CS 182
Midterm review

Outline 1/3

- Biology
  - Neuron mechanics
    - spiking, neurotransmitters, ion channels, Na+
  - Development
    - growth cones, chemical gradients, activity-dependent pruning
- Models
  - McCullough-Pitts model
    - backpropagation: minimize error by slow steps
  - triangle node
    - recruitment learning

Outline 2/3

- Psych experiments
  - Stroop task, priming, spreading activation
- Brain study
  - PET, fMRI, EEG, MEG, TMS, lesion, single-unit
- Learning
  - backprop, Hebbian, LTP, calcium, retrograde, blank slate (not)
- Colors
  - language variations and invariants; intermediate representations

Outline 3/3

- Categories
  - basic categories: functional distinction & effects
  - category structure
- Schemas
  - Image schemas
  - FrameNet
  - Regier's model
    - hand-built feature extraction, learned mapping

Neurobiology

- Ion pumps
  - polarized
  - resting potential
  - ions: Na+, K+, Cl-
- Neurotransmitters
  - voltage admits Ca+, vesicles to release transmitters
  - bind to ionotropic receptors
  - allow ions into postsynaptic cell
    - different types of ions for different receptors/transmitters

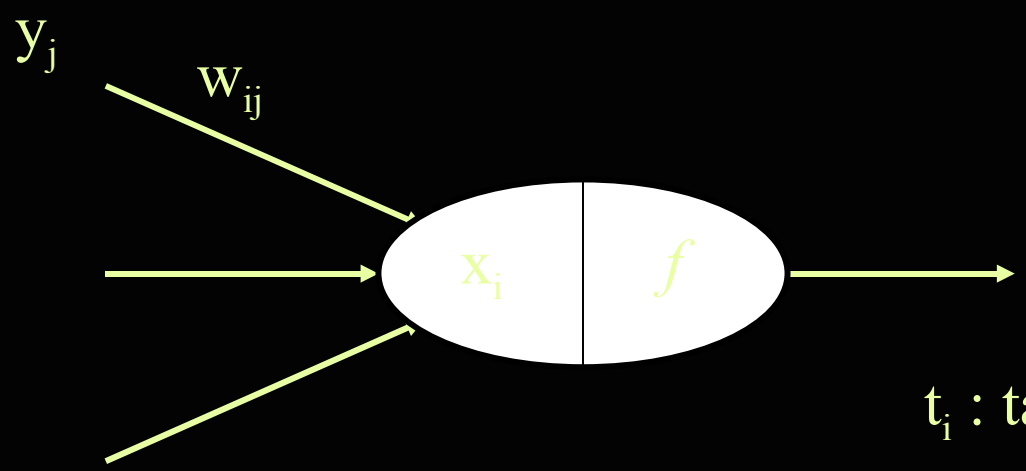
Neurobiology 2

- Action potential
  - threshold
  - all-or-nothing
  - voltage-gated channels
  - hysteresis & refractory period
- Myelin
  - electrical transmission
  - only in mammals

Neural development

- Neurons migrate to correct positions
- Grow axons with “growth cones” on tips
- Axons follow chemical gradients in increasing or decreasing directions, attracting or repelling them
  - brain areas grow axons generally together
- Axons meet other neurons, form synapses
  - overconnect
  - prune based on activity
  - humans not blank slate!

The McCullough-Pitts Neuron



t_i : target

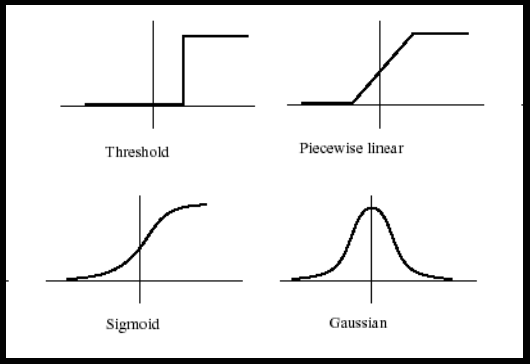
$$x_i = \sum_j w_{ij}\, y_j$$

$$y_i = f(x_i)$$

y_j: output from unit j

W_{ij}: weight on connection from j to i

x_i: weighted sum of input to unit i



Backpropagation

- Minimize squared error
  - gradient descent
  - use momentum (constant times previous change)
- Minimum error on training set may not be minimum error on all data!
  - overfitting
    - memorize training data at expense of generalization
  - reduce it by checking against a validation set or just stopping early

Triangle nodes

- Triangle nodes
  - Reciprocal connections to three other units
  - Activates whenever 2 units activate
  - Activates all 3 units
  - Can be implemented as group of McCullough-Pitts neurons
- Recruitment learning
  - Intermediate units activated by multiple sources strengthen connections to sources
  - Now intermediate unit represents conjunction

Hebbian learning

- Neurons that fire together, wire together
  - If presynaptic neuron helps cause postsynaptic neuron to fire, synapse strengthened
- Biology
  - Ca2+ enters postsynaptic cell when synapse active and cell fires
  - Temporarily makes receptors more sensitive; also slowly adds new receptors
  - releases nitrous oxide (NO)--retrograde messenger
    - causes changes in presynaptic neuron, too
    - releases more neurotransmitter

Psych experiments

- Measure behavioral differences that indicate processing differences
  - Stroop task
    - difficulty in reading words in other color
    - indicates topic-specific interference in language processing
  - Word priming
    - related words make recognizing words faster
    - timing-dependent effects
      - opposite words speed up without time to process; slow down processing with more time
      - explained by slower-onset inhibition

Brain study

- PET
- fMRI
- lesion
- EEG
- single-unit recording
- TMS

Colors

- Biology
  - 3 input signals
  - neural representations of sums & differences
    - e.g. yellow = green + red – blue
- Psychophysics
  - quantitative measurements of psychological quantities
  - e.g. find out how small a color difference subjects can discern
- Language
  - different languages have different groups
  - certain groupings maintained: no one groups red + green
  - certain central concepts maintained: no one says turquoise is a good example of “grue” (green-blue color group)