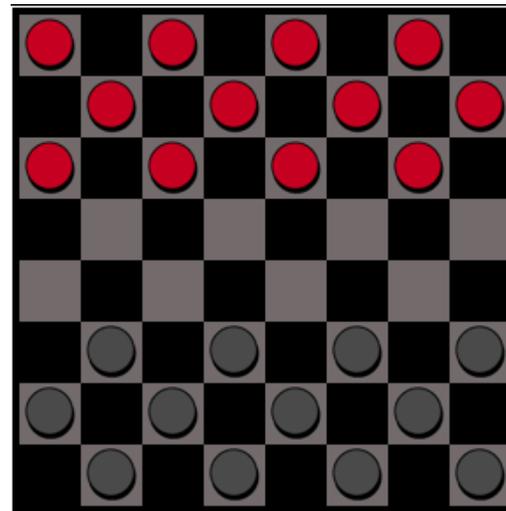


Machine Learning and Artificial Neurons

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%

1011913485726803224414186
6359720299299722510046701
3084114591010613406103631
1064111030473262009979966
8412056708557131427935460
2014750187112993089970984
0109707597331972015519035
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18235108503047520439401

80322-4129 80806

40004 14310

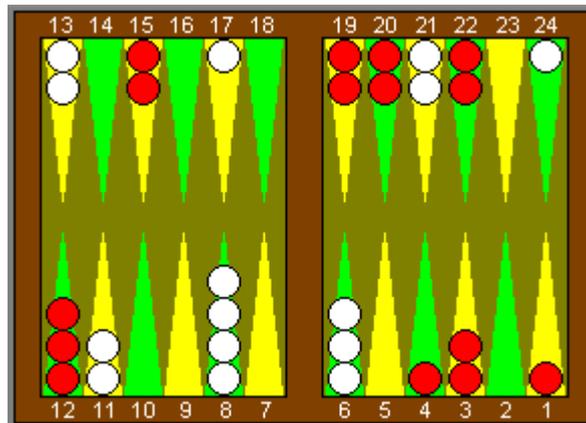
37879 05453

~~33~~02 75216

35460 44209

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

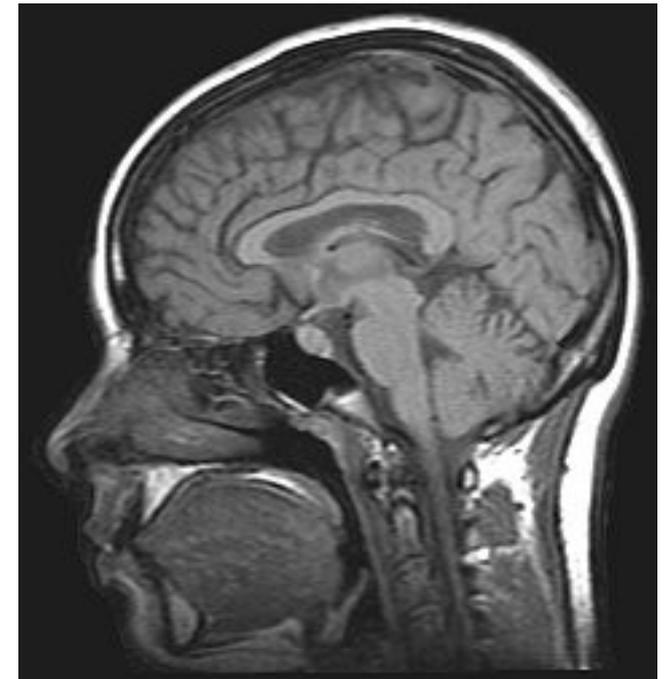
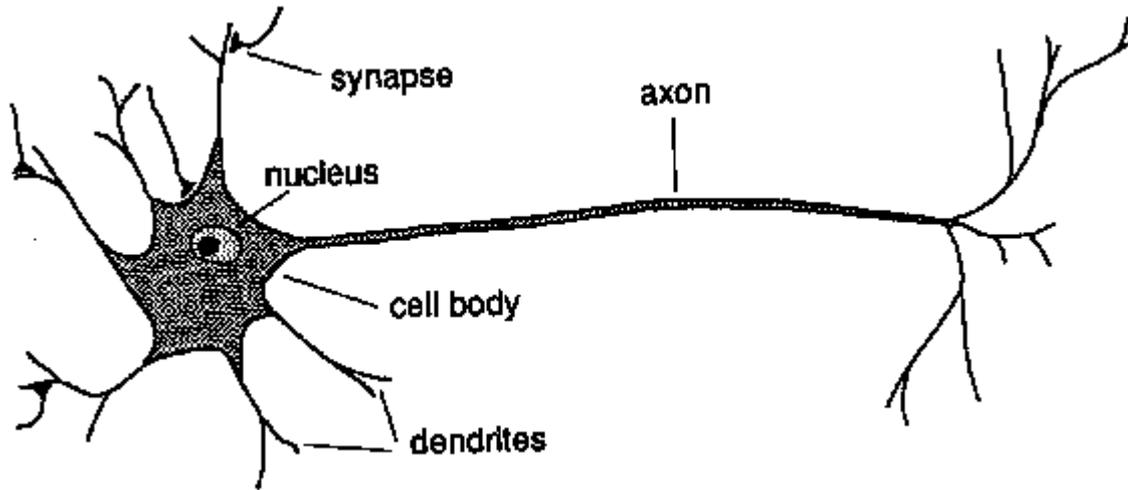


