Two Handed and Gaze Input

Stanford and Princeton Lecture Nov 29, 1999

Shumin Zhai

The Present and Future of Computer Input

- Two - handed input
  - Example of present input research
- Gaze tracking
  - Example of (possible) future input

Two-handed Inputs

- *Buxton and Myers, CHI' 86*
  - left hand scrolling
  - right hand pointing
- *Bier et al, CHI'93*
  - left hand "tool glass"
  - right hand pointing

Asymmetric division of labor in bimanual action

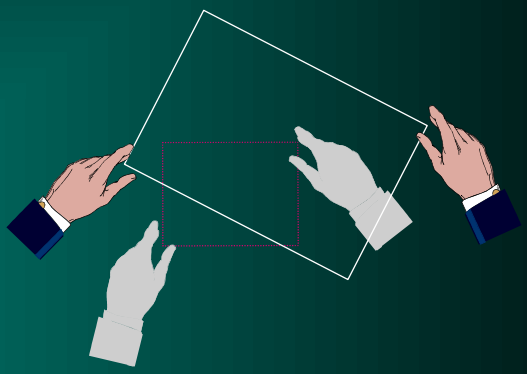
The kinematic chain as a model
Yves Guiard (1987) *Journal of Motor Behavior* 19, 4, 486-517

- *The left hand sets the frame of reference for the action of the right hand.*
- *Left hand greater scale than right hand*
- *Left-hand precedence in action*
- *Right (terminal) hand dominance*

Leganchuck, Zhai, Buxton, ACM *ToCHI, 1998*

Cognitive Benefits

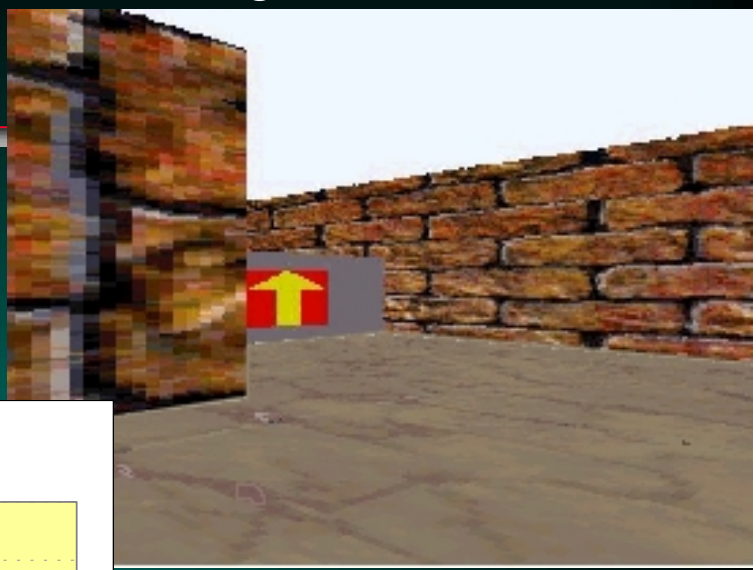
- Physical - time motion efficiency
- Cognitive benefits - visualization model

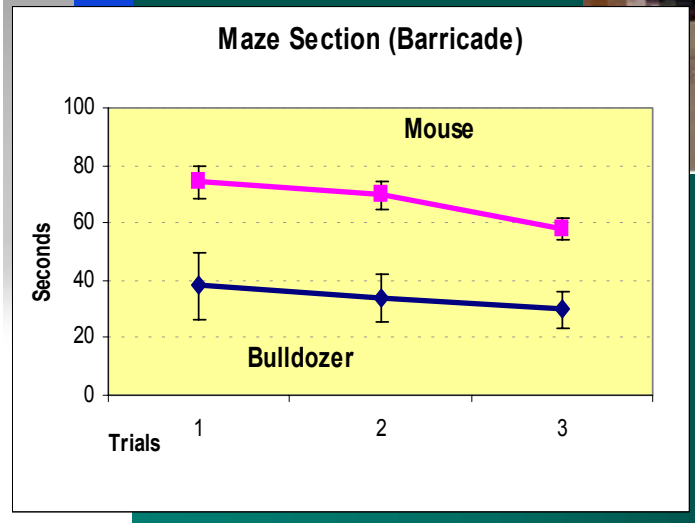


Natural Metaphor

Zhai, Kandogan, Smith, Selker, *JVLC, 1999*

- Navigation in 3D
- Bulldozer





Multi-handed input

Human Computer "Communication"

