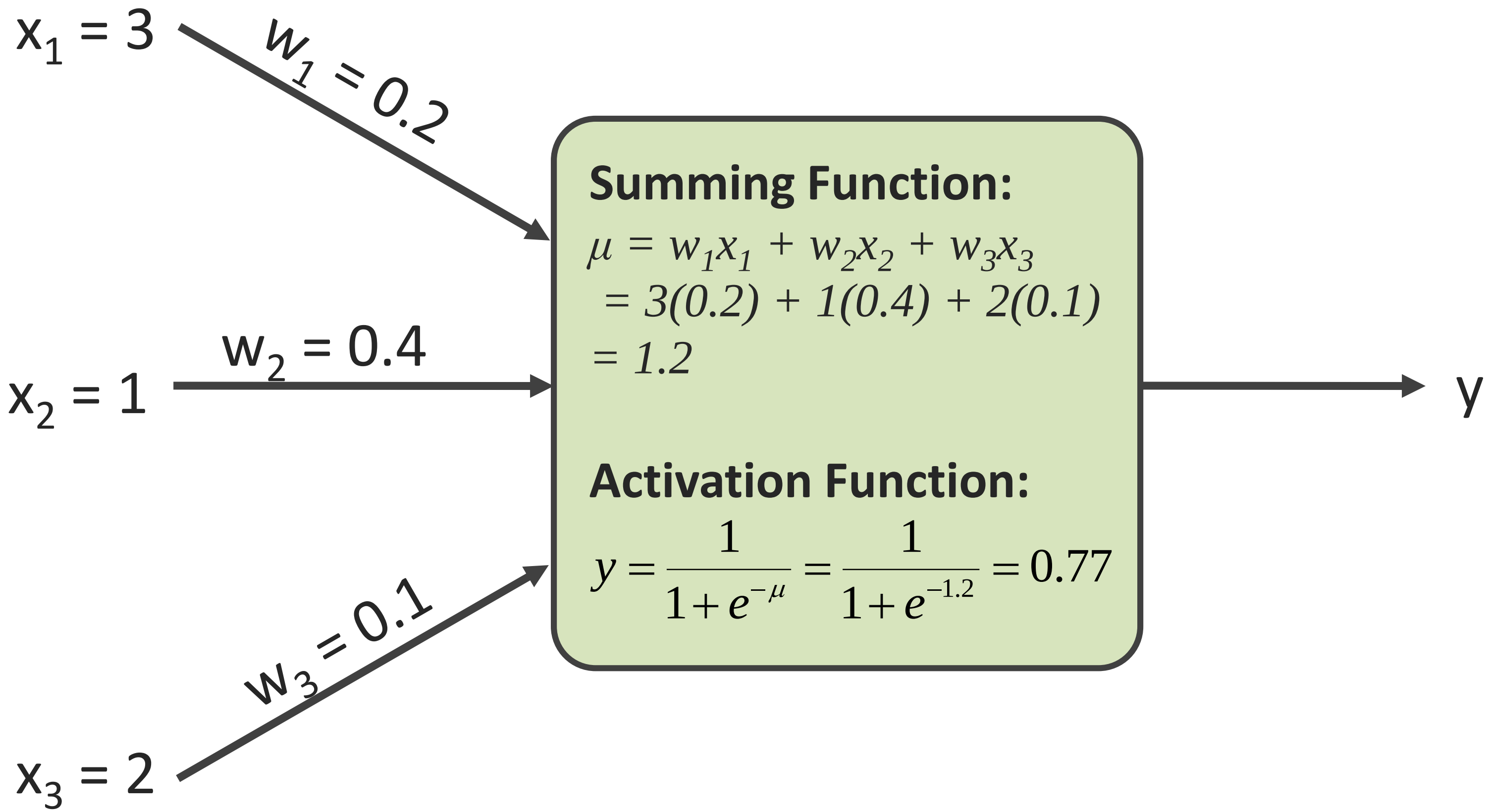


Perceptron Model of Neuron

- **Input signals**:
  - Continuous or discrete values fed from previous neurons
  - Each input associated with a Weight
- **Integration Function**:
  - Usually a weighted summation function
  - Threshold/Bias regulates result of Integration Function
  - Output is called *neuron net input*
- **Activation/Transfer Function**:
  - Usually a non linear function
  - Output interval [0,1] or [-1,1]
  - Output values continuous or discrete

