INTERACTION DESIGN AND EVALUATION. SESSION 2

Professors IDI

Dept. Computer Science – UPC

OUTLINE

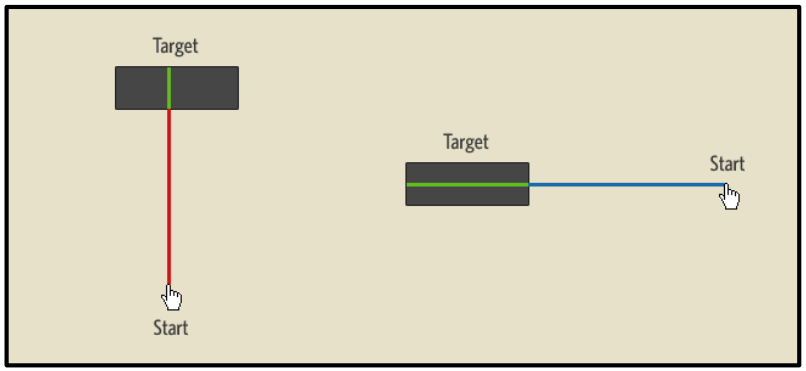
- **Fitts Law in UI Design**
  - Implications
  - Applications
  - Fitts' Law in Mobile Devices
- Accelerating Target Acquisition
- Law of Crossing
- Steering Law
- Pointing Devices

FITTS' LAW IN UI DESIGN.

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

$$MT = a + bID$$

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



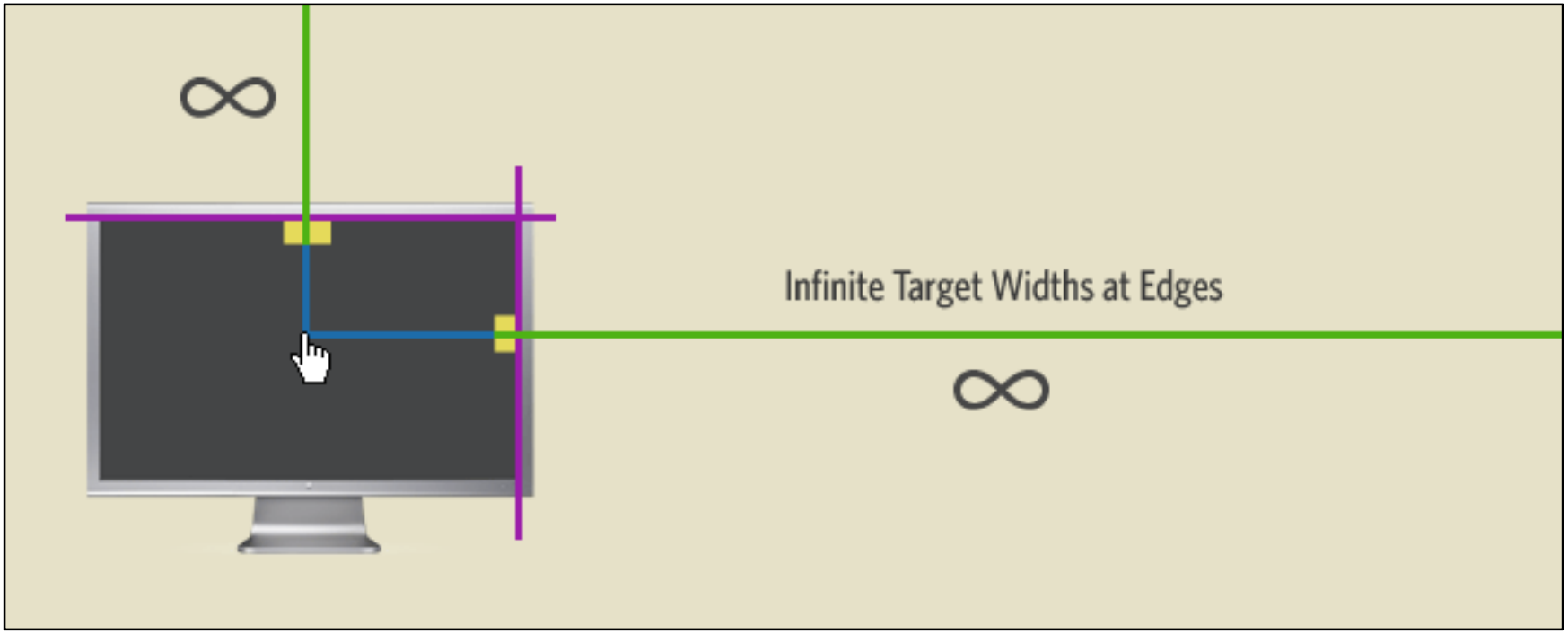
FITTS' LAW IN UI DESIGN. IMPLICATIONS

- 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,….

