T8

Cognitive Systems

2020 edition

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cognitio

PSI 3560 – COGNITIVE SYSTEMS

class T8

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MACHINE LEARNING AND THE CONNECTIONISM

Statistical learning, traditional neural network approach, deep learning, advanced networks

Session T8

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Summary

  - First Session (7:30 – 9:10)
- Deductive versus Inductive inference
- Neuronal Nets
  - Purposes
  - Topologies
  - Learning procedures
- Correlation in datasets
- Causality
- Applications

Section 1

Deductive versus Inductive

- The cognitive quest
  - Cognition → Knowledge
    - Build it, use it…
    - Classical A.I. ("GOFAI")
      - Deductive inferences only
      - Knowledge is provided **to** the system
        - » No knowledge is actually produced by the system
        - » It is only transformed, reduced, summarized
      - Searches don't introduce new knowledge either
        - » The search space is specified, with all its contents
        - » The ontology of search space is known
          - All objects, all relationships…
          - Everything can be reduced to a symbol system
            - Inferences come from symbol manipulations

Deductive versus Inductive

- The cognitive quest
  - Cognition → Knowledge
    - Build it, use it…
    - Change deductive inference to inductive inference
      - Probabilistic inference
      - Machine Learning
        - » Is here a hope for building knowledge ?
        - » Knowledge can be learned from the data …
        - » … through an inductive process
          - The inductive process detects patterns in the data
            - These patterns bring the invariants
              - … that make the knowledge…

Deductive versus Inductive

- The cognitive quest
  - Cognition → Knowledge
    - Build it, use it…
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      - Probabilistic inference
      - Machine Learning
        - » Is here a hope for building knowledge ?
        - » Knowledge can be learned from the data …
        - » … through an inductive process
          - The inductive process detects patterns in the data
          - These patterns can be used to build new rules for behavior control, making the system more adaptive

Not actually !

Not machine learning

machine learning is just a tool

Knowledge here comes actually via training. For unsupervised learning, it is subsumed in the dynamics

Artificial Neural Networks

- The network, after being presented to an extensive set of cases (images or generally datasets) and trained to classify them, keeps a signature of those datasets (what is common to all or most of them)
- And then can identify among new data, if (how) do they belong to groups with that characteristic

Artificial Neural Networks

Human brain	
Neurons	90 B
Human cortex	
Neurons	30 B
Columns	500 k with 60 k neurons each
Pattern Recognizers	300 M with 100 neurons each

- Purposes
  - Classification
  - Comparison
- Topologies
  - Feedforward
    - multilayer perceptron (sequential connectivity)
  - Feedback
    - Hopfield (sequential connectivity)
  - Cooperative
    - Self Organized Maps (parallel connectivity)
- Learning Procedures or Training Strategies
  - Supervised Learning (guided by a professor)
  - Unsupervised Learning (reinforcement or self organized)

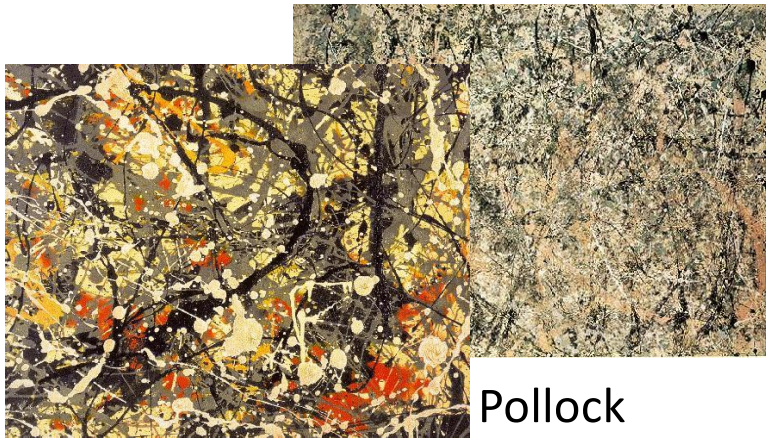
How / Why do we cluster things

- This is one of our cognitive abilities

Kandinsky

Van Gogh

Vermeer

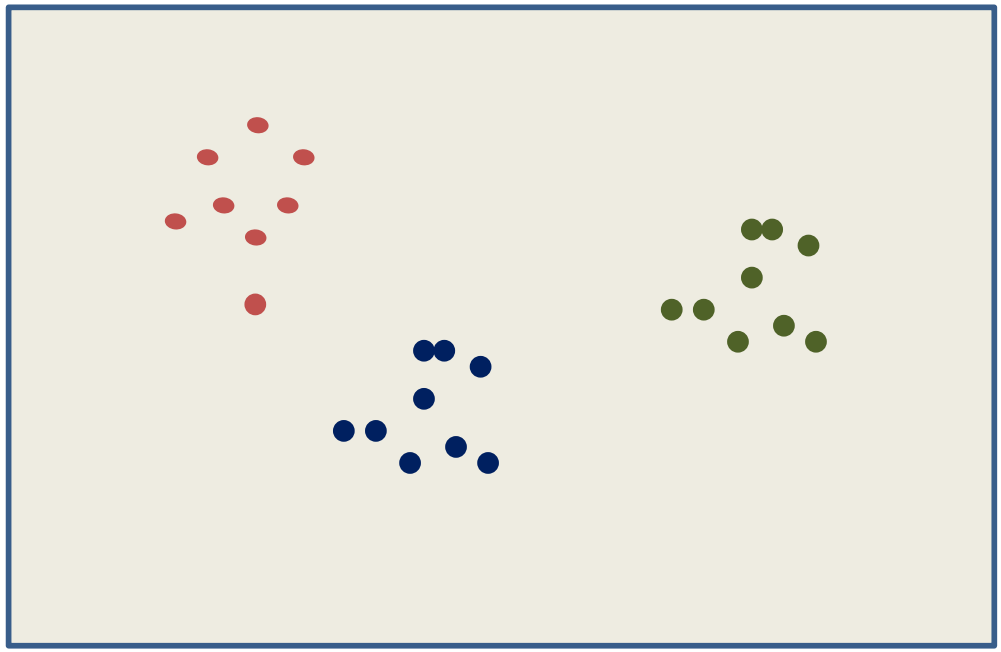


Pollock

Section 2

How / Why do we cluster things

- Features map: multidimensional (here 2D)
  - Exploring / identifying coherence
  - Similarity among features



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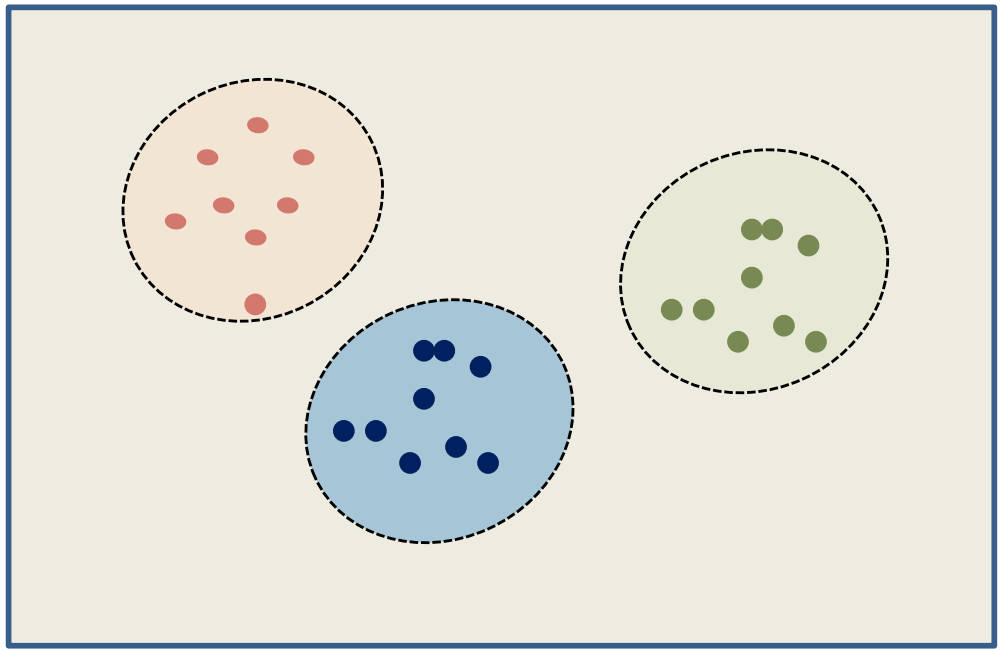