Machine Learning: Early Work

- **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)

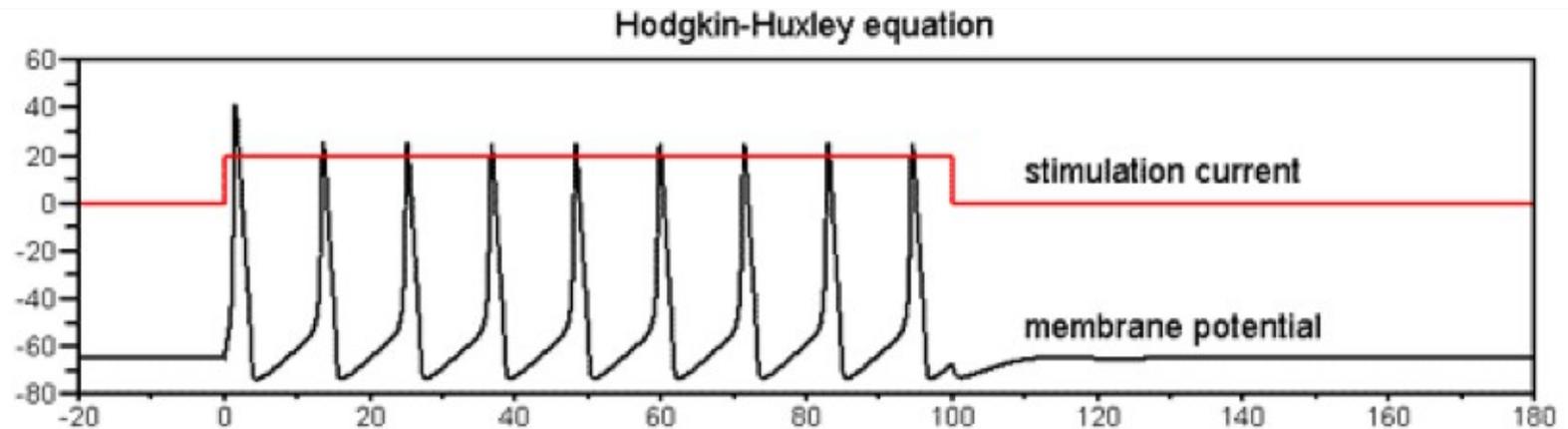
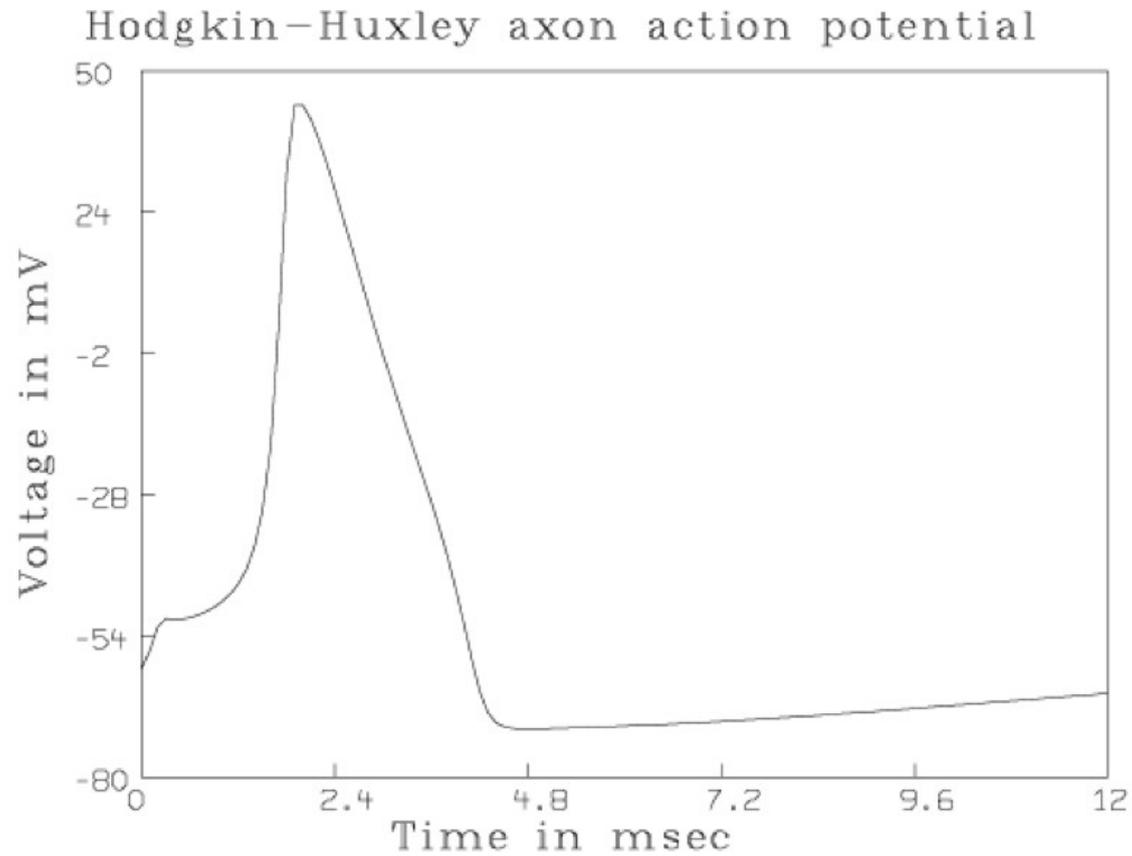


