Leibniz Universität Hannover

Mensch-Computer-Interaktion 2

Interaction Techniques

Human-Computer Interaction Group

Prof. Dr. Michael Rohs
michael.rohs@hci.uni-hannover.de

Lectures

Session	Date	Topic	
1	6.4.	Introduction	
2	13.4.	Interaction elements	GUI toolkits, interaction techniques
3	20.4.	Event handling	
4	27.4.	Scene graphs	
5	4.5.	Interaction techniques	
	11.5.	no class (CHI)	
	18.5.	no class (spring break)	
6	25.5.	Experiments	design and analysis of experiments
7	1.6.	Data Analysis	
8	8.6.	Data Analysis	
9	15.6.	Visualization	
10	22.6.	Visualization	current topics beyond-desktop UIs
11	29.6.	Modeling interaction	
12	6.7.	Computer vision for interaction	
13	13.7.	Computer vision for interaction	

Klausur:
28.7.2016
8-11 Uhr
HG E214

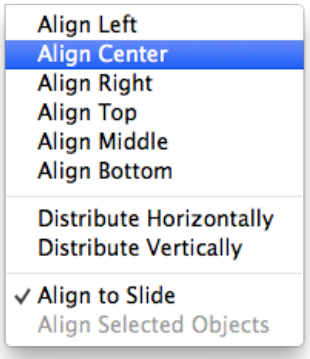
ALIGNMENT TECHNIQUES

Alignment Techniques

- Placing objects in 2D is a typical interaction in graphical UIs
- Translating, rotating, scaling, stretching to precise spatial relationships with other objects
  - Exactly horizontal or vertical lines, exactly parallel lines
  - Aligned rectangles, attached rectangles
  - Distance and angle constraints between objects

Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Alignment Techniques



- After selecting objects
  - User selects objects, then selects function from menu or toolbar
  - Indirect, no fluid interaction (→ instrumental interaction)
- While dragging objects
  - Handles on objects
  - Dedicated alignment objects

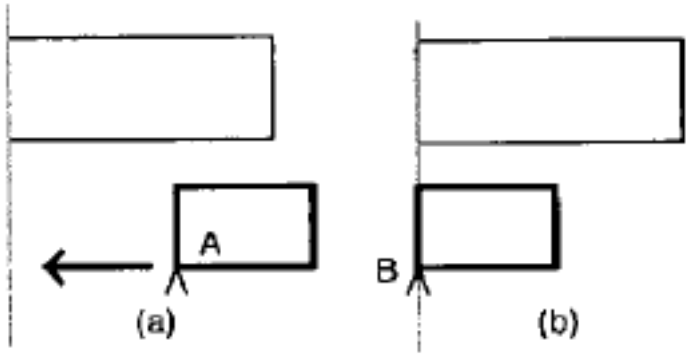


Figure 1(a) Picking up a vertex with the caret.

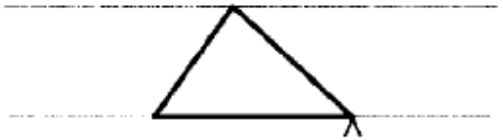
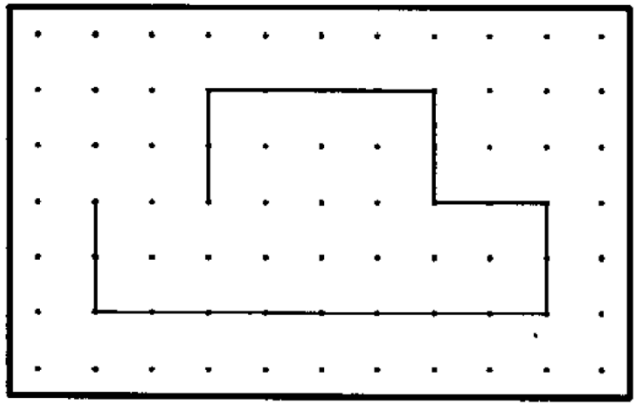


Figure 1(b) Snapping the caret onto an alignment line.

Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Grid Snapping

- Snapping object points to a grid of discrete points
- Less general and flexible than object snapping
  - Predefined grid scale may not always be right
  - Impossible to draw a equilateral triangle
  - Placing a smaller square in the center of another one
- Makes scaling difficult
  - Scaled objects may fall between grid points
  - Impossible to align objects with them



Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Snap Dragging: Precisely Placing Objects on a Plane

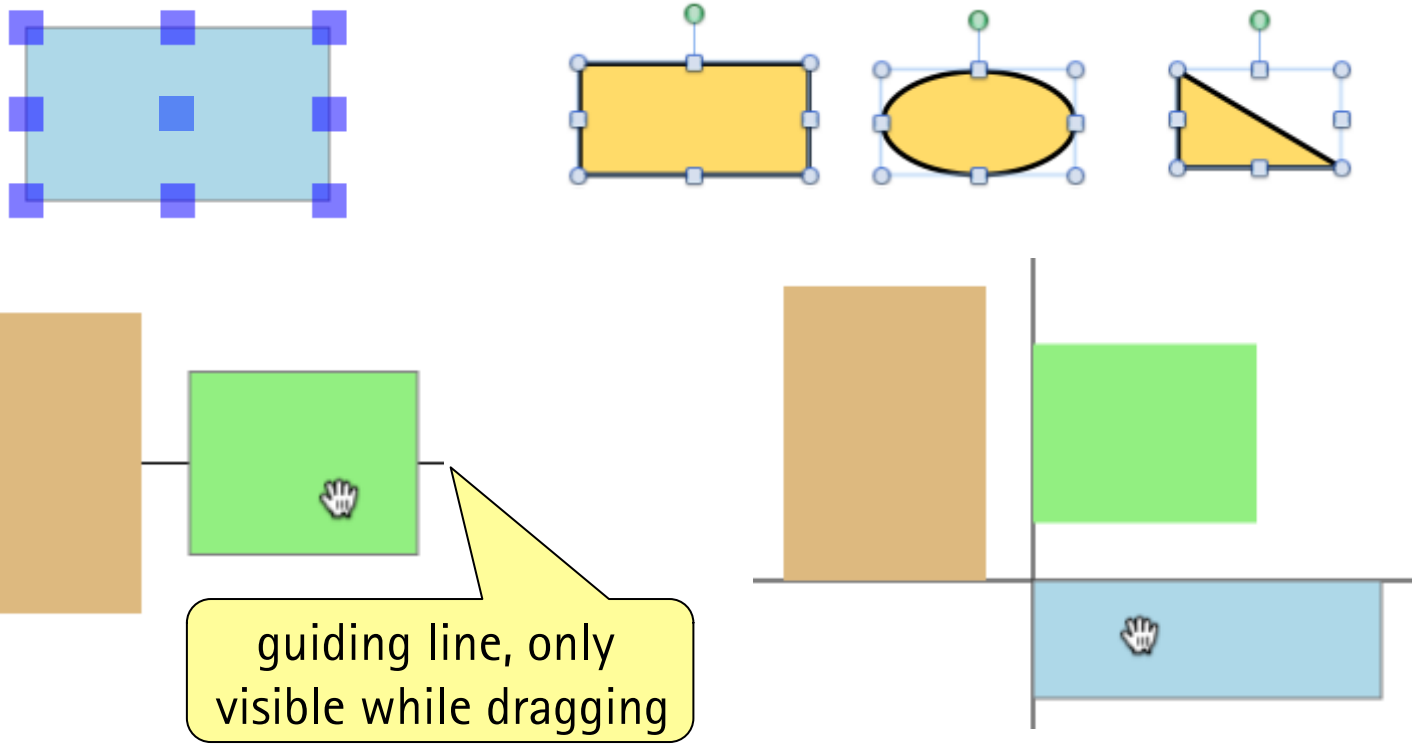
- Snap Dragging: When objects are dragged or stretched, positions that correspond to preferred ending points are given "gravity"

- Dynamic guiding lines at specific object points
  - Only visible when object is dragged
- Warp ("snap") objects to gravity points, when close enough
- Makes common alignment operations simple
  - Requires suitable choice of anchor points

Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Snap Dragging: Translation

- Anchor points: Specific points that attract other points
- Example rectangle: Corners, center, midpoints

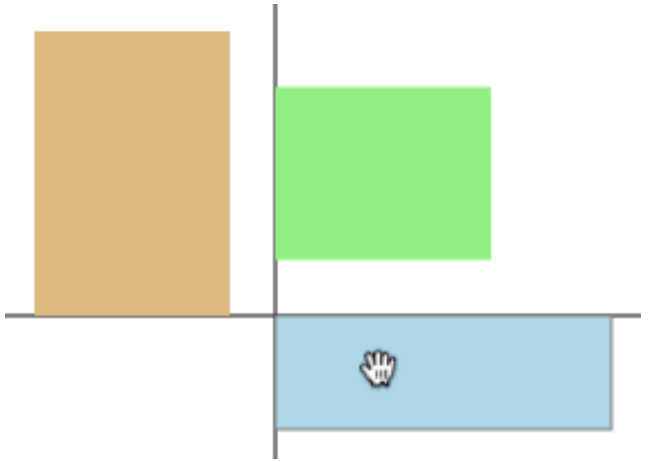


Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Snap Dragging: Translation

- Anchor points: Specific points that attract other points
- Example rectangle: Corners, center, midpoints

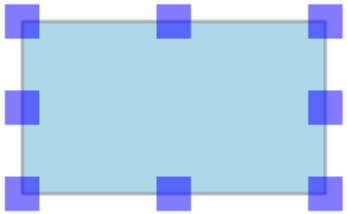
- Allows for common alignment operations
  - Adjacent rectangles
  - Edge-aligned rectangles
  - Center-aligned rectangles
  - Center-to-edge alignment



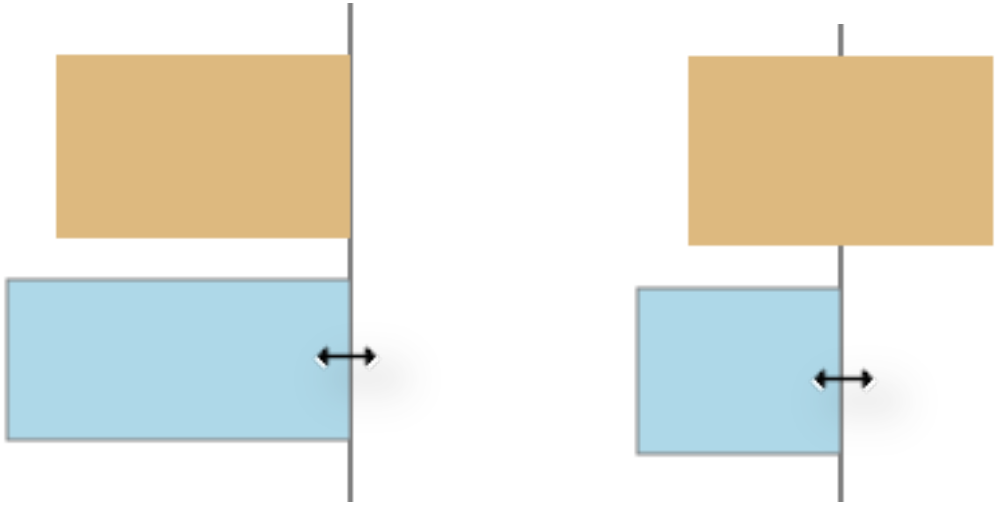
Bier, Stone: Snap-Dragging. SIGGRAPH 1986.

