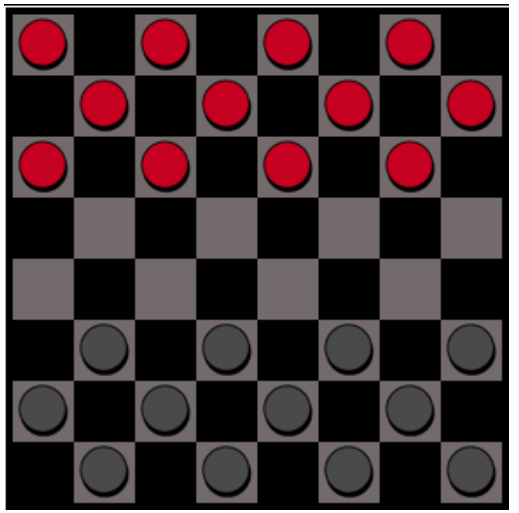
Machine Learning and Artificial Neurons

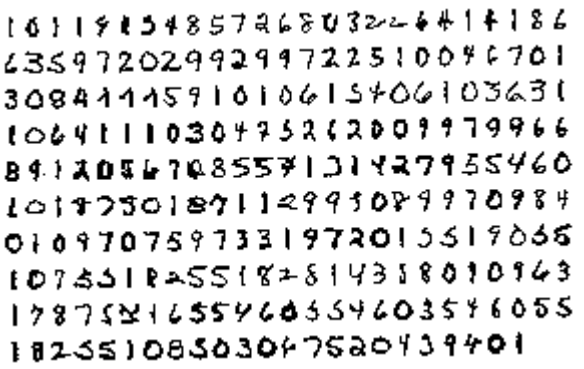
Machine Learning: Early Work

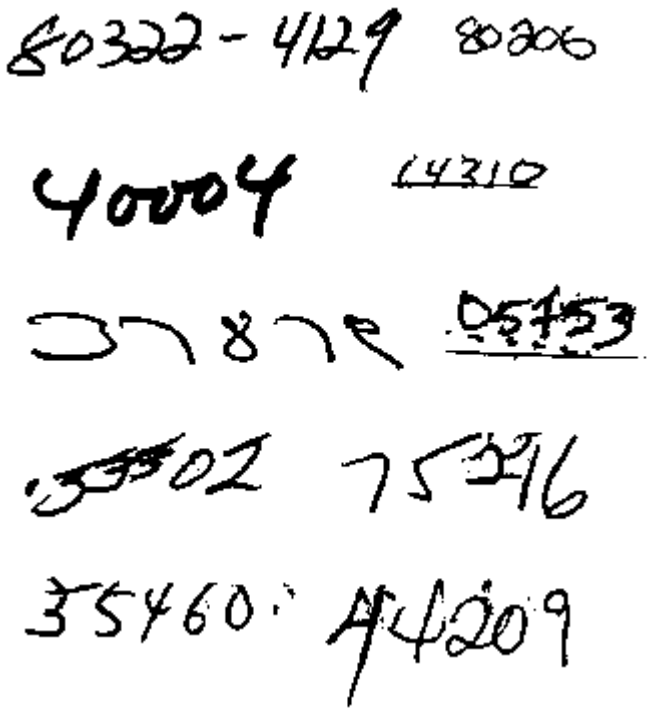
- **Checkers** (Arthur Samuel, IBM, 1950s)
  - First successful machine learning program
  - Learned to play checkers better than Samuel himself
  - Beat 4th ranked player in the nation in 1961