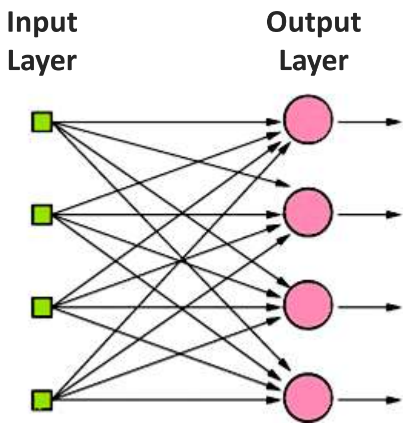


Perceptron Model Example

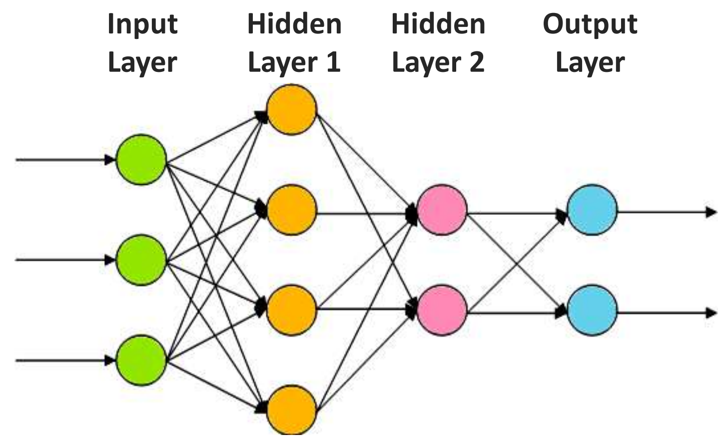


Neural Networks Modeling

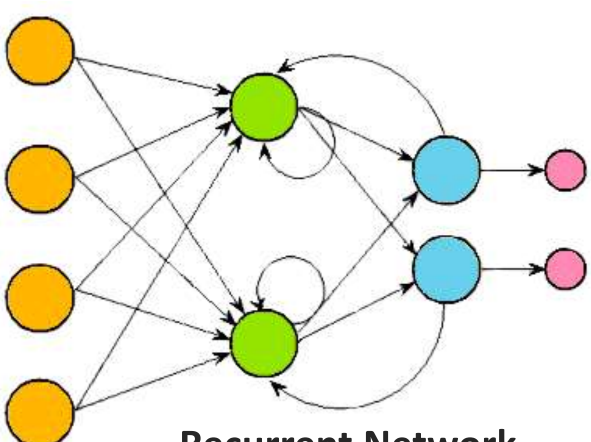
Connecting Neurons to Build Networks



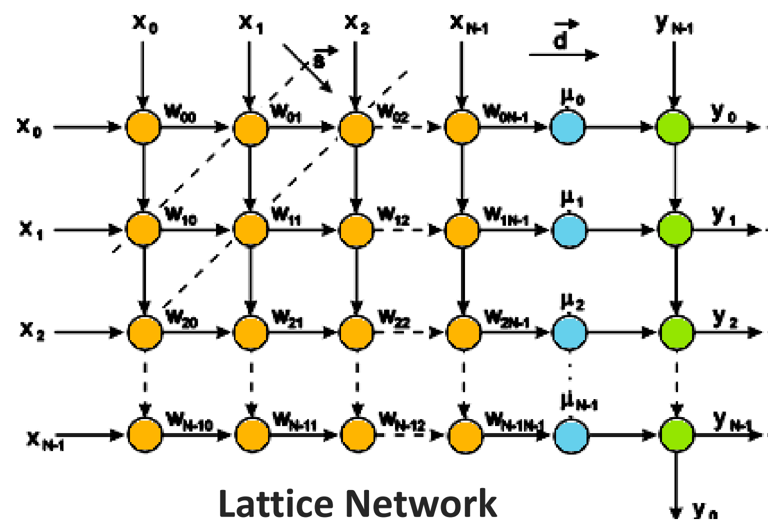
Single Layer Feedforward Network



Multi- Layer Feedforward Network



Recurrent Network

