Defining the Terms – Image Understanding

Image Understanding

Image

Processing

Scene description

Computer Graphics
Defining the Terms – Image-Based Measurement

e.g. 3D surface reconstruction (geometry) + radiometry (color)

More definition: tomorrow’s lecture “Bildgestützte Messverfahren”
Human Visual System

Vision is claimed to be the “richest” human sense

- Huge amount of input data
- Relatively slow processing speed
- Approx. 100 steps from sensory input to action

⇒ Massively parallel processing
Vision from various points of view

• Neurophysiology
  • Neuron
  • Eye
  • Brain

• Cognitive Psychology
  • Bottom-up, top-down grouping
  • Visual pathways, FMRI, activation of cortical areas
  • Visual illusions, tasks, depth, hemispheres

• Information processing
  • The *process* of vision
  • Representations
  • Algorithms
Vision from various points of view

• **Neurophysiology**
  - Neuron
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• **Cognitive Psychology**
  - Bottom-up, top-down grouping
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• **Information processing**
  - The *process* of vision
  - Representations
  - Algorithms

*Today’s lecture*
Approx. numbers for the human brain:

- $10^{11}$ neurons
- $10^{14}$ synapses
- 1 kHz

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Real neurons

Visual cortex of a rat
Information processing in the brain [Hubel, 1986]
The human eye

Hornhaut (Cornea)

Pupille

Linse

Glaskörper (Corpus vitreum)

Netzhaut (Retina)

Sehnerv (Nervus opticus)

vordere Augenkammer

Regenbogenhaut (Iris)

Schgrube (Fovea)

“blind” spot
The retina

20° SLO (“scanning laser ophthalmoscope”) image
The retina – a total of approx. 126 M receptors

From [Frisby & Stone 2010]

http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rodcone.html
~ 6-7 M cones  ~120 M rods
The retina
The fovea

“honeycomb” structure
cones
6-neighborhood

patchwork
regular patches
irregularities @
5-, 7-neighbor nodes

As compared to pixels
squares
regular grid
4- or 8-neighborhood
The visual pathway

- Retina rods, cones
- Optic nerves chiasm
- Laterate geniculate nuclei LGN
- Visual cortex
- Hemispheres ↔ left/right field of view

From [Hubel & Wiesel 1986]
Mapping
Retina → visual cortex

Retina
rods, cones

Optic nerves
chiasm

Laterate geniculate nuclei
LGN

Visual cortex

Hemispheres ↔
left/right field of view

From [Frisby, 1983]
Receptive Fields

Mapping regions on the retina to particular neurons
Receptive fields [Hubel & Wiesel]

On-Off & Off-On cells

Bright/dark dots on dark/bright background @ various scales

Respond also to bright/dark lines through center of receptive field
Receptive fields [Hubel & Wiesel]

Simple cells:

Lines/edges
orientation & position

Grayvalue profiles:
line
edge
Receptive fields [Hubel & Wiesel]

Complex cells:
orientation, @ any position → “spatial frequencies”, spatial scale
Columns in visual cortex [Hubel & Wiesel]

Columns ↔ discrete orientations

Coarse angular resolution

Retinal ganglion cells, LGN, layer IV:
On_off / Off_on ↔ Blobs @ various scales

→ so: What is it?
What is it?  [Lowe, 1986]
What is it? [Lowe, 1986]
What is it? [Lowe, 1986]

→ Cognitive psychology