INTERACTION DESIGN AND EVALUATION. SESSION 2

Dept. Computer Science – UPC

OUTLINE

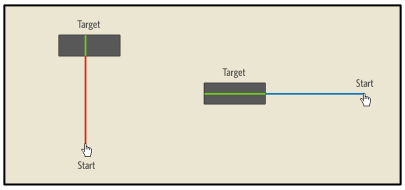
- **Fitts Law in UI Design**
  - Implications
  - Applications
  - Fitts' Law in Mobile Devices
- Accelerating Target Acquisition
- Law of Crossing
- Steering Law
- Pointing Devices
- 3D Selection

FITTS' LAW IN UI DESIGN.

- Fitts Law provides a scientific foundation for studying and designing pointing-based user interfaces.

$$MT = a + bID$$

$$MT = a + b\log_2\left(\frac{D}{W} + 1\right)$$



5. Donades les constants a = 400 ms, b = 200 ms/bit i un objectiu de mida 2.1 cm a una distància de 10.5 cm. Marca la resposta correcta assumint que fem els càlculs amb la versió de McKenzie de la llei de Fitts.

a. ID ≈ 3.4.
b. 2 < ID < 3.
c. ID ≈ 4.3.
d. MT està entre 1100 i 1200 ms.

6. La llei de Hick-Hyman:

a. Modela el temps de decisió com una funció de la informació transmesa.
b. Modela el temps de selecció d'un element com a funció de la distància a recórrer i la mida de l'element.
c. Modela el temps de decisió com una funció de la distància a recórrer i l'entropia dels elements a seleccionar.
d. Utilitza l'entropia de Shannon per a mesurar la distància del recorregut mínim.

FITTS' LAW IN UI DESIGN. IMPLICATIONS

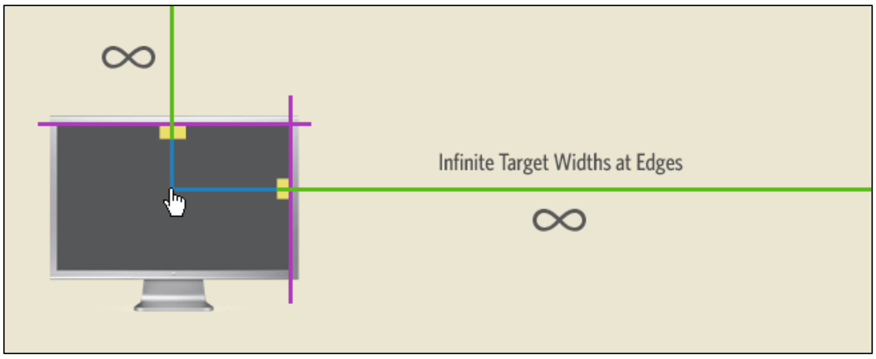
- Fitts' Law accurately predicts **pointing** movement

- If improvement required, it can help us modify our UI
  - Change target width:
    - Increase size for faster reach
  - Change de "virtual distance" or pointer movement:
    - Increase speed, pop-up menus,….

