

## WHAT IS A PATTERN?

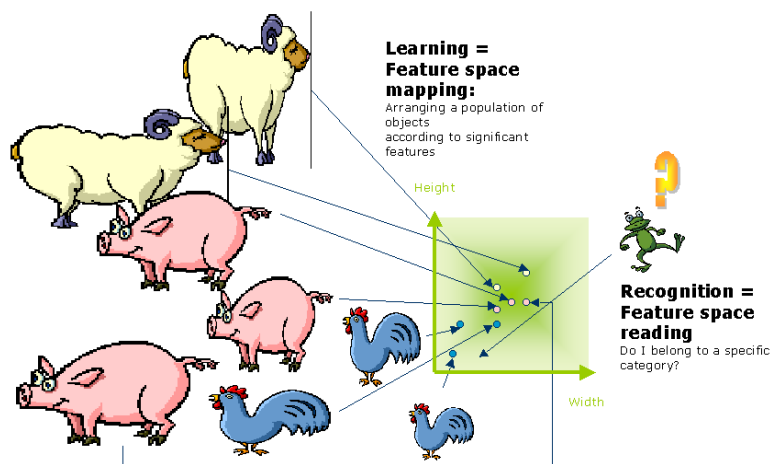
- The waveform of an electric signal:
  - A physiological signal (EKG, EEG, EMG),
  - A sound (voice, noise),
  - A radar, sonar signal or any analog signal.
- A layout of pixels:
  - Discrete object such as a mechanical part, a human face, an aircraft, sub, ship, car
  - A surface or texture such as wood, glass, vinyl, skin
  - A primitive block (fractal, vector quantization).
- Data set
  - DNA sequences, bioinformatics
  - Financial and other analytical parameters
  - Time series such as flight or engine parameters
  - Character strings, stock market trends

## WHAT IS PATTERN RECOGNITION?

- Instantly recall a pattern among millions of others
- Discern new patterns by recognizing similarities with learned ones

## WHAT IS PATTERN LEARNING?

- Always attempt recognition prior to learning
- Never learn what is already known
- Refine knowledge by learning subtle variations of generic patterns



WHY IS THE HUMAN BRAIN SO GOOD AT PATTERN RECOGNITION?

- Parallelism; an incoming pattern is compared to millions of patterns simultaneously
- No programming; neuron and neural subsystem behaviors are hard-wired and do not execute fetch and decode instructions.
- Storage capacity is enormous; ten billions neurons average is probably more than what is needed for a life time.
- Connectivity capability is huge; one single neuron can connect to about 10,000 ones.

PAST ATTEMPTS TO MIMIC THE BRAIN?

|                    |   |
|--------------------|---|
| Software solutions | <ul style="list-style-type: none"> <li>• Capable of arbitrary precision</li> <li>• Strong immunity to noise</li> <li>• Insufficient speed due to the sequential fetch and decode of Van Neuman processors</li> <li>• Time consuming learning phase</li> <li>• High cost</li> </ul>  |
| Hardware solutions | <ul style="list-style-type: none"> <li>• Reasonable speed</li> <li>• Low precision and sensitivity to noise and cross-talk</li> <li>• Need programming</li> <li>• Limited parallelism and expandability capabilities</li> <li>• Slow learning phase</li> <li>• High cost</li> </ul> |

COGNIMEM ACHIEVEMENTS

- CogniMem learns a new pattern in microseconds
- CogniMem recognizes one pattern among virtually any number of patterns in microseconds
- CogniMem recalls a pattern by its content, not by its address
- CogniMem refines its knowledge with new meaningful patterns
- CogniMem has no limit to the storage capability
- CogniMem speed does not decrease as neuron count increases
- CogniMem is available as ASIC, FPGA black box, and software IP