Machine Learning: Early Work

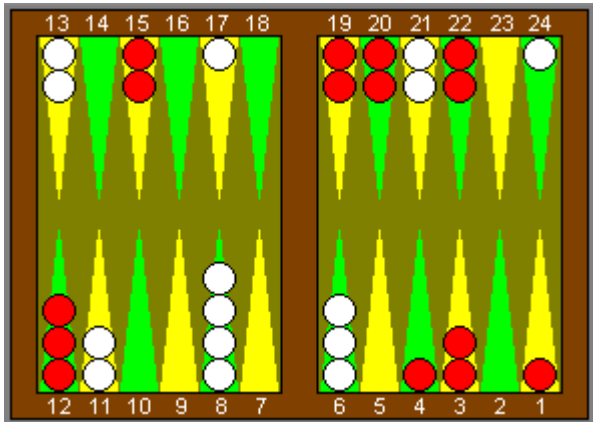
- **Zip code recognizer** (Yann LeCun, AT&T Bell Labs, 1980s)
  - Used a neural network
  - Trained on handwritten zip codes from U.S. mail
  - Achieved the state of the art in digit recognition
  - Classification accuracy > 95%





Machine Learning: Early Work

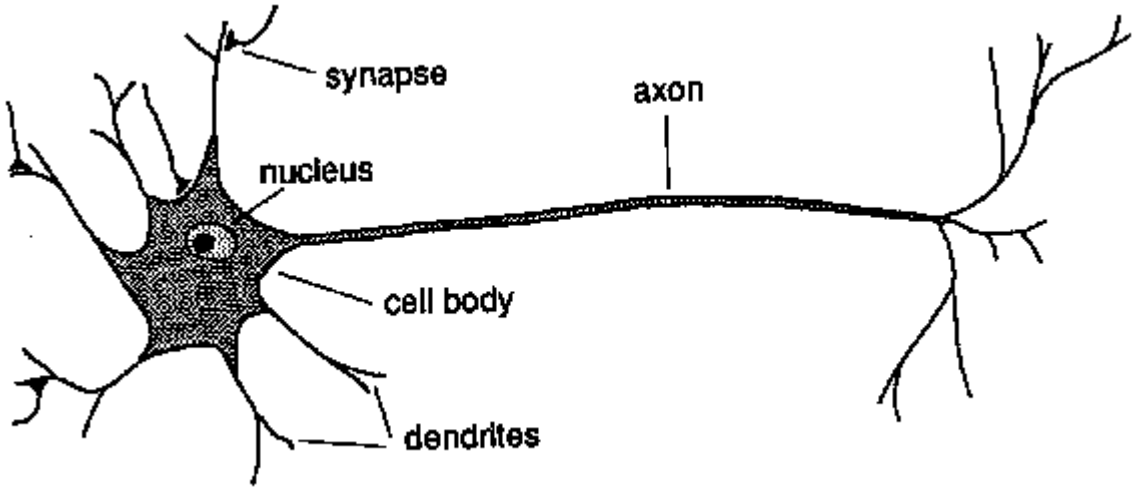
- **TD-Gammon** (Gerry Tesauro, IBM, 1990s)
  - Learned by playing over 1.5 million games against itself
  - Discovered novel board evaluation strategies
  - Used reinforcement learning and neural networks
  - Achieved parity with the top 5-10 players in the world
  - By far the best computer backgammon program