- But visual stimuli must also be taking into account…

MOVING

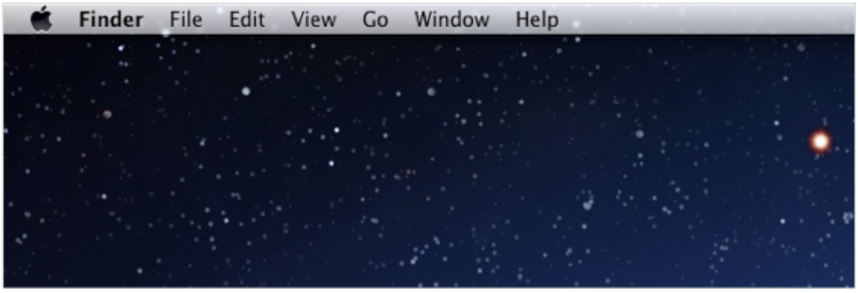
FITTS' LAW IN UI DESIGN. IMPLICATIONS

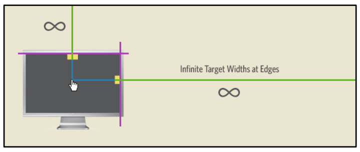


$$MT = a + b\log_2\left(\frac{D}{W} + 1\right)$$

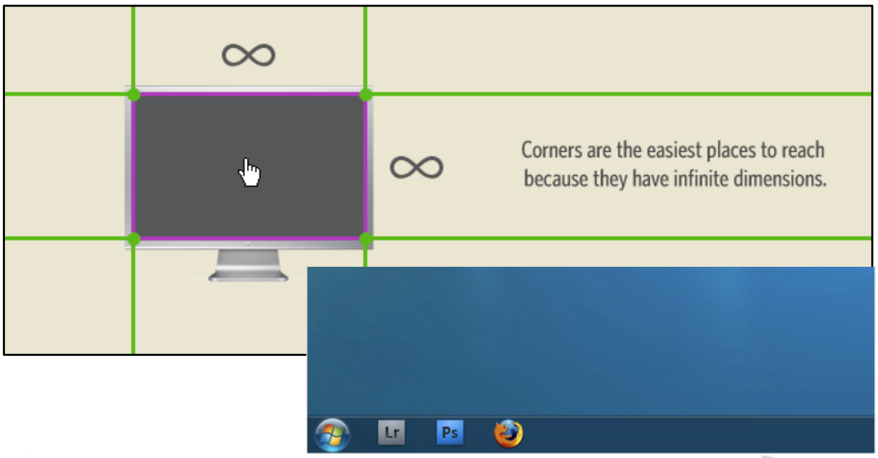
MOVING

FITTS' LAW IN UI DESIGN. IMPLICATIONS





FITTS' LAW IN UI DESIGN. IMPLICATIONS



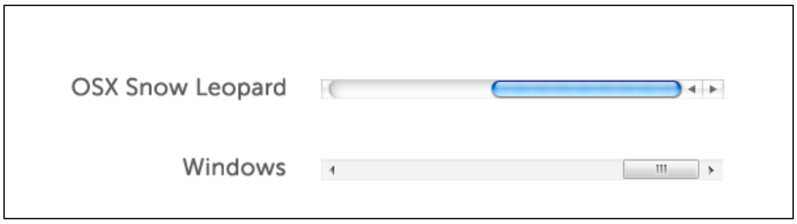
FITTS' LAW IN UI DESIGN. IMPLICATIONS

Web sites do not have edges or corners of infinite width.

:(

FITTS' LAW IN UI DESIGN. IMPLICATIONS

- **Keep related things close**
  - Mac OS scrolls are faster to navigate

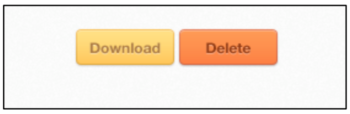


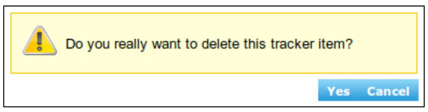
FITTS' LAW IN UI DESIGN. APPLICATIONS

- Keep related things close
  - Filters should be placed close to the search field

FITTS' LAW IN UI DESIGN. APPLICATIONS

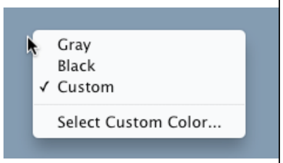
- Keep related things close **and Opposite Elements Far**
  - These buttons should be placed far away from each other





FITTS' LAW IN UI DESIGN. APPLICATIONS

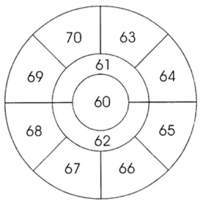
- **Pop-up menus**: Reduce travelling distance
- Improve two aspects:
  - Reduction of distance to travel (Fitts)
    - The option is close to the menu emerging place
  - Frequency-enabled may improve the time to pick an option:
    - Based on Hick-Hyman:
      Recall that *users are able to point faster objects that are known*
- Only used by experts!

