HCI Lecture 2:

Human capabilities: Input/Output systems

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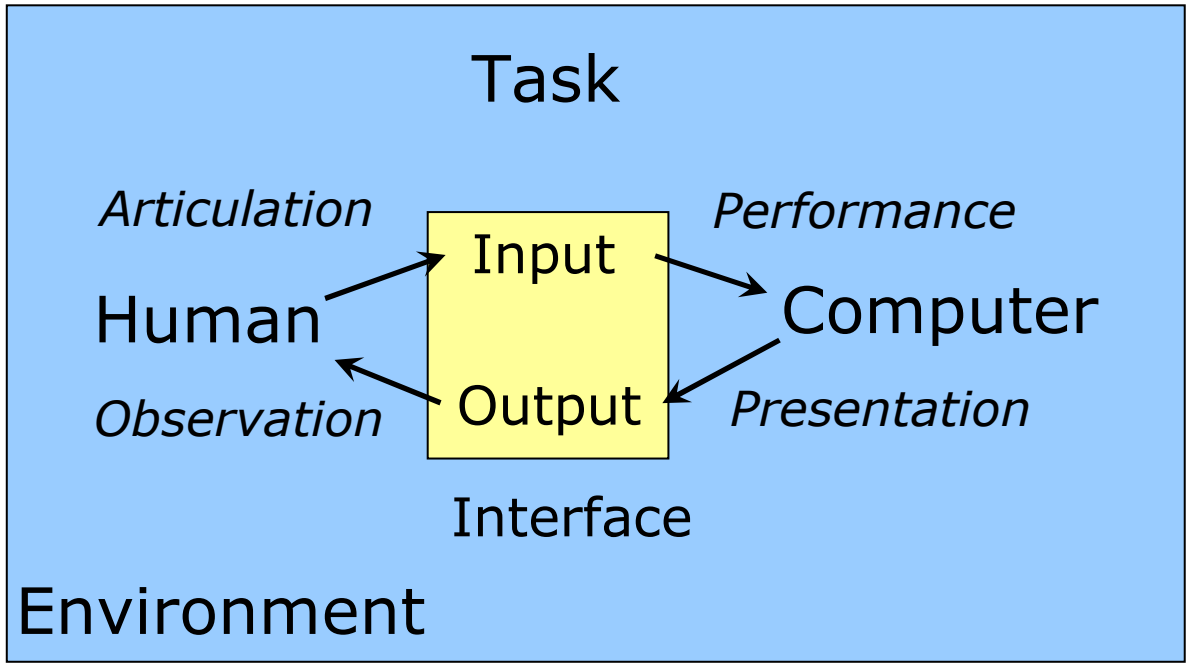
Key points:

- Human have processing constraints
- Motor limitations, e.g. Fitts' law for pointing
- Visual range for motion, shape, colour, detail and their consequences for design decisions
- Visual attention models
- Alternative sensory channels

Human constraints

- Human computer interaction depends on what humans are actually capable of observing and articulating