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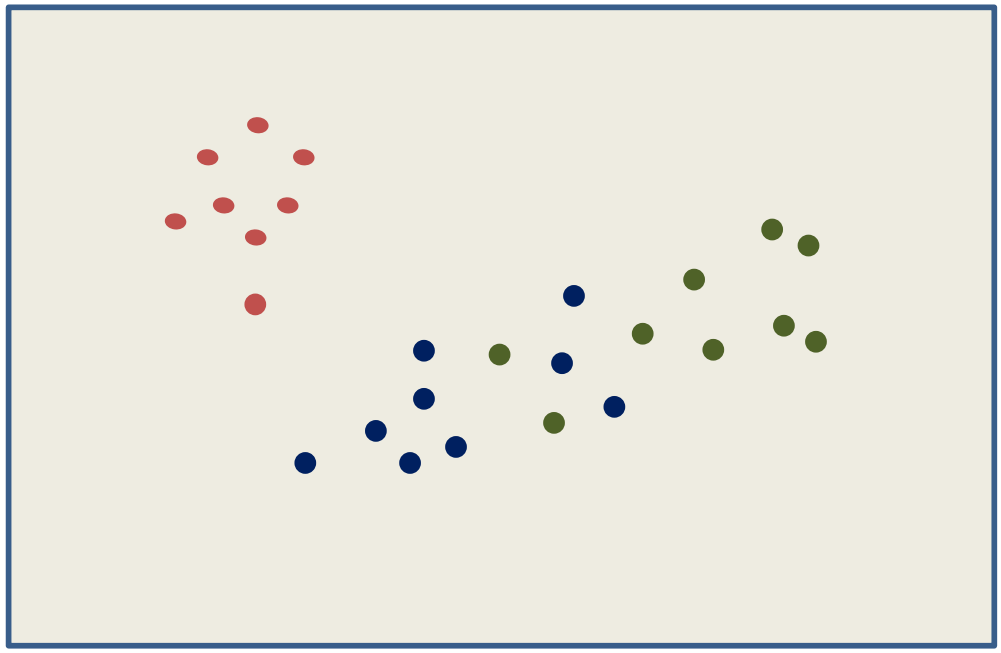

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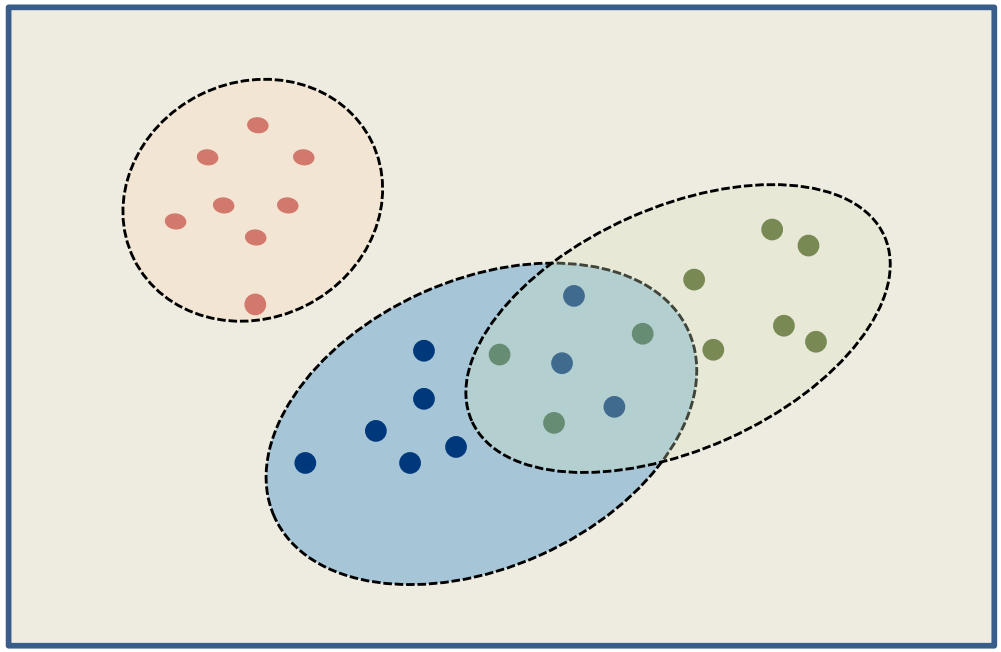

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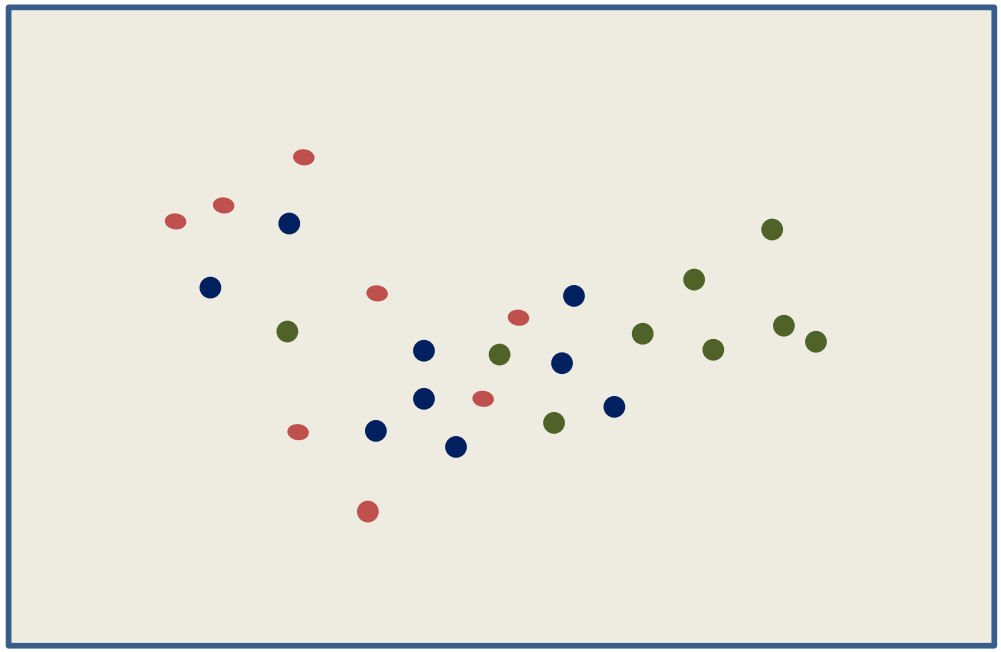