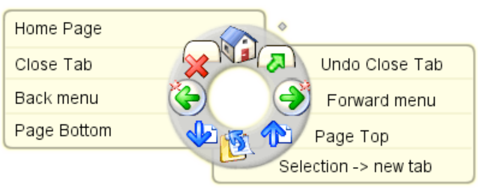


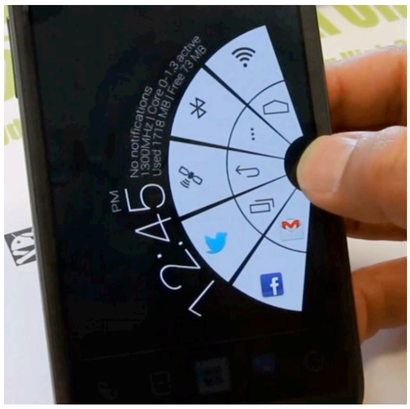
MOVING

FITTS' LAW IN UI DESIGN. APPLICATIONS

- *What about pie menus?*



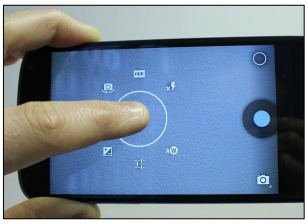


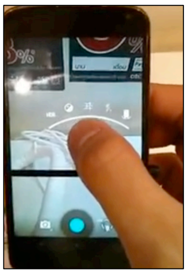


MOVING

FITTS' LAW IN UI DESIGN. APPLICATIONS

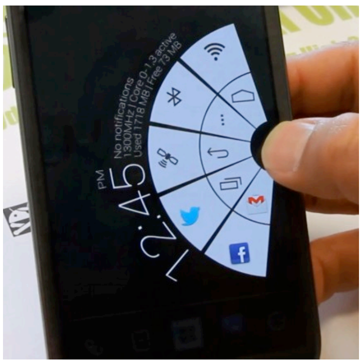
- *What about pie menus*
  - Sort of contextual menu
    - Needs to be created on demand
    - Needs some room!
  - Should not have occlusions
    - On mobile half-pie menus better than fully circular

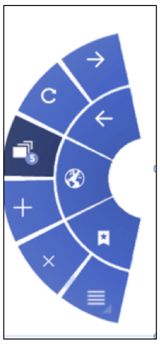




FITTS' LAW IN UI DESIGN. APPLICATIONS

- Pie menus difficult to design!
  - Second layer changes the size and distance
  - Organizing by frequency may be a problem (learning)





FITTS' LAW IN UI DESIGN. APPLICATIONS

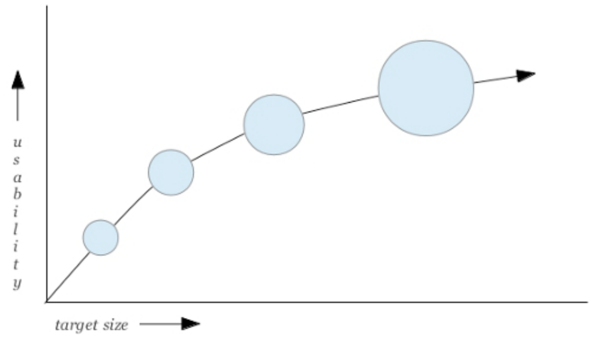
- **+ Perception:** Grouping things may improve over distance

FITTS' LAW IN MOBILE DEVICES

- For mobile take into account the thumb zones
  - Consider Fitts only within the operation range of the thumb
  - Outside elements require extra effort

FITTS' LAW IN MOBILE DEVICES

- Predicted usability of a button according to its size



FITTS' LAW IN MOBILE DEVICES

- Some alternative to increase the size that improve usability: **Visual stimulus**, undo,…
- Some "editing" actions must be dealt with care: send, upload, download, burn, share…:
  - *Possibility of undoing* (even temporarily)
    - E. g. Google's mail
  - *Make item boundaries visible*
  - *Highlight focused items*
    - May prevent accidentally return