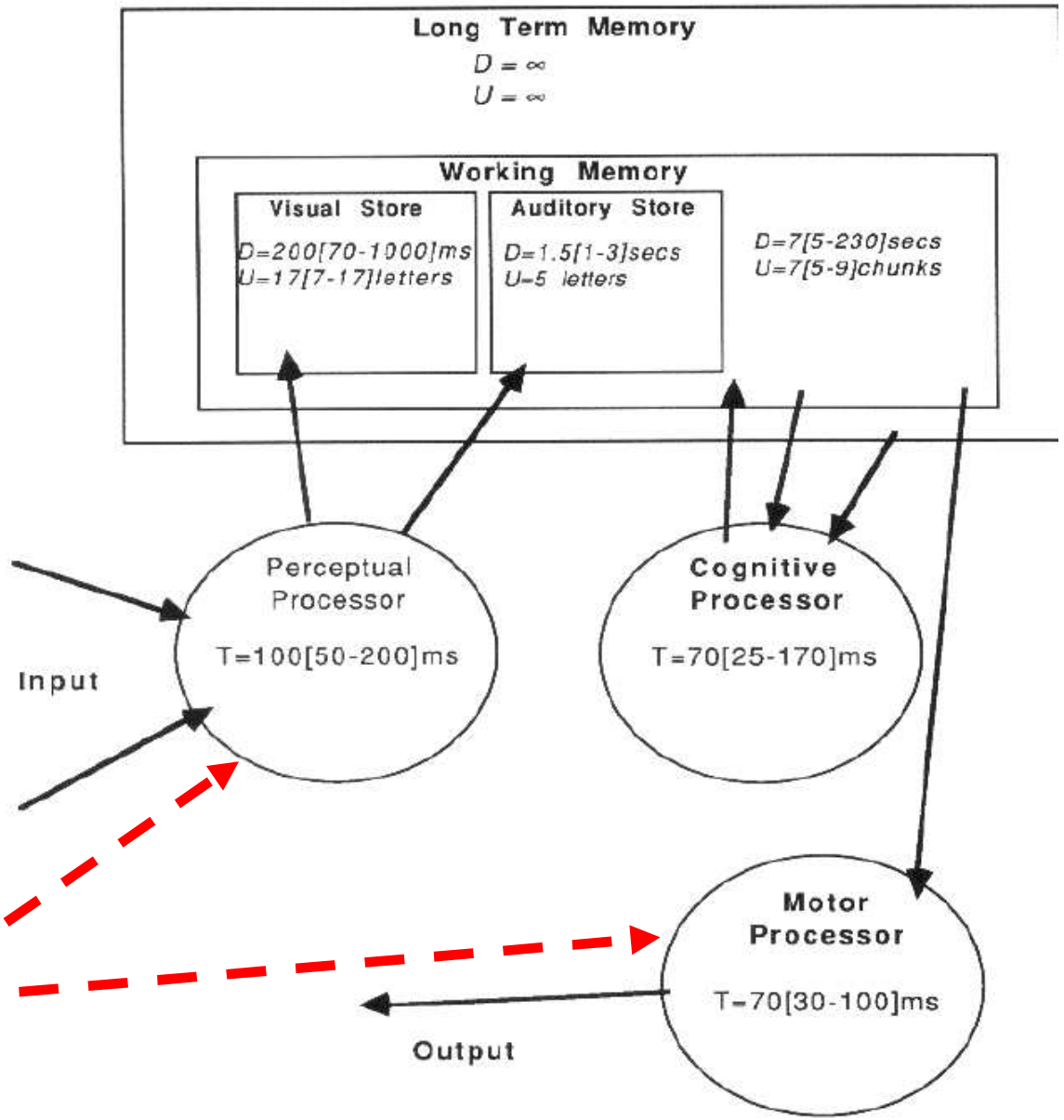
Human constraints

- What do we know about human capabilities that could or should constrain interface design?

  - Limits on perceptual capability – e.g. contrast, resolution
  - Limits on motor capability – e.g. reach, speed, precision
  - Limits on attention capacity
  - Limits on memory
  - Rates of learning and forgetting
  - Causes of error
  - Mental models & biases
  - Individual differences (the average size fits few people)
  - Variable state (e.g. stress, fatigue)
  - Special needs & age …

Human constraints

- Model Human Processor (MHP)
- One way to subdivide the main constraints
- Perceptual, Motor and Cognitive sub-systems characterised by:
  - Storage capacity *U*
  - Decay time *D*
  - Processor cycle time *T*
- We will focus today on the perceptual and motor processes



Motor constraints

- Example: Fitts' law

$T=a+b\ \log_2(D/W+1)$

T=time, D=distance, W= target width

a, b are constants that depend on the pointing device, the user, the environment etc.

- Justification?
  - By "analogy" to Shannon information

    capacity = bandwidth$\log_2$((signal+noise)/noise
  - If move fraction 1-r to target each timestep, then reach target when $r^nD = W/2$; so n is proportional to $\log_2 2D/W$
  - Empirically find good fit with $\log_2(D/W + 0.5)$

Motor constraints

- Example: Fitts' law

$$T = a + b \log_2(D/W+1)$$

T=time, D=distance, W= target width

a, b are constants that depend on the pointing device, the user, the environment etc.