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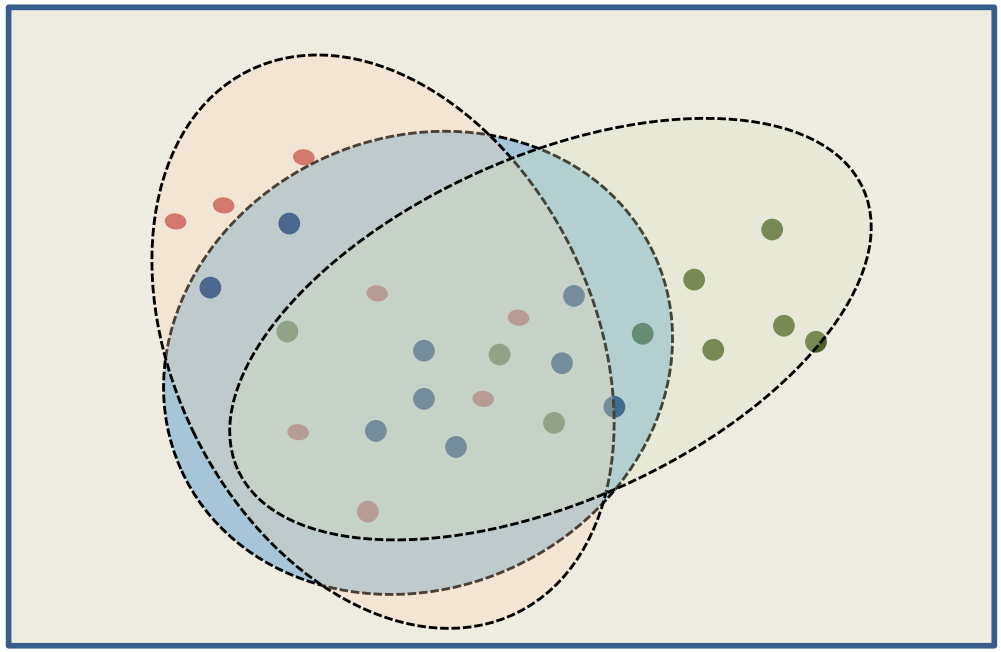
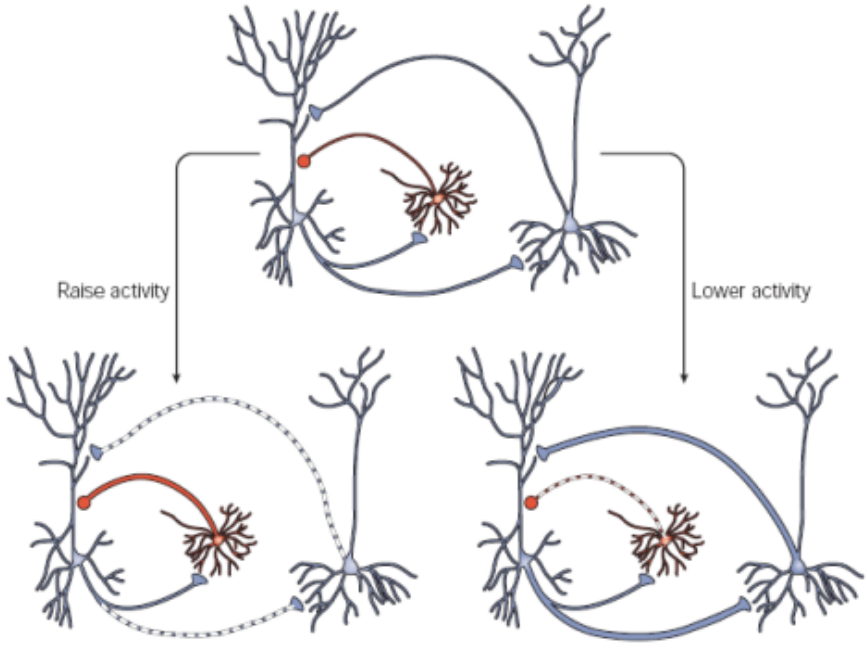


Section 3

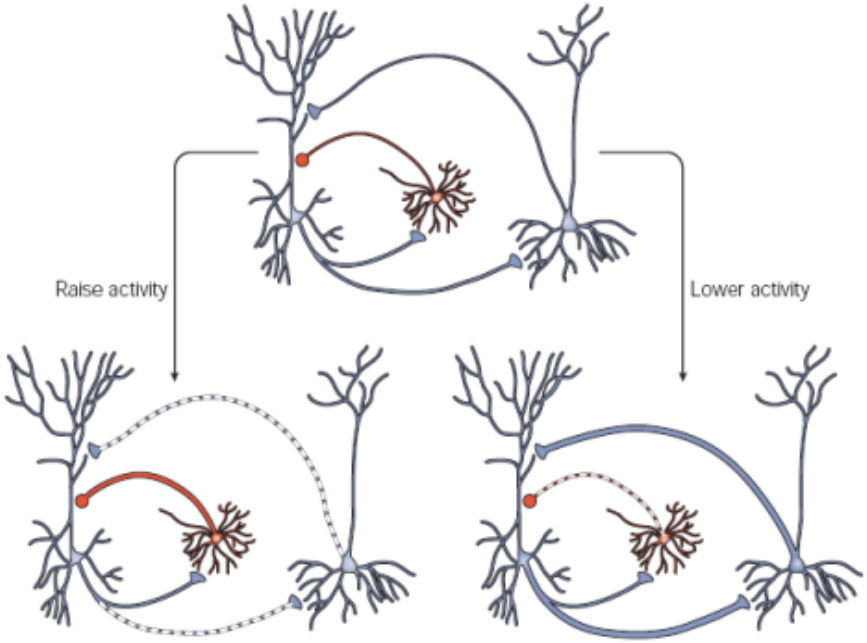
Natural Neural Networks

- Plasticity & Topology
  in Natural Neuronal Nets
  - Hebbian
    synaptic reinforcement
  - Topological / Structural
    strengthening
    or creation of
    connections