FITTS' LAW IN MOBILE DEVICES

- Rule of the thumb

Make destructive/delicate tasks more difficult

- Increasing the effort to prevent accidents
  - Buttons for non-destructive
  - Slides for destructive

MOVING

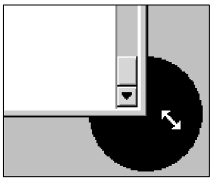
OUTLINE

- *Fitts Law in UI Design*
- **Accelerating Target Acquisition**
  - Expanding Targets
  - Expanding Cursors
  - Target Moving
  - Control-Display Ratio
- Law of Crossing
- Steering Law
- Pointing Devices
- 3D Selection

MOVING

ACCELERATING TARGET ACQUISITION. EXPANDING TARGETS

- Bubble targets:
  - Increase selectable region around target
    - Only when the mouse is close
    - Improves selection times
  - Issues:
    - Bubble appearing may distract users
    - Overlapping targets:
    Close selection points may generate several bubbles



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ACCELERATING TARGET ACQUISITION. EXPANDING TARGETS

- Increase the size of targets close to the pointer
  Implemented in Mac OSX Dock:
  - Targets resize and move
    - Increase size when getting closer and decreasing size when passed
    - Move towards the pointer and far from it

MOVING

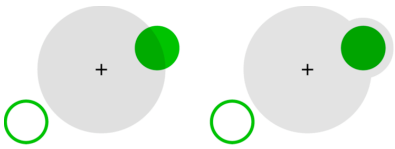
ACCELERATING TARGET ACQUISITION.
EXPANDING TARGETS

- Increase the size of targets close to the pointer:
- Issues:
  - Moving targets reduces selectable size
    - Some users get frustrated
    - Especially on vertical (vs horizontal moves of the targets) moves
    - Target scaling when close to the pointer is sometimes confusing
  - May reduce effects if overlapping is allowed

MOVING

ACCELERATING TARGET ACQUISITION.
EXPANDING CURSORS

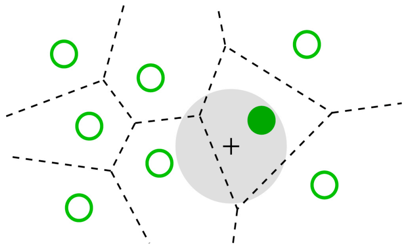
- Bubble cursor [Grossman2005] ➔ Reduction of amplitude movement
  - Cursor size increases when it is close to objectives
  - It may even grow to *absorb* closer objectives if its size does not allow it to
    - Based on position, no speed
    - In experiments Control-Display ratio fixed to 1



MOVING

ACCELERATING TARGET ACQUISITION.
EXPANDING CURSORS

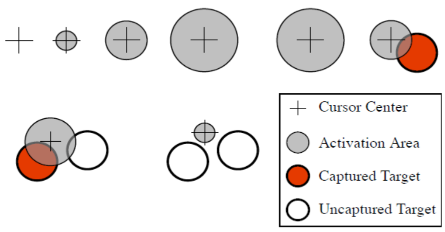
- Bubble cursor: Implementation
  - Previous determination of the area of influence of each target
  - Voronoi map of the targets
    - Once we know in which area we are, we know the closer target and the distance



MOVING

ACCELERATING TARGET ACQUISITION.
EXPANDING CURSORS

- Dynamic Bubble cursor [Chapuis2009]:
  - Reduction of amplitude by area cursor increase
    - Area increases according to speed and position
    - Visual cues to indicate the captured target



MOVING

ACCELERATING TARGET ACQUISITION. TARGET MOVING

- May reduce selection time
  - Reducing distance to the pointer
- Two different strategies:
  - **Move targets closer** to the user
  - **Generate** targets next to the user

MOVING

ACCELERATING TARGET ACQUISITION. TARGET MOVING

- Move targets to the user:
  - Mac OSX Dock
    - Though movement is relatively small
    - Studies have demonstrated no effective gain
  - Issues:
    - Difficult to correctly determine the appropriate target
    - Moving elements on screen cause spatial disorganization
      - May eliminate other benefits