- Asymmetry *(R.J.K. Jacob, 1990-93)*
  - High bandwidth from computer to human
    - Text
    - Graphics
    - Sound
  - Low bandwidth from human to computer
    - Mouse
    - Keyboard

Enabling multi-modal interaction

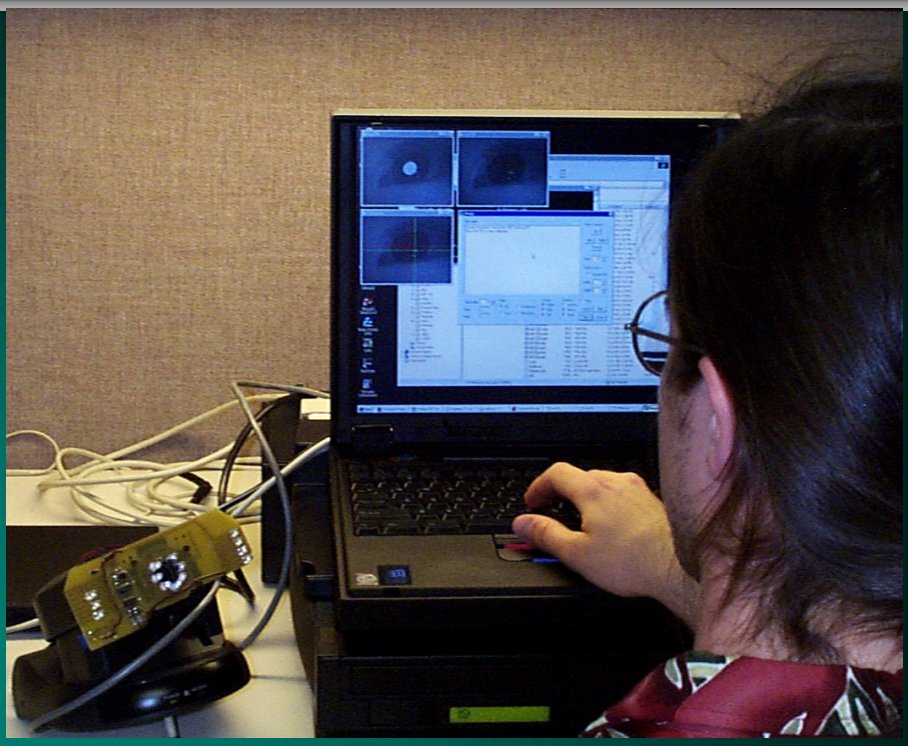
- Increasing computing power
- Speech recognition
- Low cost ($10) camera to appear
- Computer Vision / Image Processing

- Gaze tracking

What if computer can "see"

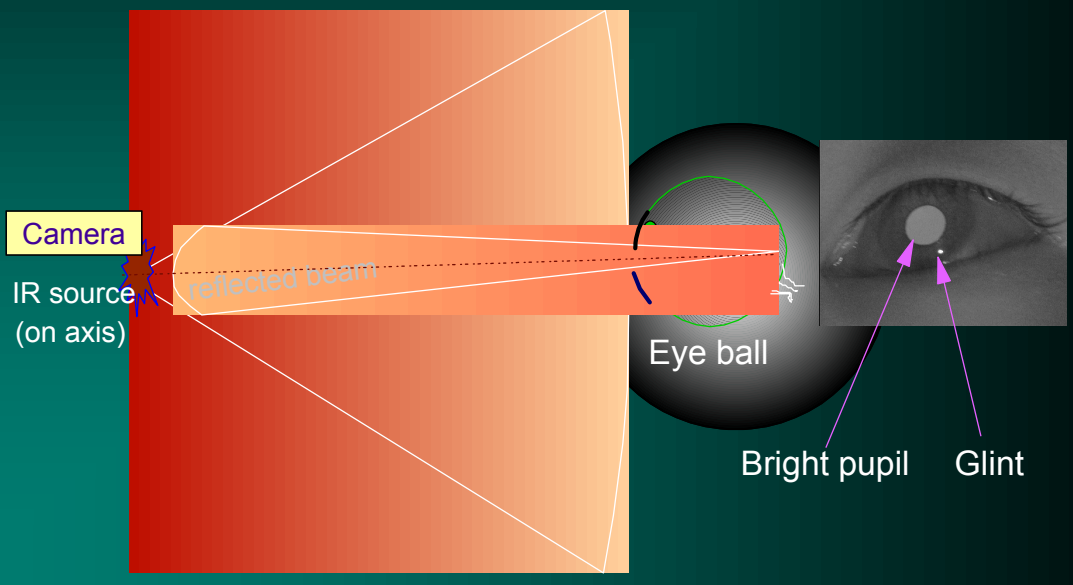
- More efficient and effective HCI?
- Can computer know user "intention"?
- What if the computer can see the user's gaze?