Snap Dragging: Stretching

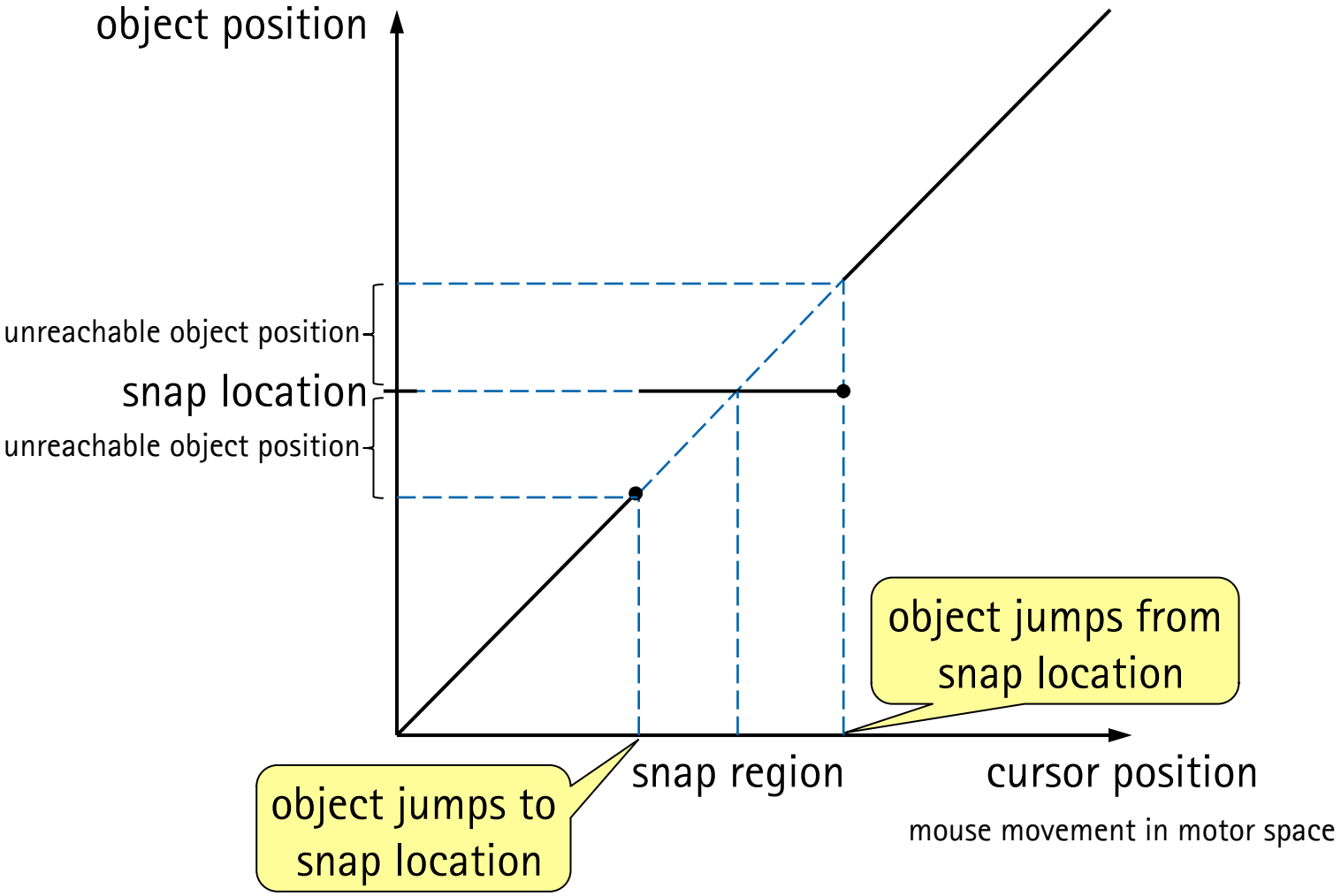
- Example rectangle: Corners, midpoints



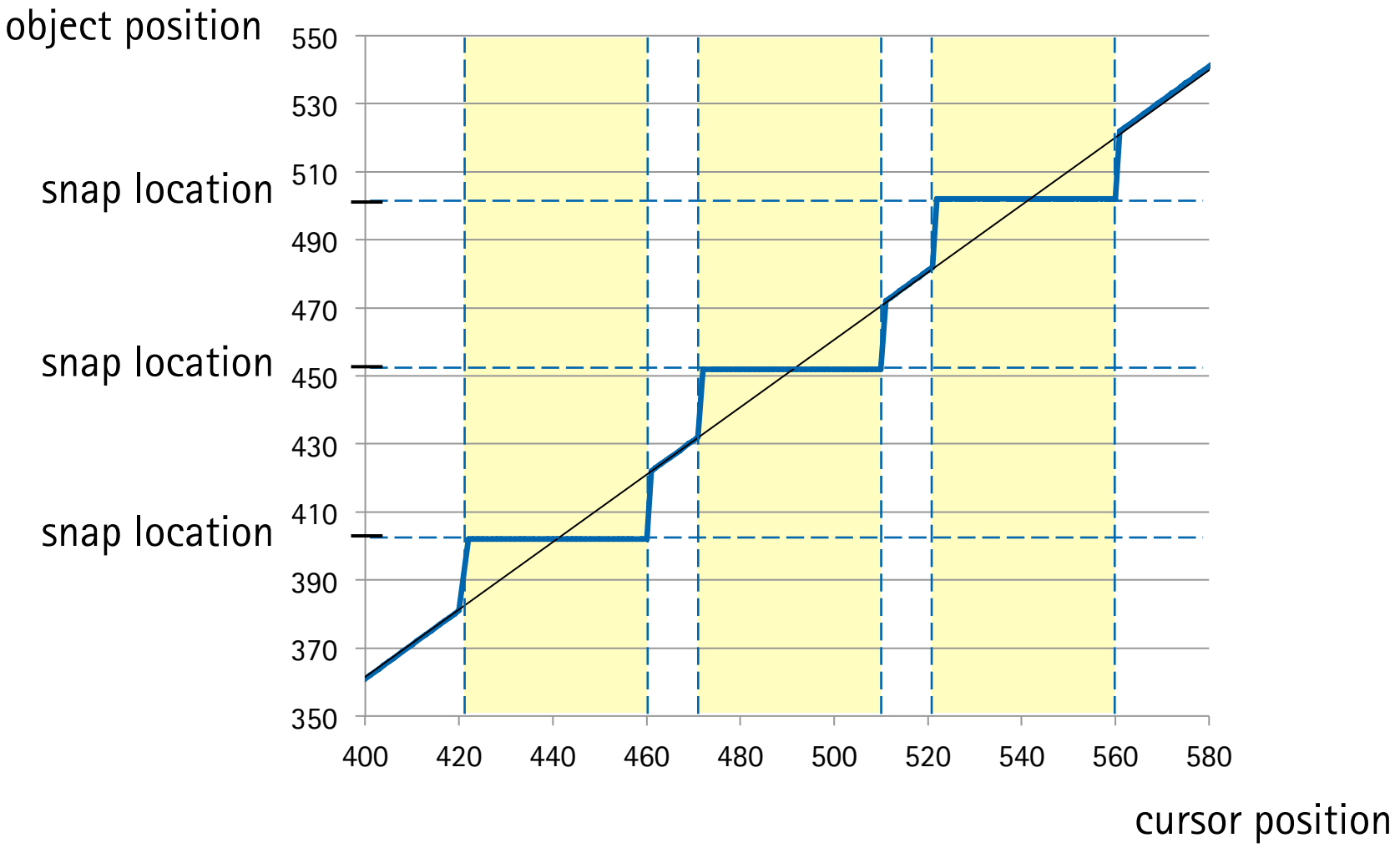
- Draggable center point would lead to unintuitive behavior



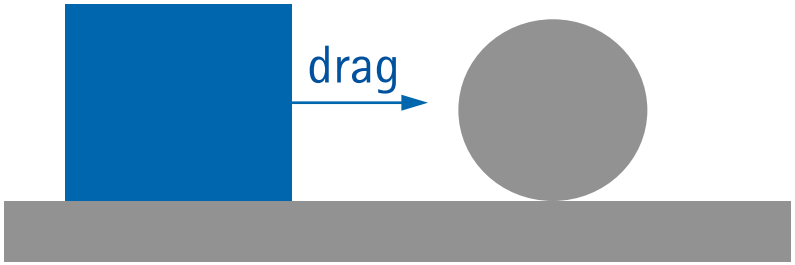
Traditional Snapping: Mapping Cursor to Object Position



Traditional Snapping: Cursor to Object Position

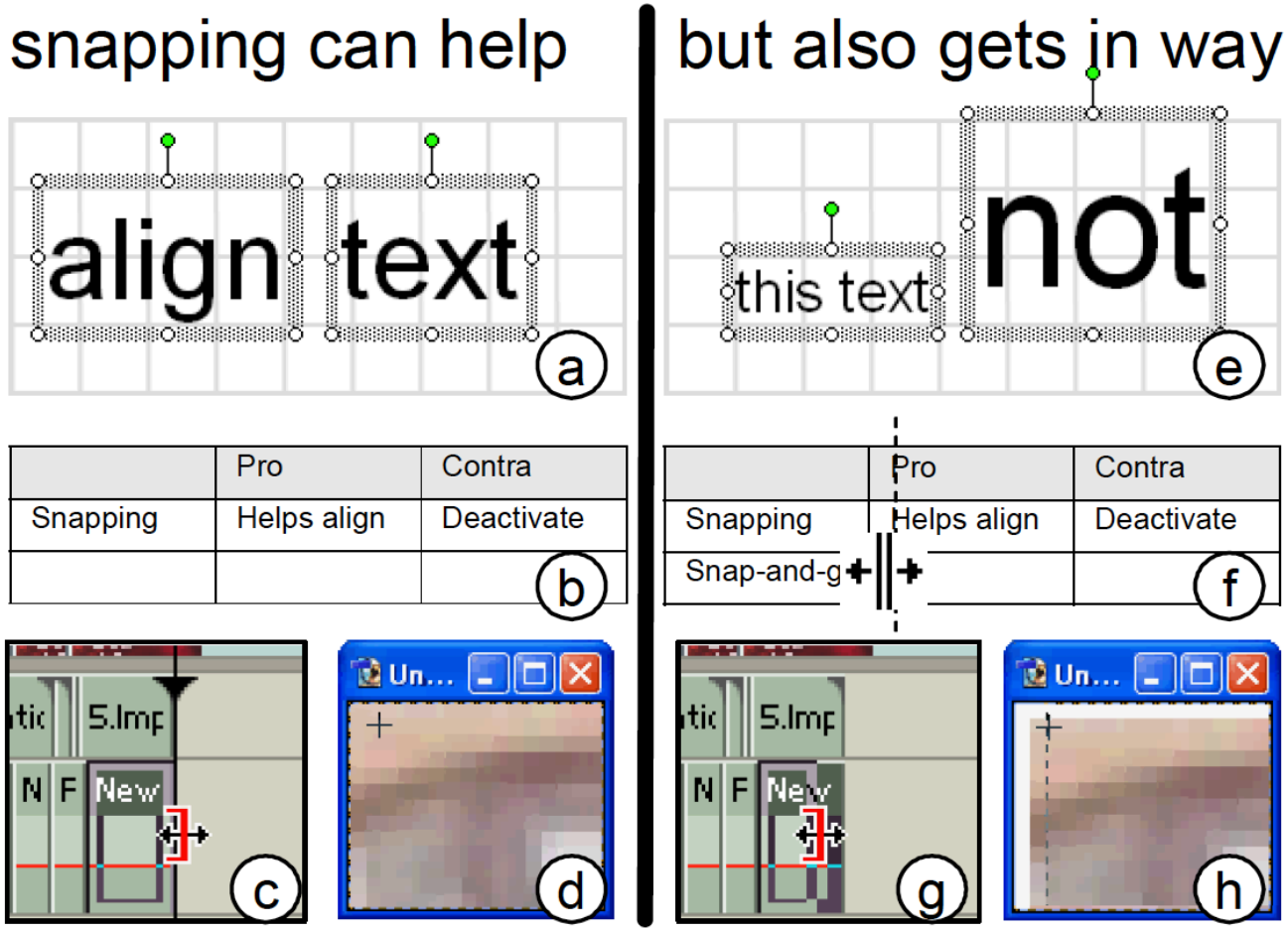


Drag Snapping Can Be Problematic



Problems of Drag Snapping

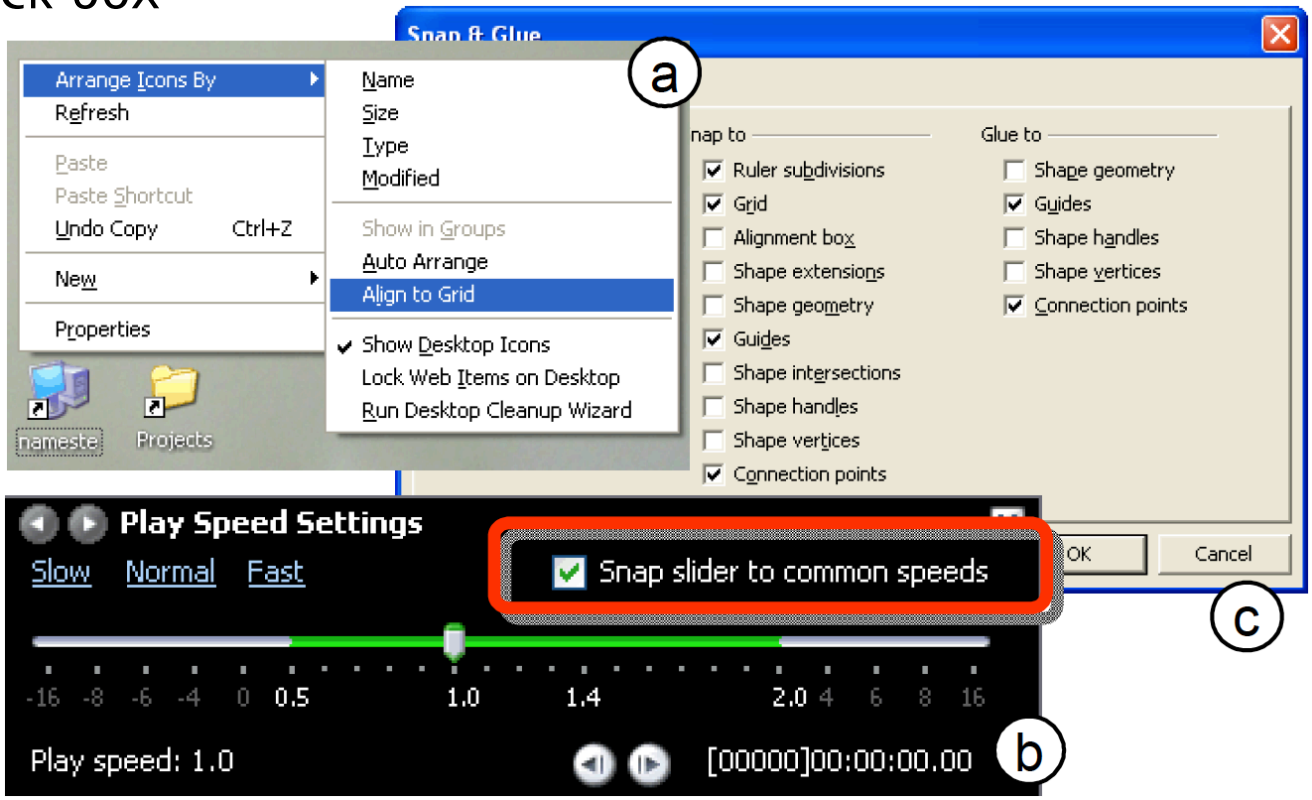
- a, e: align baselines
- b, f: adjust column width
- c, g: put voice clip a bit before video clip
- d, h: adjust pixel-precise region



Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Explicit Deactivation of Snapping

- Modifier keys to activate / deactivate snapping
- Check box



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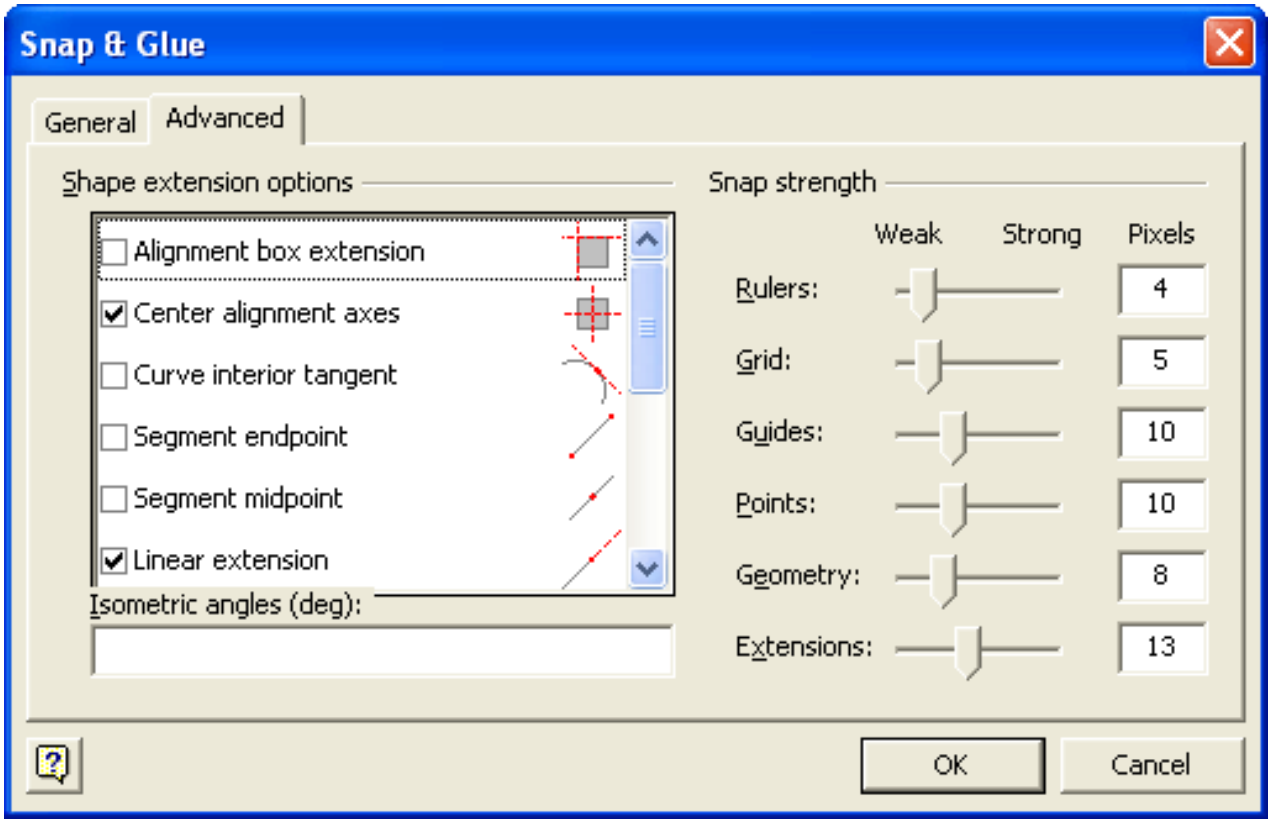
Controlling the Details of Snapping

