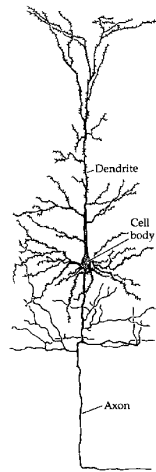


1

Neurons

How do they do it?



2

Detector Model

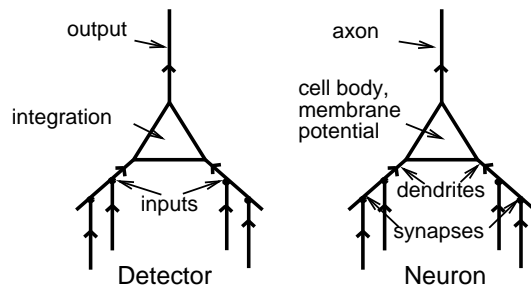
Each neuron detects some set of conditions (e.g., smoke detector).

Neurons feed on each other's outputs — layers of ever more complicated detectors.

(Things can get very complex in terms of *content*, but each neuron is still carrying out basic detector *function*).

3

Understanding Neural Components in Detector Model



4

Building on simple detectors: Pandemonium

Feature demons:

1. Vertical line: |
2. Horizontal line: —
3. Up-right tilted line: /
4. Up-left tilted line: \

5

Building on simple detectors: Pandemonium

Cognitive demons:

5. V: 3, 4

6. T: 1, 2

7. A: 2, 3, 4

8. K: 1, 3, 4

Decision demons

More confident → louder.

6

Features

|

7

Features

—

8

Features

/

9

Features

\

10

T

11

A

12

V

13

A

14

K

15

L

16

/

|

\

17



18

T

19

Pandemonium Example

Each neuron has a simple job, but together...

Layers of more and more complicated detectors.

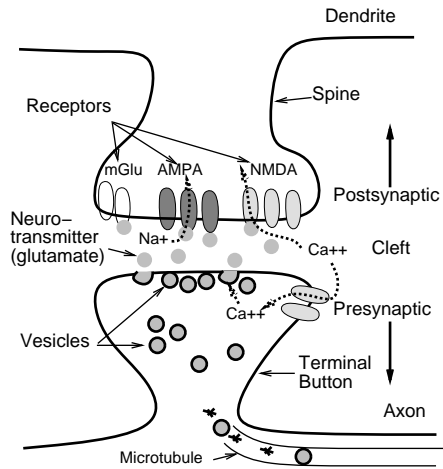
Simple example, but raises question of what kind of detectors needed for language, face recognition, creativity, etc.?

20

How do we simulate this?

- Neural activity (and learning) can be characterized by mathematical equations.
- We use these equations to specify the behavior of artificial neurons.
- The artificial neurons can then be put together to explore behaviors of networks of neurons.
- Simulation.

21 How can biology (e.g., synapse) be reduced to numbers?



22 How can biology (e.g., synapse) be reduced to numbers?

Synaptic efficacy = activity of **presynaptic** (sending) neuron communicated to **postsynaptic** (receiving) neuron:

- Presynaptic: # of vesicles released, NT per vesicle, efficacy of reuptake mechanism.
- Postsynaptic: # of receptors, alignment & proximity of release site & receptors, efficacy of channels, geometry of dendrite/spine.

Connection weight = synaptic efficacy.

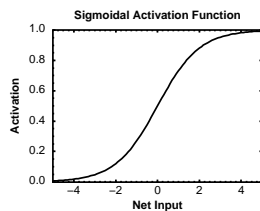
23 Abstract Neural Nets

1. Compute weighted, summed *net input*:

$$\eta_j = \sum_i a_i w_{ij} \quad (1)$$

3. Pass through *sigmoidal* function to compute output:

$$a_j = \frac{1}{1 + e^{-\eta_j}} \quad (2)$$



24 Bio Neural Nets

1. Compute weighted, summed *net input*:

$$\eta_j \approx \sum_i a_i w_{ij} \approx g_e \quad (3)$$

2. Compute V_m :

$$V_m = \frac{g_e \bar{g}_e E_e + g_i \bar{g}_i E_i + g_l \bar{g}_l E_l}{g_e \bar{g}_e + g_i \bar{g}_i + g_l \bar{g}_l} \quad (4)$$

3. Compute output as: Spikes, or rate code equiv.

Or, rate code via *sigmoidal* function:

$$a_j = \frac{1}{1 + (\gamma[V_m(t) - \Theta]_+)^{-1}} \quad (5)$$

25

Summary

- Neuron as detector.
- Can be characterized mathematically.
- Serves as the basis of simulation explorations.

26

Remaining

- Physiology behind the equations.
- Simple detector network.
- Room for free will?...