Pathways to perception in 3 (or fewer) synaptic steps

0  Input through sensory organ/tissue
1  Synapse onto neurons in spinal cord/brain stem
2  Synapse onto neurons in thalamus
3  Synapse onto cortical neurons in “primary ____ cortex”
4* Further cortical processing

Touch/“Tactile”

Mechanoreceptors in skin
- Pacinian corpuscles – vibrations
- Meissner’s corpuscles – light touch
- Merkel’s discs – pressure and texture
- Ruffini endings – stretch

Hearing/“Auditory”

Thalamus – the “relay” station

Touch: Inputs


3/31/2014

Regions of the brainstem

Dorsal view (back-of-the-head)

2-3 synapses in auditory brainstem path

Seeing/“Visual”

Retina
Optic nerve
Lateral geniculate nucleus (LGN)
Cortex
Primary visual cortex (VI)

HMAX – model of hierarchical vision

• Higher cortical levels cover larger visual spans
• Object recognition invariant to changes in location and orientation

Higher HMAX layers cover more space

Example coverage for layer x neurons

1. Gabor “filters” (edge detectors)
2. Perform “Max pooling” (semi-invariance over space)
3. Weighted combination of space-invariant edges
4. Further max pooling

Functions of HMAX layers

• Odd layers (layer 1, 3, 5, ...) look for specific combinations of lower-level features
• Even layers (layer 2, 4, 6, ...) provide invariance to some feature changes (e.g., shift in position)
Functions of HMAX layers

• Odd layers (layer 1, 3, 5, ...) look for specific combinations of lower-level features

\[ h = \sum_j w_j r_j^{in} \]

\[ r^{out} = g^{rad}(h) \]

• Even layers (layer 2, 4, 6, ...) provide invariance to some feature changes (e.g., shift in position)

\[ r^{out} = \max(r_1^{in}, r_2^{in}, \ldots, r_j^{in}) \]

Visual attention

• Perceive objects one at a time

• Ignore irrelevant details

Model of Attention/Recognition

Find blob Match w/memory Inhibit blob

1. Pick dim area
2. Run Athlete
3. Ignore area in future

Olshausen et al., 1993

Non-spatial attention

CAT

Modulating inputs through multiplication

Algorithm: “Sigma-Pi Node”

• Multiply rates to modulate each input

• Sum to compute output rate

\[ h_i = \sum_{jk} w_{ijk} r_i^{in} r_k^{in} \]

Biology

• Pre-synaptic: acetylcholine causes axon to release more Ca^{2+}, which increases NT release rate

• Post-synaptic: voltage-dependent NT-receptors (like NMDA receptors) will detect NTs only when membrane voltage increased by other NT receptors