- Application?
  - Time will increase with distance – can we keep everything close?
  - Time will decrease with width – can we make width infinite?

See quiz regarding HCI applications of Fitts' law here:
http://www.asktog.com/columns/022DesignedToGiveFitts.html

Perception

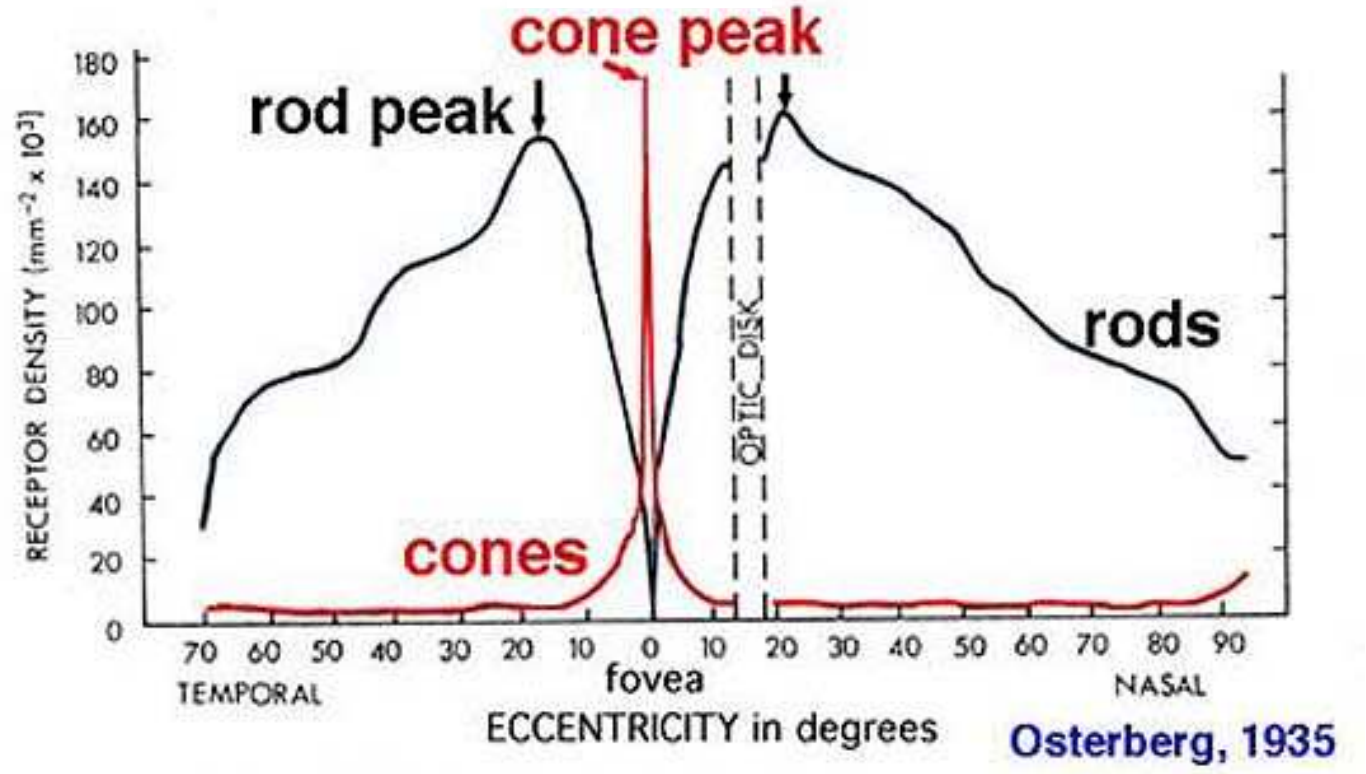
- What can we see?

detail

colour

shape

motion



Perception

- Some consequences of what we can see:
  - Motion – will be visible (and distracting) anywhere in visual field
  - Colour – main advantage is "pop-out":