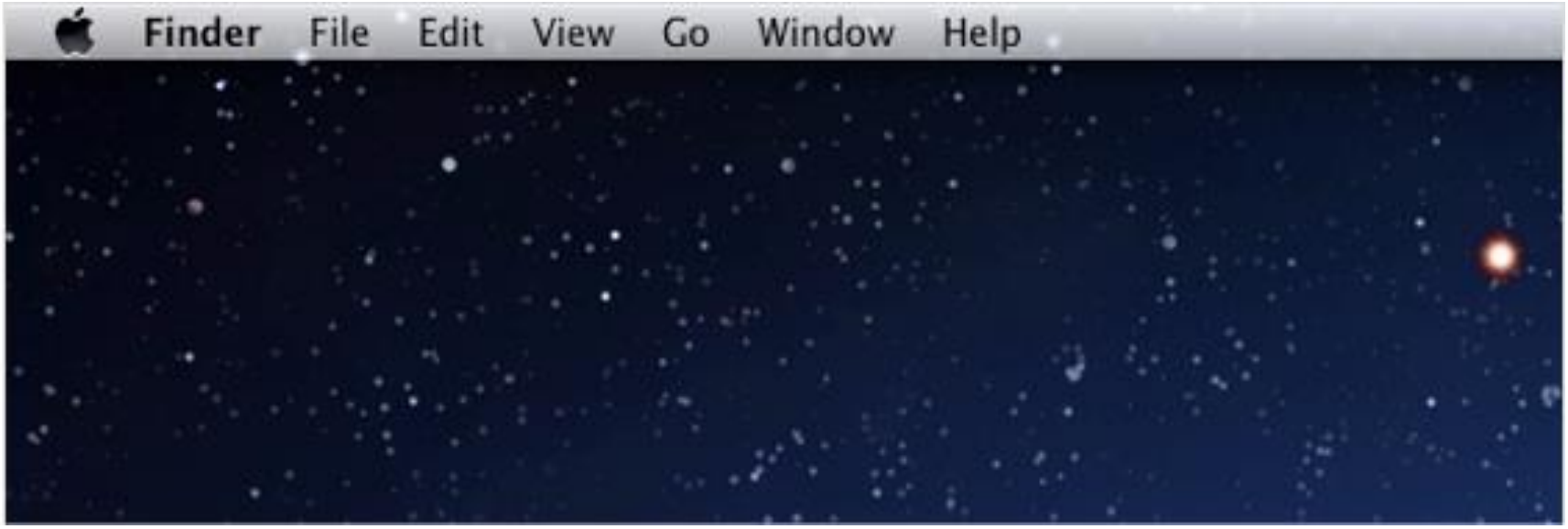
- But visual stimuli must also be taking into account…

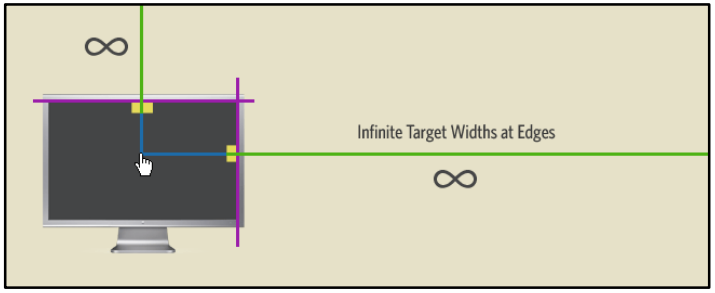
FITTS' LAW IN UI DESIGN. IMPLICATIONS



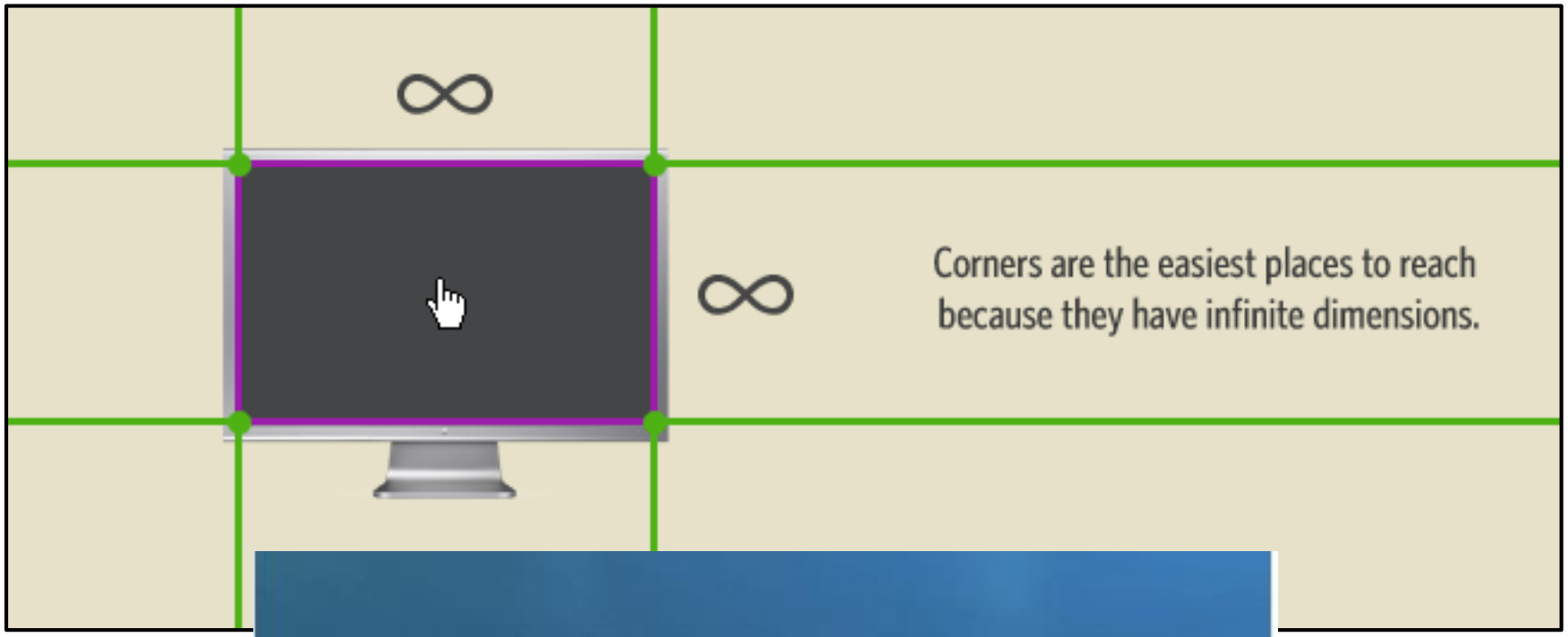
$$MT = a + b\log_2\left(\frac{D}{W} + 1\right)$$