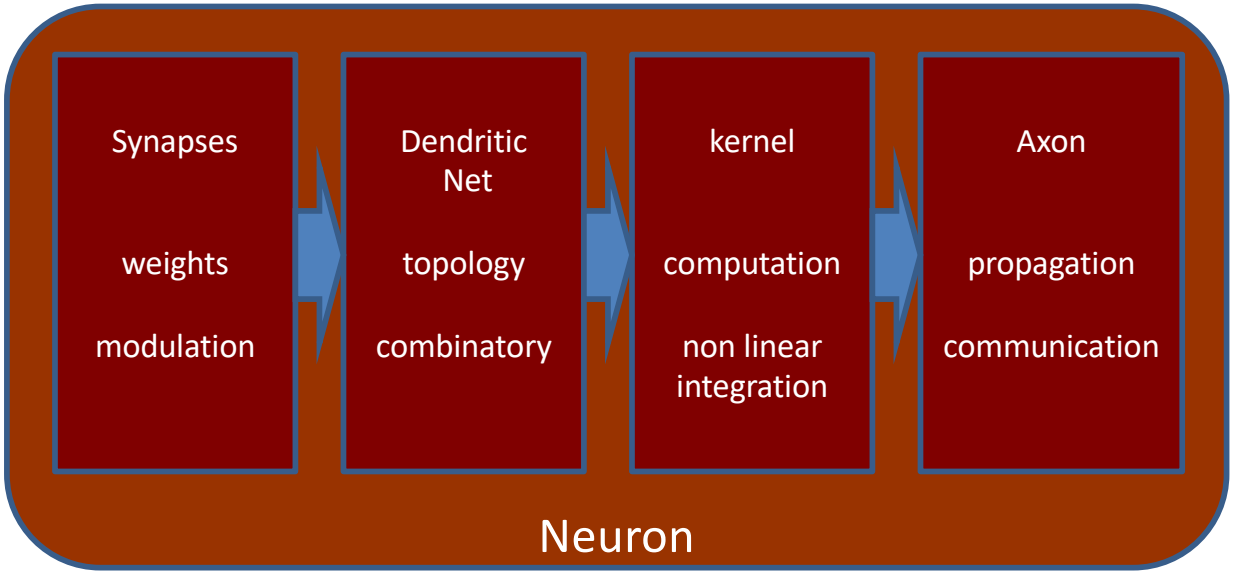


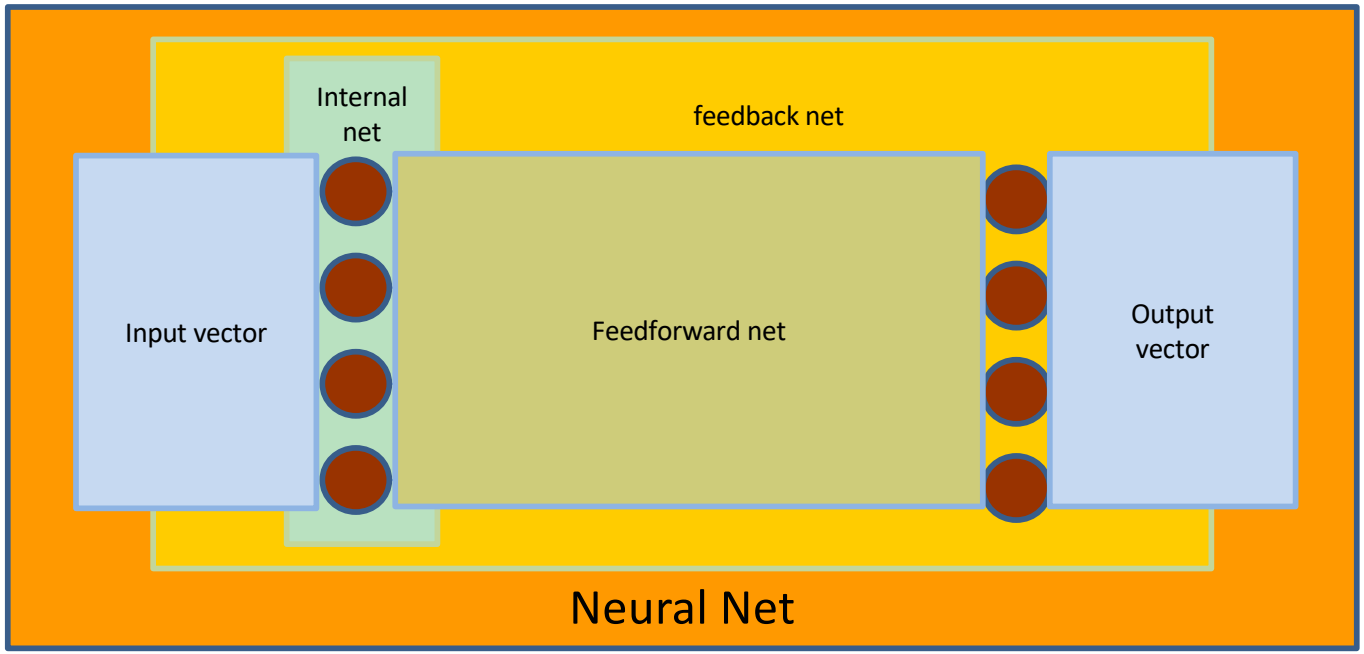
Natural Neural Networks

- Plasticity & Topology
  in Natural Neuronal Nets
  - Synaptic weight adjustment
  - Topological / Structural adjustment
  - equilibrium
    - Homeostatic
    - Bio-chemical
    - Dynamic
    - Complex systems