- Microsoft Visio



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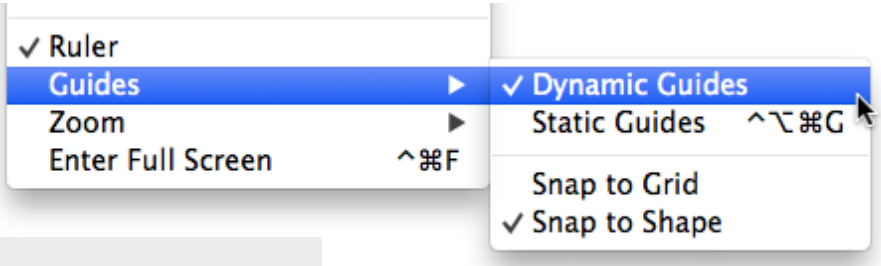
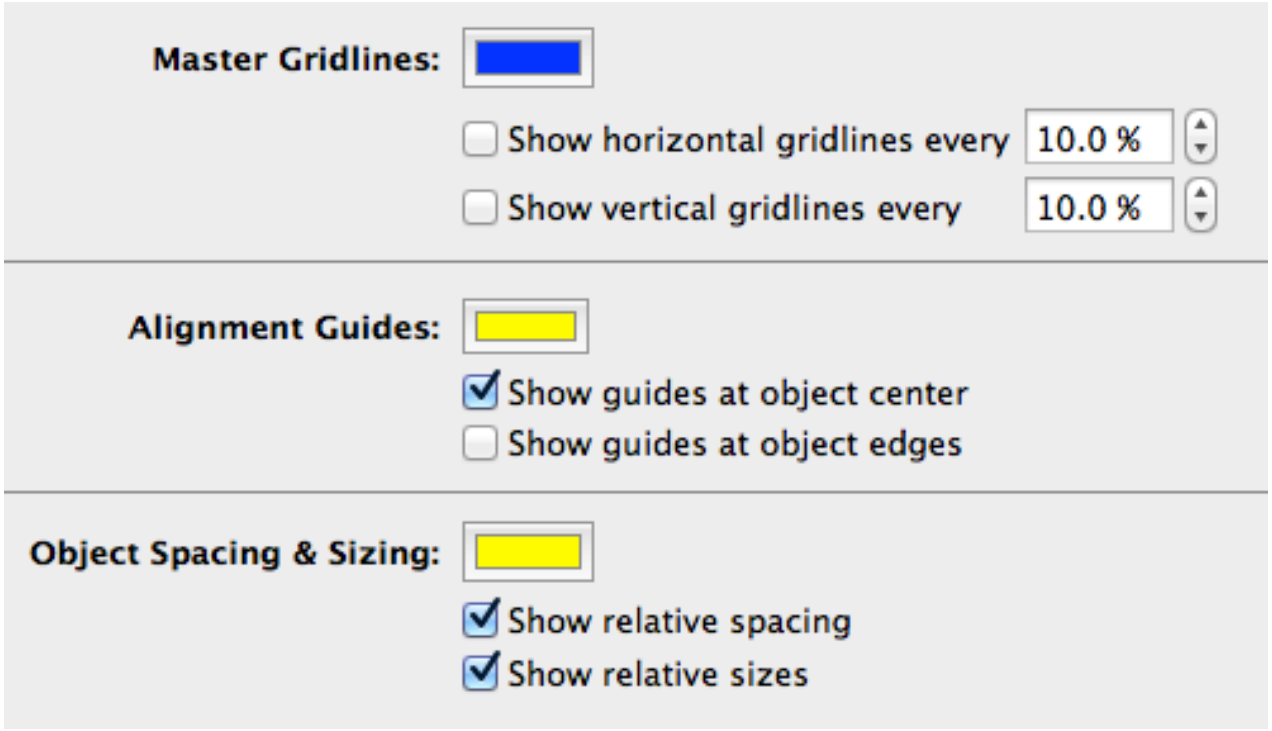
Controlling the Details of Snapping

- Keynote, PowerPoint

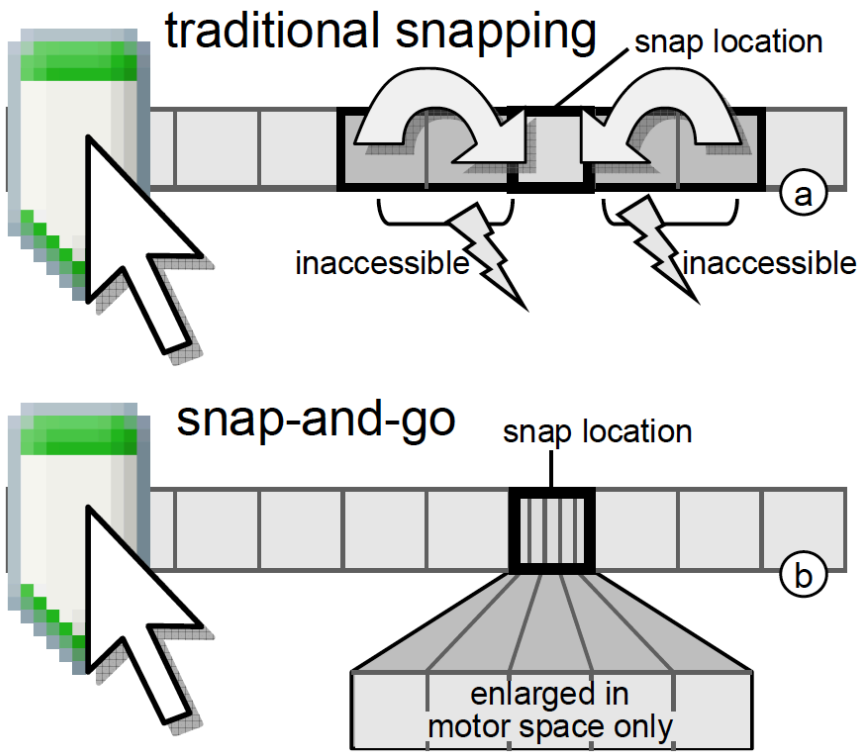




Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Snap-and-Go

- Traditional snapping warps objects to snap location
  - Area in close proximity of snap location is inaccessible
- Snap-and-go stops object at snap location
  - Inserts additional motor space at the snap location
  - Shifts the cursor position relative to the object
- Online Demo
  - http://www.patrickbaudisch.com/projects/snapandgo/demo/index.html



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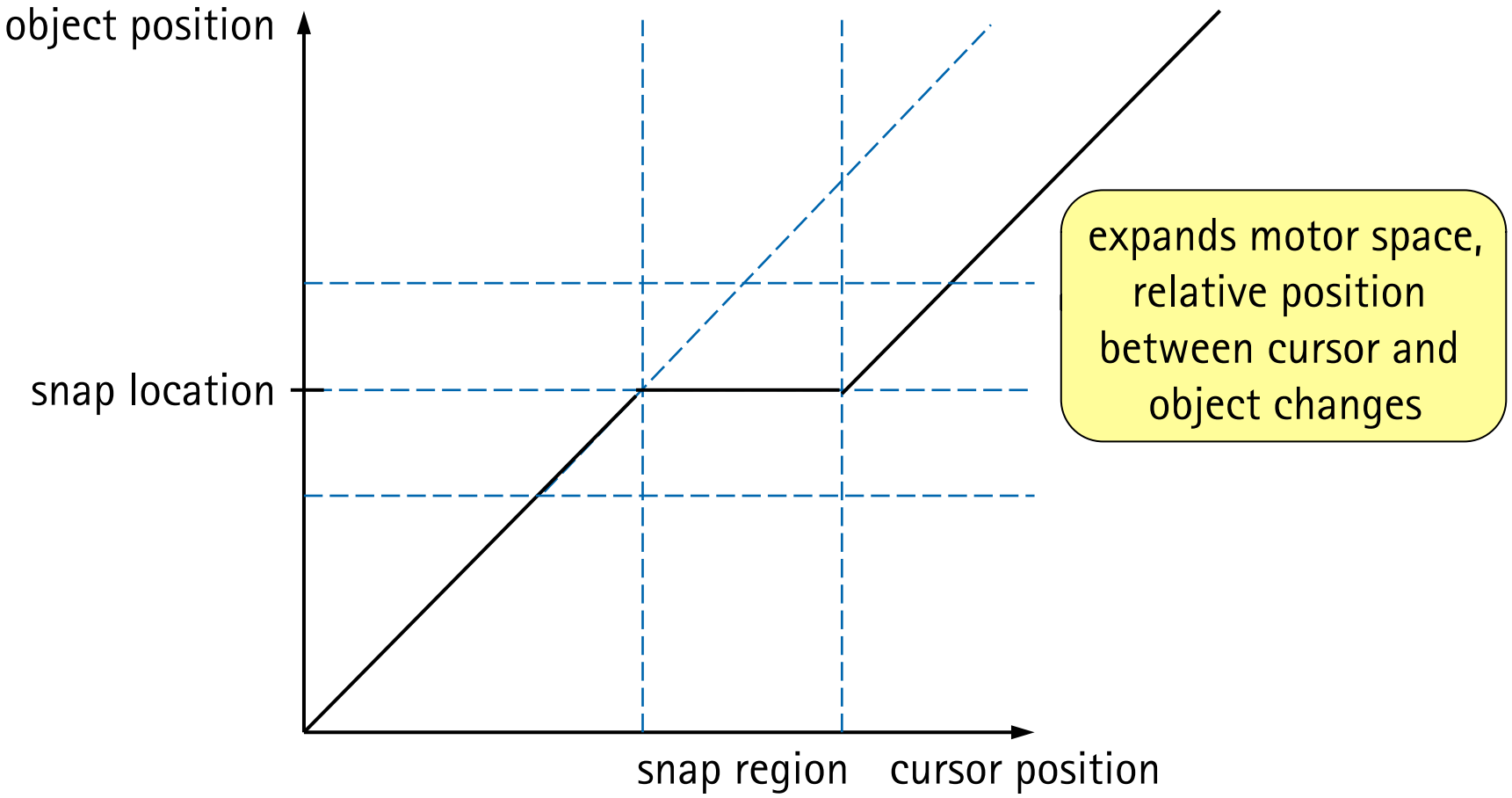
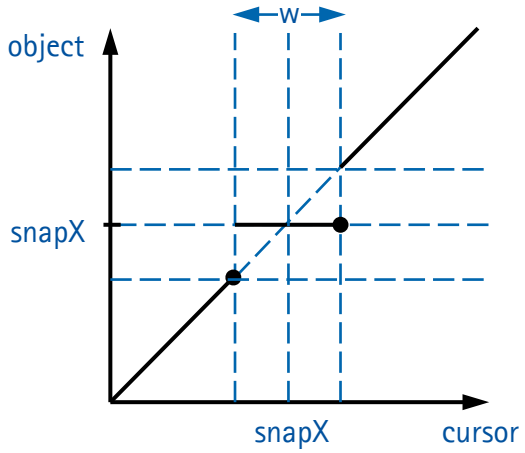
Snap-and-Go: Mapping Cursor to Object Position



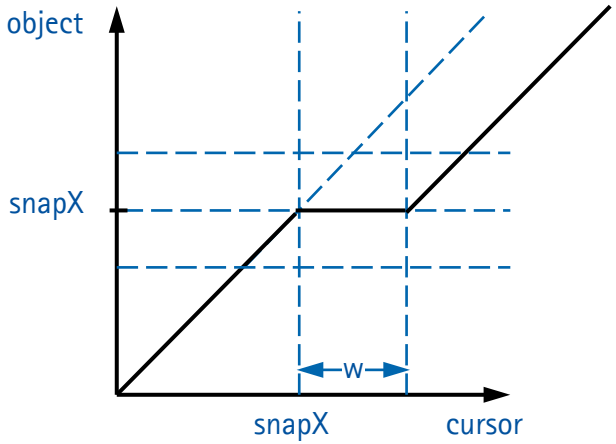
Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Implementation: Drag-Snapping vs. Snap-and-Go (1D)

```
snapTo_TraditionalSnapping(x, w, snapX) {
    if (snapX - w/2 < x < snapX + w/2) {
        return snapX;
    } else {
        return x;
    }
}
```




```
snapTo_SnapAndGo(x, w, snapX) {
    if (x >= snapX + w) {
        return x - w + 1;
    } else if (x > snapX) {
        return snapX;
    } else {
        return x;
    }
}
```

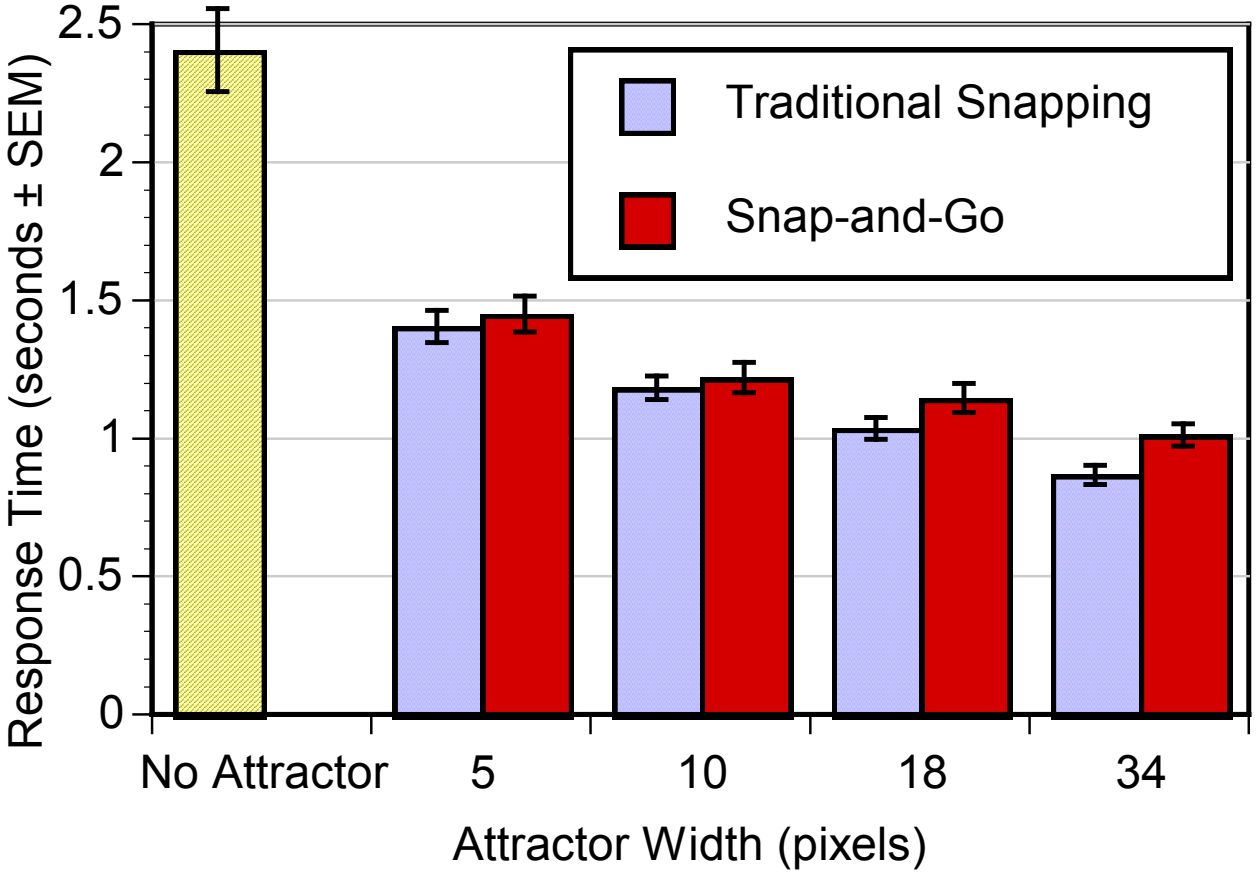


Evaluation of Snap-and-Go

- 9 participants
- 2 x 4 x 4 within subjects design
- Independent variables
  - Snapping technique (2 levels: traditional snapping, snap-and-go)
  - Snapping width (4 levels: 5, 10, 18, 34 pixels)
  - Target distance (4 levels: 100, 200, 400, 800 pixels)
- Dependent variables
  - Task completion time
  - Error rate

Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Evaluation of Snap-and-Go: Task Time



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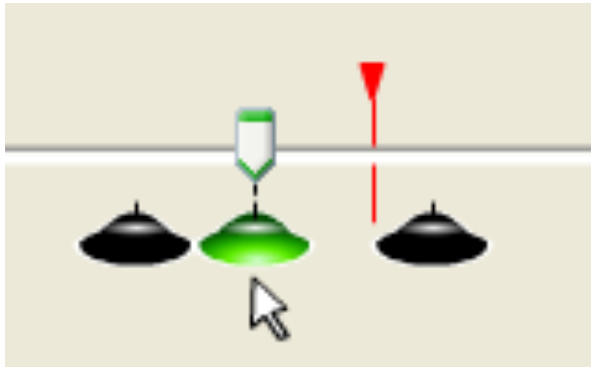
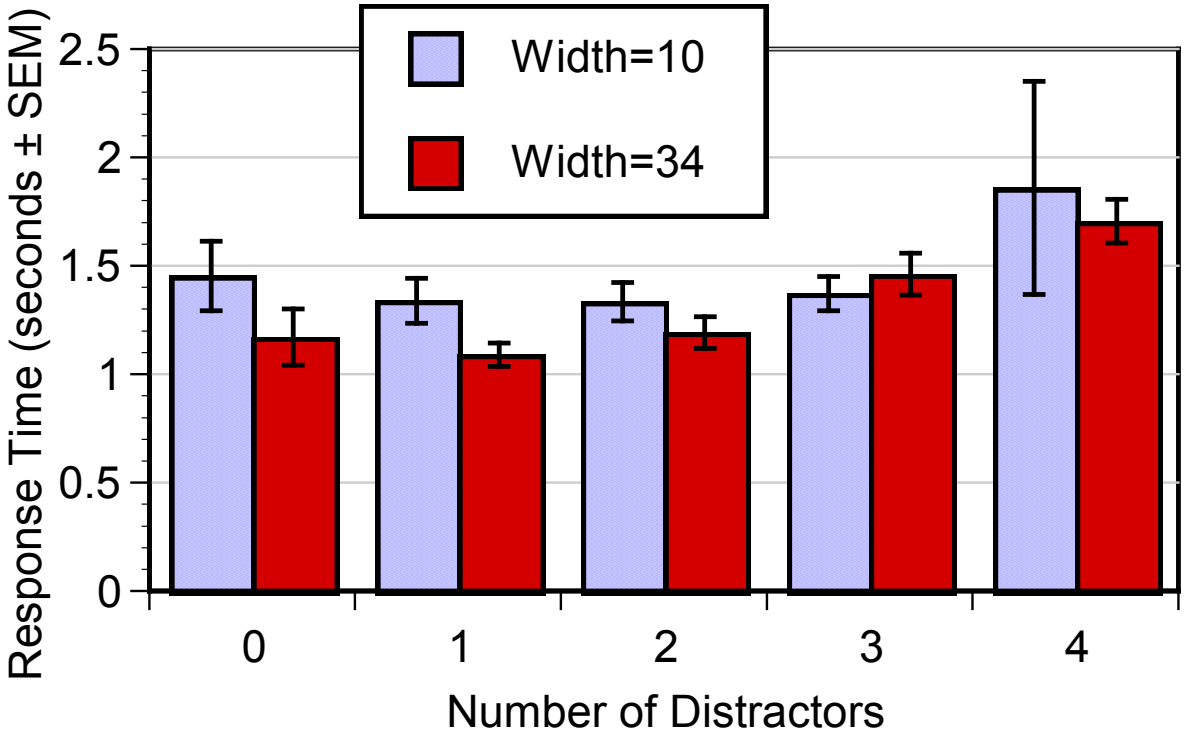
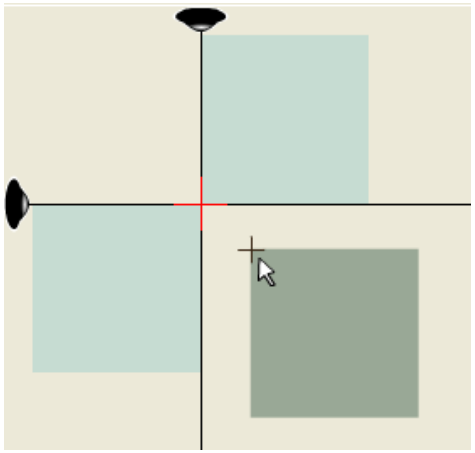
Evaluation of Snap-and-Go: Influence of Distractors

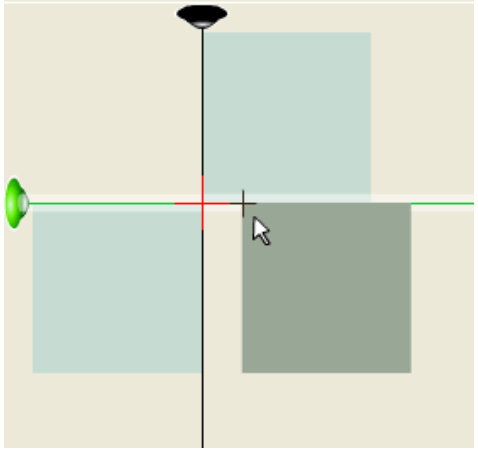


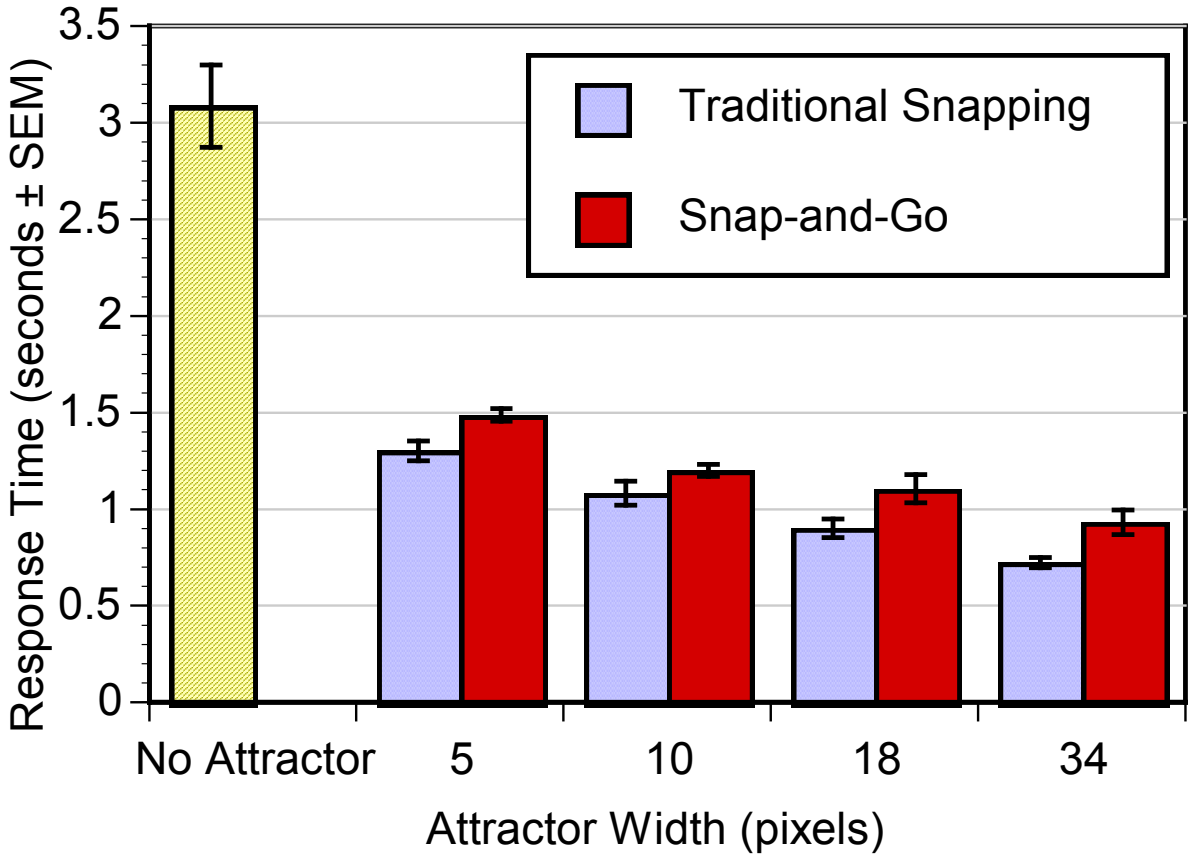


Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Evaluation of Snap-and-Go: 2D Translation Task







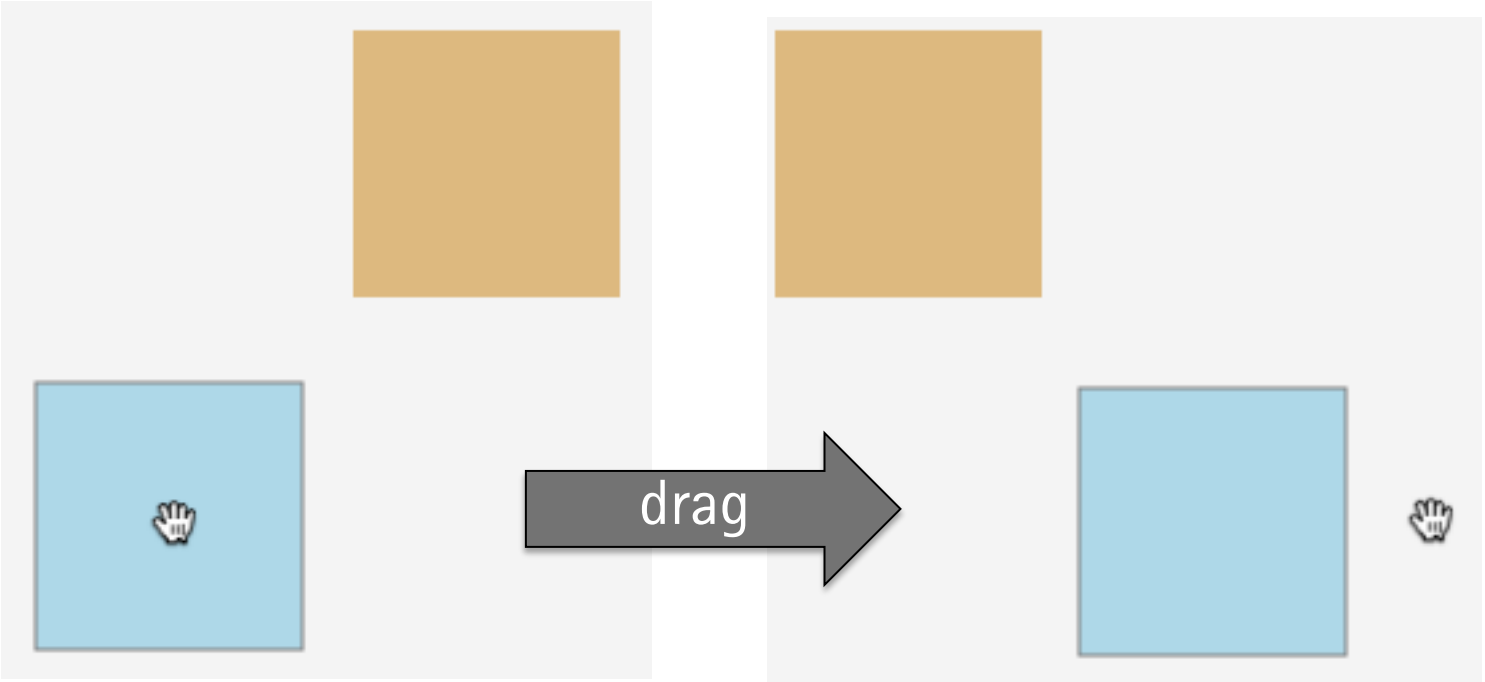
Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Evaluation of Snap-and-Go: Overall Result

- Snap-and-go faster than no snapping
  - 138% in 1D
  - 231% in 2D
- Snap-and-go slightly slower than traditional snapping
  - 3% in 1D
  - 14% in 2D
- Fairly robust against distractors

Baudisch, Cutrell, Hinckley, Eversole: Snap-and-go: Helping users to align objects without the modality of traditional snapping. CHI 2005.