Machine Learning: Early Work

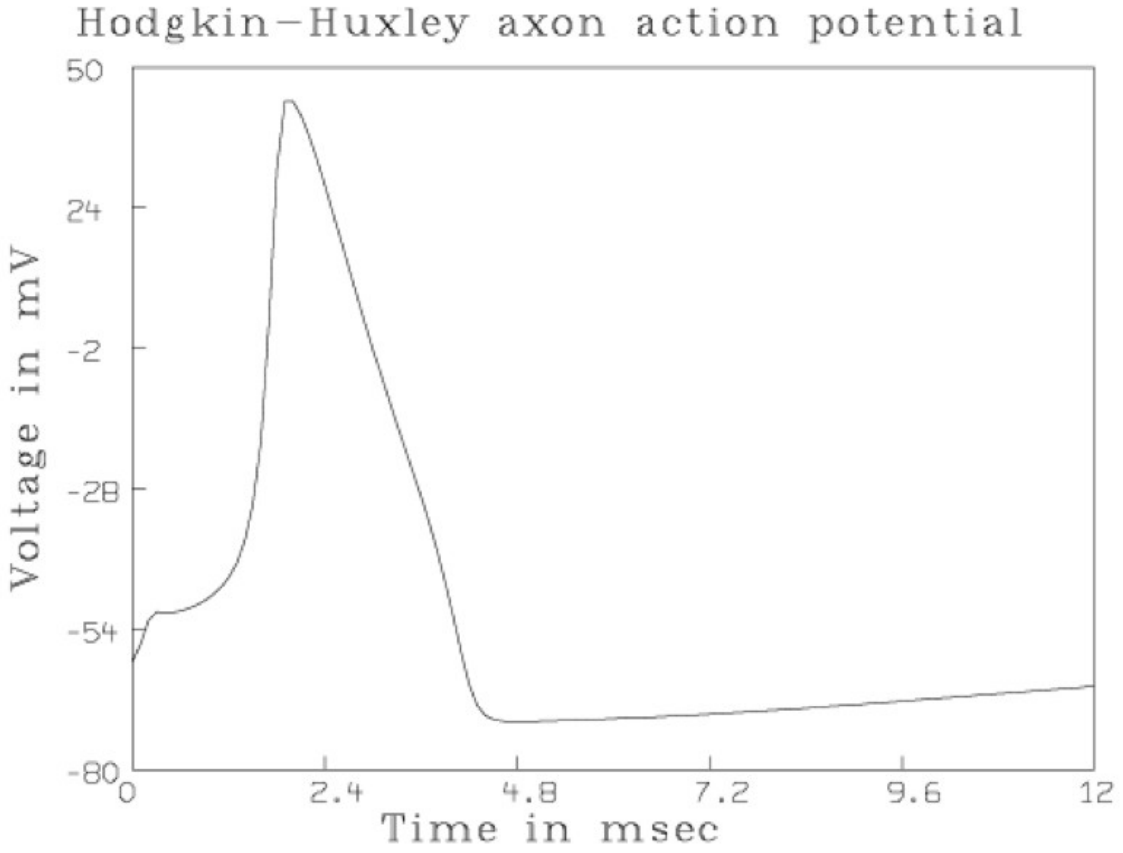
- **ALVINN** (Dean Pomerleau, CMU, 1990s)
  - Autonomous vehicle controlled by a neural network
  - Input: image of road, Output: steering wheel position
  - Neural network learns by “observing” a human driver
  - In 1995, steered a car semi-autonomously from coast to coast (all but 50 of 2,850 miles)

