CIMVSP Panel Discussion

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Questions

- Is there a single dominant functional/operational principle of brain function and biological intelligence?
- What is (are) your favorite principle(s) of brain function/biological intelligence, and why do you think so?
- What is needed to progress?

My interpretation: As engineers who hope to build "intelligent" systems, what aspect of the brain should we focus on?

My answer: The brain uses a distributed representation of input stimuli based on neurons selective along a multi-dimensional stimulus space.

Cortical Visual Processing

From E. R. Kandel et. al., Principles of Neural Science

Why multidimensional selectivity?

- Measured in cortex
- Important perceptually
  - (van Ee and Anderson, Nature, 2001)

Multidimensional selectivity

- Position
- Spatial frequency (size)
- Temporal frequency (change)
- Color
- Orientation
- Binocular Disparity (depth)
- Direction/speed of motion
- Curvature

Improvement over isolated cues

Motion and stereo
Motion only
Stereo only

Motion and stereo
Motion only
Stereo only
Conjecture

- V1 (and visual cortex in general) reformat
  the visual data so that it is easier to interpret
  - I/O ratio for retina: 100/1 (compression)
  - I/O ratio V1: input:output ratio ~ 1:50
    (expansion!)
- Neuromorphic systems for visual perception
  should simultaneously integrate information
  from all cues (orientation, disparity, motion)
  at a very early stage.

Why is this important?

- The brain’s representation of input stimulus
  is what enables it to learn a wide variety of
  tasks
  - rapidly
  - flexibly
  - generically
  - efficiently
- Although we have focused on perception, it
  is likely that a similar principle will hold for
  action.

What is needed?

- Biology: Mapping the multidimensional
  selectivity of neurons in the visual cortex,
  especially in areas beyond V1
- Theory: Probabilistic models of the relationship
  between model neural responses and
  behaviorally relevant input stimulus variables
- Hardware: Efficient hardware architectures for
  simulating large populations of neurons with
  multidimensional selectivity
- Systems: Robotic systems that couple
  neuromorphic representations with action to
  generate behavior