Neurons and Brains

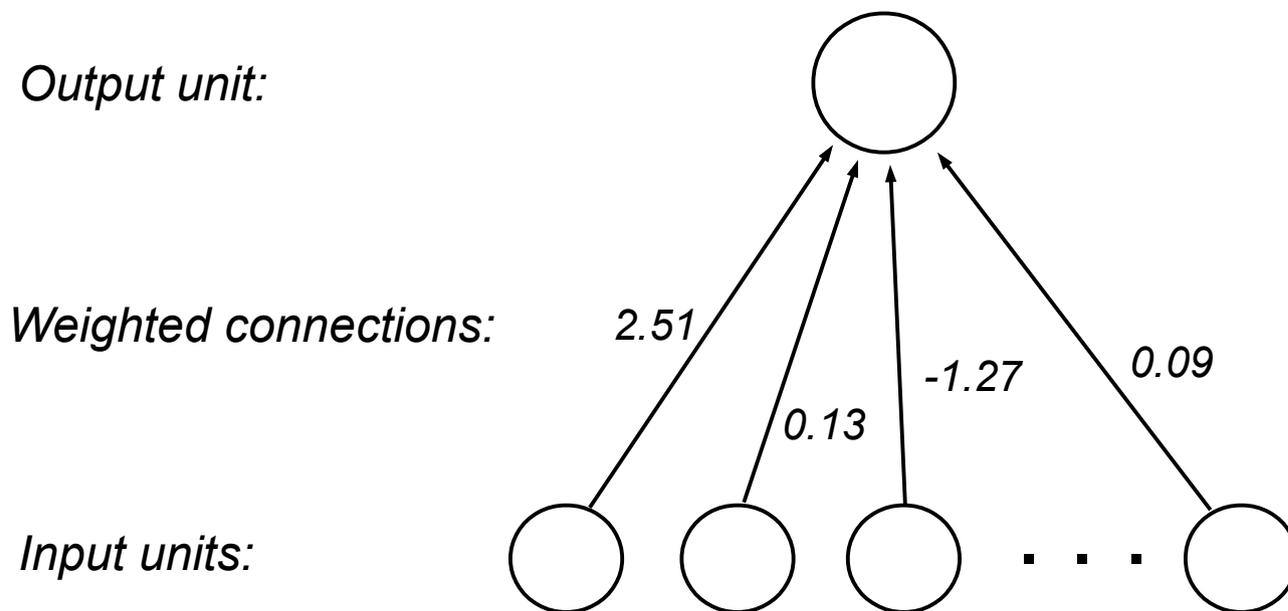


- Your brain has ~ 100 billion neurons
- Each neuron has ~ 10,000 synaptic connections to other neurons
- Hundreds of trillions of connections
- Learning induces changes in the connection strengths between neurons