    But many disadvantages:

  - Shape important in text recognition: SO ALL CAPS BAD
  - Limits on resolution – recommend minimum font size; ideally individual can adjust
  - High resolution only in tiny area of fixation

Eye tracking

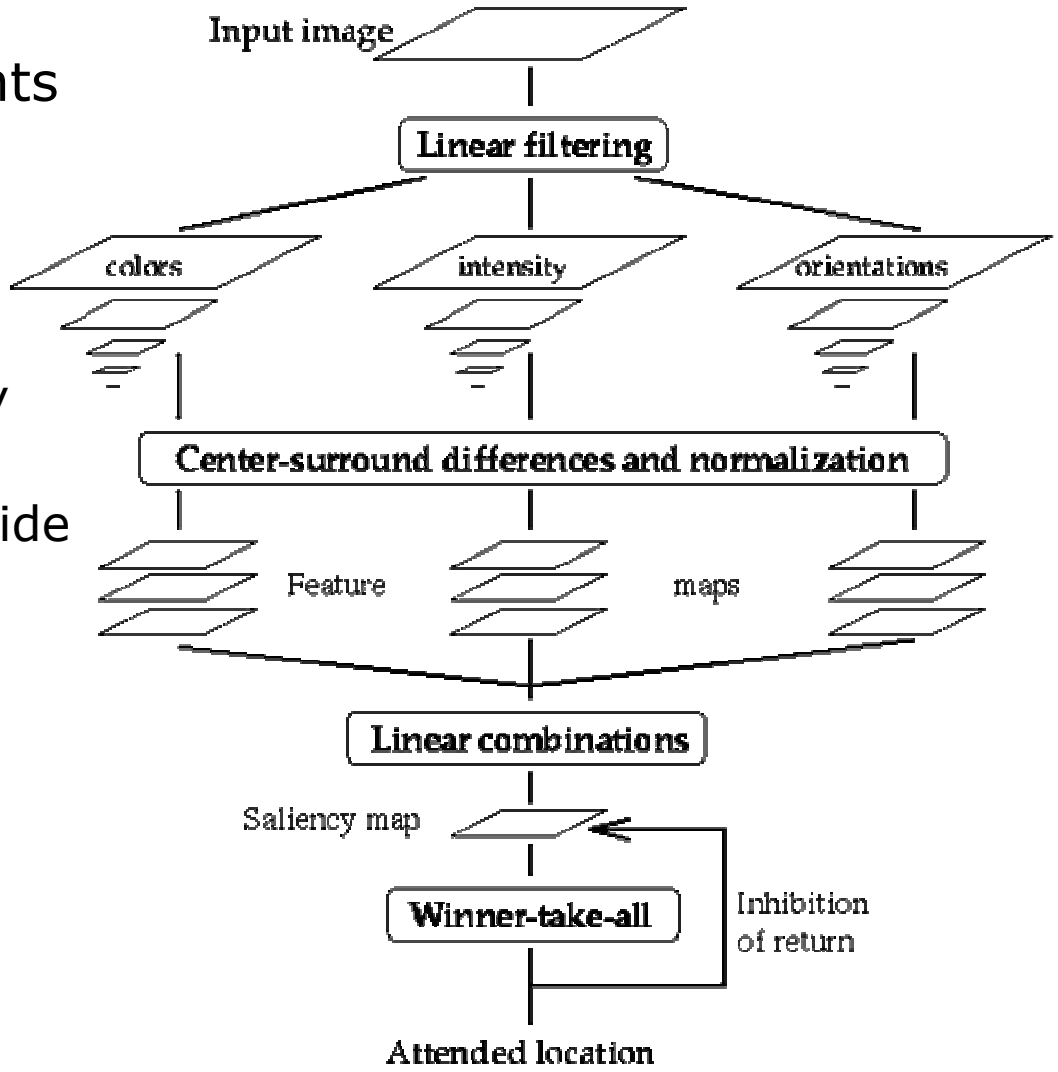
- Fixation pattern is a good indicator of attention
  - Where do people look, how often, for how long, in what order?
- Recent technology is making this a standard tool for HCI

Babcock & Pelz 2004

- Also used as input device.