Snap-and-Go Problem: Cursor/Finger Moves Off Object

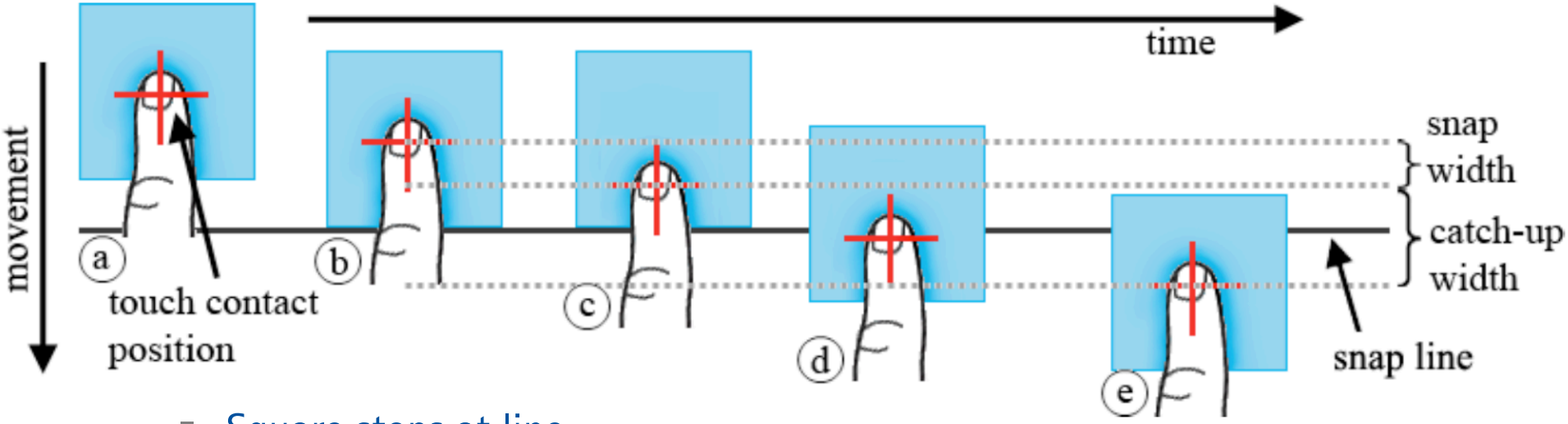


start dragging,
mouse on
object center

still dragging,
but mouse
shifted off object

"Oh Snap": Catching up After Snapping

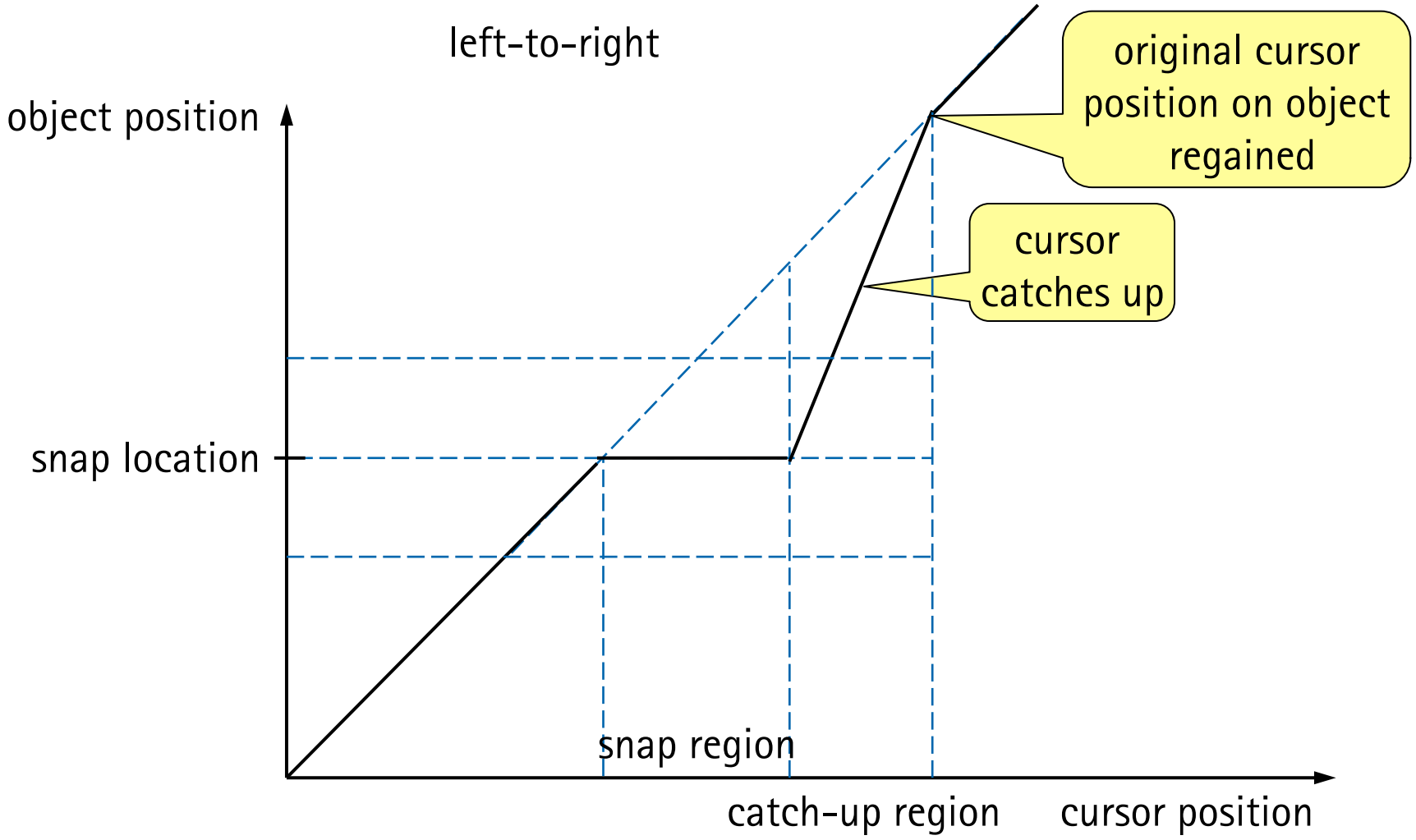
- Avoids object jumps towards snap location
- Avoids displacement by catching up after snap location



- Square stops at line
- Stays at line while finger movement continues through snap width
- Catches up while finger movement continues through catch-up width

Fernquist, Shoemaker, Booth: "Oh Snap" - Helping users align digital objects on touch interfaces. Interact 2011.

"Oh-Snap": Mapping Cursor to Object Position



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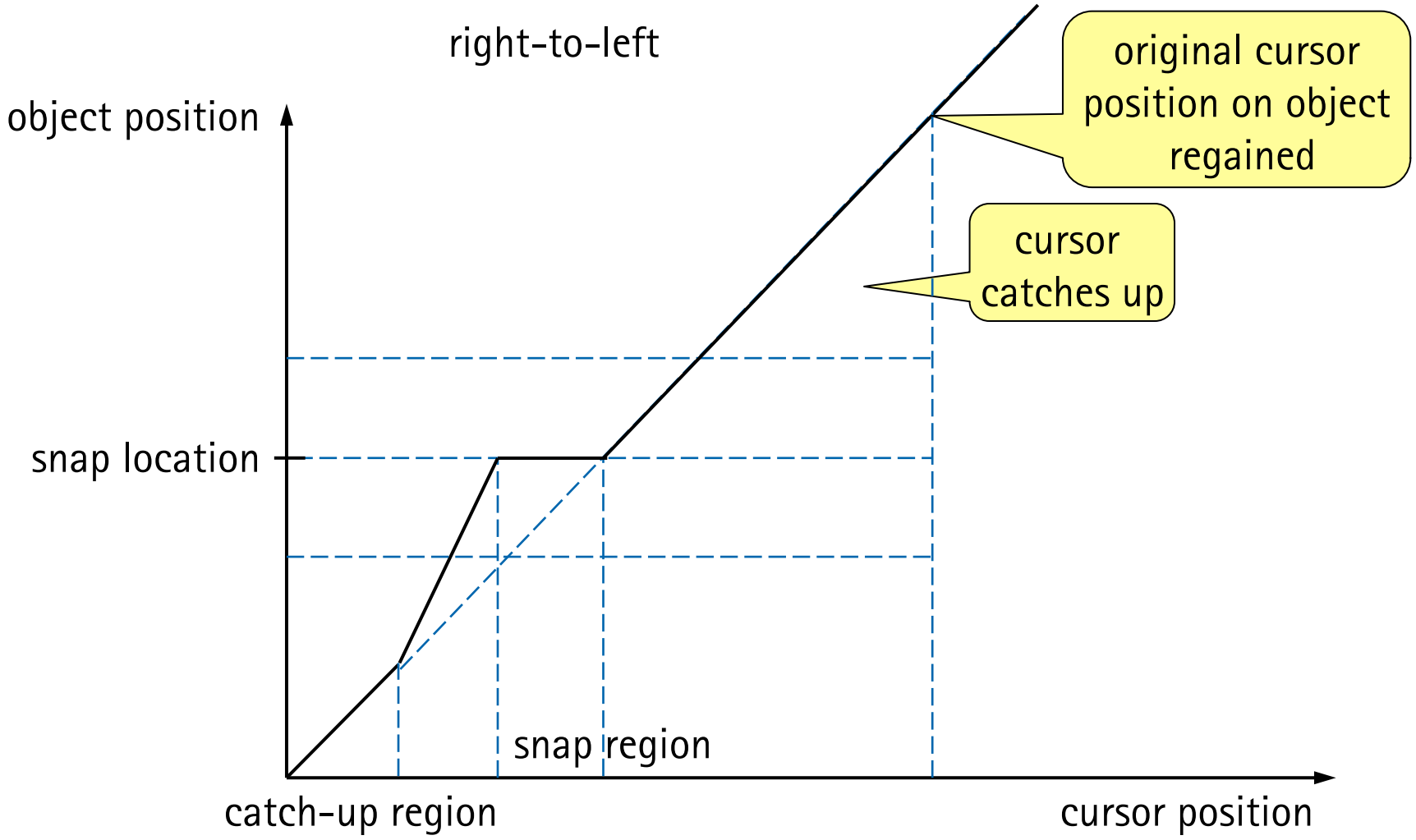
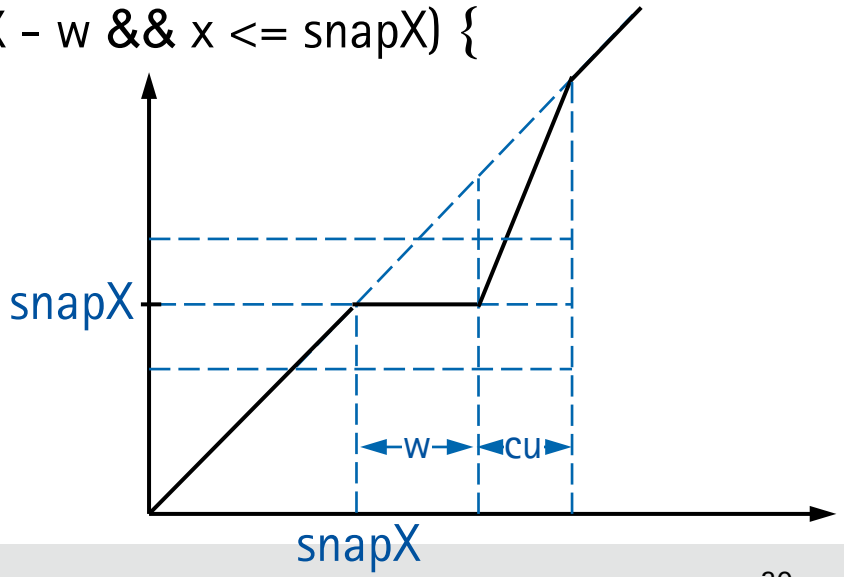


Fernquist, Shoemaker, Booth: "Oh Snap" - Helping users align digital objects on touch interfaces. Interact 2011.

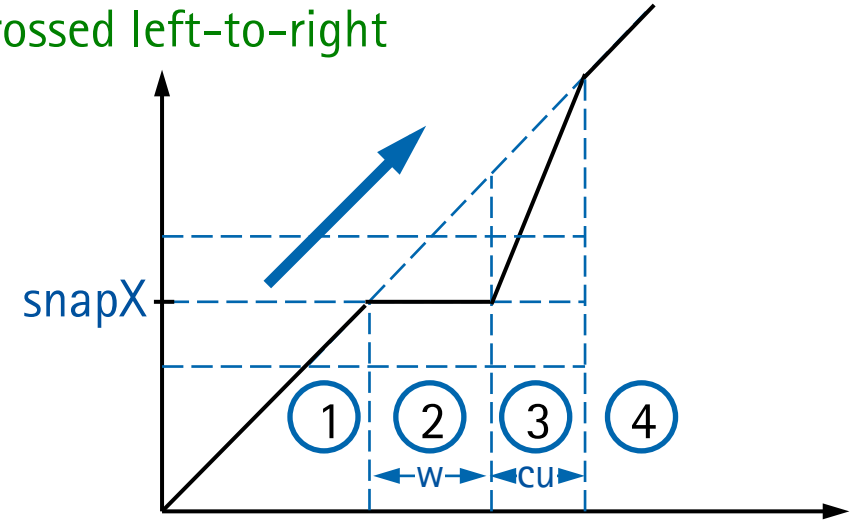
“Oh-Snap” Implementation

```
double snap(double x, double w, double snapX, double catchUp) {
    if (!isSnapped) { // if not yet in snapping region, check
        // xPrev is previous x value
        if (xPrev < snapX && x >= snapX && x < snapX + w) {
            isSnapped = true;
            isIncreasing = true;
        } else if (xPrev > snapX && x > snapX - w && x <= snapX) {
            isSnapped = true;
            isIncreasing = false;
        }
    }
    xPrev = x;
    ...
```



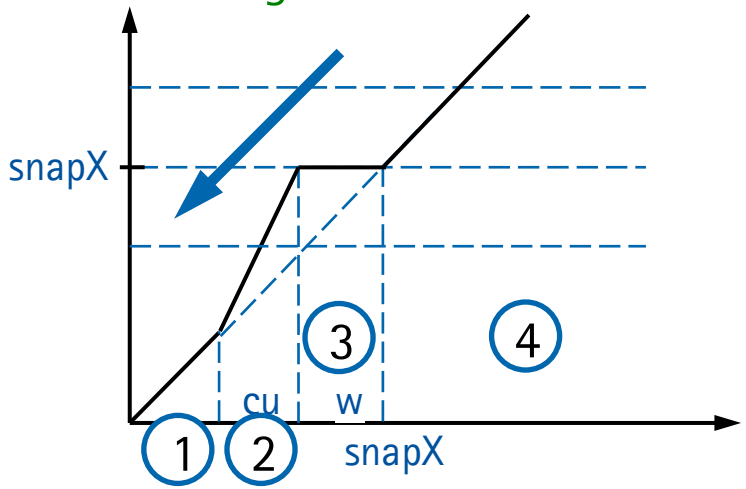
"Oh-Snap" Implementation

```
if (isSnapped) {
    if (isIncreasing) { // snapping region is crossed left-to-right
        if (x < snapX) {
            isSnapped = false;
            return x; (1)
        } else if (x < snapX + w) {
            return snapX; (2)
        } else if (x < snapX + w + catchUp) {
            return snapX + (x - (snapX + w)) / catchUp * (w + catchUp);
        }  (3)
    } else /* isDecreasing */ { ... }
    ...
```