IBM Almaden Eye-tracker



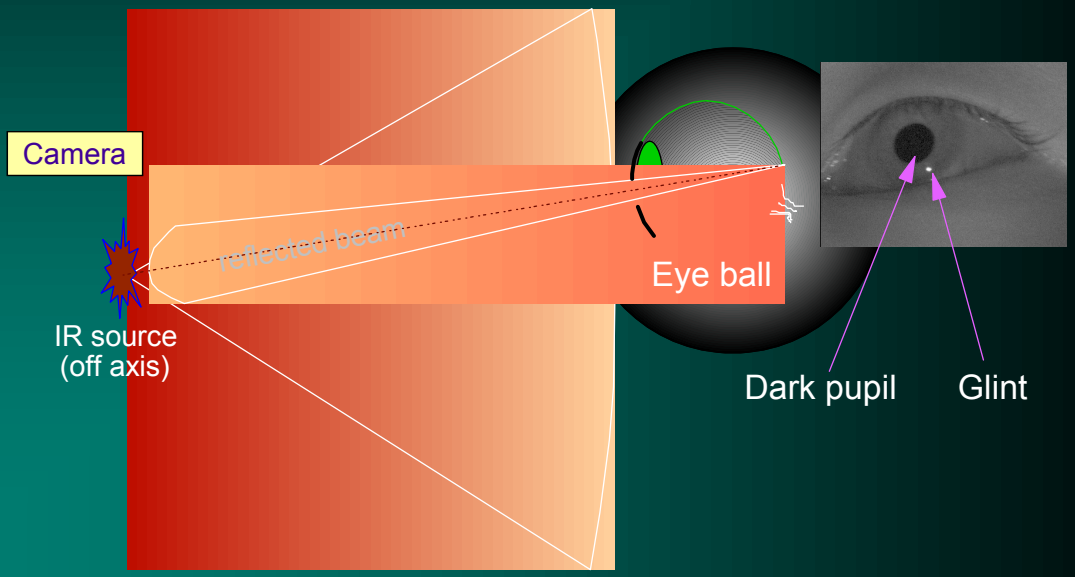
The Bright Pupil Effect

- On-axis IR produces a bright pupil image

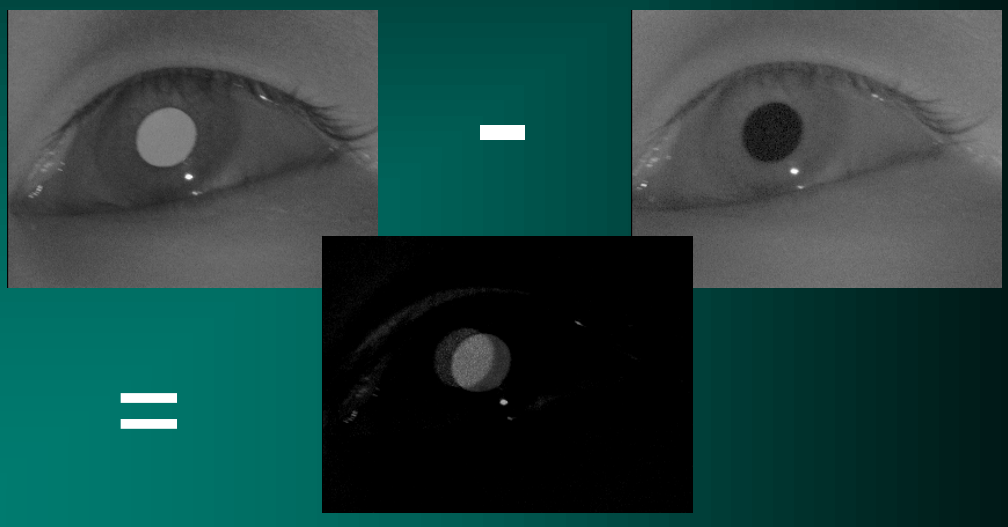


How - The Dark Pupil Effect

- The off-axis IR produces a dark pupil image



Dual light source gaze tracking



Gaze for Pointing?