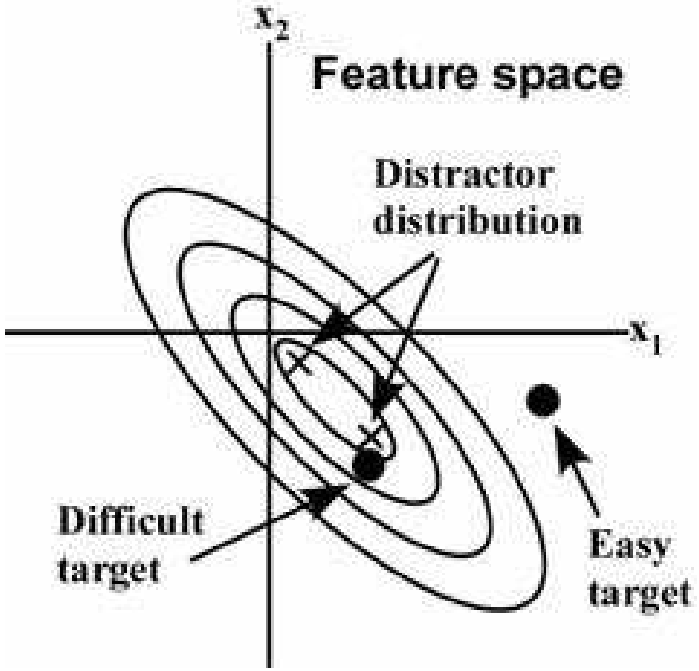
Perception

- Importance of eye movements
  - Must shift the tiny high resolution area around constantly
  - Movements called saccades occur > 2 per second all day long
  - How does visual system decide where to move next?
- Models of attention
  - e.g. Itti et.al. 1998



Attention

- Simple statistical model of saliency
  Rosenholtz et al (2005)
- Provides definition of 'clutter': size of local covariance ellipsoid
- To measure:
  - Compute local feature covariance at multiple scales
  - Take maximum across scales
  - Average for different features
  - Pool over space
- Produces good correlation with human estimates of clutter
- Can also use to determine what feature added where would best draw attention



Attention

- So what went wrong here?
  - Task: find current population of U.S.

  - 86% of users failed…

http://www.useit.com/alertbox/fancy-formatting.html

Perceptual constraints

Bottom up visual processing sets some constraints on optimal layouts, but must also consider top down issues:

- Cultural and learned factors – familiarity
- Underlying domain knowledge of user
- Need to reflect logical structure, e.g., placement and grouping according to function, sequence, frequency of use
- Dependence on task to be carried out, e.g. getting an overview vs. seeking specific information

- Note that layout and visualisation are already widely explored fields, with conclusions that carry over to HCI

Alternative sensory channels

- Different sensors provide parallel channel capacity

Sound:

- Not so easy to localise but can detect from any direction
- Grabs attention – warning mechanisms
- Good signal of causal relation – use as confirmatory feedback
- Monitoring state, 'background information'
  - Disk, printer noise etc.
  - Example of user improvisation in use of 'data'
- Interface sound design is typically arbitrary and synthetic

Touch and haptics:

- Exploit our natural ability to 'handle' objects

References

Fitts law: for a detailed account see MacKenzie, I.S. (1992) Fitt's law as a reseach and design tool in human-computer interaction. Human Computer Interaction, 7, 91-139.

Itti model of visual attention: see ilab.usc.edu/bu for details of the model, images, movies, an interactive demo and source code.

Jay, C et al. (2007) How people use presentation to search for a link: Expanding the understanding of accessibility on the web www.cs.man.ac.uk/~jayc/papers/web_presentation_new.pdf

Rosenholtz, R. et al. (2005) Feature congestion: a measure of display clutter. SIGCHI 2005, 761-770

- See also:

Dix et. al. sections 1.2, 3.2, 3.4, 12.5