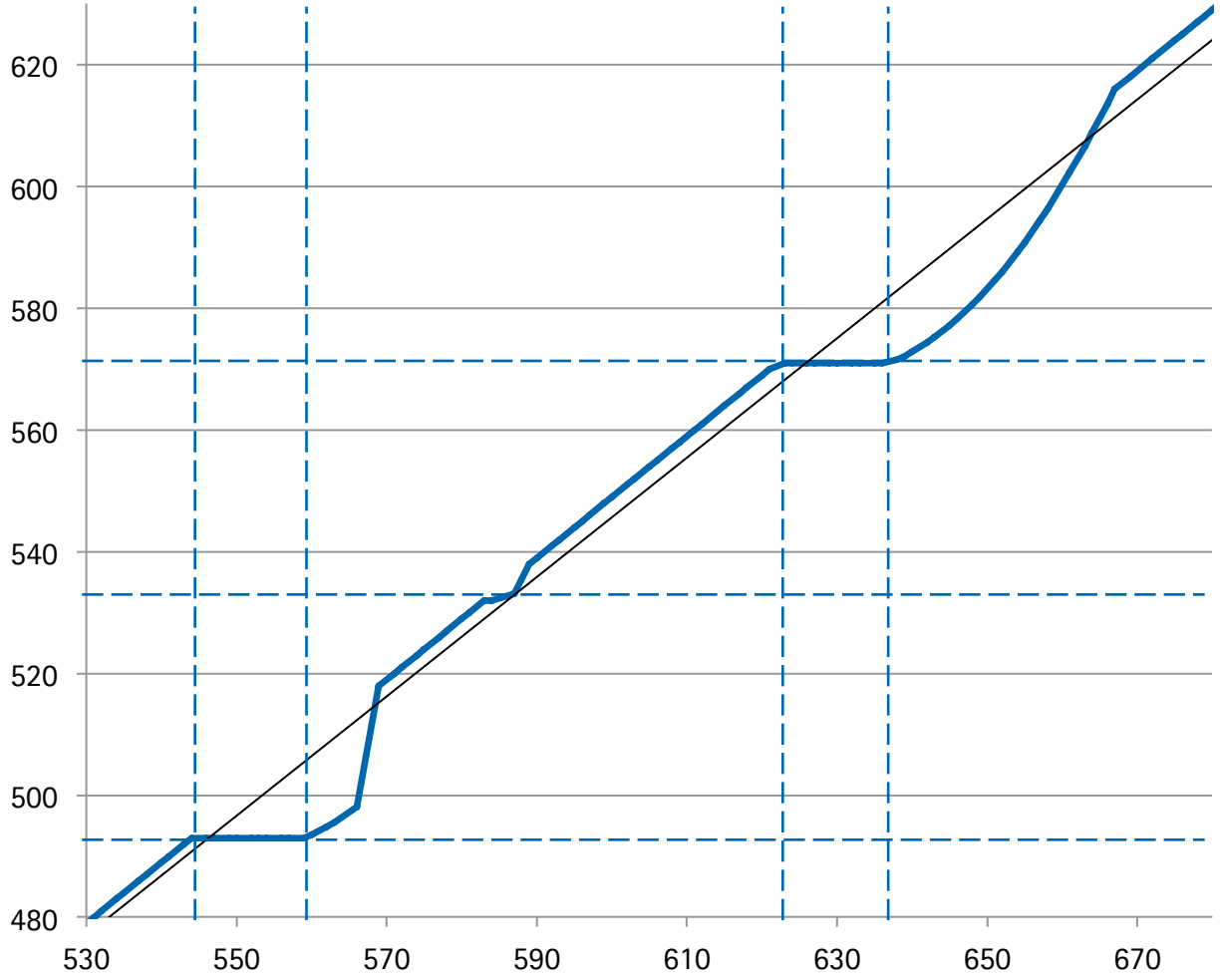


“Oh-Snap” Implementation

```
    } else /* isDecreasing */ { // snapping region is crossed right-to-left
        if (x > snapX) {
            isSnapped = false;
            return x; (1)
        } else if (x > snapX - w) {
            return snapX; (2)
        } else if (x > snapX - w - catchUp) {
            return snapX + (x - (snapX - w)) / catchUp * (w + catchUp);
        } (3)
    }
}
isSnapped = false;
return x; (4)
```



Overlapping Regions Lead to Problems



“Oh Snap”: Catching up After Snapping

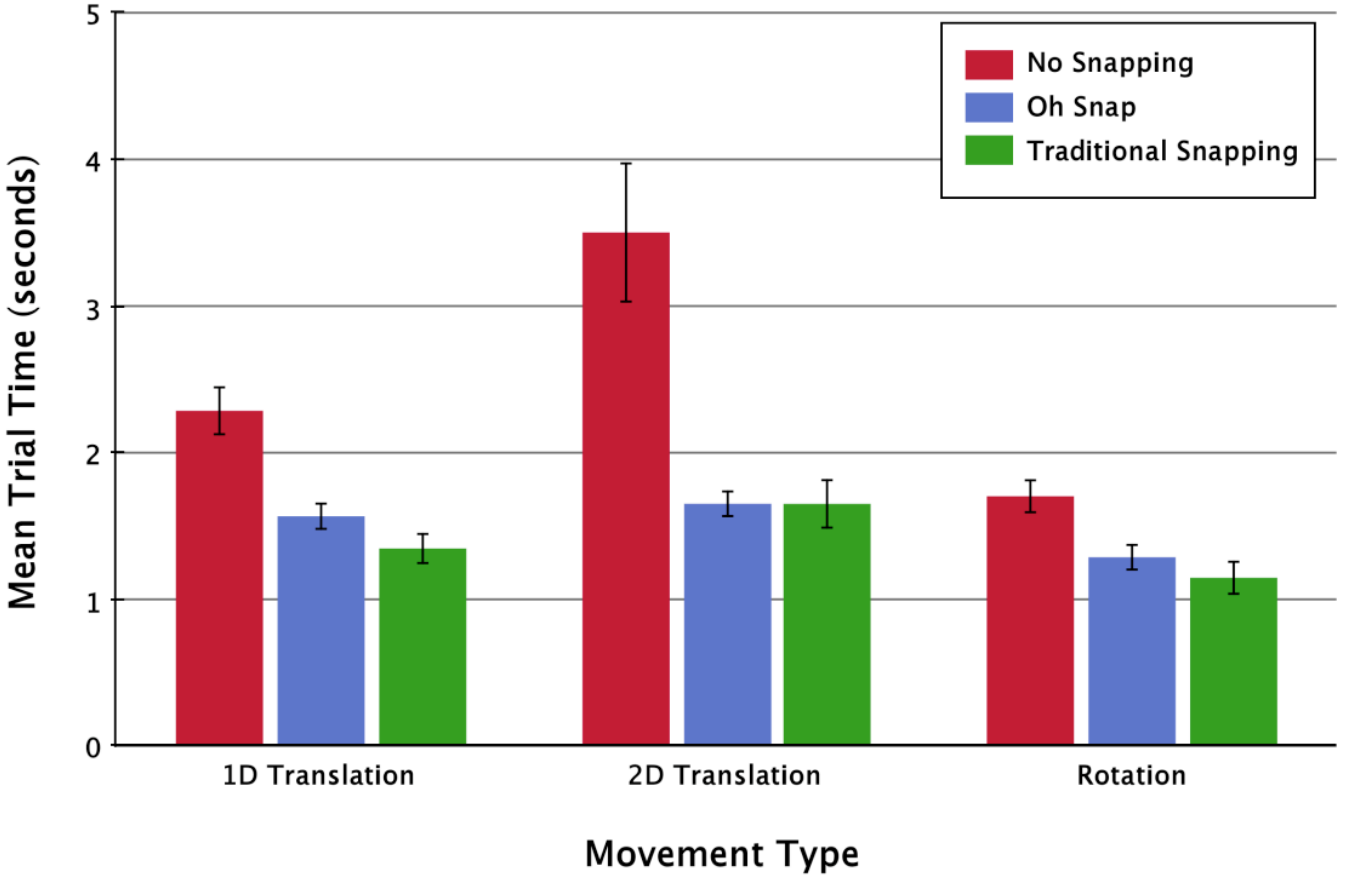
- “Oh Snap” allows positioning objects nearby snapping locations

Technique	Mapping maintained	Close placement
Oh Snap	Yes	Yes
Snap-and-Go	No	Yes
Traditional snapping	Yes	No
No snapping	Yes	Yes

Fernquist, Shoemaker, Booth: "Oh Snap" - Helping users align digital objects on touch interfaces. Interact 2011.

"Oh Snap" Performance Comparison

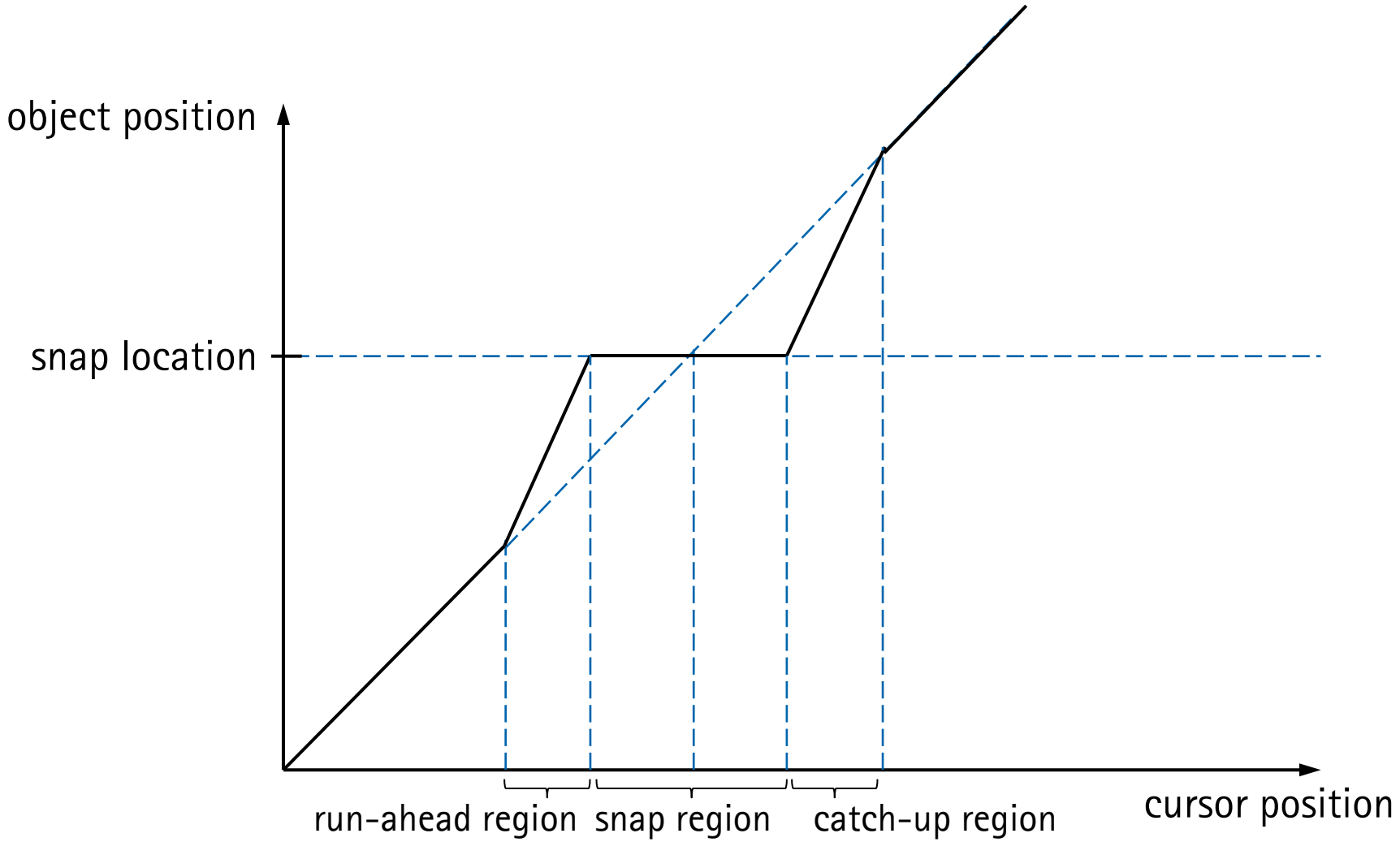
- Mean trial times for snapping tasks



Error bars show standard error

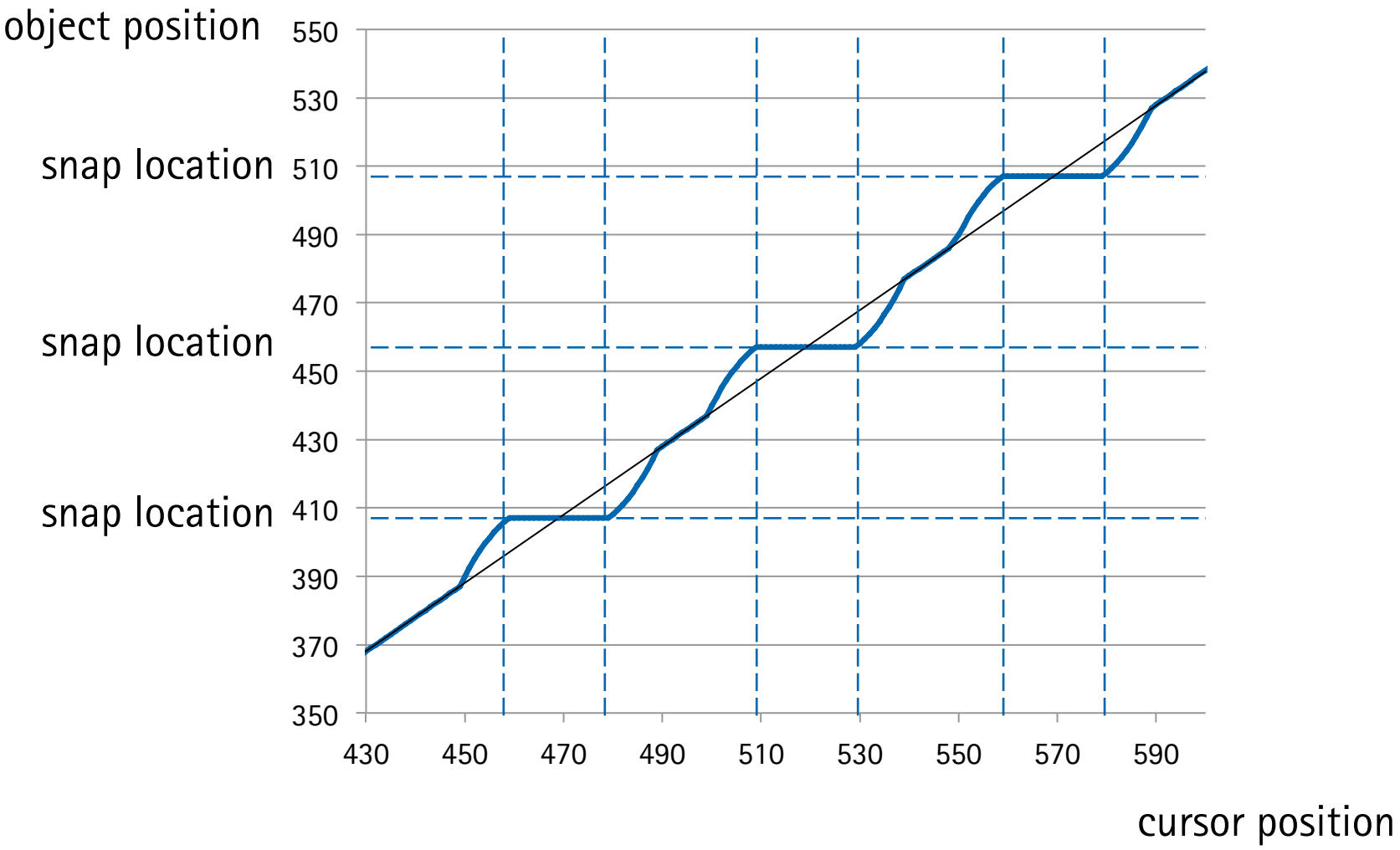
Fernquist, Shoemaker, Booth: "Oh Snap" - Helping users align digital objects on touch interfaces. Interact 2011.