- A classic topic:
  - "What you look at is what you get!"
    - J.L. Levine 1981
    - C. Ware and Mikaelain 1987
    - R.J.K Jacob 1990
- Why gaze pointing?
  - Hand unavailable
  - Eye faster than other organs
    - Look first, manipulation follow
  - Fatigue / injury in hand pointing

Difficulties with Gaze Pointing

- Eye tracking not precise
  - Measurement error
  - Eye movement - saccades and fixations (1 degree - twice scrollbar width)
- Only large targets work (0.5 in)

Difficulties with Gaze Pointing

- How to do buttons (click)?
  - Blink - often subconscious
  - Dwell time - continuous fixation for set period (e.g. 200 ms)
    - False selections ("Midas touch")
    - Misses
  - What about double or right click?

Difficulties with Gaze Pointing

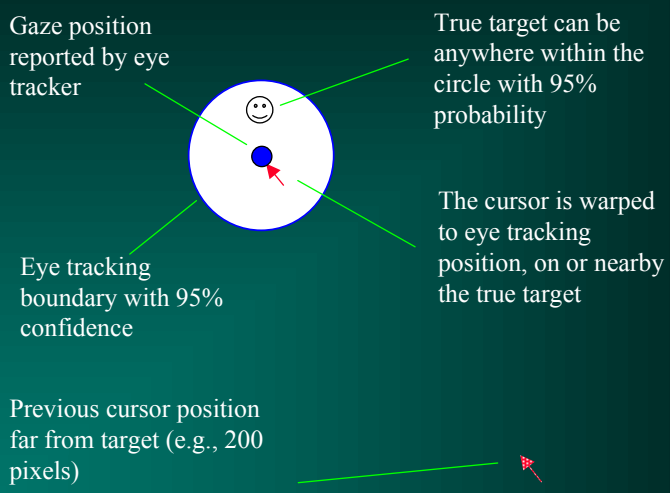
- Unnatural model:
  - eye - perception organ, driven by mind and world
  - hand - manipulation (motor) organ
  - gaze pointing - loading perceptual channel with motor tasks
- Dead end ????

Utilize Eye Gaze Implicitly?

- Combining hand and eye movement
- Reposition (warp) cursor by gaze
- Hand remains to be the control device (fine movement and selection)
- Defy Fitts' law?

Zhai, Ihde, Morimoto, *CHI'99*

MAGIC Pointing



- Manual And Gaze Input Cascaded Pointing
- Manual Acquisition with Gaze Initiated Cursor

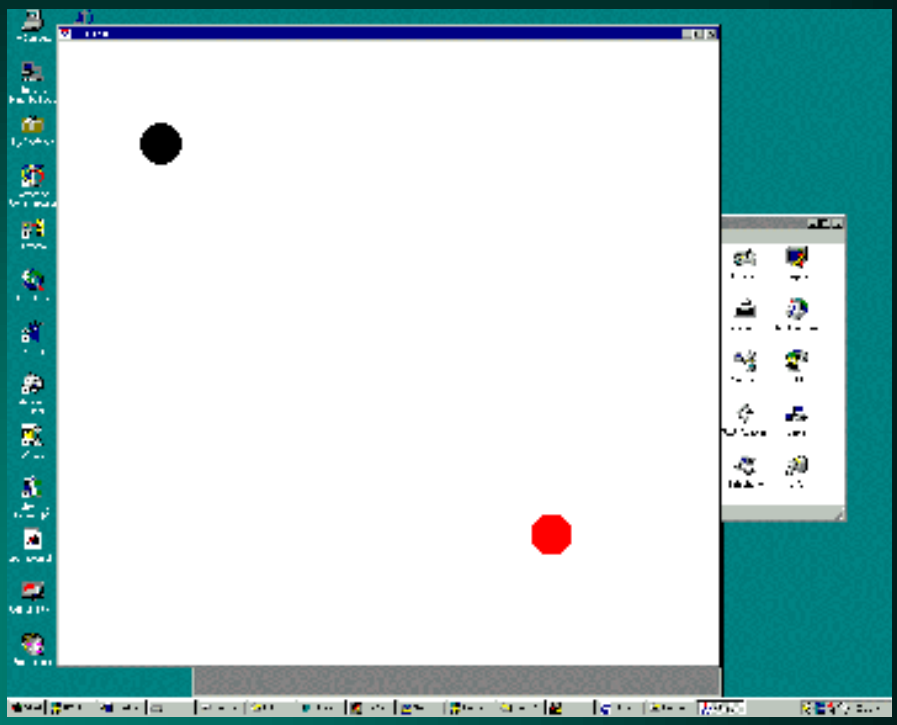
When to warp?