MOVING

ACCELERATING TARGET ACQUISITION. TARGET MOVING

- Generate targets next to the user:
  - Pop-up menus
    - Very useful, though for power users
    - Reduce pointer movement
    - Many techniques: Classical menus, pie menus, semi-circular menus

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MOVING

ACCELERATING TARGET ACQUISITION. TARGET MOVING

- Sticky targets:
  - Attract pointer
    - When the pointer is close to a selectable area
    - May reduce selection time
      - Precision not required
    - Users adapt easily

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MOVING

ACCELERATING TARGET ACQUISITION. CONTROL-DISPLAY RATIO

- Relation between the amplitude of movements of the user's real hand and the amplitude of movements of the virtual cursor
- Moves in real world (physical move) mapped to moves in virtual desktop (cursor move)
- Different strategies:
  - Constant
  - Dependent on mouse speed
  - Dependent on cursor position
- Interpretation according to Fitts Law:
  - Dynamic C-D ratio adaptation can be interpreted as dynamic change of physical motor space

MOVING

ACCELERATING TARGET ACQUISITION. CONTROL-DISPLAY RATIO

- Mac OSX and Windows both use mouse acceleration
  - When mouse moves fast, it is accelerated
    - Reducing the amplitude of movement to cover large distances
  - When mouse moves slow, it is decelerated
    - Magnifying amplitude of movement to improve precision
- No clear how the mapping affects perception and productivity
  - Some studies say it is not intuitive
  - Some studies say it improves some pointing tasks

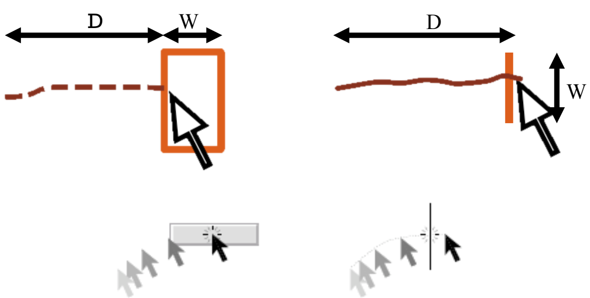
MOVING

OUTLINE

- *Fitts Law in UI Design*
- *Accelerating Target Acquisition*
- **Law of Crossing**
- Steering Law
- Pointing Devices
- 3D Selection

LAW OF CROSSING

- Crossing movement as compared to pointing

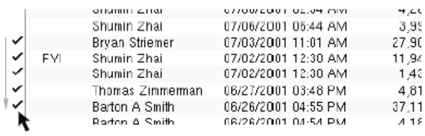


(a) Pointing a target (b) Crossing a goal

LAW OF CROSSING

- Stylus or fingers naturally lead to crossing gestures
  - Especially useful in tactile devices
    - Drag & drop, sketch…
- It may be investigated in the same v
  - So that we can predict both time and
  - So that we can improve UI design
    - Or detect problems

(a) Pointing a target (b) Crossing a goal



MOVING

LAW OF CROSSING

- Crossing performance across two goals [Accot99, Zhai2002]:
  - Follows the same characterization than the Fitts' Law:

$$T = a + b\log_2\left(\frac{D}{W} + 1\right)$$

    - T is the average moving time between passing the two goals.
    - *D* is the distance between the two goals
    - *W* is the width of each goal
    - *a* and *b* are constants to be determined

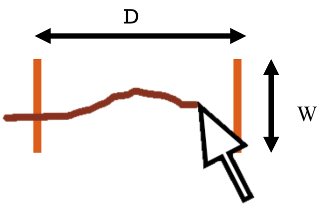
MOVING

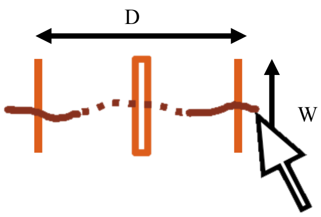
LAW OF CROSSING

- Crossing configurations:
  - Discreteness vs continuity of the movement:
    - Landing [and lifting off the stylus]