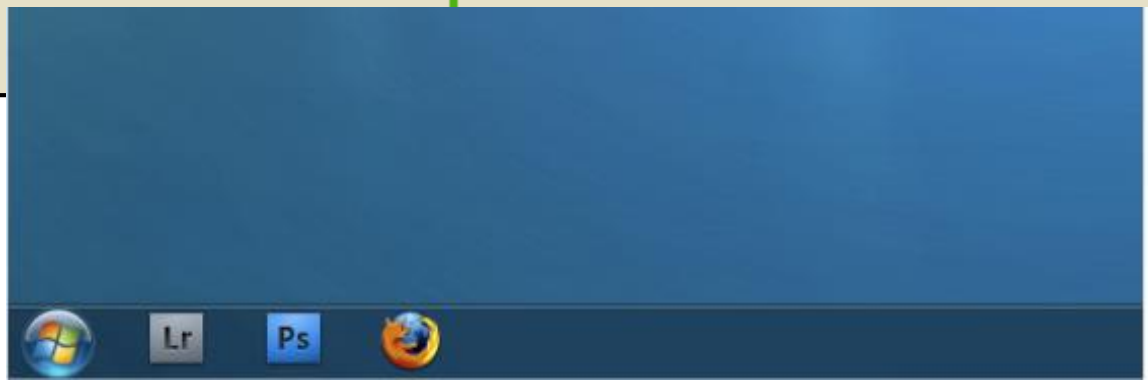
FITTS' LAW IN UI DESIGN. IMPLICATIONS





FITTS' LAW IN UI DESIGN. IMPLICATIONS





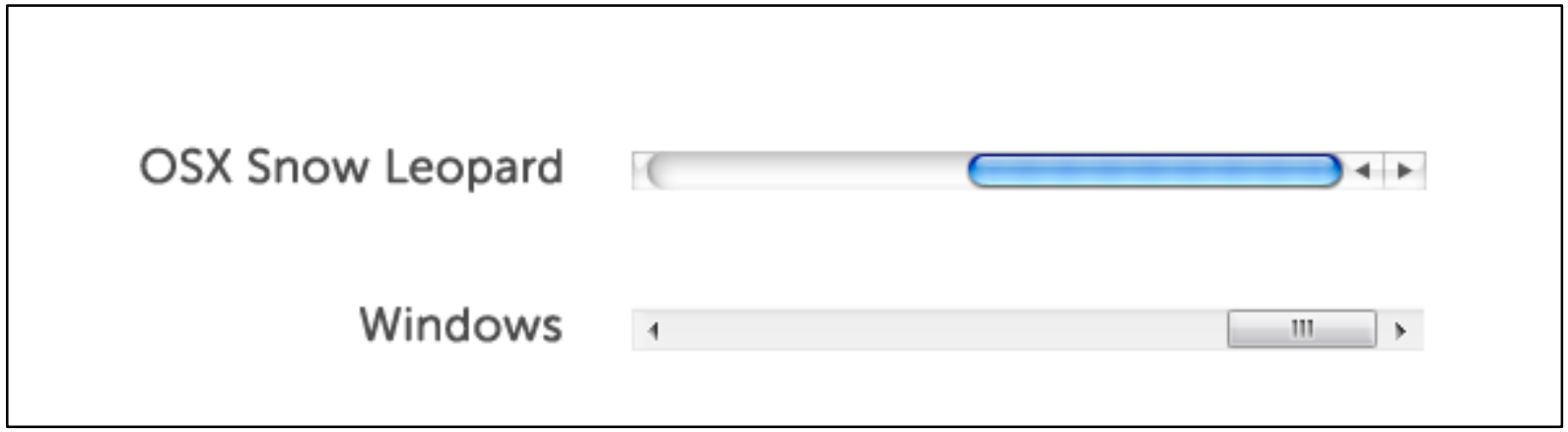
FITTS' LAW IN UI DESIGN. IMPLICATIONS

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

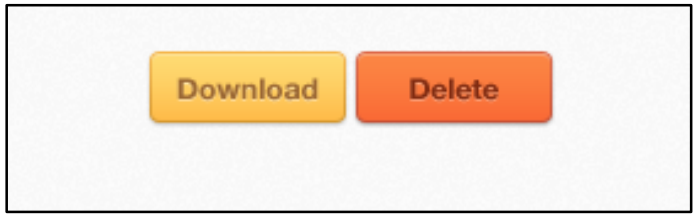


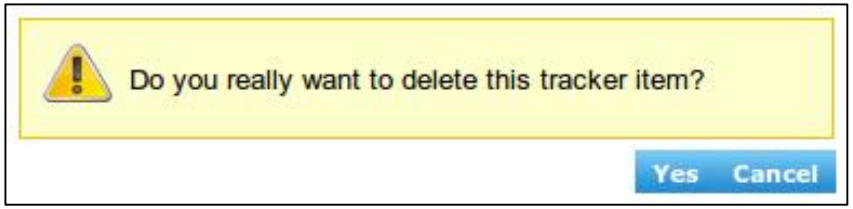
FITTS' LAW IN UI DESIGN. APLICATIONS

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

FITTS' LAW IN UI DESIGN. APLICATIONS

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



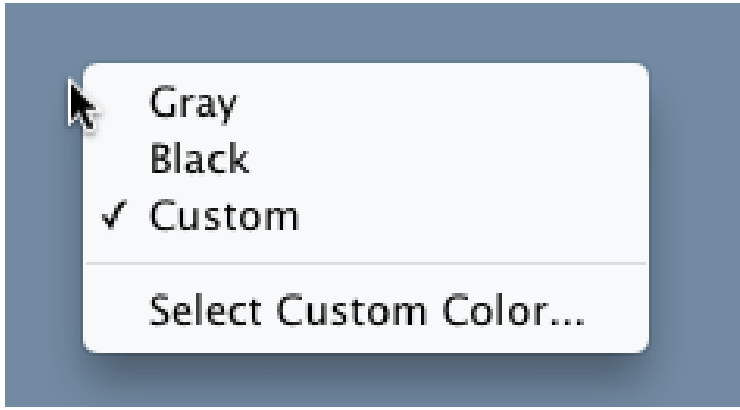


FITTS' LAW IN UI DESIGN. APLICATIONS