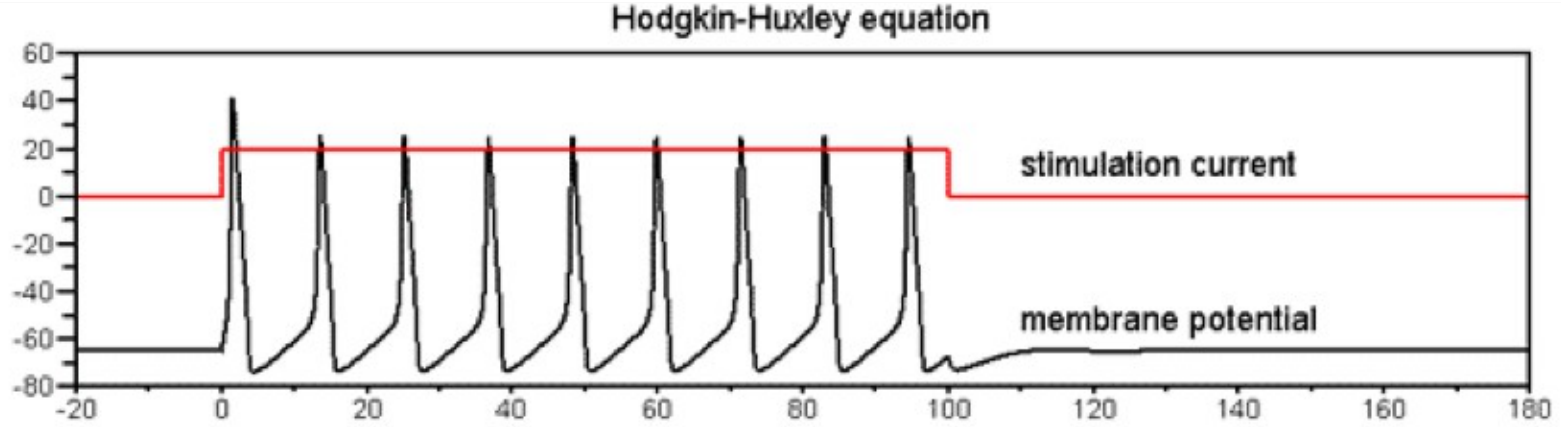
Neurons and Brains



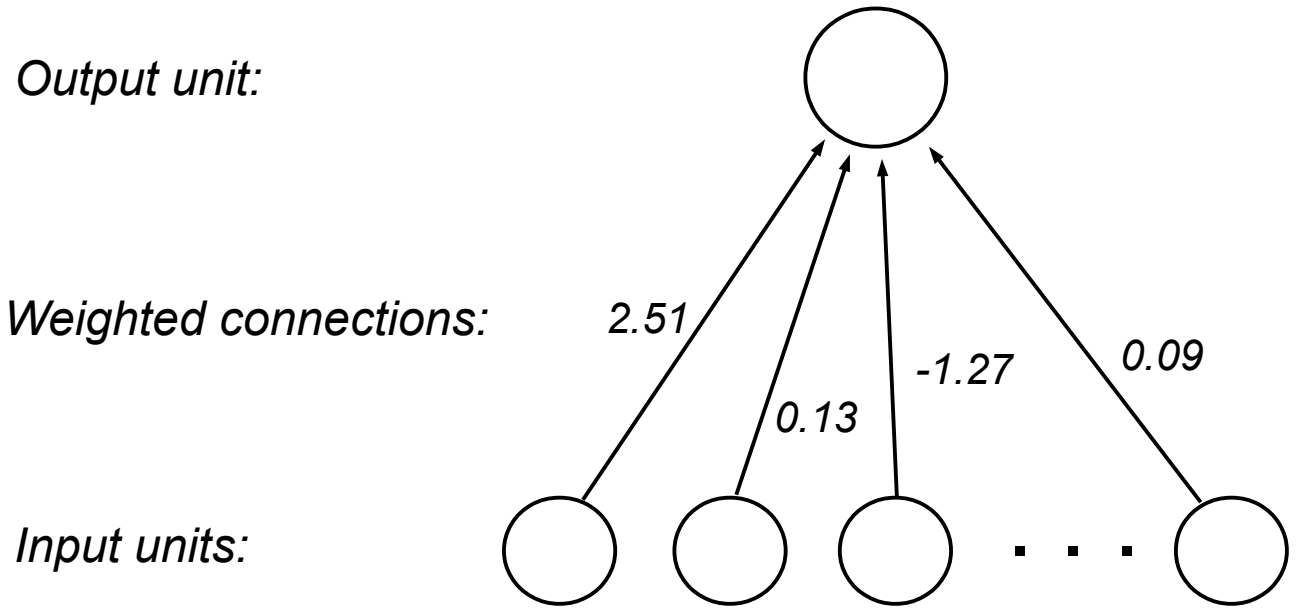
- Your brain has ~ 100 billion neurons
- Each neuron has ~ 10,000 synaptic connections to other neurons
- Hundreds of trillions of connections
- Learning induces changes in the connection strengths between neurons