Continuous crossing

Discrete crossing





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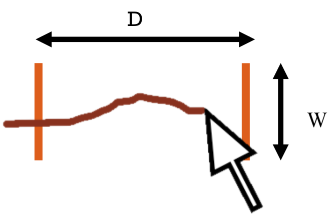
MOVING

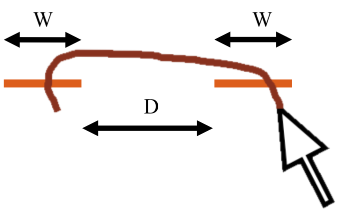
LAW OF CROSSING

- Crossing configurations:
  - Direction of the targets vs direction of the movement:
    - Targets can be orthogonal to the direction of the movement, or parallel
    - If parallel, the trace will be larger

Orthogonal crossing

Collinear crossing





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MOVING

LAW OF CROSSING

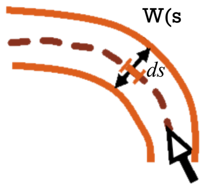
- Results of the experiments:
  - Crossing-based interfaces achieve similar (or faster) times than pointing.
  - The error rate in crossing is smaller than in pointing.
  - Discrete crossing becomes more difficult if the distance between the targets is small.
  - Crossing (especially continuous) seems superior than pointing for *ID* values > 5.

OUTLINE

- *Fitts Law in UI Design*
- *Accelerating Target Acquisition*
- *Law of Crossing*
- **Steering Law**
- Pointing Devices
- 3D Selection

STEERING LAW

- Navigating through a constrained path is an useful operation in modern UIs
  - Navigating through nested menus
  - 3D navigation
  - Dragging elements
  - Free-hand Sketching/Drawing

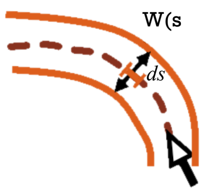


STEERING LAW

- Navigating through a **generalized path** can be expressed as [Accot97]
- Movement time across the path T_s:

$$T_s = a + b\int_C \frac{ds}{W(s)}$$

  - *C* is the length of the path
  - *W(s)* is the path width at point s



STEERING LAW

- Navigating through a **generalized path** can be expressed as [Accot97]:
  - Movement time across the path T_s follows Fitts' expression:

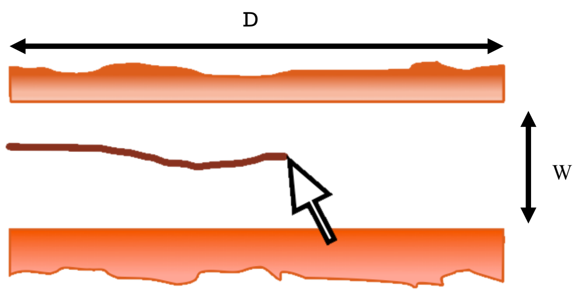
$$T_s = a + bID_s$$

  - Where ID_s is:

$$ID_s = \int_C \frac{ds}{W(s)}$$

STEERING LAW

- Steering through a **straight path**:



STEERING LAW

- Time to navigate through a **straight path** (tunnel) T_p[Accot97]:

$$T_s = a + b\int_C \frac{ds}{W(s)} \qquad T_P = a + b\frac{D}{W}$$

  - D is the length of the path/tunnel
  - W is the width of the path/tunnel
- Applying Fitts formatting:

$$T_P = a + bID_P \qquad ID_P = \frac{D}{W}$$

  - Which also applies to circular paths of constant width

MOVING

STEERING LAW

- Results [Accot97, Zhai2004] show that the steering law is applicable to different configurations:
  - Different path shapes: cone, spiral, straight
  - Works with different devices
  - Can be used to analyse navigation through nested menus, compare menu designs…