- Every large saccade
  - pre-intent, “liberal”, proactive
  - possible distraction
- When input device actuated
  - post-intent, “conservative”
  - new form of hand-eye coordination

Experiment

- Difficult: every thing has to go “right”
- Imperfect tracking system
  - error: 1 degree or more
  - delay: 66 ms or more

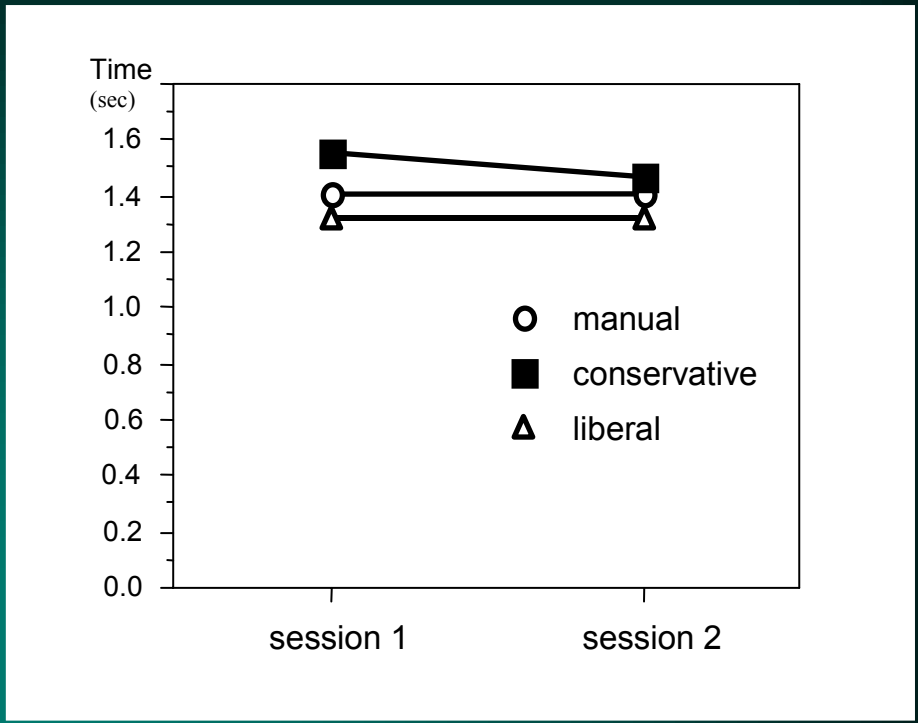
Task



Experimental Design

- Two target size - 20 vs. 60 pixels
- Three distances - 200, 500, 800 pixels
- Three pointing direction
  - horizontal, vertical, diagonal
- Three pointing techniques
  - two magic
  - one manual
- 12 subjects

Trial completion time



Other observations

- *$20 prize claimed with magic technique*
- *User's subjective experience*
  - *rated both magic techniques higher than manual (1.5 and 3.5 on -5 to +5 scale)*
  - *The "liberal" technique was "easier"*
  - *Disappointed with pure manual - subjective ease of operation (work done at will)*

What can we conclude?

- Reduced fatigue (less manual work)
- More precise than traditional gaze pointing (small target)
- More practical than traditional

Future work

- tracking system limitations
  - Frequency
  - resolution
  - Calibration!
- magic method limitations
- experimental limitations

There is more ……