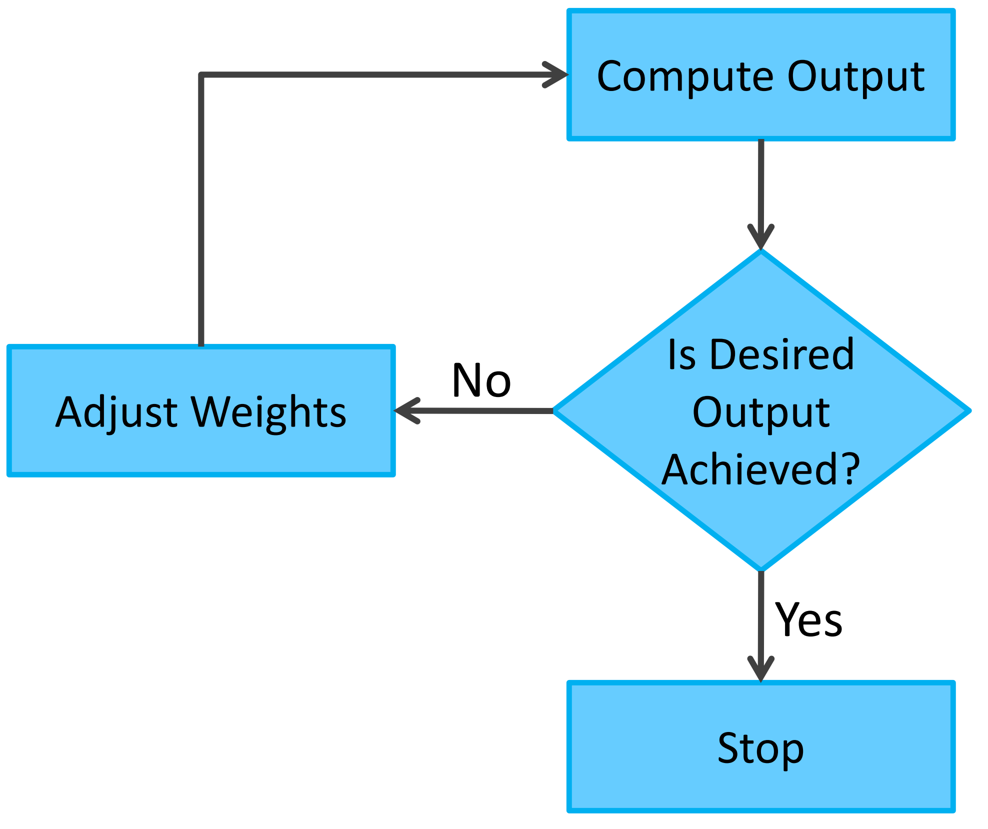


Lattice Network

Learning Algorithms in Neural Networks

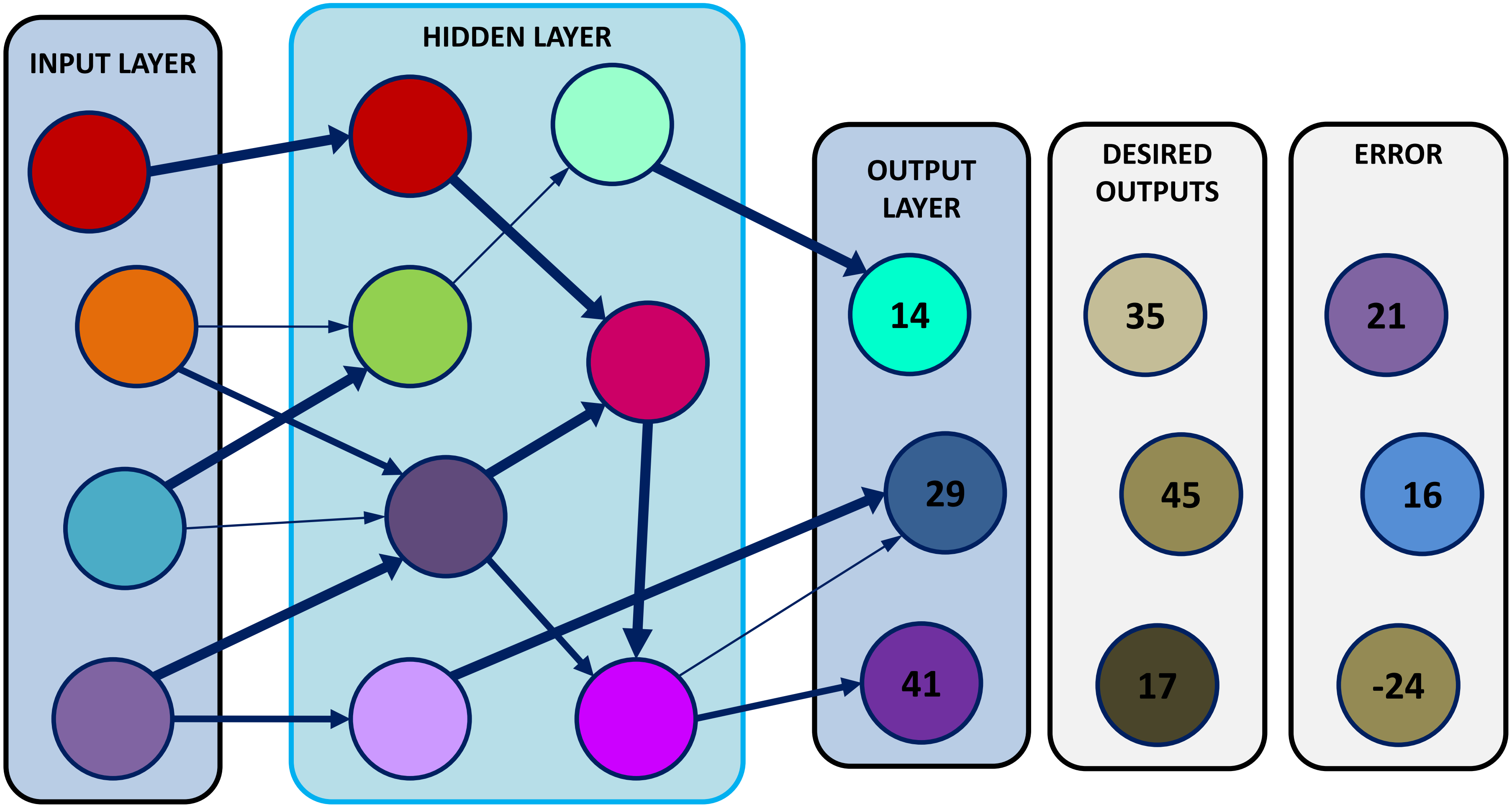
	Supervised Learning	Unsupervised Learning
Binary Valued Input	• Hopfield Network • Boltzmann Machine	• ART I
Continuous Valued Input	• Backpropagation • Percepteron	• ART II • Self-Organising Feature Maps