Snapping with Symmetrical Catch-Up Region



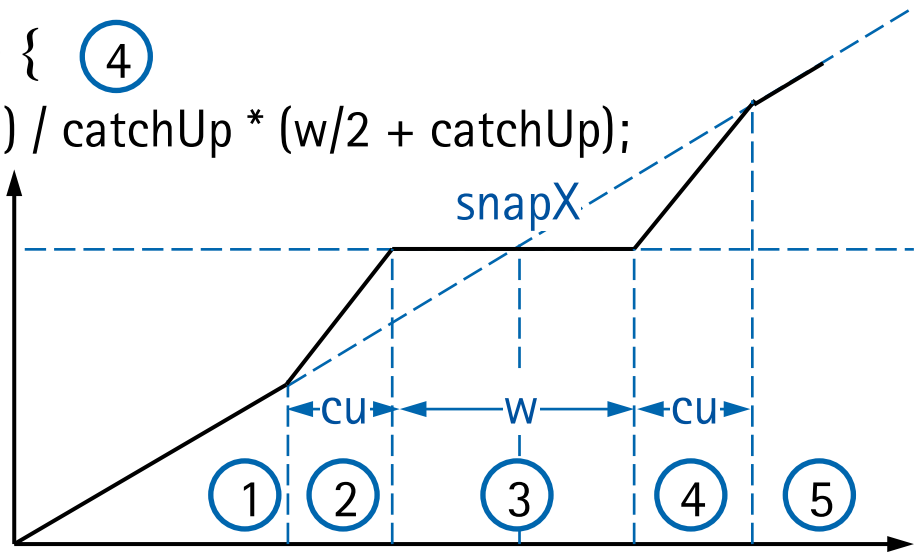
Fernquist, Shoemaker, Booth: "Oh Snap" - Helping users align digital objects on touch interfaces. Interact 2011.

Snapping with Symmetrical Catch-Up Region

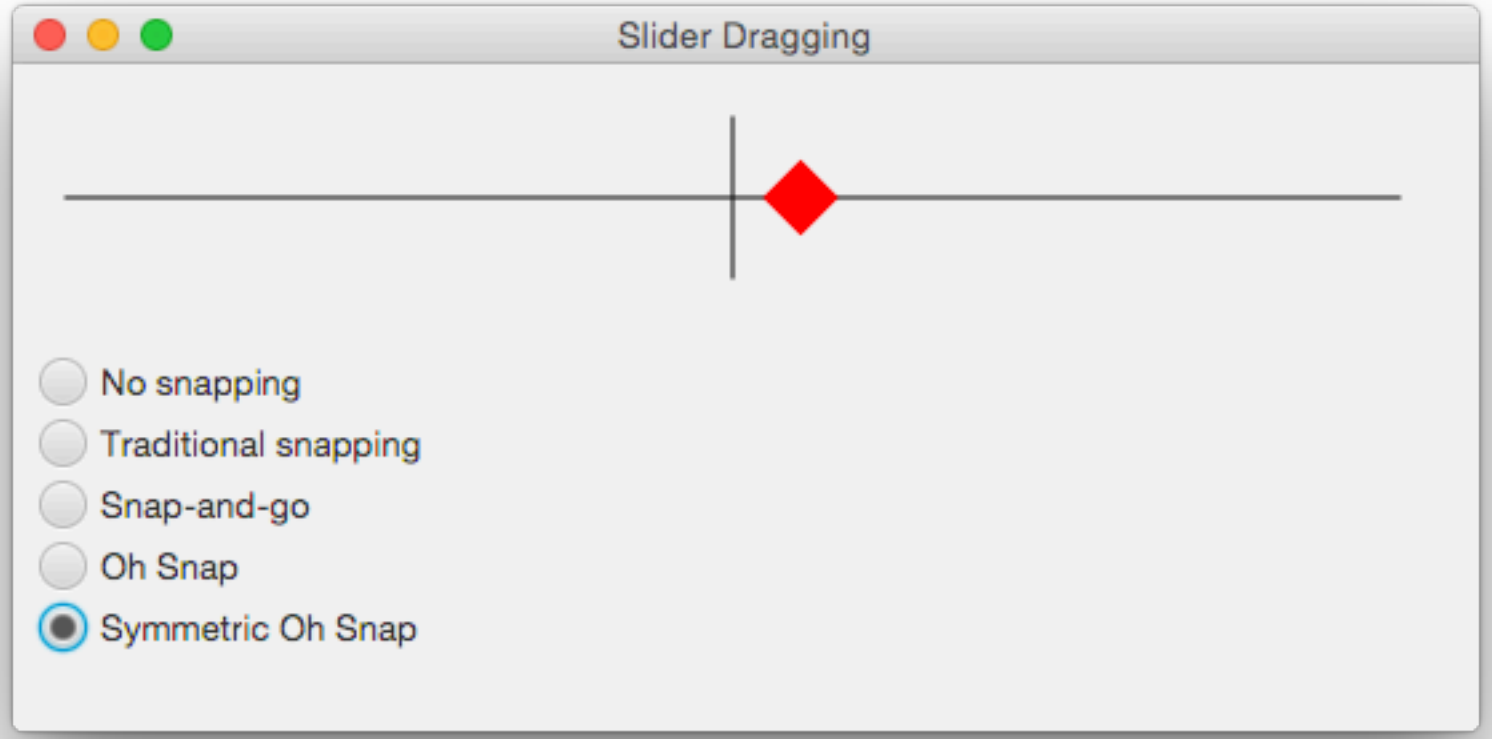


Symmetrical Snapping Implementation

```
double snap(double x, double w, double snapX, double catchUp) {
    if (x < snapX - w/2 - catchUp) {
        return x;  (1)
    } else if (x < snapX - w/2) {
        return snapX + (x - (snapX - w/2)) / catchUp * (w/2 + catchUp);  (2)
    } else if (x < snapX + w/2) {
        return snapX;  (3)
    } else if (x < snapX + w/2 + catchUp) {  (4)
        return snapX + (x - (snapX + w/2)) / catchUp * (w/2 + catchUp);
    }
    return x;  (5)
}
```



Snapping Technique Demo: SliderDragging

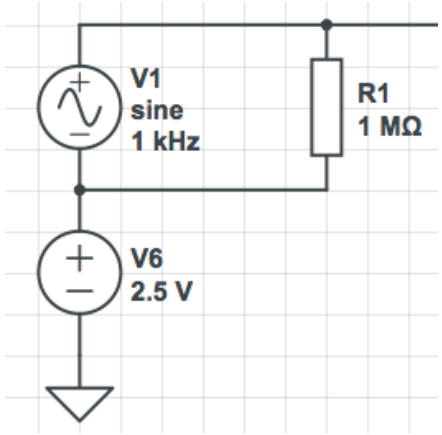


Stud.IP: SliderDragging.zip

Semantic Snapping

- Geometric aspect and semantic aspect
- Geometric: Objects in close proximity snap into position
- Semantic: Reflects semantic consequences of a snap

- Example: Schematic editor
  - Geometric: Snap component symbols and wires
  - Relaxes requirements on input precision
  - Semantic: Only snap compatible components
  - Prevents errors before they occur
  - Anti-gravity feedback, repelling force
  - Improves directness of interface (compared to error dialog)



Hudson: Adaptice semantic snapping - A technique for semantic feedback at the lexical level. CHI 1990.

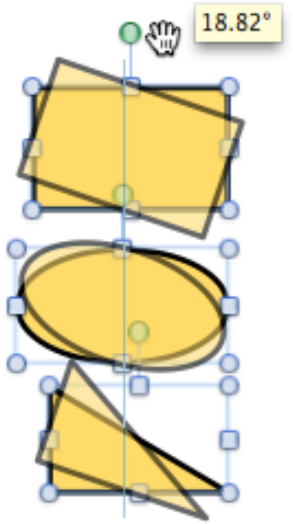
Semantic Snapping

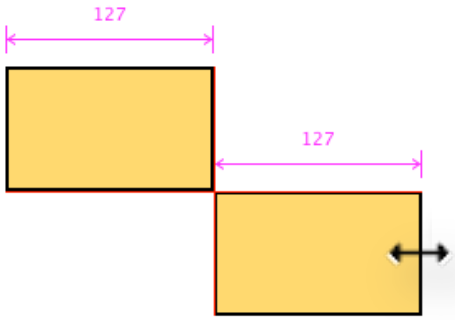
- Semantic snapping based on snap sites
  - Each object associated with one or more snap sites
  - Sites may be active or inactive depending on object/system state
- System continuously looks for closest snap sites
  - Whether snap site is active
  - Whether snap site is within snapping distance
  - Whether semantic test on involved snap sites passes
- Snapping system provides feedback for valid snap sites
  - Anti-gravity feedback if constraint fails
- Informing involved snap sites on entry and exit into snap range

Hudson: Adaptice semantic snapping - A technique for semantic feedback at the lexical level. CHI 1990.

Other Placement and Alignment Techniques

- Explicit rejection of snaps (modifier key)
- Fixing aspect ratio (modifier key)
- Scaling around center (modifier key)
- Multi-selection (lasso tool or shift-click)
  - Operation performed on one object is replicated on all objects
  - Example: Rotating one object rotates all selected objects
- Grouping
  - Group is treated as a new object
- Size constraints when stretching
  - Make object same size as other objects





POINTING TECHNIQUES

Pointing Techniques

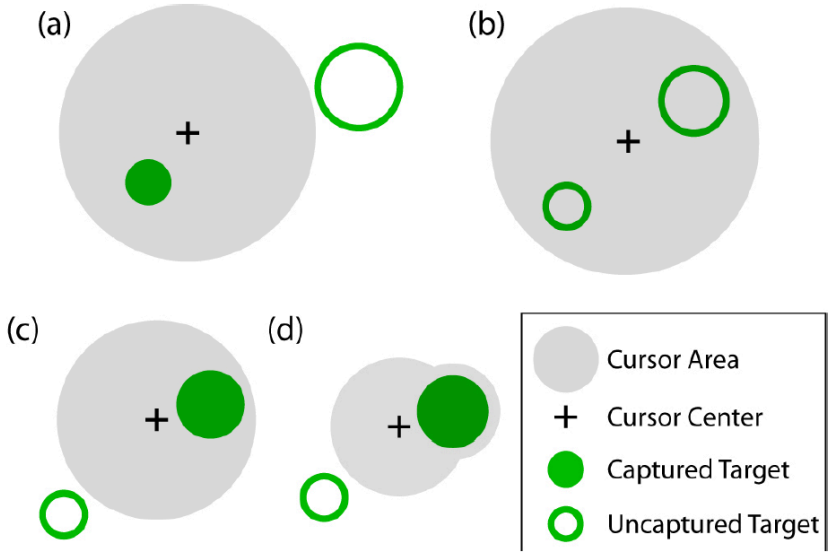
- Selecting one object among a larger set of candidates is a fundamental activity
- Tradeoff between precision (low control:display ratio) and speed (high control:display ratio)
- Non-linear C:D ratio depending on speed
- Improvements when candidate positions are known
- Point cursors: Single-pixel "hotspot"
  - Problematic for small targets
- Area cursors: Extended active area
  - Well-suited for small targets
  - Area may dynamically resize depending on distance to closest target

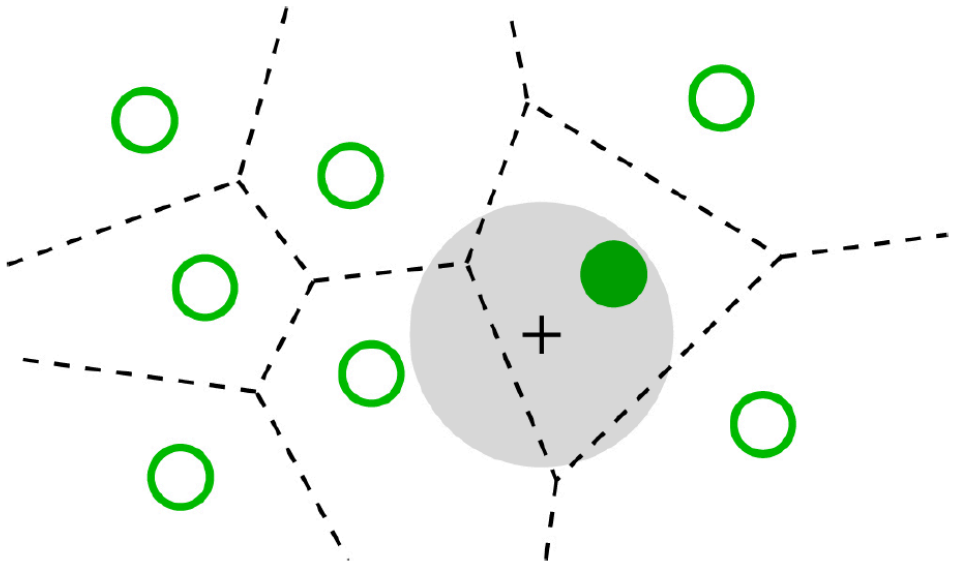
Improvements over Point Cursors

- Fitts' Law
  - Movement time MT depends on target width W and distance D
- Movement time (MT)
  - MT = a + b * ID [sec]
- Index of difficulty (ID)
  - $ID = \log_2(D / W + 1)$ [bits]

- In order to reduce MT
  - Increase target size (dynamically)
    - Expand active area of object or of cursor, increase motor space
  - Reduce distance (dynamically)
    - Bring cursor closer to target, or vice versa