Hodgkin-Huxley Neuron Model

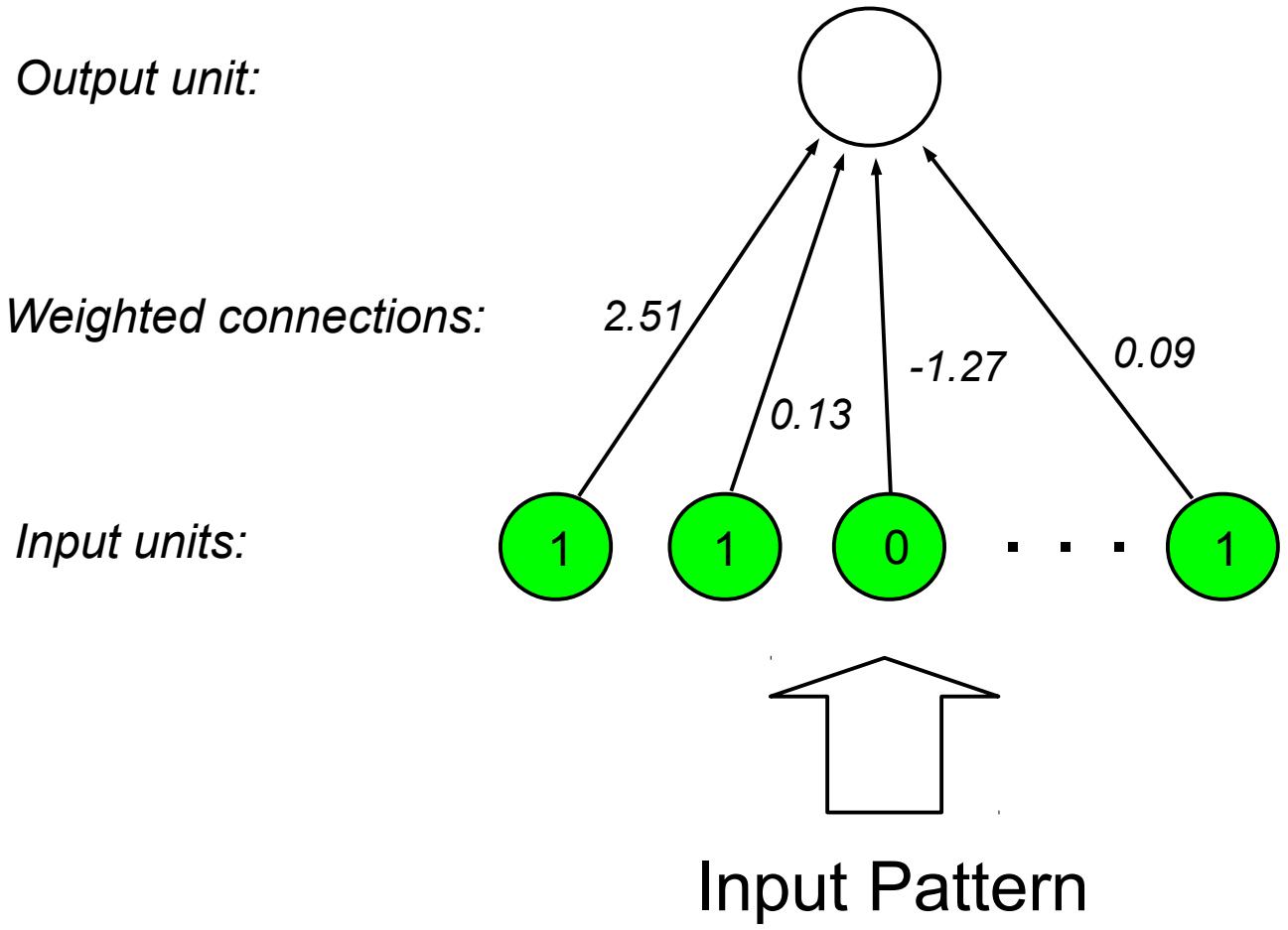




Artificial Neurons: Binary Version

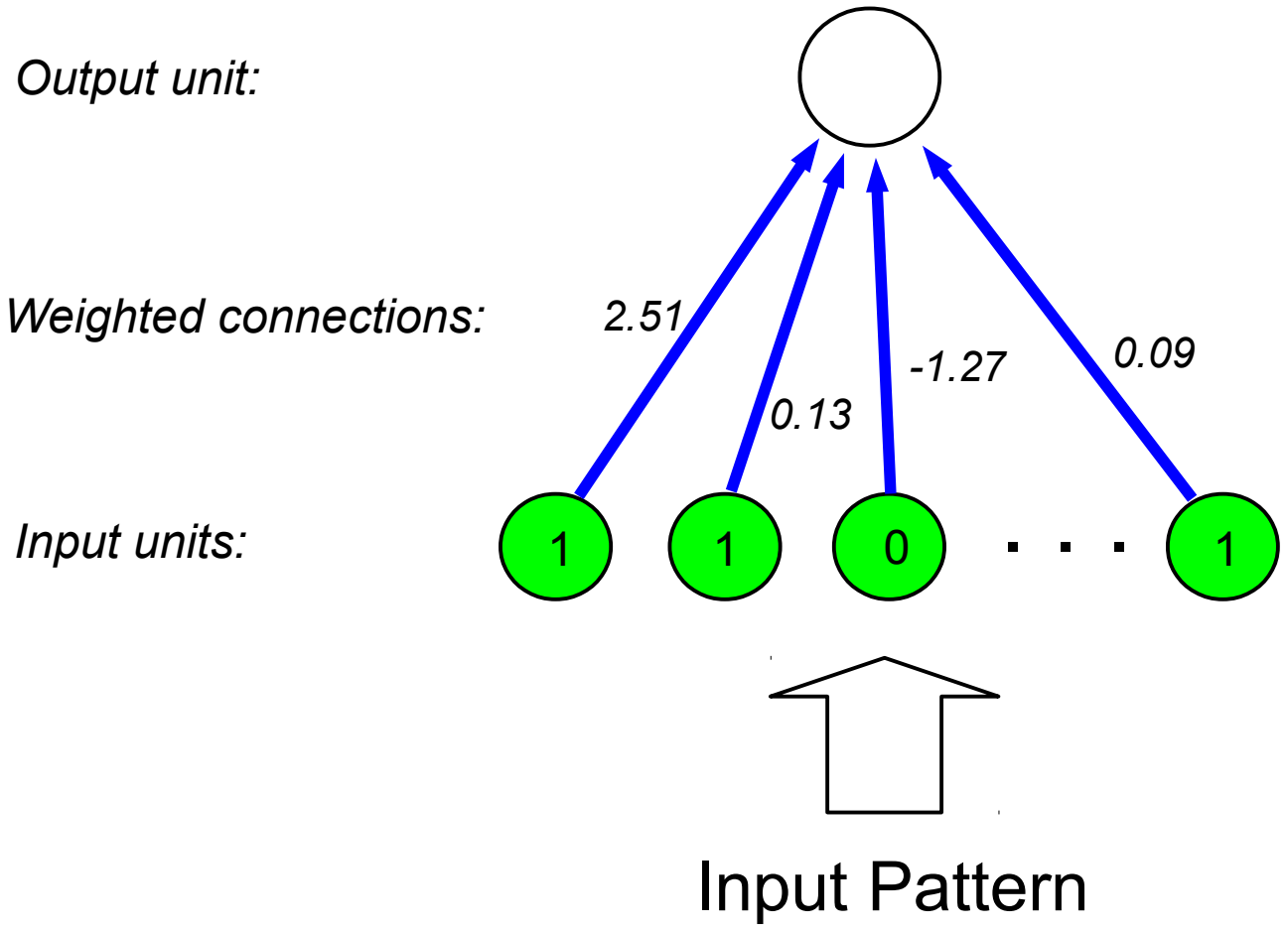


Artificial Neurons: Binary Version