- **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:

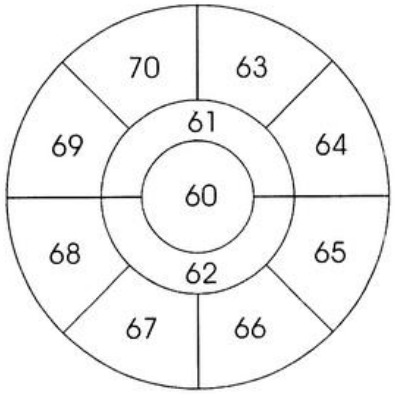
      Recall that *users are able to point faster objects that are known*

- Only used by experts!



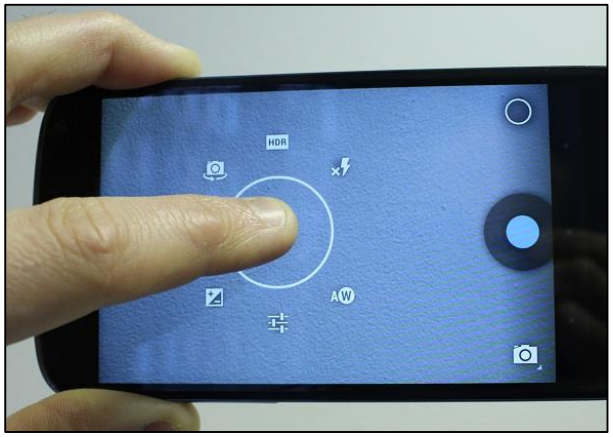
FITTS' LAW IN UI DESIGN. APLICATIONS

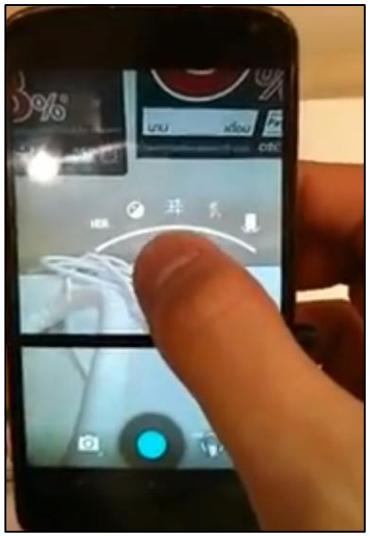
- *What about pie menus?*



FITTS' LAW IN UI DESIGN. APLICATIONS

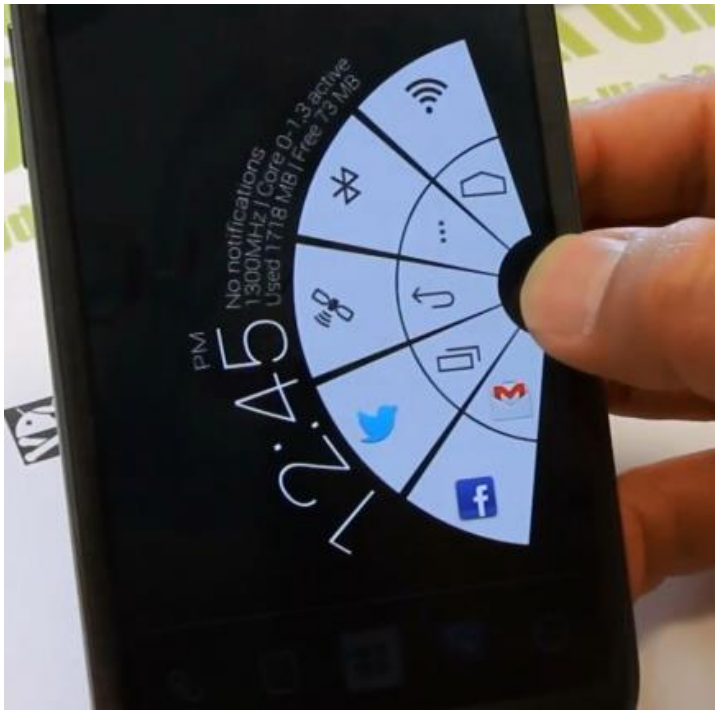
- *What about pie menus*
  - Sort of contextual menu
    - Needs to be created on demand
    - Needs some room!
  - Should not have occlusions
    - On mobile half-pie menus better than fully circular