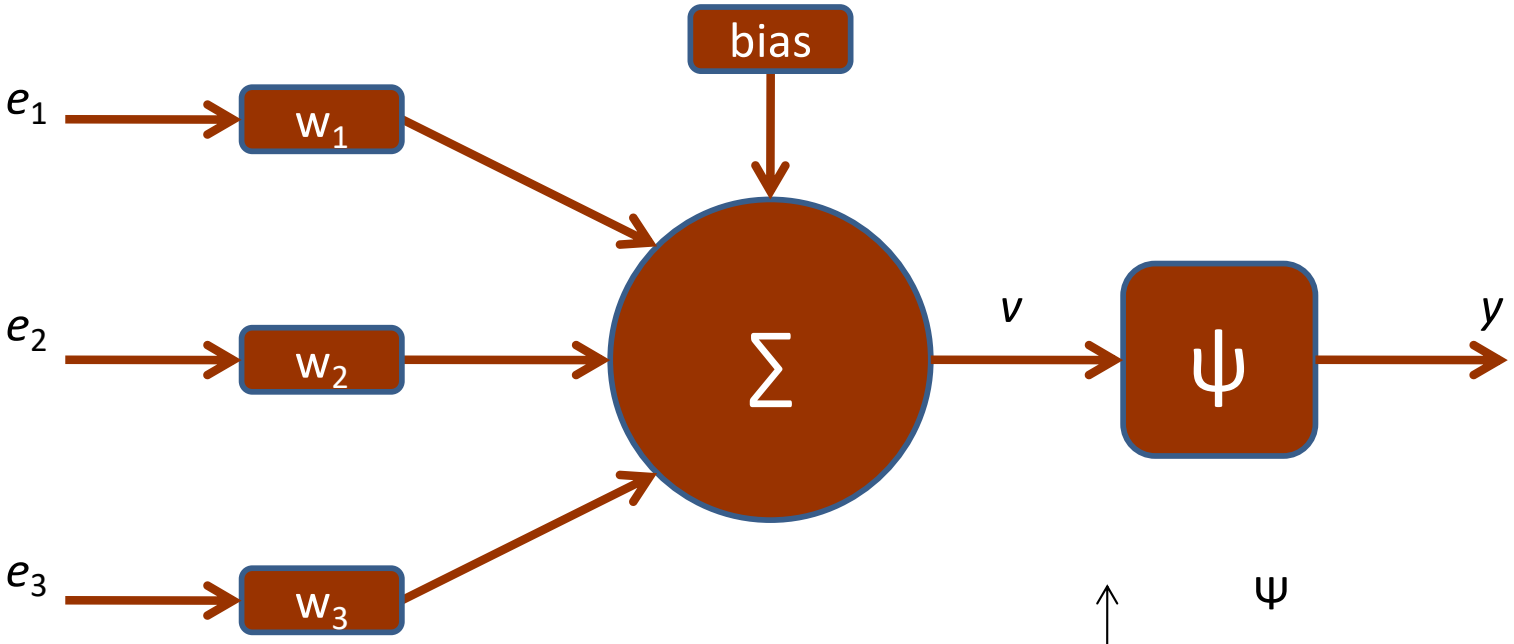
Artificial Neuronal Nets

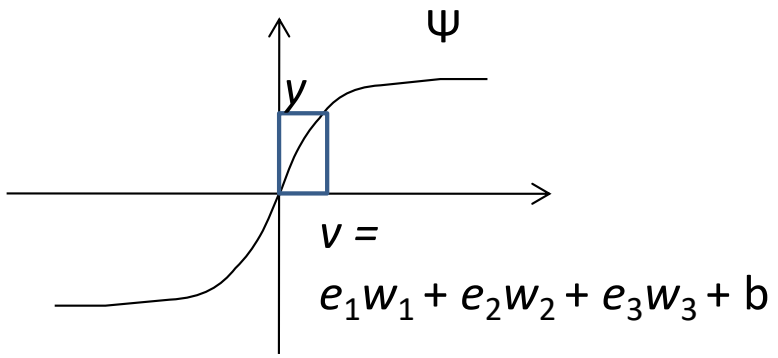




Artificial Neural Networks

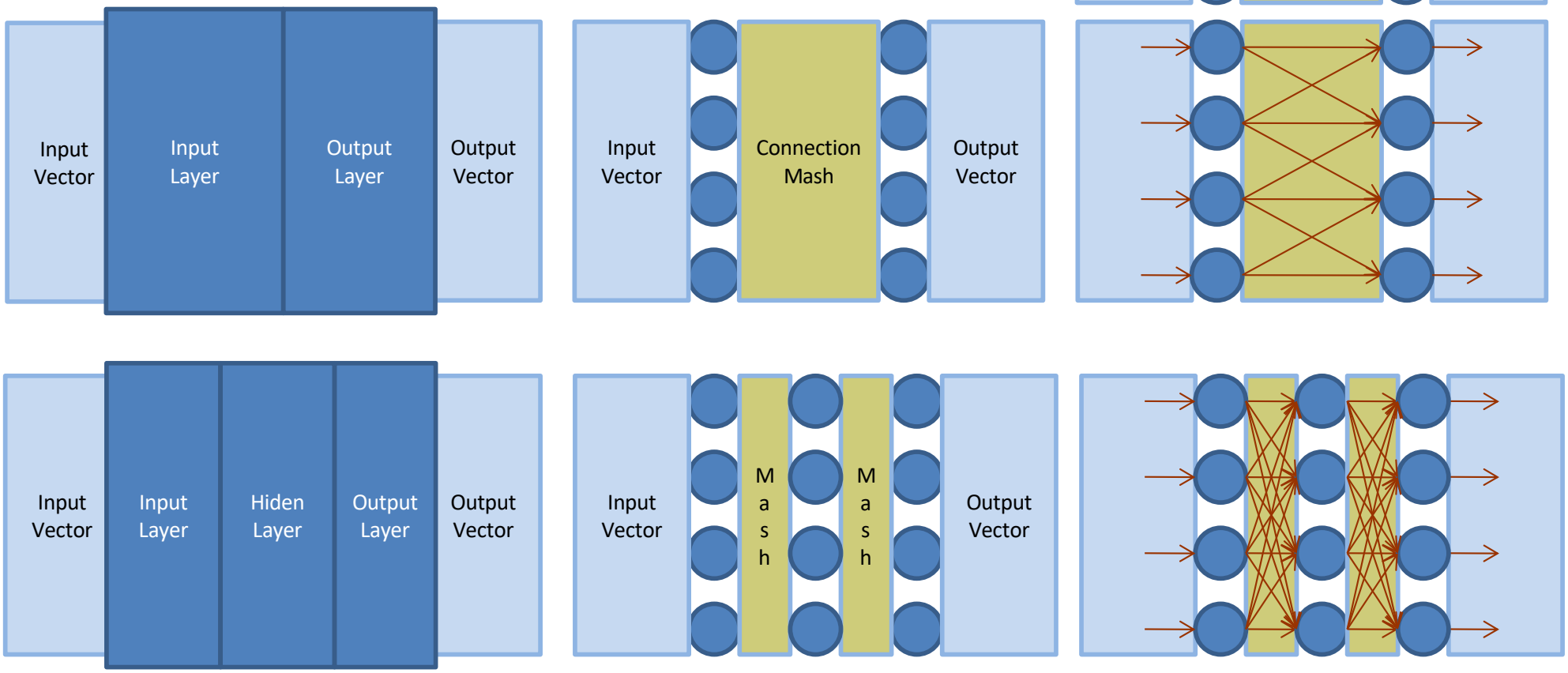
Neuron





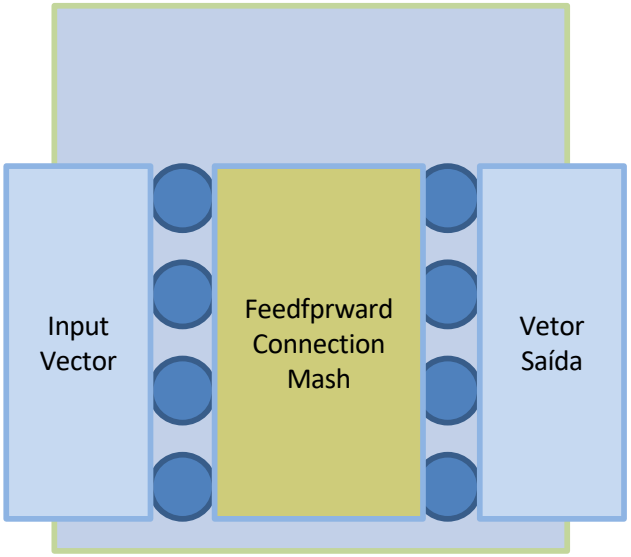
Artificial Neural Networks

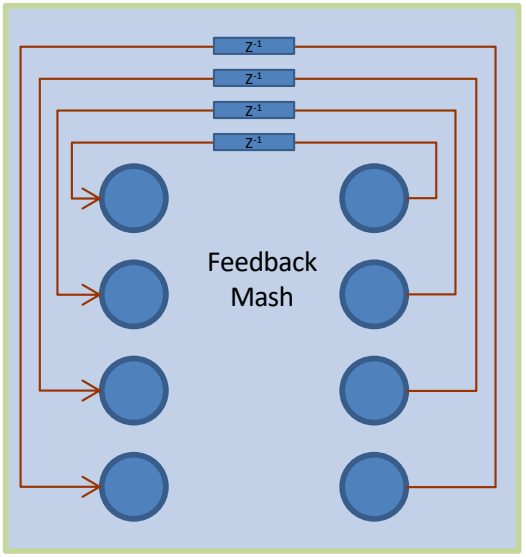
- Feedforward Nets



Artificial Neural Networks

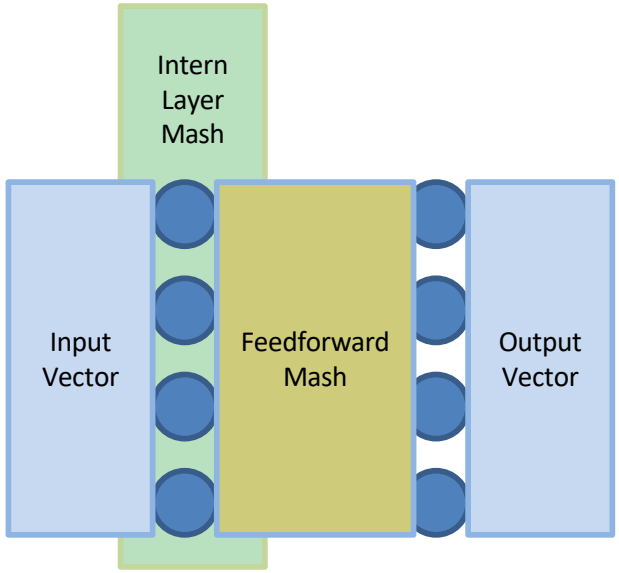
- Feedback Nets
  - Temporal memory (keeping facts - history)