Supervised Learning in Neural Networks

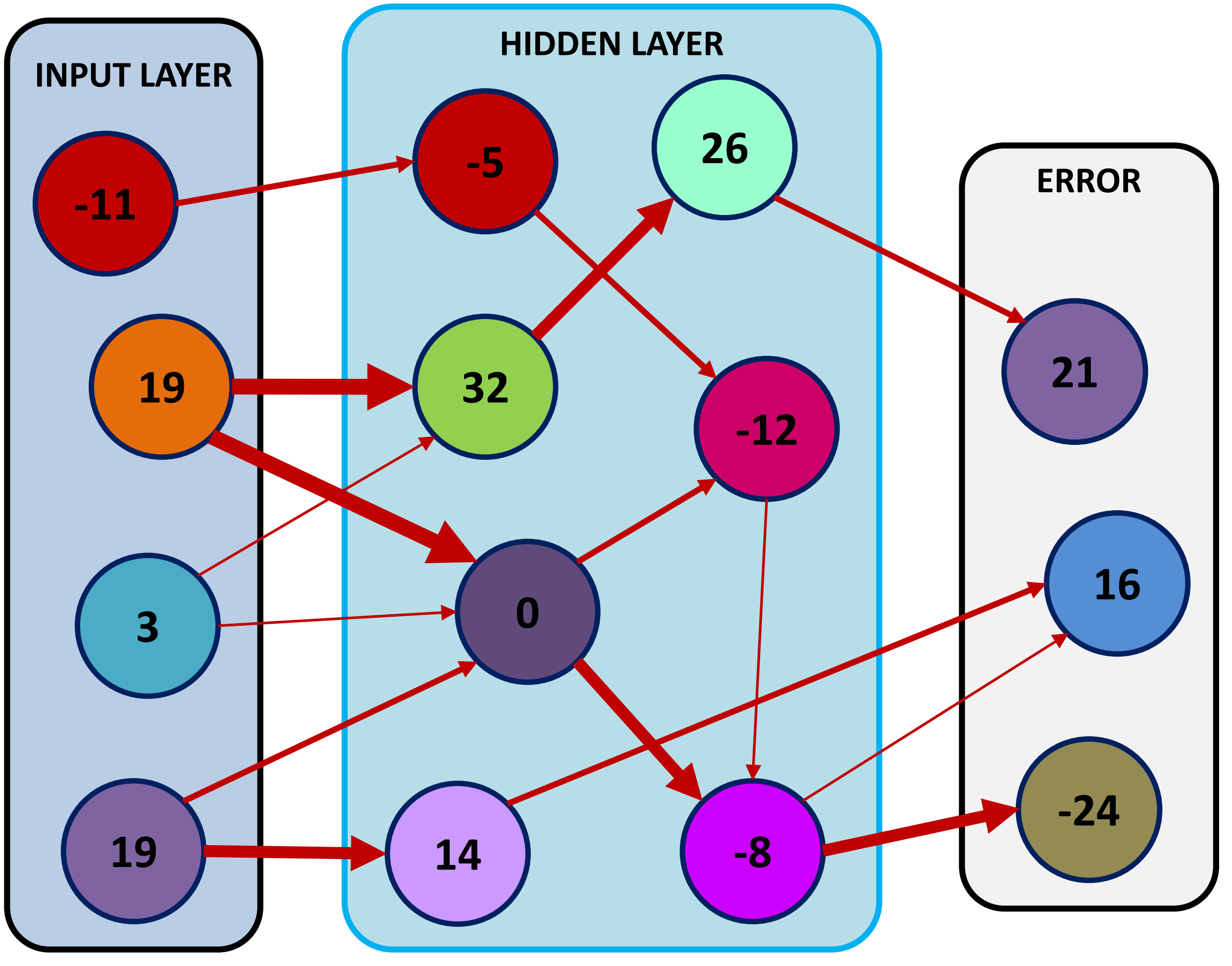


Neural Networks Modeling

First Run of the Network

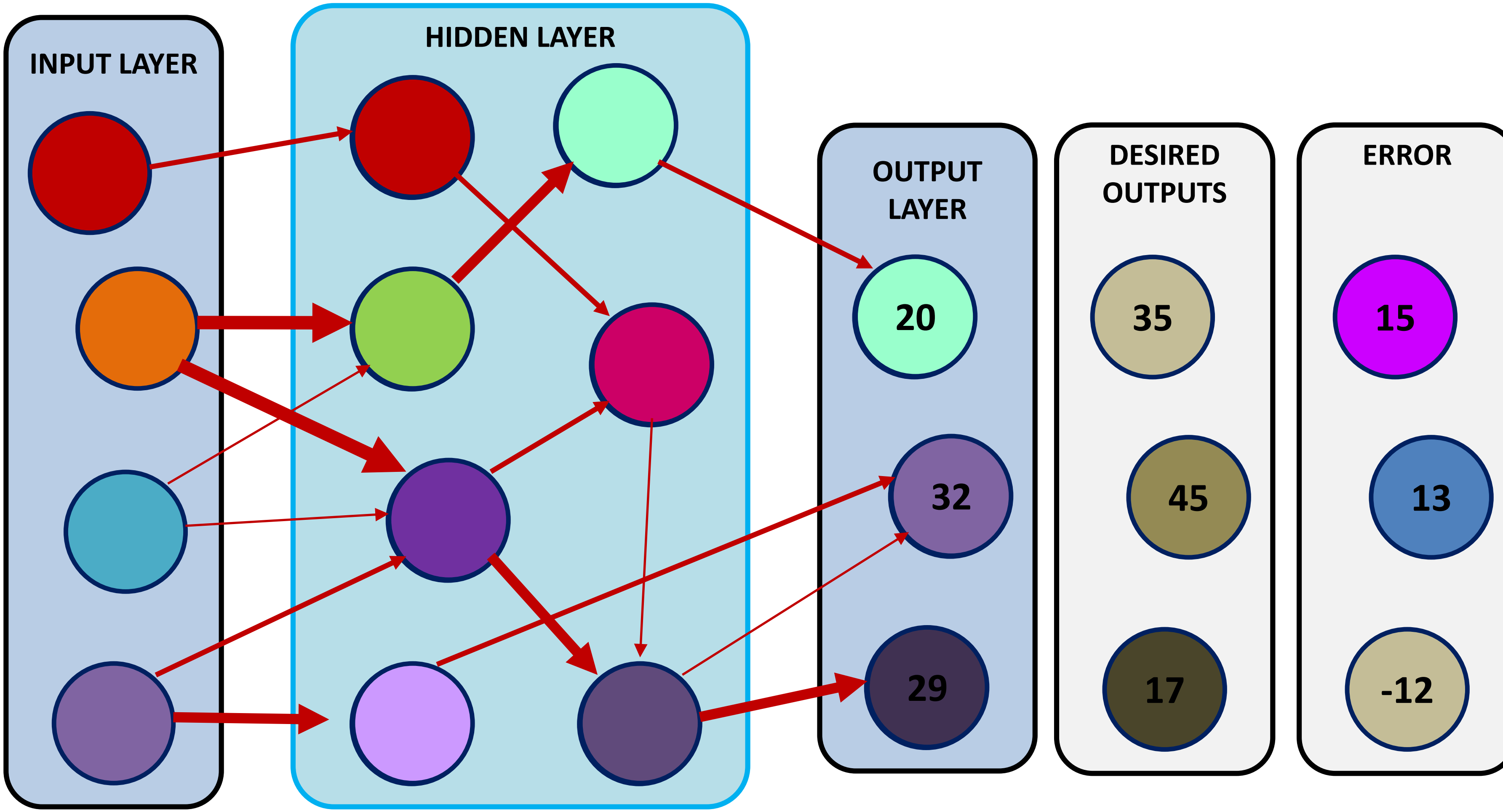


Backpropagation of Output Error

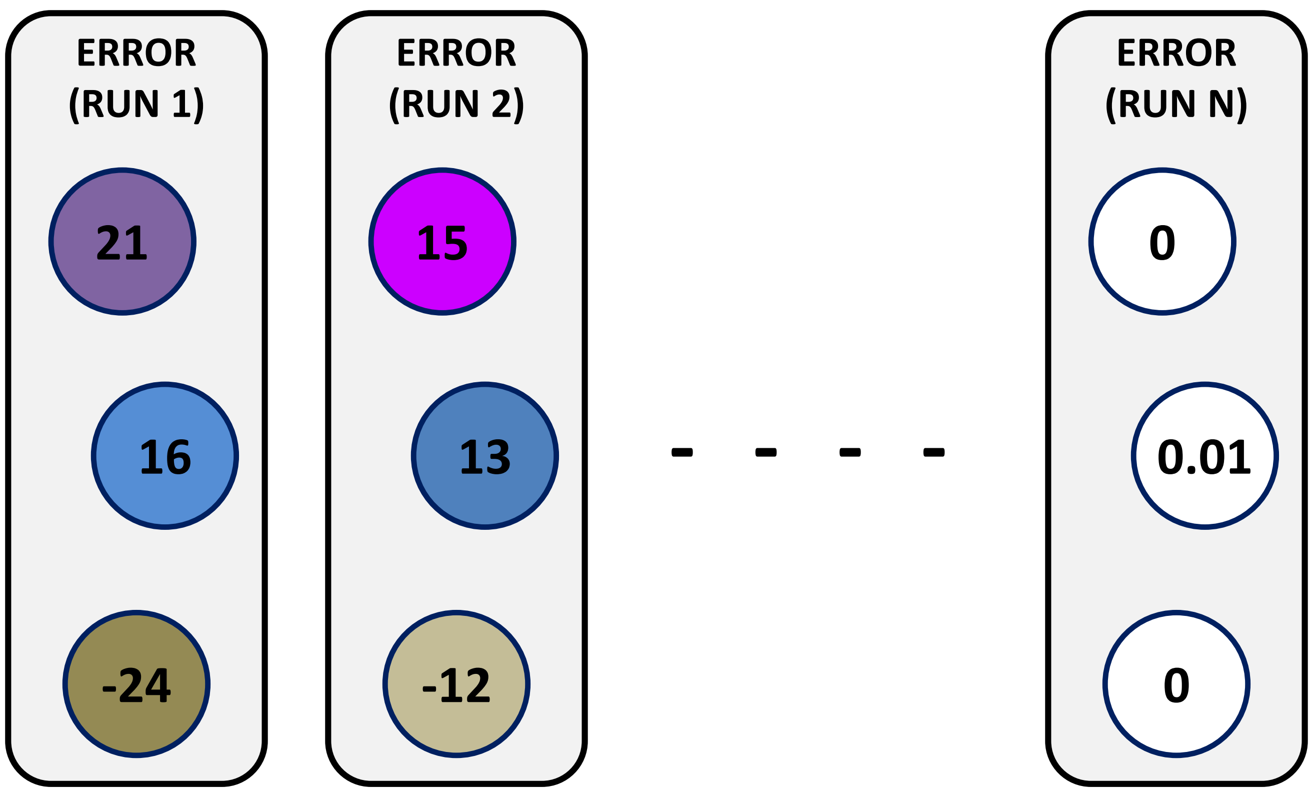


Neural Networks Modeling

Second Run of the Network

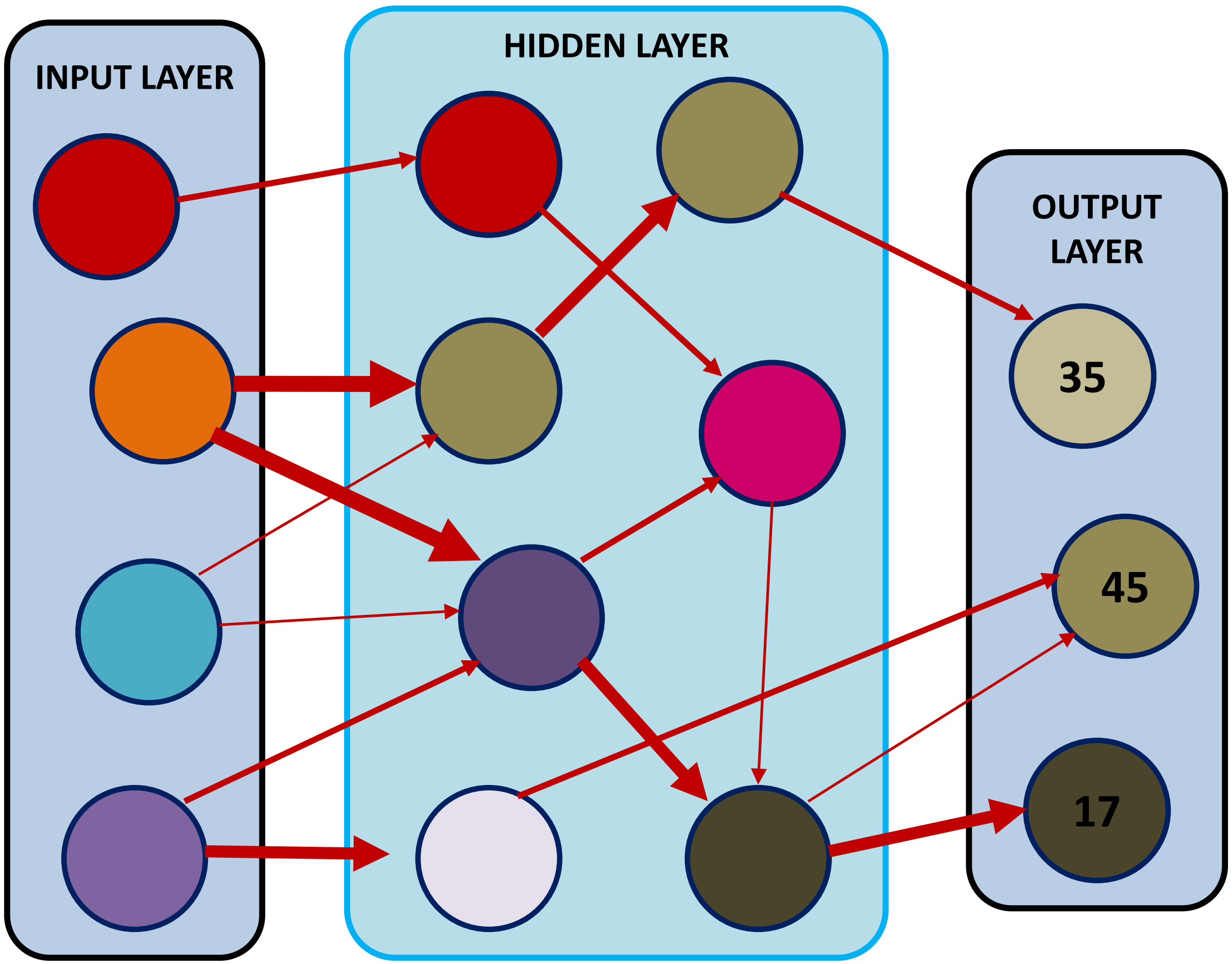


Reduction of Output Error



