Computational Perception

Prof. Michael Langer

- Perception is knowing what is where (by seeing, hearing, touching, smelling...).
- Perception is a process.

Sensation and Perception

- Physical stimulus → Sensory organ → Perceptual system (brain)
  - Optics, eye, vision (seeing)
  - Acoustics, ear, audition (hearing)
  - Mechanics, skin, haptics (touching, feeling)
  - Chemistry, mouth, nose, olfaction (tasting, smelling)
  (+ kinesesthesia, balance, pain, ...)

Perception is a process,

- Physical stimuli → Sensory organ → Perceptual system (brain)
- Stakes of measurement → Computation of world + events
- Internal models of events → What? Where?

Eg. Visual Perception

- Physical 3D world ≠ Perceived 3D world
  - Light source
  - Surfaces
  - Light + reflection
- Objects
  - Surface shape, color, material, layout
  - Category...
- Motion events
- Illumination

Eg. Auditory Perception

- Physical 3D world ≠ Perceived 3D world
- Objects
  - Location
  - Layout (soundscape)
- Vibrations
  - Elastic body + source + resonator
- Sound emission
Scientific Approaches to Perception
- Physiology, Anatomy, Biology
  - neuron, nervous system, brain
- Behavioral Psychology
  - detection and discrimination, recognition, memory, attention
- Computation
  - signal processing, neural networks, machine learning
  - computer vision, hearing

This course (13 weeks)
- Vision (5)
  + Linear Systems (2)
  + Psychophysics (2)
- Audition (3)
- Taste, Smell, Touch, ... (0)
- two midterm exams (1)

Levels of Analysis

Computer Science
- algorithms
- programs in high-level language
- architecture
- machine and assembly language
- transistors, gates, circuits

Visualization of Perception
- computational models
- behavior (psychophysics)
- cortical areas & maps
- receptive fields
- cell membranes, synapses, spikes

Vision 1
- image formation
  - 3D to 2D (linear algebra)
  - binocular stereopsis
  - blur and focus (optics)
  - color (linear algebra)
  - spatial/temporal/chronic

Linear Systems
- convolution
- auto/cross correlation
- Laplacian, difference of Gaussian
- Fourier transform
- filtering, convolution theorem

(heavy use of complex numbers and linear algebra, e.g. $UU^T = I$)

Vision 2
- cortical maps
  - orientation/edges
  - binocular disparity
  - motion
  - eye and head movements"
Vision 3 (new)

- attention
- perceptual organization
- recognition
- natural image statistics

Psychophysics (behavior)

- detection & discrimination
- acuity
- noise
- cue combinations (maximum likelihood vs Bayes)

Audition

- sound
- neural coding
- source localization (passive)
- echolocation (active)

Related Courses (this semester)

- NEUR 603
  Introduction to Computational Neuroscience
- COMP 558
  Fundamentals of Computer Vision
- ECSE 626
  Statistical Computer Vision

Applications (beyond science)

- computer graphics
  - rendering
  - displays (HDR vs LDR, 3D)
  - virtual reality (HMDs)
  - visualization
- computer vision
  - hybrid systems
    - human
    - computer
    - computer-assisted vision

Prerequisites

- COMP 250 (or equiv)
- multivariable calculus (MATH 222)
- linear algebra (MATH 223)
- probability
  - e.g. normal distribution
### Evaluation

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<th>final exam</th>
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