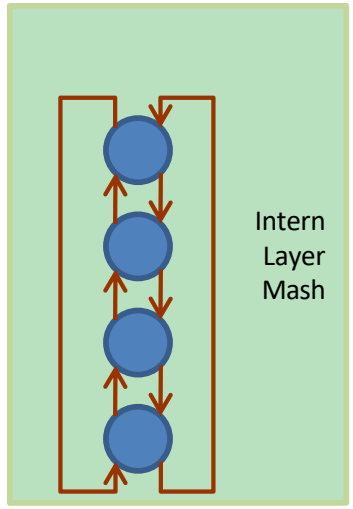




Artificial Neural Networks

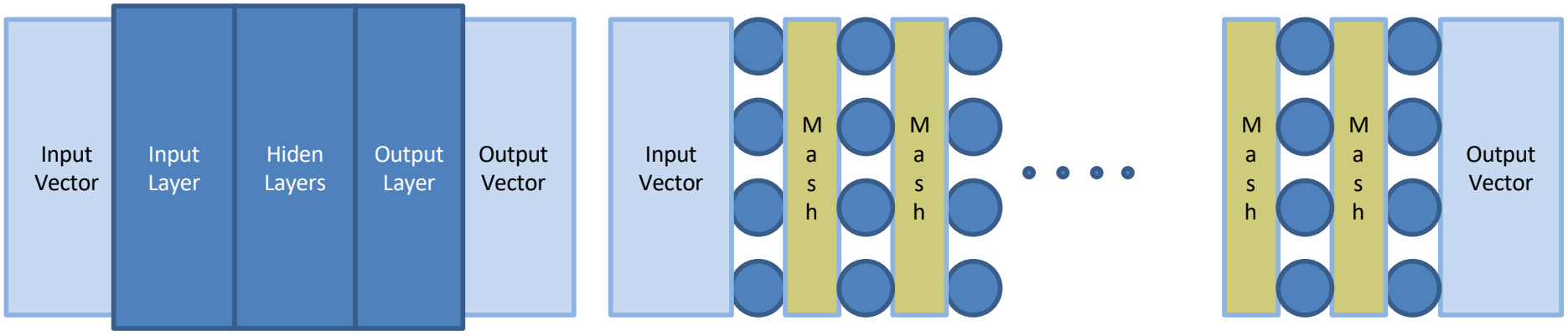
- Associative Nets (SOM)

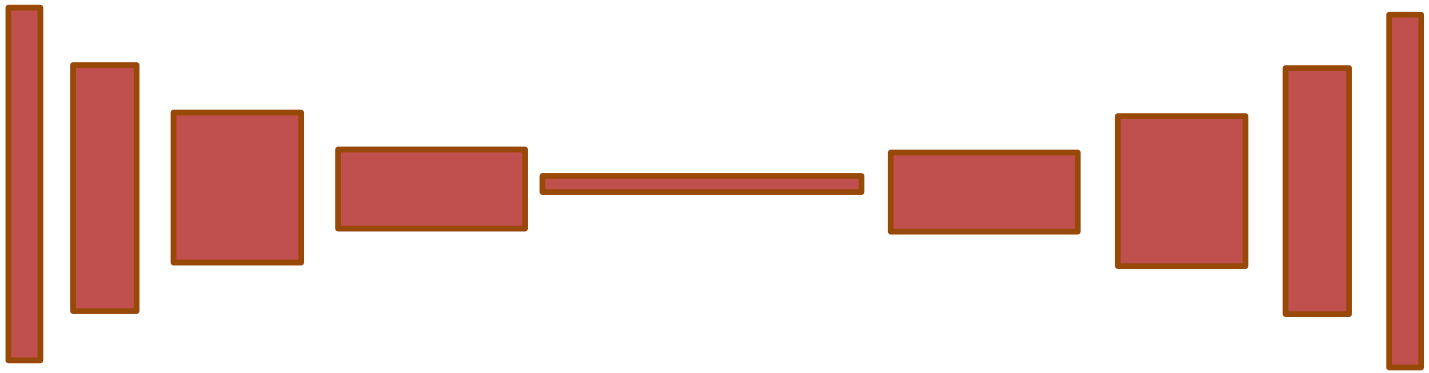




Artificial Neural Networks

- Convolutional Nets





Section 4

Artificial Neural Networks

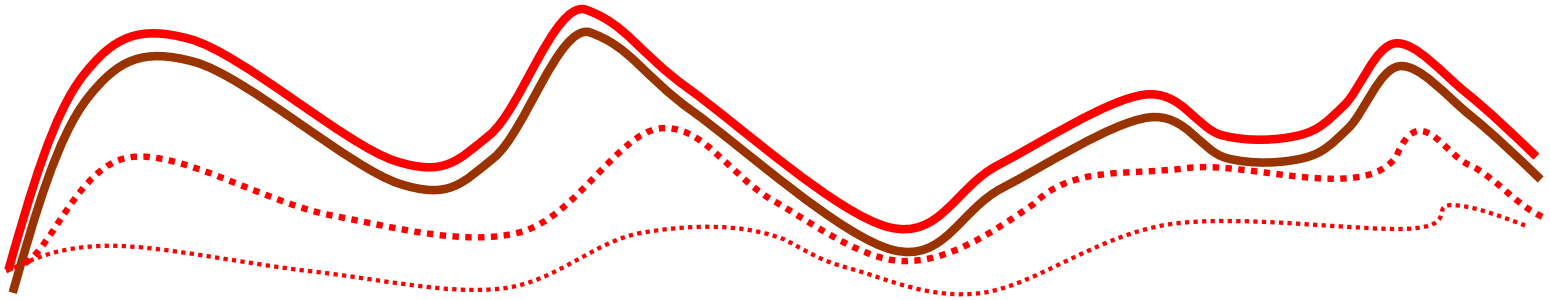
- Training Phase
  - Exposing the ANN to a large set of data
  - Conducting successive adjustments
    - Error backpropagation
- Test Phase
  - When the NN is tested on new samples
- Usage Phase
  - Recognition / Classification

Artificial Neural Networks

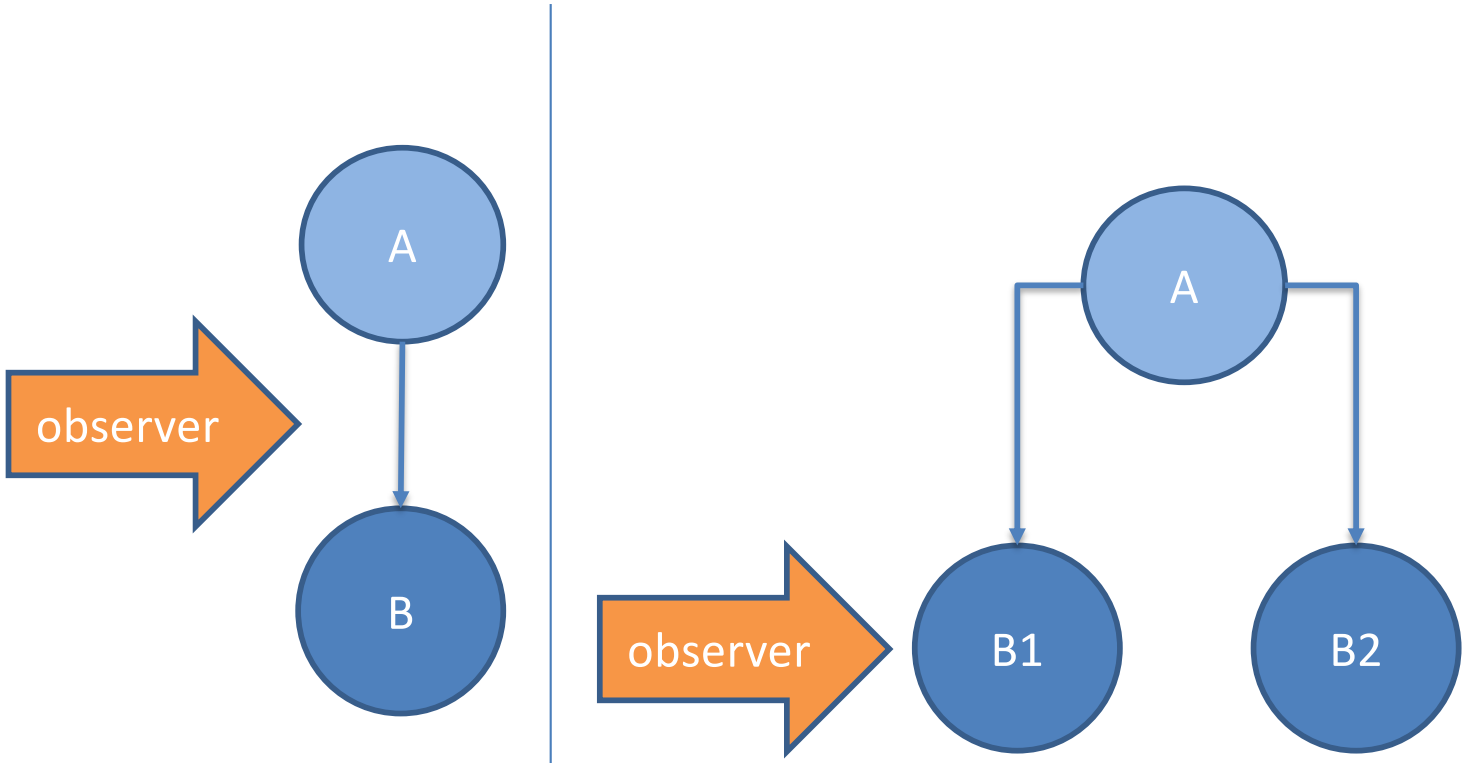
- Supervised Training
  - Requires an expert to evaluate the results
  - After being trained the ANN matches that expertise
- Unsupervised Training
  - Self adaptive
    - exploiting similarities
    - reinforcement