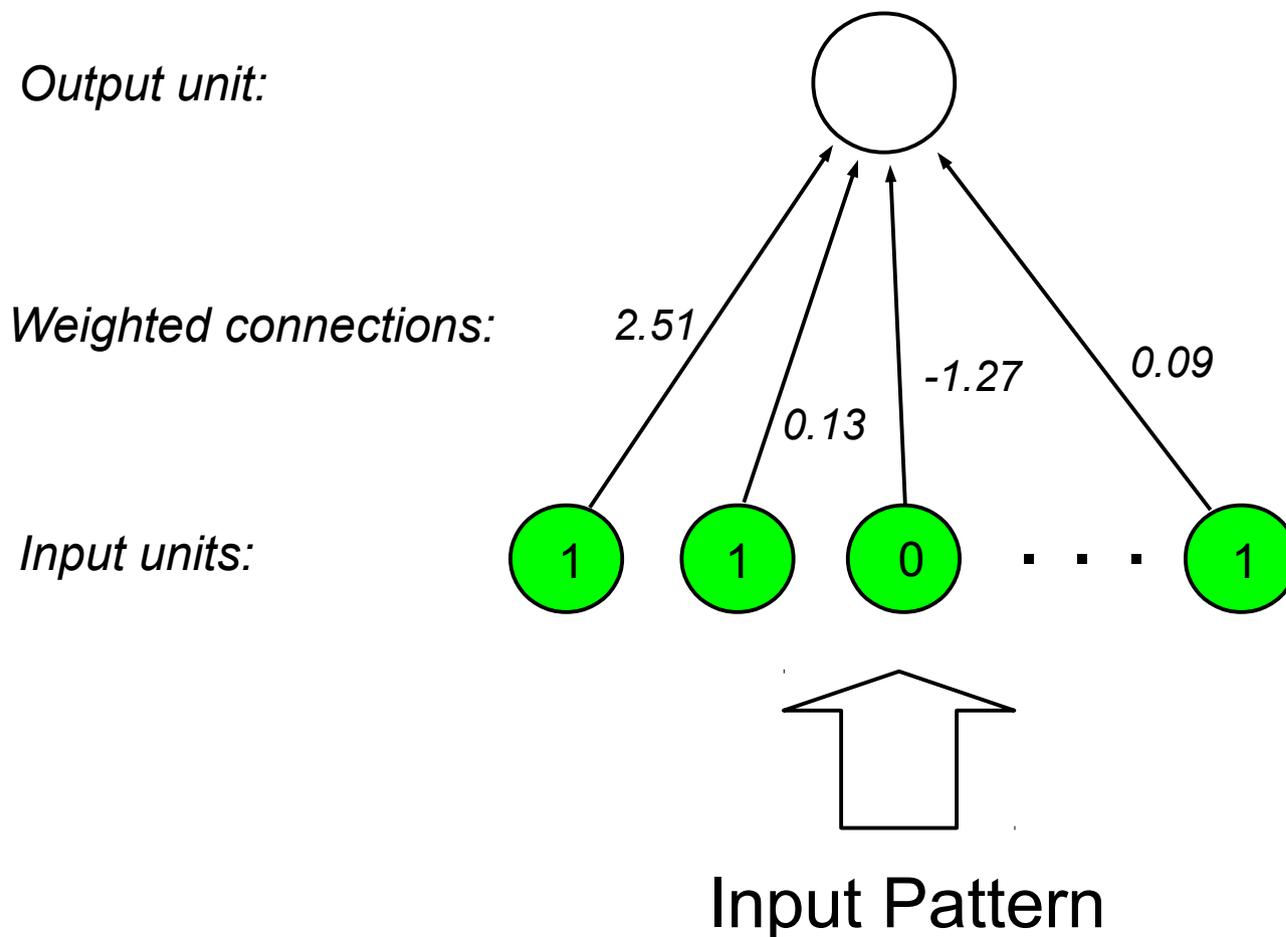
Hodgkin-Huxley Neuron Model



Artificial Neurons: Binary Version



Artificial Neurons: Binary Version



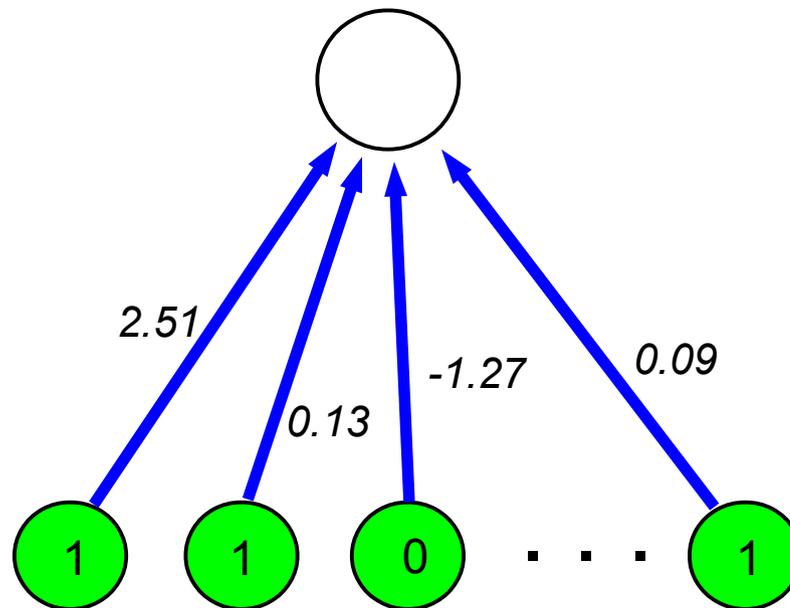
Artificial Neurons: Binary Version

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

Output unit:

Weighted connections:

Input units:



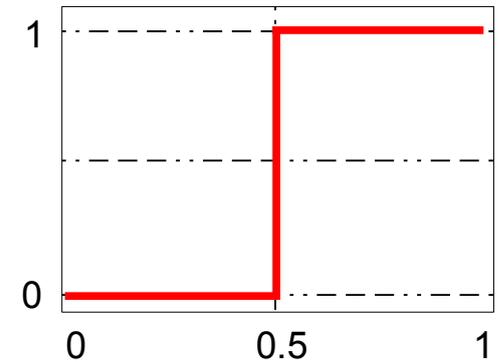
Input Pattern

Artificial Neurons: Binary Version

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

Output unit:

$$2.73 \geq 0.5$$



Weighted connections:

2.51