Artificial Neurons: Binary Version

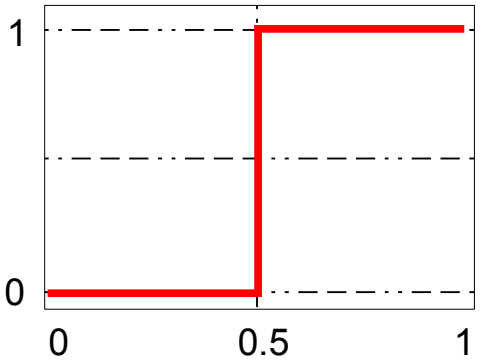
1 × 2.51 + **1** × 0.13 + **0** × -1.27 + . . . + **1** × 0.09 = 2.73



Artificial Neurons: Binary Version

$$1 \times 2.51 + 1 \times 0.13 + 0 \times -1.27 + \ldots + 1 \times 0.09 = 2.73$$

$$2.73 \geq 0.5$$

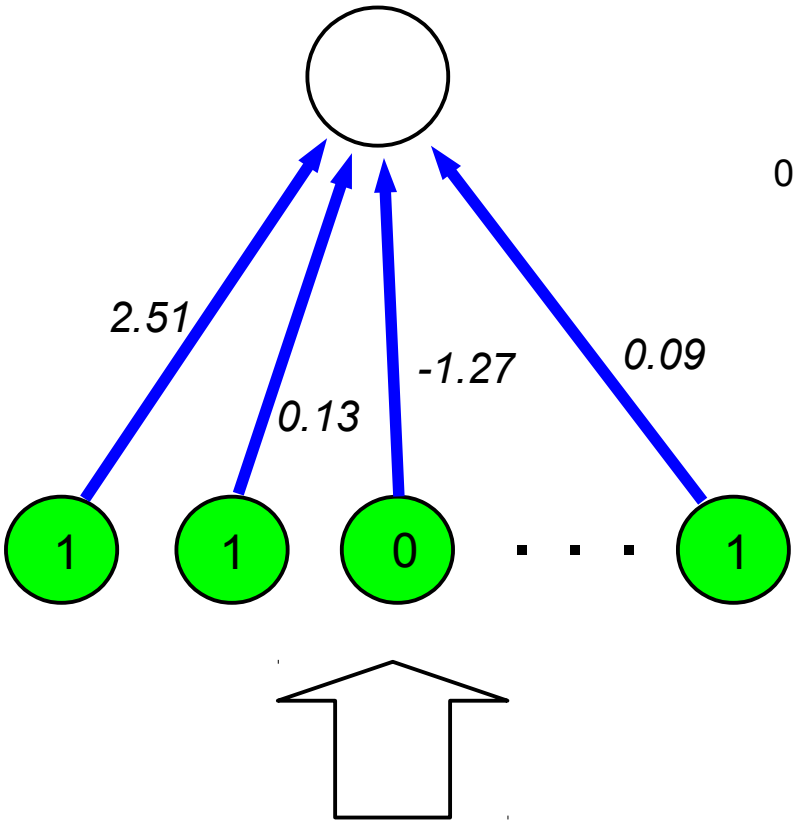


threshold = 0.5

Output unit:

Weighted connections:

Input units:

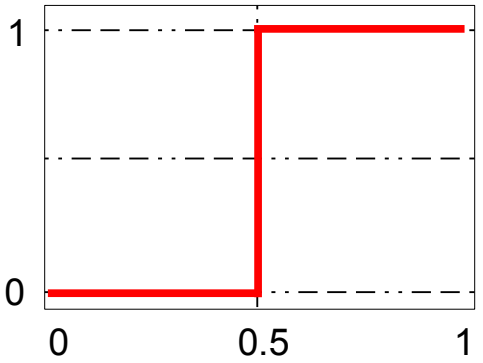


Input Pattern

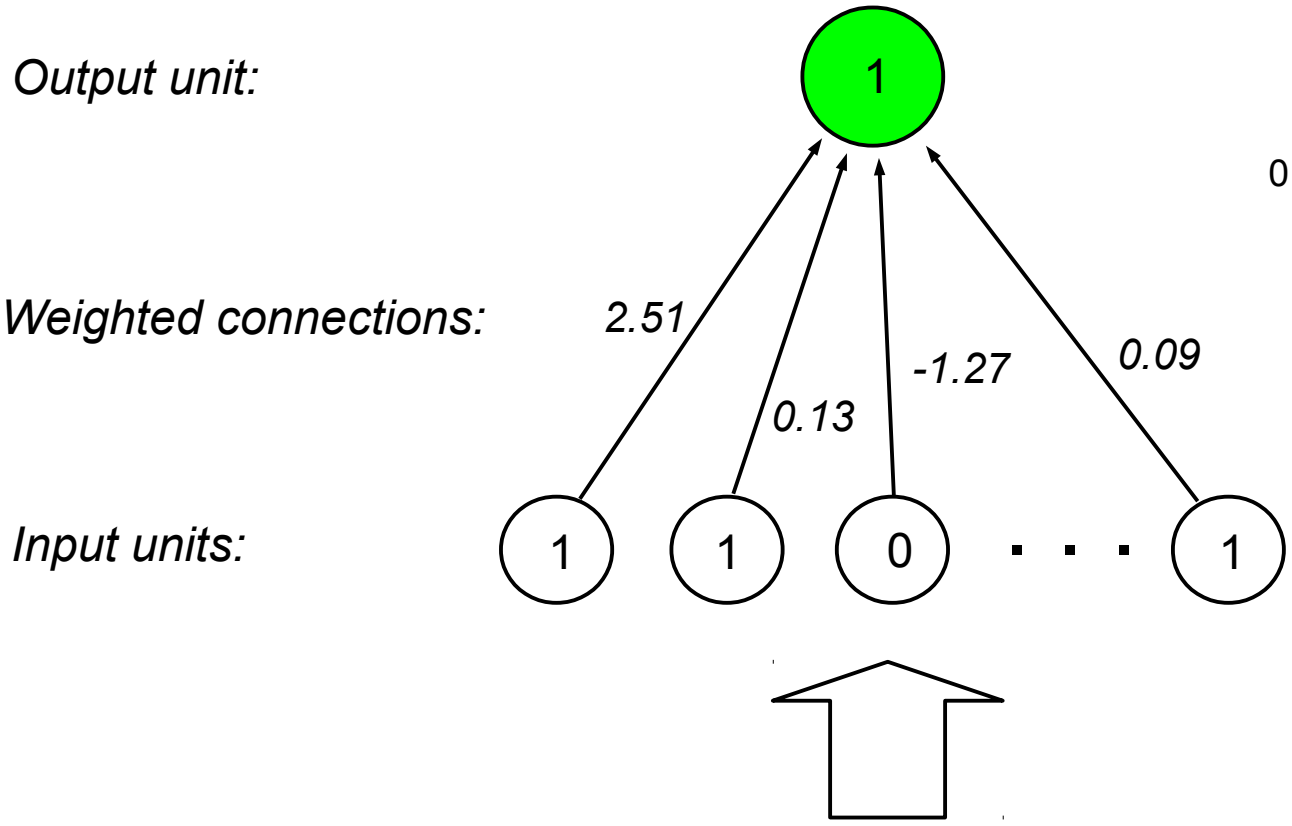
Artificial Neurons: Binary Version

$1 \times 2.51 + 1 \times 0.13 + 0 \times -1.27 + \ldots + 1 \times 0.09 = 2.73$

$2.73 \geq 0.5$



threshold = 0.5



Input Pattern