MOVING

STEERING LAW

- Results [Accot97, Zhai2004] show that the steering law is applicable to different configurations:
  - Works for more complex interactions such as locomotion in a VR setup
    - Straight paths, circular paths…

MOVING

OUTLINE

- *Fitts Law in UI Design*
- *Accelerating Target Acquisition*
- *Law of Crossing*
- *Steering Law*
- **Pointing Devices**
- 3D Selection

MOVING

POINTING DEVICES

- Direct-control devices: Work directly on the surface of the screen
- Indirect-control devices: Work away from the surface

MOVING

POINTING DEVICES

- **Direct-control devices**:
  - Old
    - Lightpen worked back in 1976

  - May produce fatigue:
    - Moving the lightpen on the screen required much effort
    - Should have a surface to rest the arm

MOVING

POINTING DEVICES

- **Direct-control devices.** Issues:
  - Imprecision in pointing. Many factors:
    - *Quality of the screen:* Capacitive screens less precise than resistive
    - *Size of the pointer*
      - *Fat* and *not-so-fat* fingers

MOVING

POINTING DEVICES

- **Direct-control devices.** Issues:
  - Land-on strategy:
    - Select on clicking point
    - Faster feedback
    - Prone to errors
  - Lift-off strategy:
    - Initial click creates cursor, dragging used for precision pointing, lift-off selects
    - More time consuming

MOVING

POINTING DEVICES

- **Direct-control devices.** Advantages:
  - Touch screens can be designed with no moving parts
    - Durable
    - Only device that has survived Walt Disney's theme parks
  - Multi-touch allows for complex data entry or manipulation
    - Pinch-to-zoom gestures

MOVING

POINTING DEVICES

- **Direct-control devices.** Other issues:
  - Pens may be more suitable for some tasks
    - Reduce occlusion
    - Familiar to users
    - But require to be picked up and put down
  - Fingers are less precise than wrist-based movement

MOVING

POINTING DEVICES

- **Indirect-control devices.**
  - Examples:
    - Mouse, trackball, joystick, touchpad, graphics tablets…
- Issues:
  - Alleviate hand fatigue
  - Eliminate screen occlusion
  - Mouse is the clear king
    - Cost-effective
    - Precise
    - Hand has a surface to rest on
    - Buttons easy to press
    - Long movements require to pick up mouse and replace
      - May be improved using accelerated moves

UPC MOVING

OUTLINE

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- *Law of Crossing*
- *Law of Steering*
- *Pointing Devices*
- **3D Selection**

UPC MOVING

3D SELECTION

- Definitions
  - **3D interaction**
    - HC Interaction where user's tasks are carried out in a 3D spatial context
    - Using 3D or 2D input devices with direct mappings to 3D
  - **3D user interface**
    - A User Interface that involves 3D interaction.
  - **3D interaction technique**
    - Technique designed for solving a task
      - Involves the use of hardware and software

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3D SELECTION

- 3D interfaces can make several tasks easier than classical 2D systems
  - Even better than reality?
- **3D selection:** selection task in a 3D immersive environment

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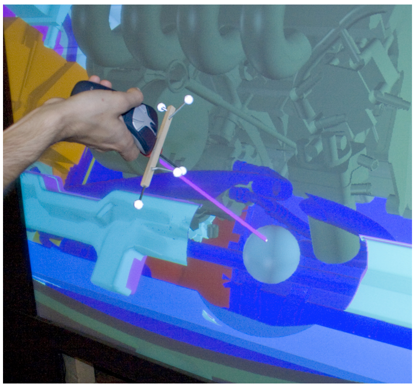
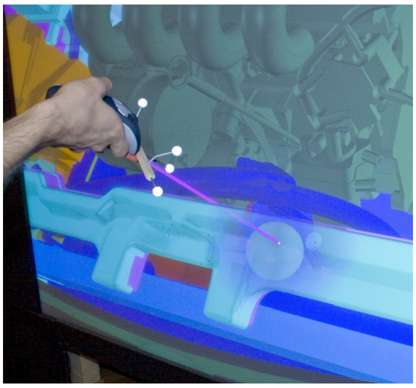
MOVING