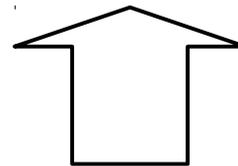
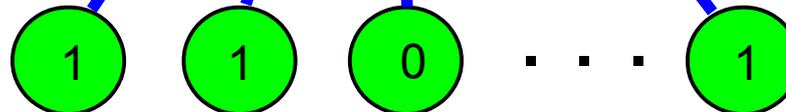
0.13

-1.27

0.09

threshold = 0.5

Input units:



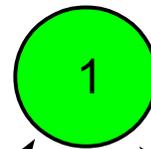
Input Pattern

Artificial Neurons: Binary Version

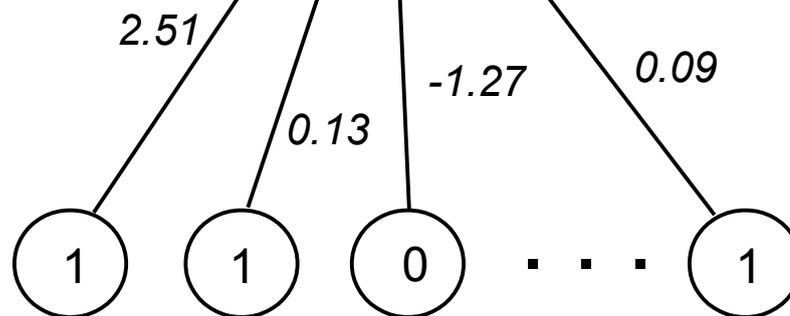
$$1 \times 2.51 + 1 \times 0.13 + 0 \times -1.27 + \dots + 1 \times 0.09 = 2.73$$

$$2.73 \geq 0.5$$

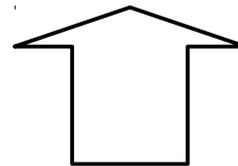
Output unit:



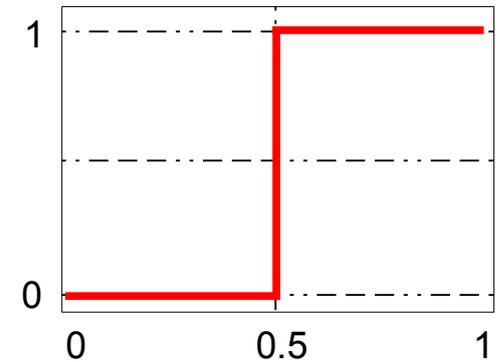
Weighted connections:



Input units:



Input Pattern



threshold = 0.5