FITTS' LAW IN UI DESIGN. APLICATIONS

- 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. APLICATIONS

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

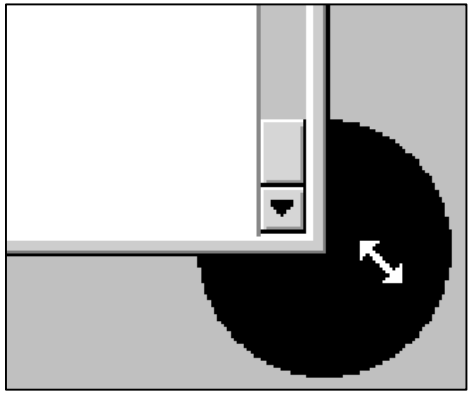
OUTLINE

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

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



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

ACCELERATING TARGET ACQUISITION.
EXPANDING TARGETS

- **Increase the size of targets close to the pointer**

ACCELERATING TARGET ACQUISITION.
EXPANDING TARGETS

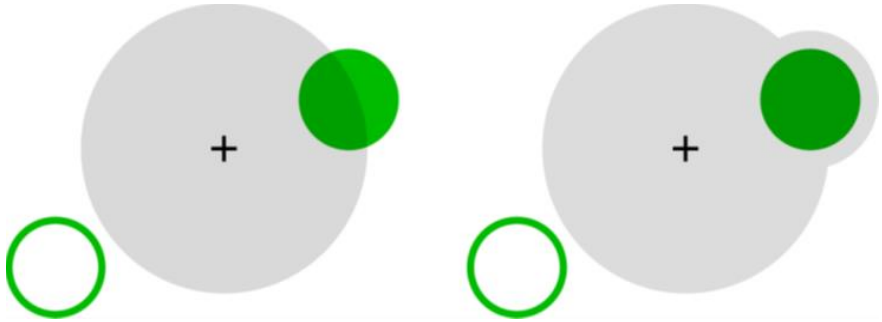
- Increase the size of targets close to the pointer:
- Issues:
  - Moving targets reduces selectable size
    - Some users get frustrated
    - Especially on vertical (vs horizontal moves of the targets) moves
    - Target scaling when close to the pointer is sometimes confusing
  - May reduce effects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

ACCELERATING TARGET ACQUISITION.
EXPANDING CURSORS

- **Bubble cursor** [Grossman2005] ➔

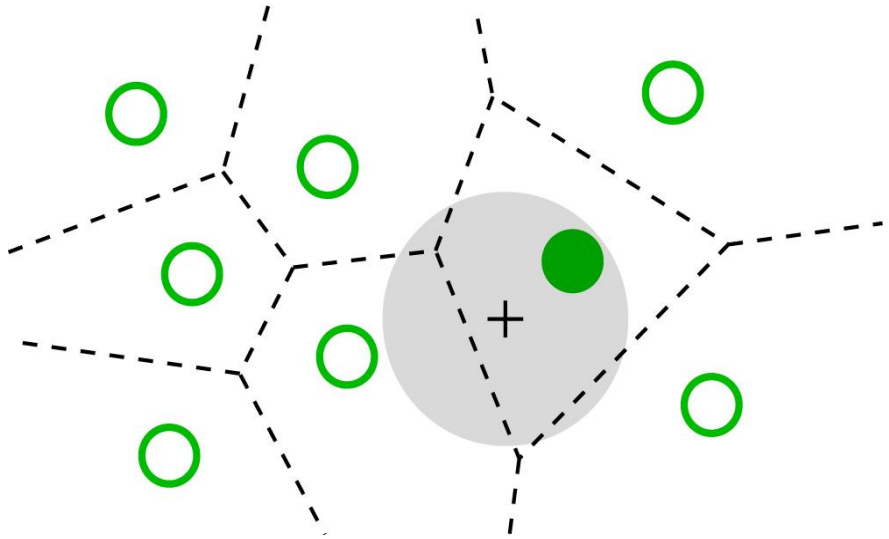
  Reduction of amplitude movement

  - 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



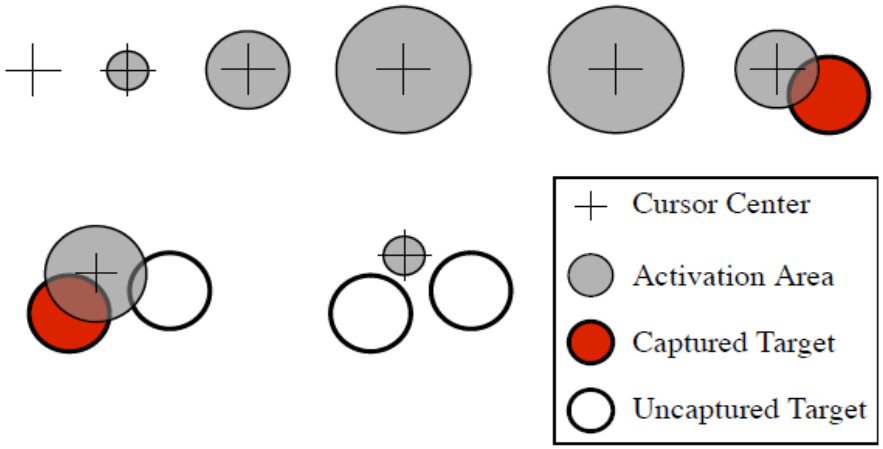
ACCELERATING TARGET ACQUISITION.
EXPANDING CURSORS