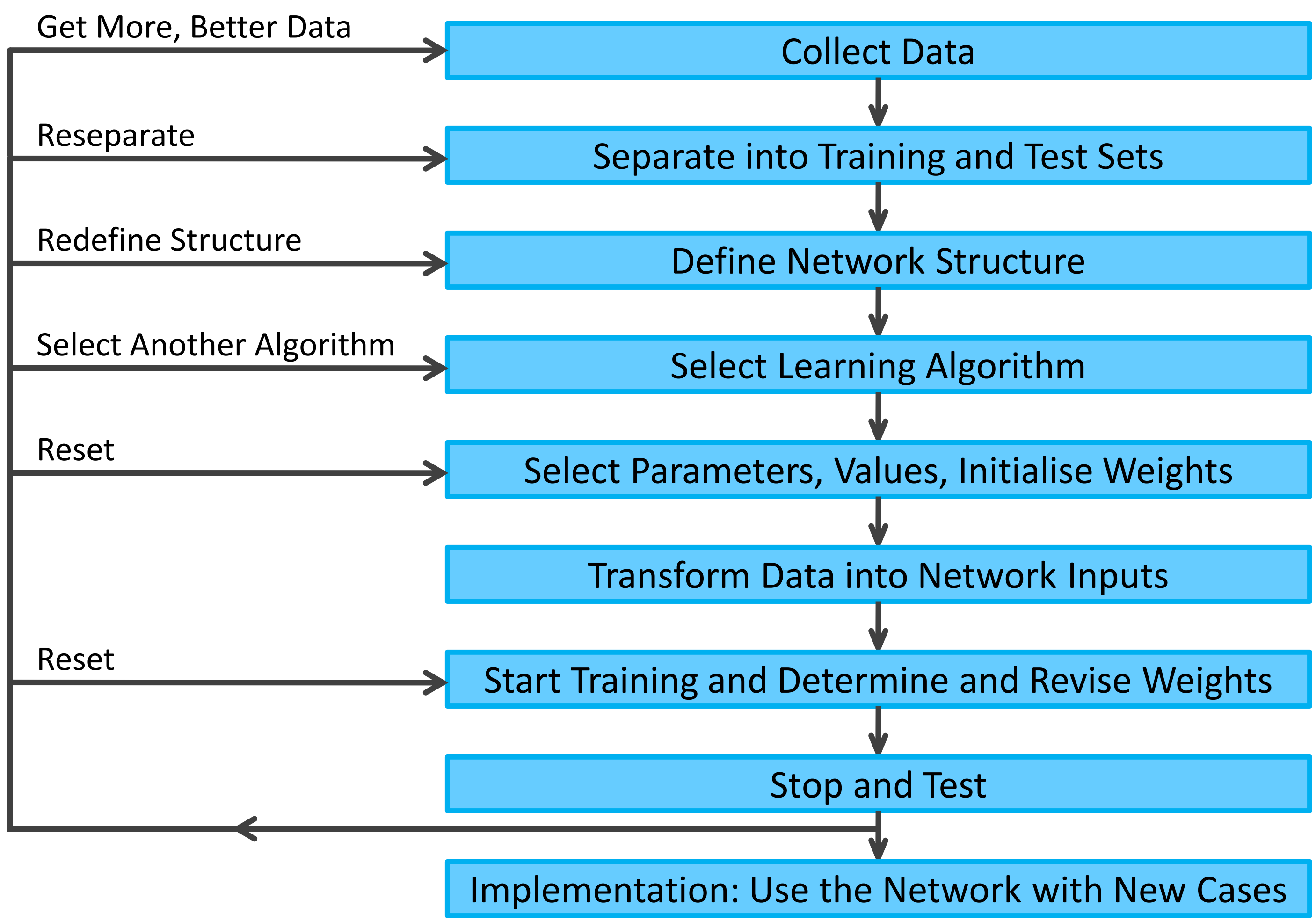
Neural Networks Modeling

After Many Runs of the Network



Neural Networks Modeling

Developing a Neural Network



Artificial Neural Networks

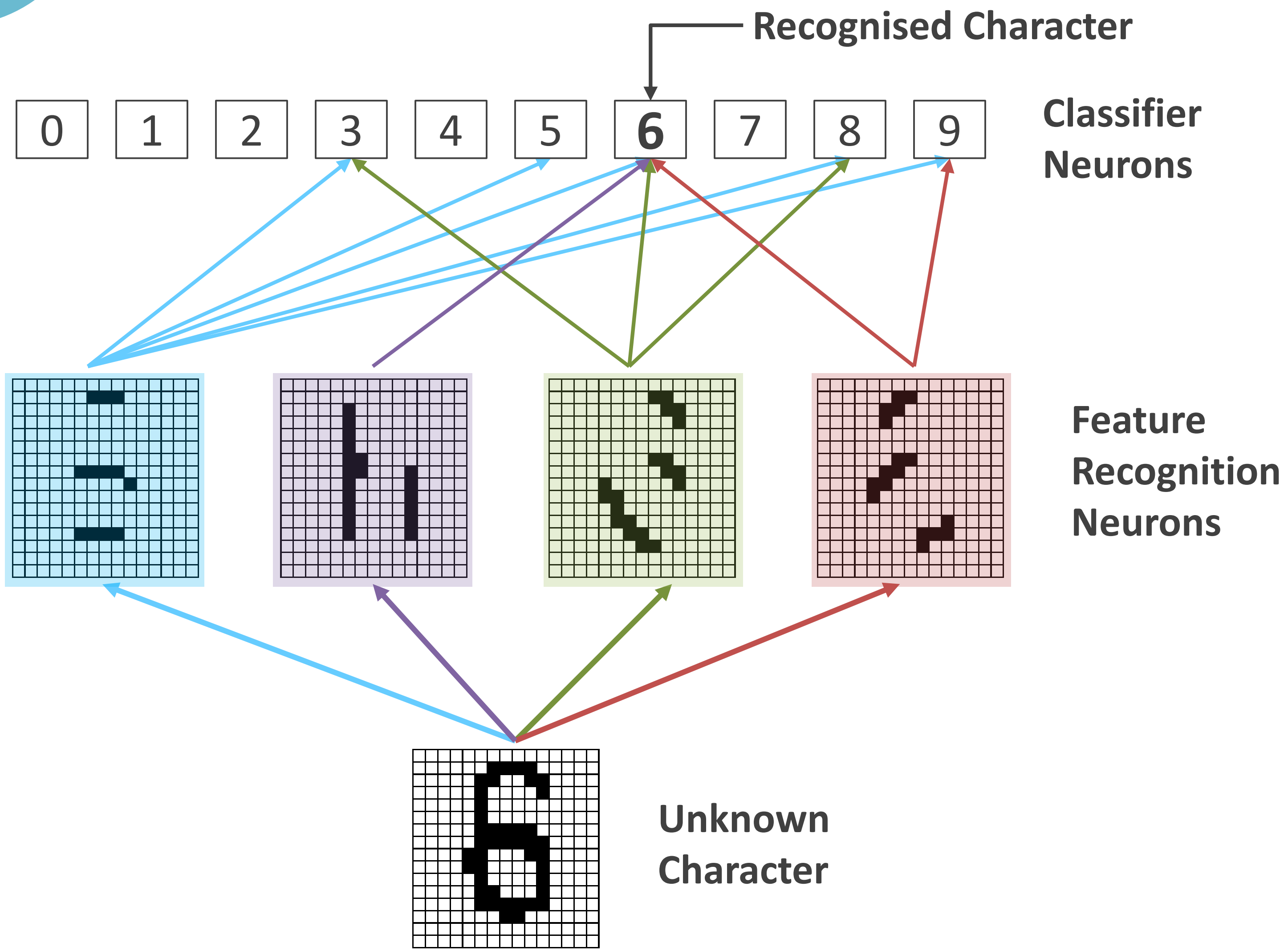
Neural Networks Applications

What are neural networks used for?

- **Classification**: Assigning each object to a known specific class