3D SELECTION

MOVING

3D SELECTION





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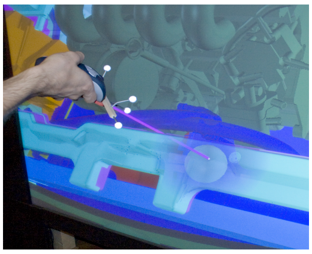
3D SELECTION

- **Selection techniques**:
  - Hand extension techniques or 3D point cursors
    - A 3D point in space is represented as a mapping of the user's hand position.
  - Ray-based techniques
    - Use the hand position and some element to indicate orientation
    - A ray is generated a ray in space and is used as a pointer
      - Also called aperture-based selection techniques or ray cursors



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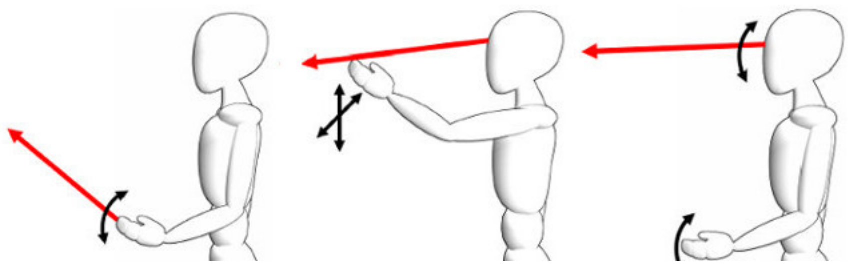
3D SELECTION

- Hand extension:
  - May require ample movements due to the direct mapping with 3D world
  - Sometimes elements are difficult to reach
  - May be more intuitive if virtual world represents some real world

MOVING

3D SELECTION Ray-based techniques:



MOVING

3D SELECTION

- Ray-based techniques:
  - Hand position + wrist orientation
  - Head position and hand direction
- Problems:
  - Visible objects may be occluded to the ray
    - Difficult to reach
    - Selection of objects needs to visit all of them
    - Sticky targets, enlarging objects, flatten regions…
  - Region selection not easy

MOVING

3D SELECTION

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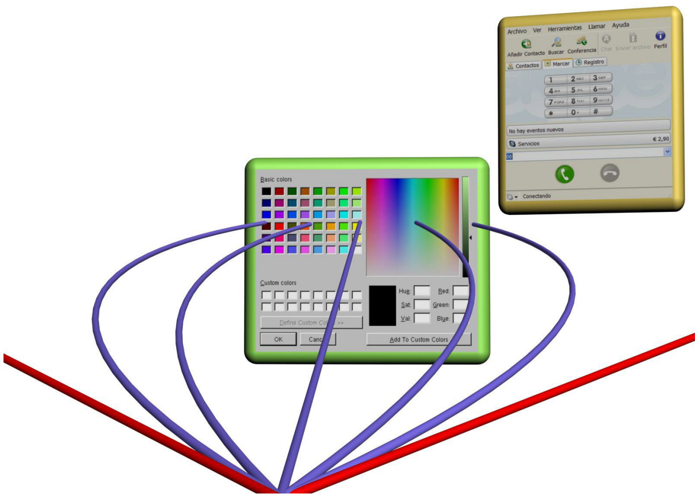
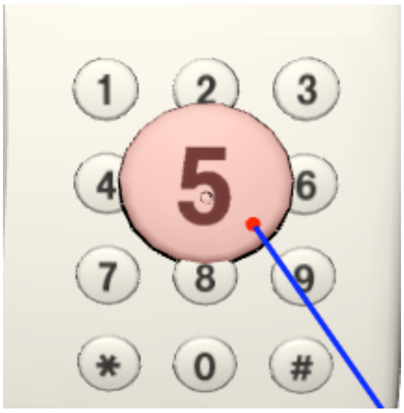


3D SELECTION



Dynamic Scaling (DS)

Objects near the selection ray are dynamically scaled

UPC

MOVING