- 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



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



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

ACCELERATING TARGET ACQUISITION.
TARGET MOVING

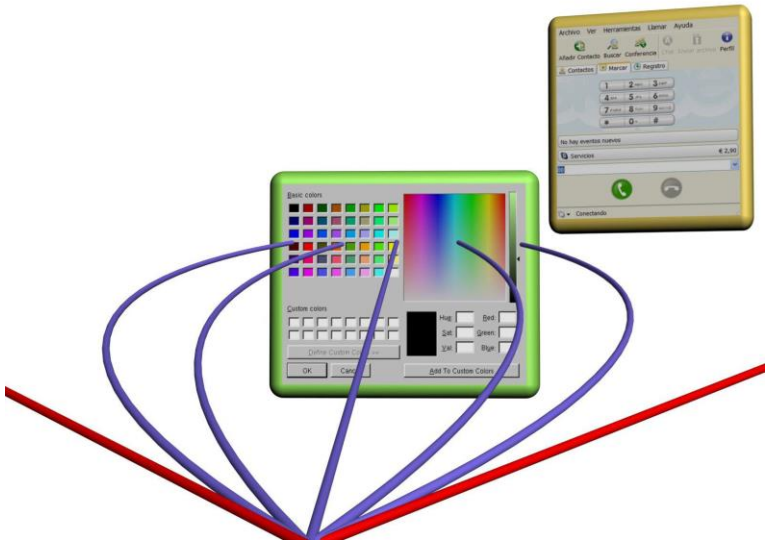
- **Move targets to the user:**
  - Mac OSX Dock
    - Though movement is relatively small
    - Studies have demonstrated no effective gain
  - Issues:
    - Difficult to correctly determine the appropriate target
    - Moving elements on screen cause spatial disorganization
      - May eliminate other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

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

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



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

ACCELERATING TARGET ACQUISITION.
CONTROL-DISPLAY RATIO

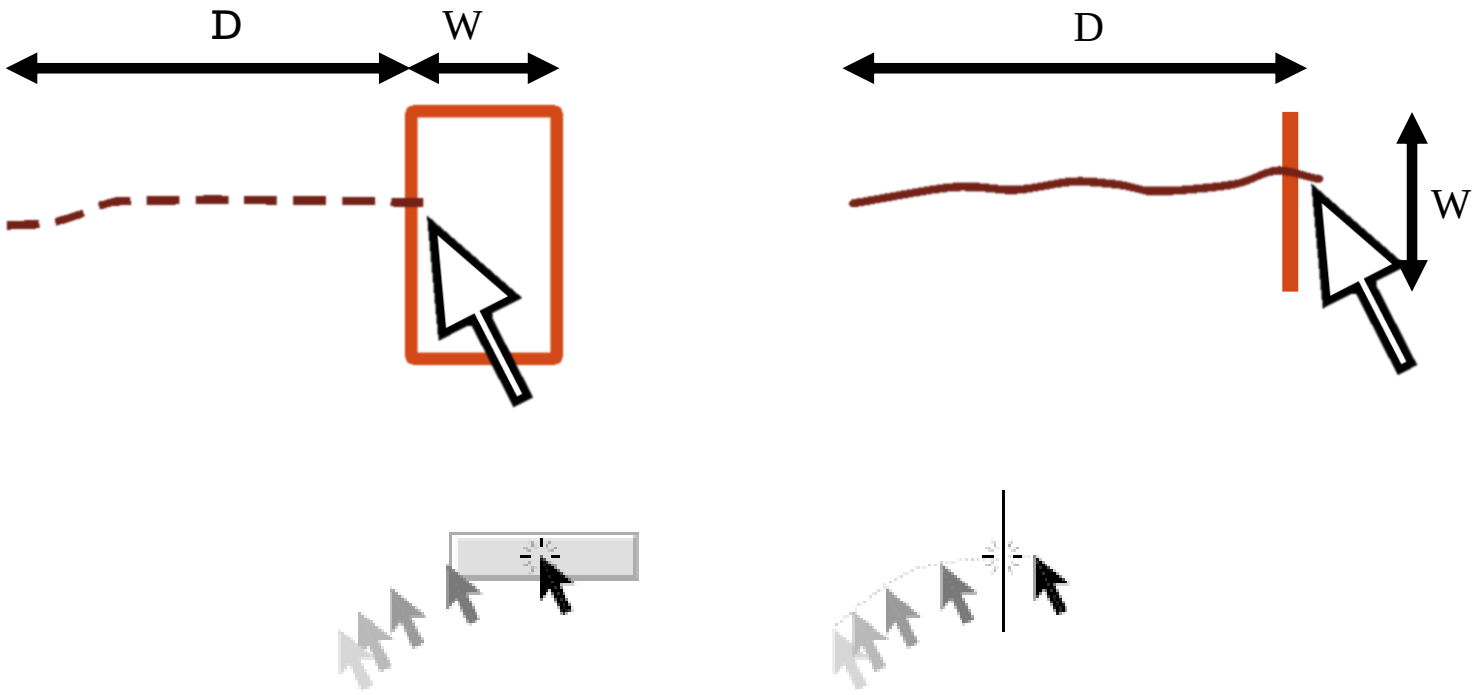
- Mac OSX and Windows both use mouse acceleration
  - When mouse moves fast, it is accelerated
    - Reducing the amplitude of movement to cover large distances
  - When mouse moves slow, it is decelerated
    - Magnifying amplitude of movement to improve precision
- No clear how the mapping affects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

OUTLINE

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

LAW OF CROSSING

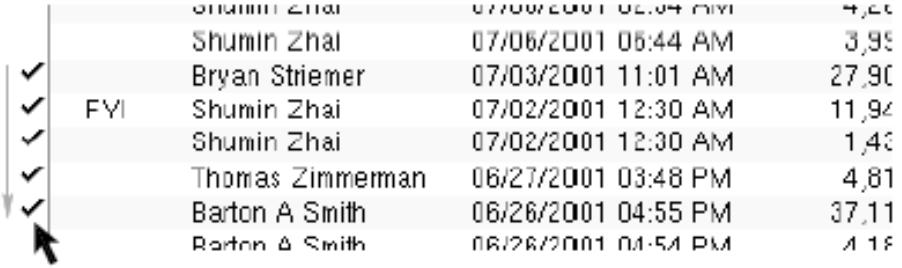
- Crossing movement as compared to pointing