- **Clustering**: Grouping together objects similar to each other
- **Pattern Association**: Presenting of an input sample triggers the generation of specific output pattern
- **Function approximation**: Constructing a function generating almost the same outputs from input data as the modeled process
- **Optimization**: Optimizing function values subject to constraints
- **Forecasting**: Predicting future events on the basis of past history
- **Control**: Determining values for input variables to achieve desired values for output variables

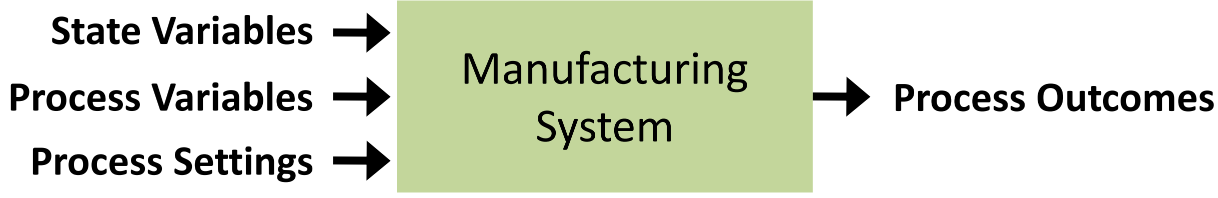
Applications of Neural Networks

ANN Feature Recognition (OCR Software)

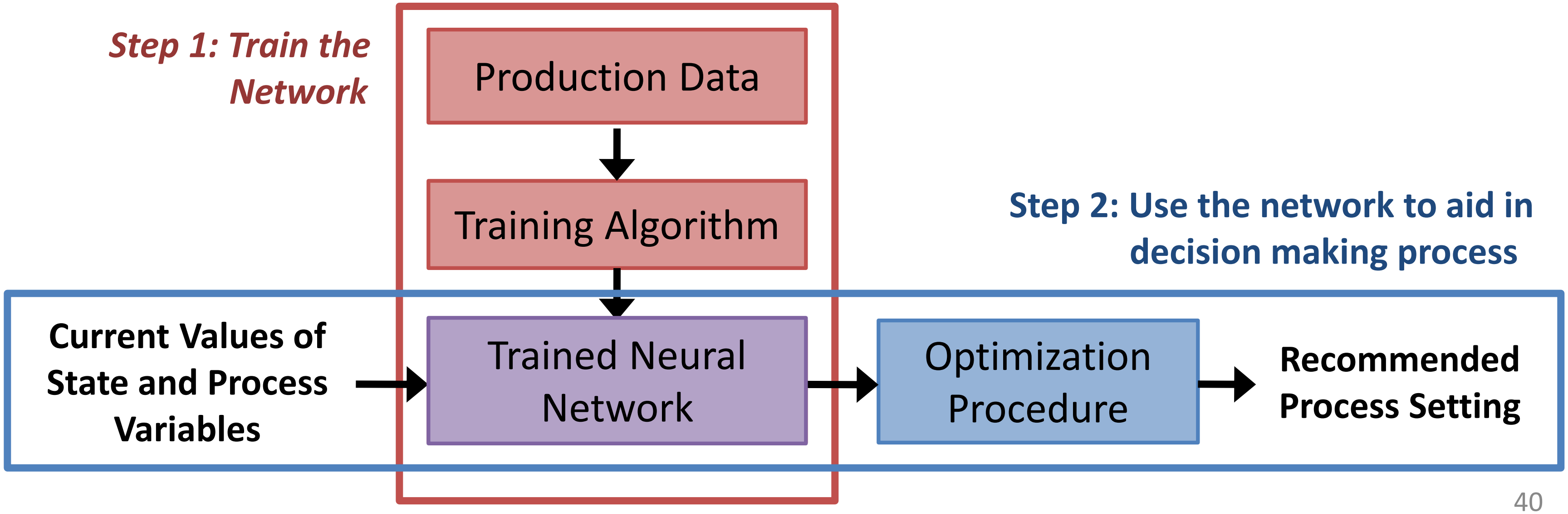


Neural Networks in Manufacturing

- Manufacturing process decision problem:



- Neural network enabled decision support system:



Neural Networks in Manufacturing

- Modeling and Design of Manufacturing Systems
  - Cell Formation for Agile and Flexible Manufacturing
  - Optimization and Simulation of manufacturing system
  - Forecasting and Cost Estimation
  - AGV path determination

- Modeling, Planning, and Scheduling of Manufacturing Processes
  - Production and Machine-scheduling
  - Kanban Determination
  - Resource queuing and scheduling
  - Economic order quantity

Neural Networks in Manufacturing

- Monitoring and Control of Manufacturing Processes
  - Parameter Selection
  - Automated Process Control eg: pressing, rolling, welding, EDM, WEDM
  - Condition Monitoring for Machines and Tools
  - Robot part handling

- Quality Control, Quality Assurance, and Fault Diagnosis
  - Recognizing Handwritten Characters and Graphs
  - Visual Edge Detection
  - Pattern recognition
  - Fault Diagnosis and Troubleshooting

Neural Networks Applications

Neural Networks in Injection Moulding

Inputs		Encoding	Inputs		Encoding
Part envelope length [mm]	L_P	True Value	Mould height [mm]	H_M	True Value
Part envelope width [mm]	W_P	True Value	Parting line/surface complexity	CX_{PL}	-1=Simple / Flat 0=Moderately complex (Smoothly shaped, Small steps) +1=Free-form (Complex, non-tangential surfaces, big steps)
Part envelope height [mm]	H_P	True Value	Number of sliders per cavity, Ejection side	$N_{S,ES}$	True Value
Part surface area [mm²]	S_P	True Value	Number of lifter cores per cavity, Ejection side	$N_{LC,ES}$	True Value
Part volume [mm³]	V_P	True Value	Ejection	EJ	0=Simple/ Single stroke 1=Multiple strokes
Nominal part thickness [mm]	T_P	True Value	Injection system	IS	-1=Cold runner system 0=Combined system +1=Hot runner system
Part material	M_P	-1= Semi-crystalline +1=Amorphous	Cavity material, Injection side	$M_{C,IS}$	0=Non Hardened or Pre-Hardened 1=Hardened steel

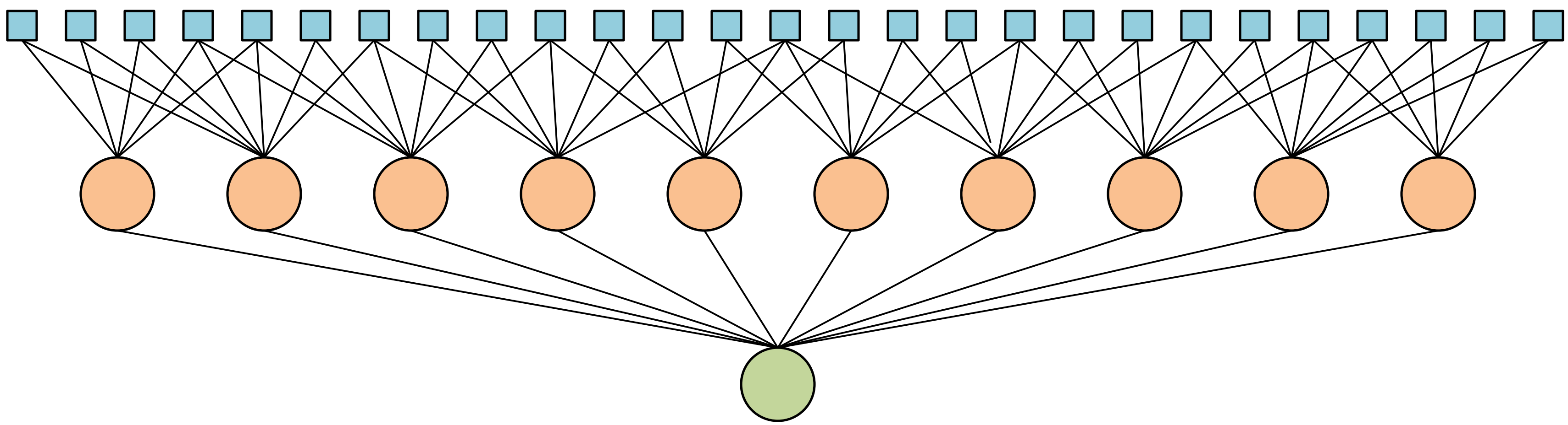
Neural Networks in Injection Moulding

Inputs		Encoding	Inputs		Encoding
Envelope volume [mm³]	V_E	True Value	Cavity material, Ejection side	$M_{C,ES}$	0=Non Hardened or Pre- Hardened 1=Hardened steel
Part complexity /Cavity detail	CX_P	-1=Simple/ Low detail 0=Moderately complex +1=Complex/ High detail	Surface finish, Injection side	SF_{IS}	0=Polished with sandpaper, Fine EDM, Fine milled/ Machined ... 1/2=High polished 1=High polished-Class A surfaces
Overall dimensional tolerance requirements of the part	DT_P	0=Class 4 (<0.5), Class 5 (<1), Class 6 (>1) 1=Class 3 (<0.1), Class 2 (<0.05), Class 1 (<0.01)	Surface finish, Ejection side	SF_{ES}	0=Polished with sandpaper, Fine EDM, Fine milled/ Machined ... 1/2=High polished 1=High polished-Class A surfaces
Mould length [mm]	L_M	True Value			
Mould width [mm]	W_M	True Value			

Outputs		
Manufacturing hours	*VMH*	True Value

Neural Networks in Injection Moulding

- Neural Network Configuration: 27-10-1



- Correlation coefficient = 0.9254
- RMSE = 1.3%-19%

Final Words

“ Artificial neural networks are still far away from biological neural networks , but what we know today about artificial neural networks is sufficient to solve many problems that were previously unsolvable or inefficiently solvable at best. ”

Artificial Neural Networks

End Of Presentation