Artificial Neural Networks

- Learning / Adapting
  - Function approximation



Causal Models & Events Correlation



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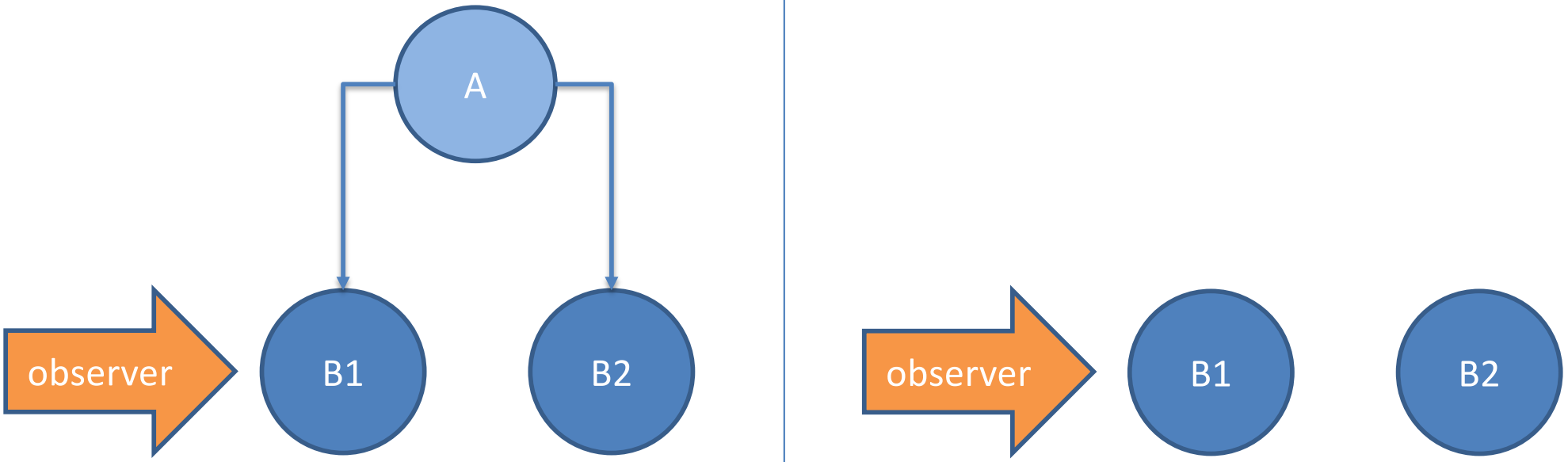


Causal Models & Events Correlation

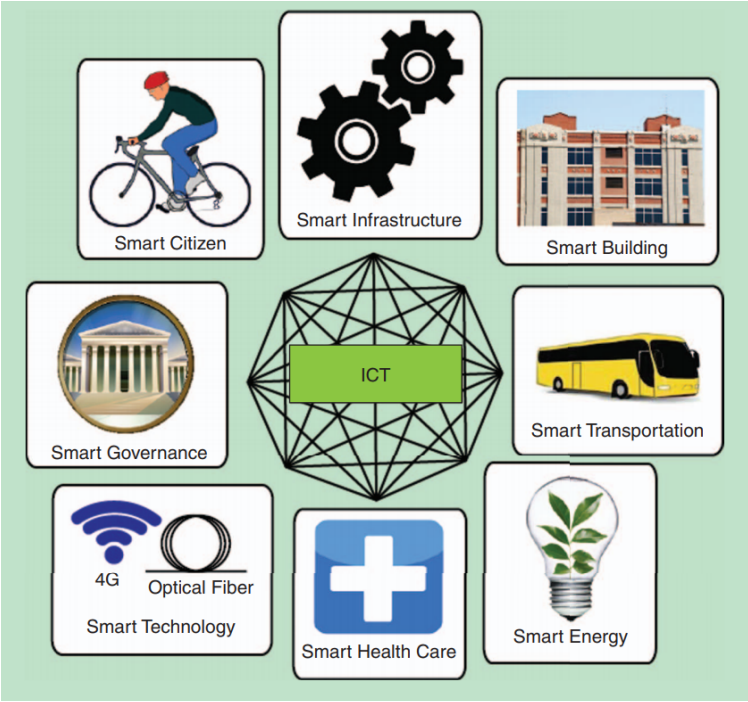
- Artificial Neural Network
  - Recognizes correlations
  - But not necessarily causalities

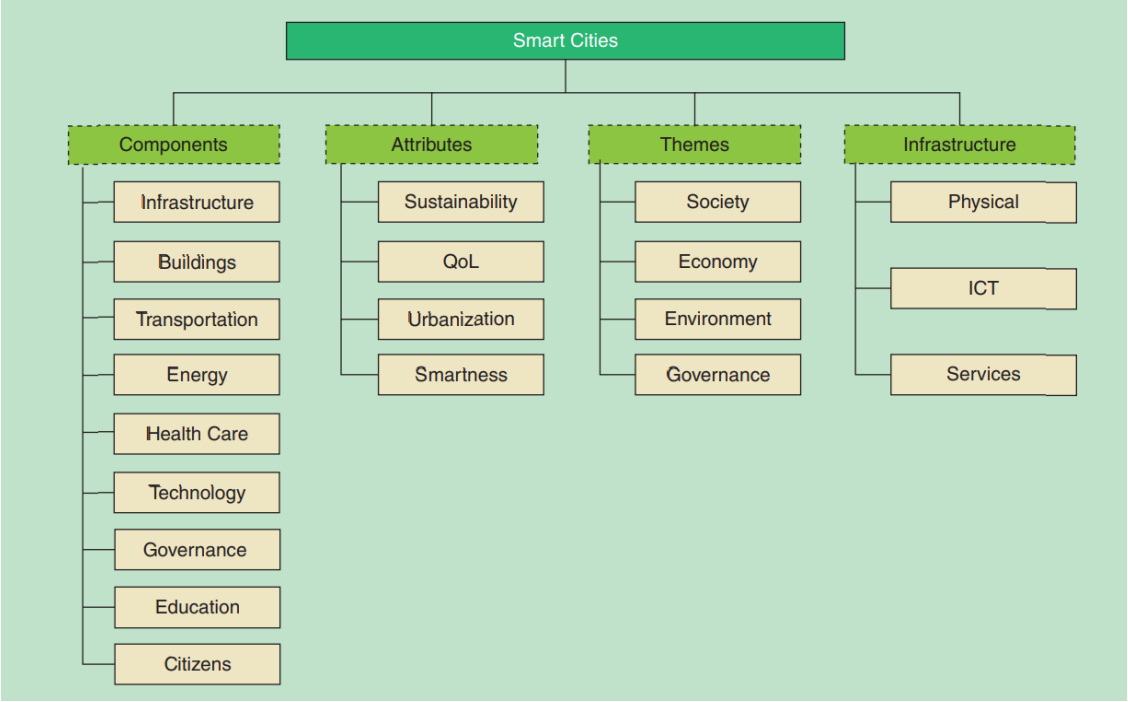
Artificial Neural Networks

- Applications
  - Extracting coherence patterns
    - Climate – Rain – Flooding – Traffic Jams
    - First identify patterns on a vast set of different conditions
      - rain and flooding
      - flooding and traffic jams
    - Then based on current evidences (climate conditions) estimate the possibility impacts
      - Flooding
      - Traffic jams