(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 way that pointing
  - So that we can predict both time and error rates
  - So that we can improve UI design
    - Or detect problems



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LAW OF CROSSING

LAW OF CROSSING

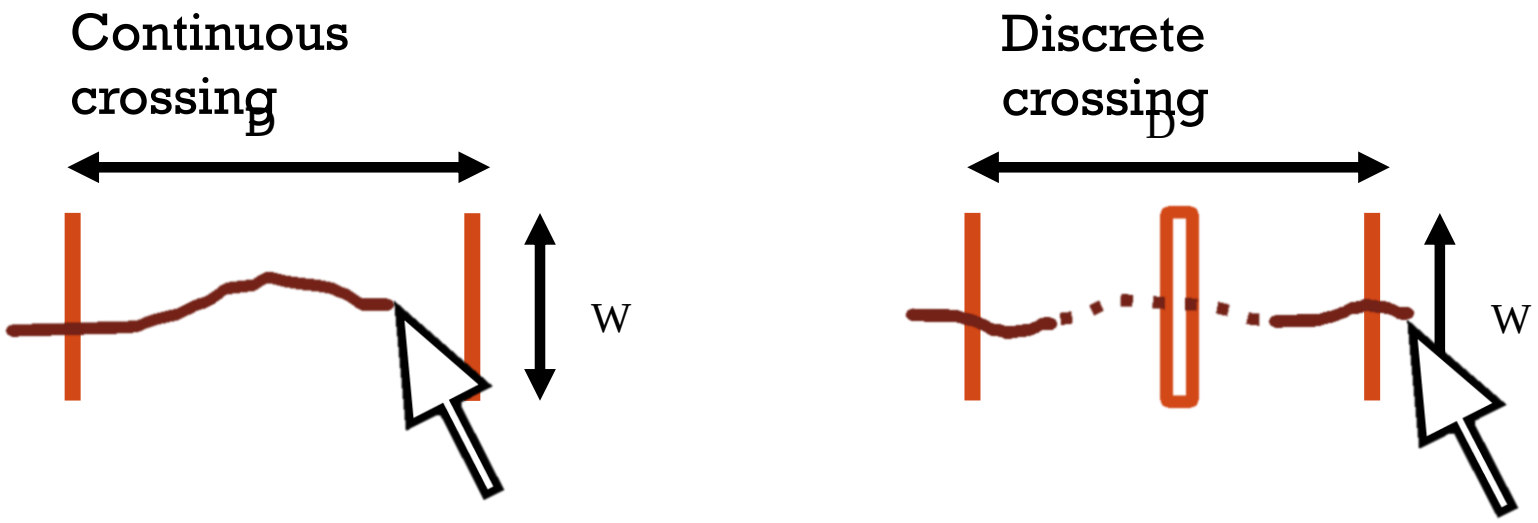
- Crossing performance across two goals [Accot99, Zhai2002]:
  - Follows the same characterization than the Fitts' Law:

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

    - 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

LAW OF CROSSING

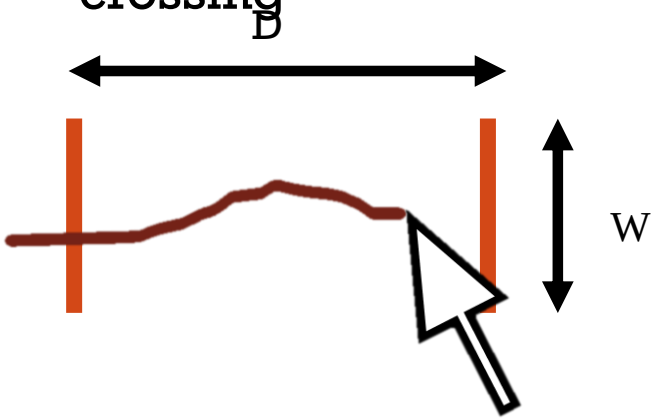
- Crossing configurations:
  - Discreteness vs continuity of the movement:
    - Landing [and lifting off the stylus]



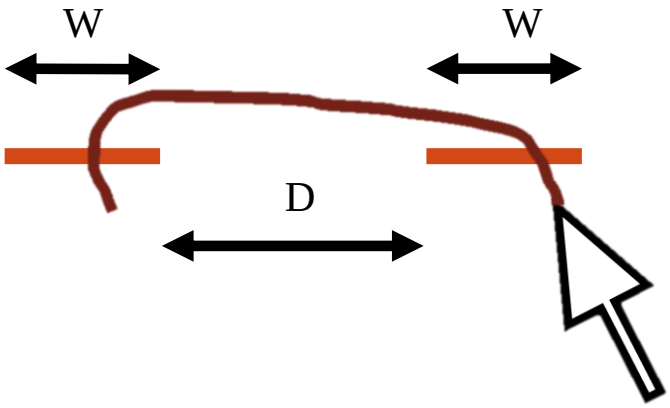
LAW OF CROSSING

- 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



LAW OF CROSSING

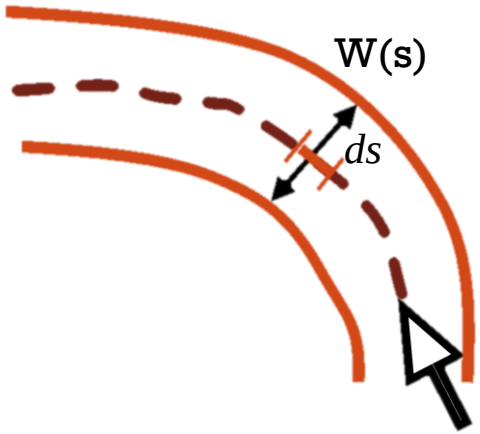
- Results of the experiments:
  - Crossing-based interfaces achieve similar (or faster) times than pointing.
  - The error rate in crossing is smaller than in pointing.
  - Discrete crossing becomes more difficult if the distance between the targets is small.
  - Crossing (especially continuous) seems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

OUTLINE

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

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

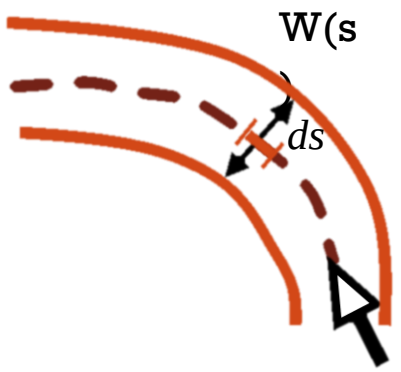


STEERING LAW

- 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:

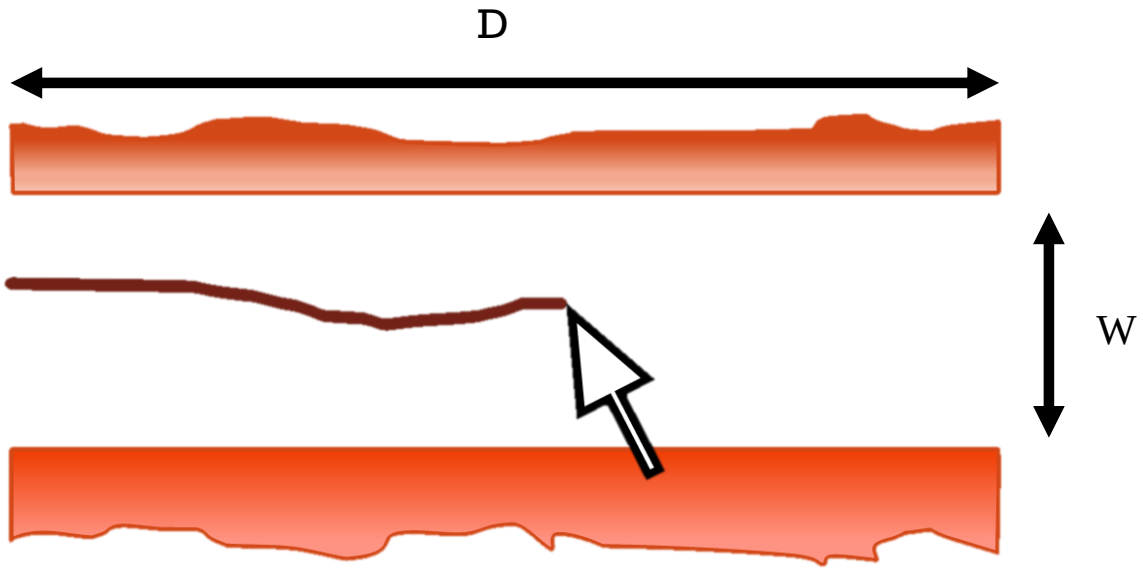
$$T_s = a + bID_s$$

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

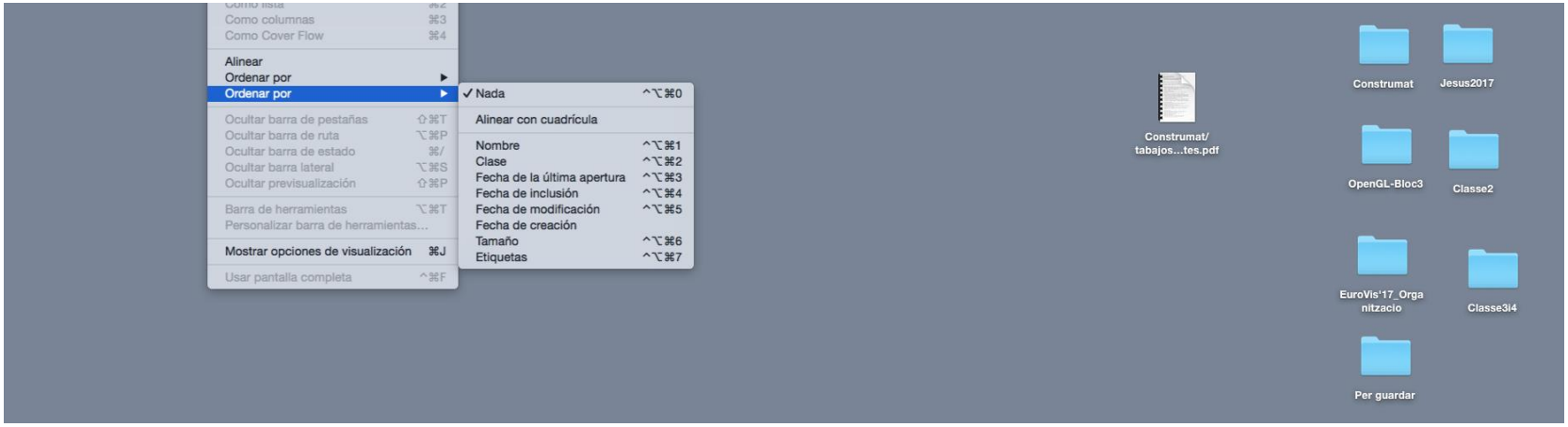
- Applying Fitts' formatting:

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

  - Which also applies to circular paths of constant width

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…



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…

OUTLINE

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

POINTING DEVICES

- Direct-control devices:

  Work directly on the surface of the screen

- Indirect-control devices:

  Work away from the surface

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

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

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

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

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

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

INTERACTION DESIGN AND MEASURES

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