Section 5

Smart Cities – Traffic





Smart Cities – Traffic

GENERAL MOBILITY ASSISTANCE TOOL

SENSOR LAYER

Data can be harvested from different sources:

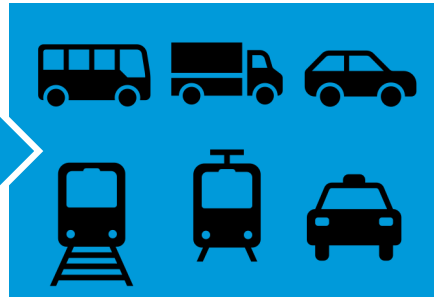
> it can be online sensors in several different networks,
> it can be in the form of manually input or historical data.

The data layer can be distributed between several databases as long as they are mapped.

DATA LAYER

ONTOLOGY LAYER

APPLICATION LAYER



A documented network of modular ontologies can enable the most intelligent applications.

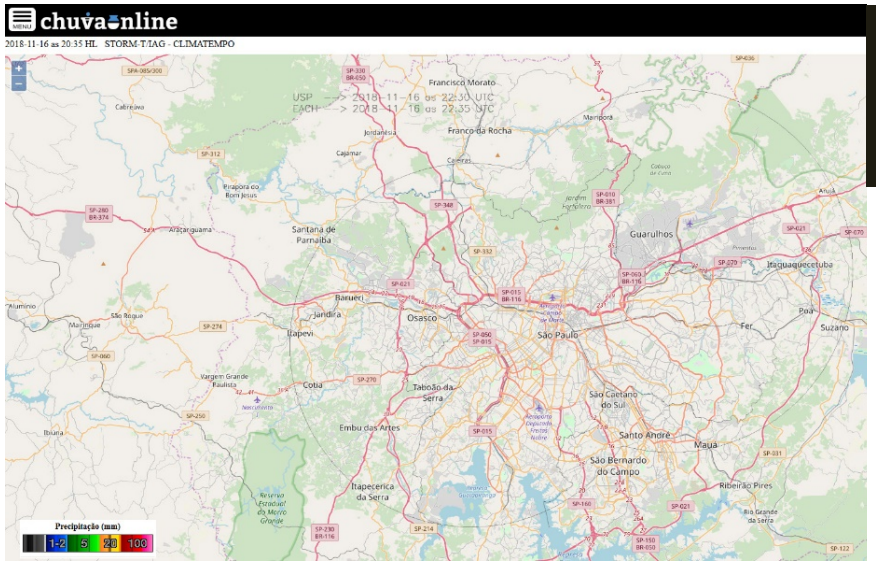
Furthermore, it is a replicable model for other locations.

ANN

SCENARIO – SÃO PAULO

Google Maps 2018

São Paulo stats		
Inhabitants Metropolitan region	22 million	UN/DESA - 2018
Inhabitants Municipality – map view	12 million	IBGE - 2018
Demographic density	7,400 inhabitants/ km²	IBGE - 2018
Number of vehicles municipality	8.76 million	DETRAN – July/ 2018
Number of cars municipality	**6.14 million**	DETRAN – July/2018
Trips/ day individual and motorized Metropolitan region	13.59 million	Metrô SP - 2012

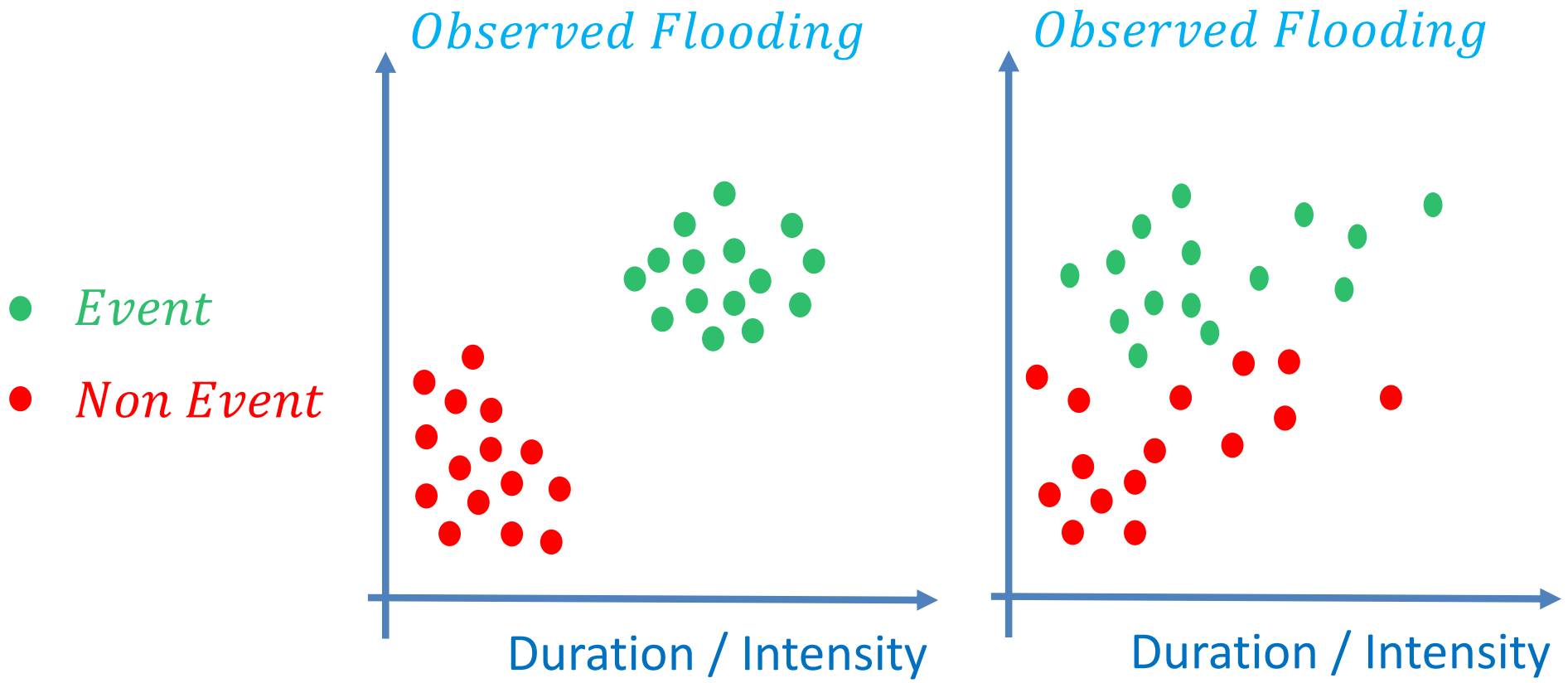


Chuva Online – Real-time rainfall data in São Paulo

CGE – Climate emergency management
Data + Information > Decision making

CET– Road transport operation
Strategies > Infrastructure optimization > Improved traffic flow

INTELLIGENCE – STATISTICAL LEARNING



This is all for today.

See you next week !