Grossman and Balakrishnan: Bubble Cursor



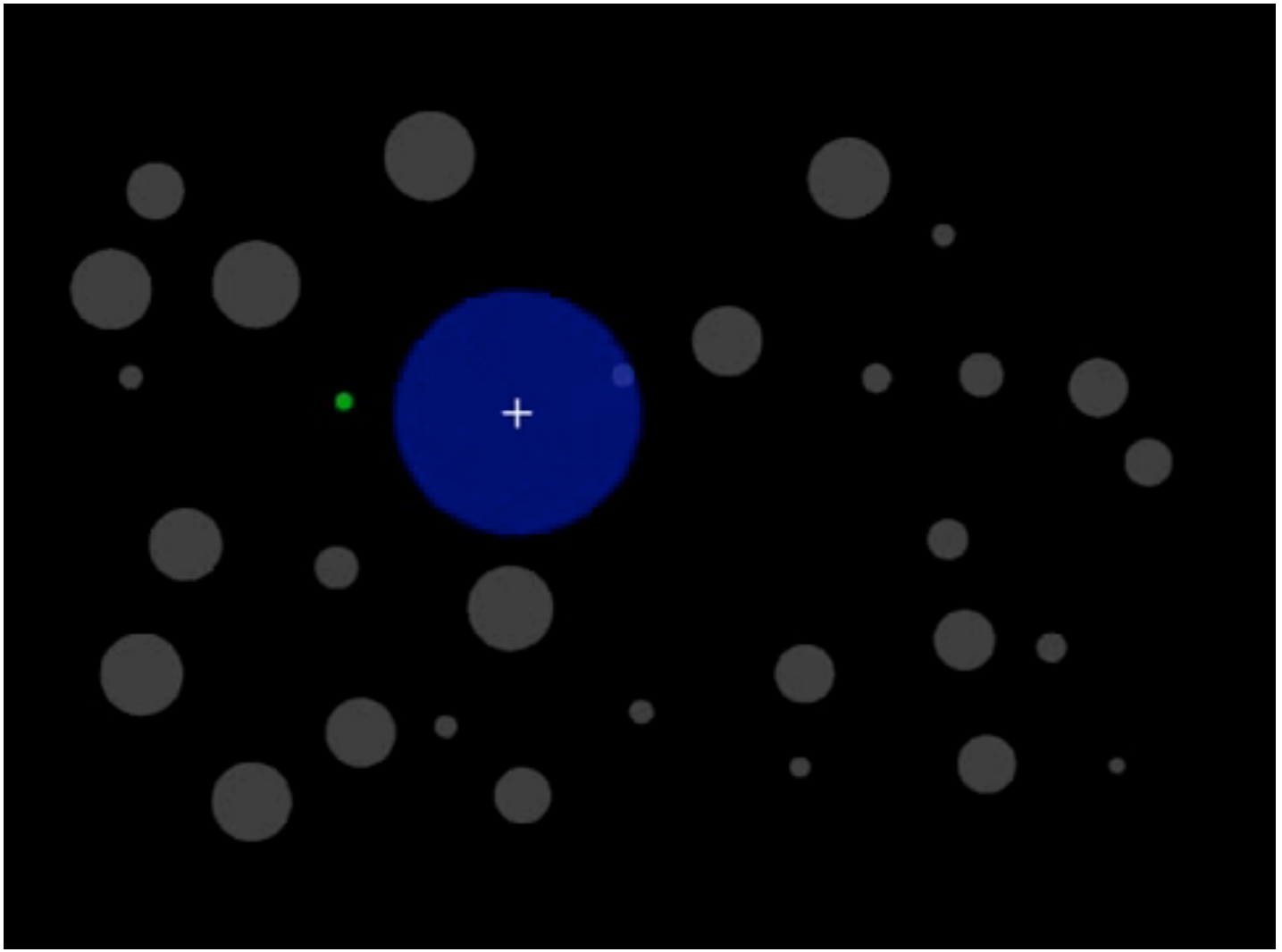


a) fixed area cursor
b) difficult to isolate target
c) dynamic change of size
d) area encompasses exactly one target

Voronoi cells define effective widths of targets

Grossman and Balakrishnan: The bubble cursor: enhancing target acquisition by dynamic resizing of the cursor's activation area. CHI 2005.

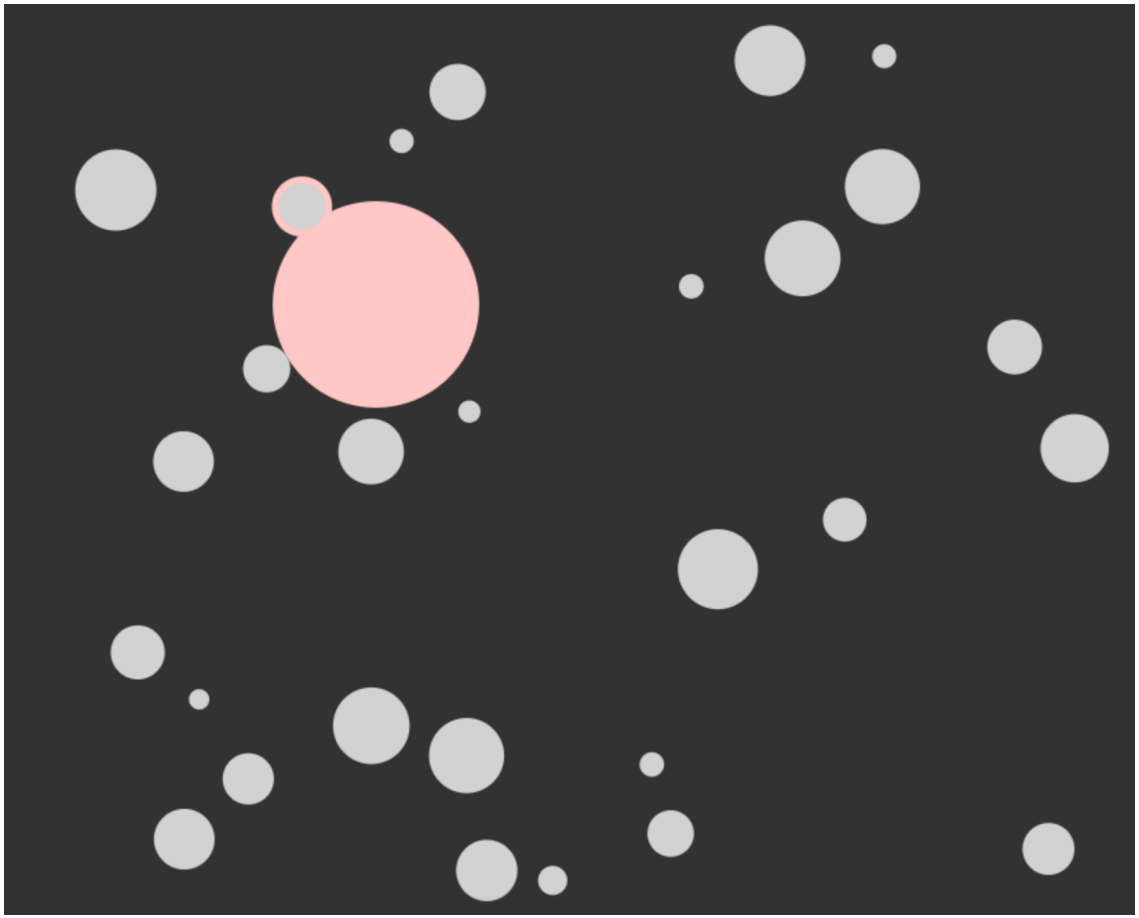
Grossman and Balakrishnan: Bubble Cursor



Grossman and Balakrishnan: The bubble cursor: enhancing target acquisition by dynamic resizing of the cursor's activation area. CHI 2005.

Bubble Cursor Web Demo

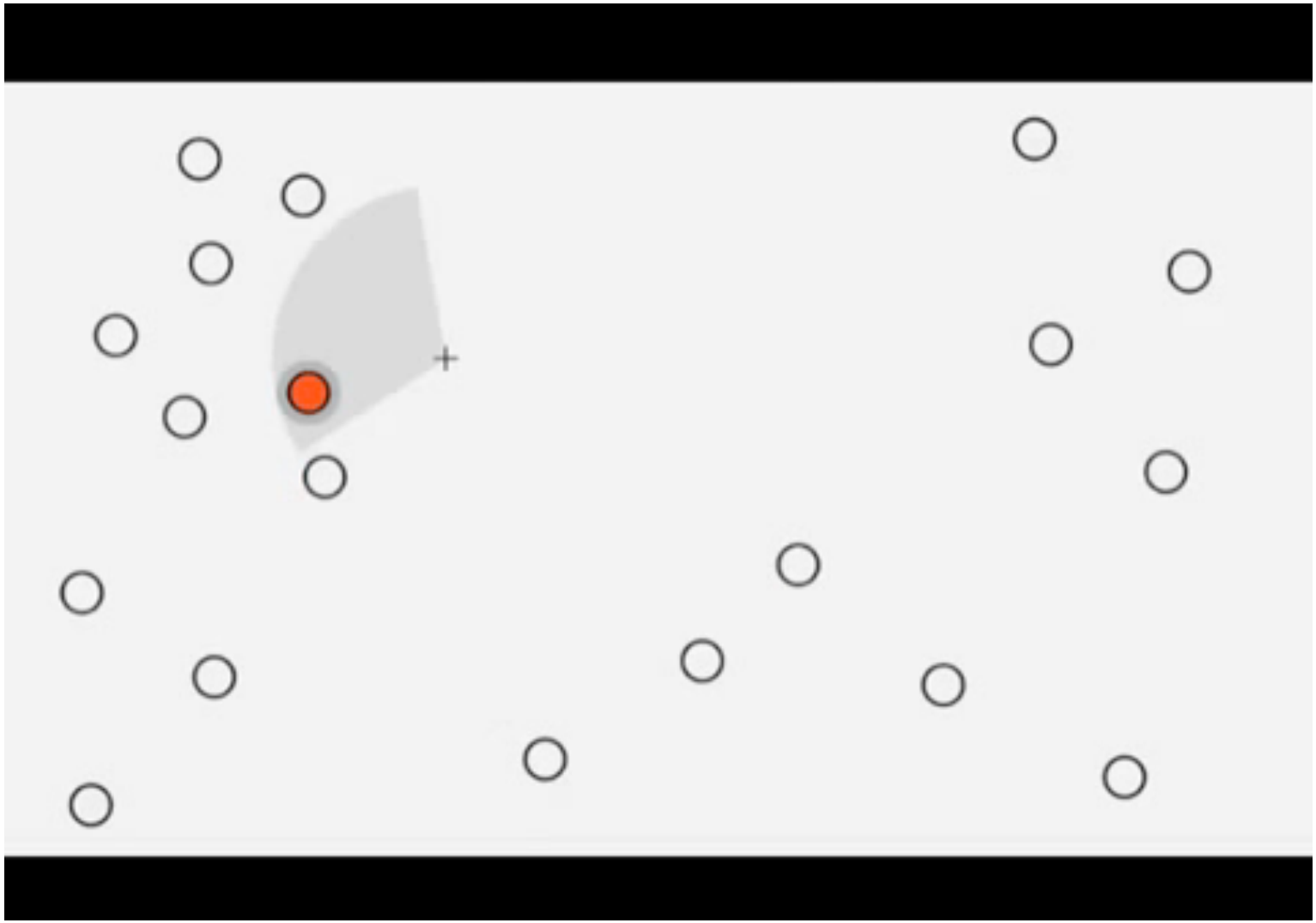
http://ieor.berkeley.edu/~anandk/bubbleCursor.html



Improvements beyond Bubble Cursor

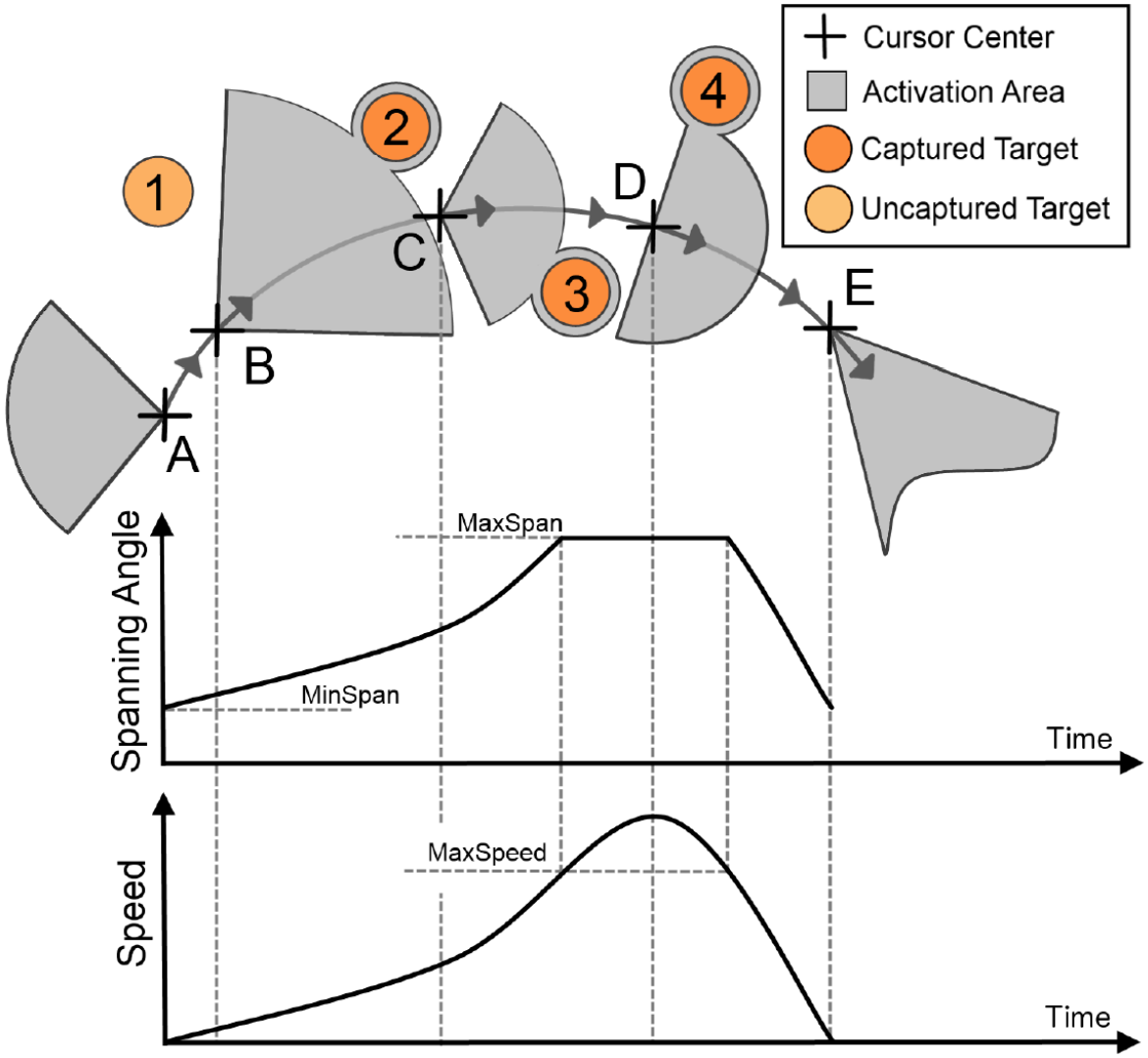
- Hide the bubble
  - Quickly changing bubble draws visual attention
  - May not be necessary selection task
  - → User test, visible vs. hidden bubble
- Take movement direction into account
  - Only select an angular sector of what is "in front of" the cursor
  - Potentially reduces required mouse movement
  - → User test: bubble vs. pie
  - → User test: different opening angles

Lau et al.: The Implicit Fan Cursor



https://www.youtube.com/watch?v=bq1x5cRqgUc

Velocity and Direction Dependent Area Cursor



- Spanning angle adapts to movement speed
  - 90°-180°
- Direction adapts to movement direction

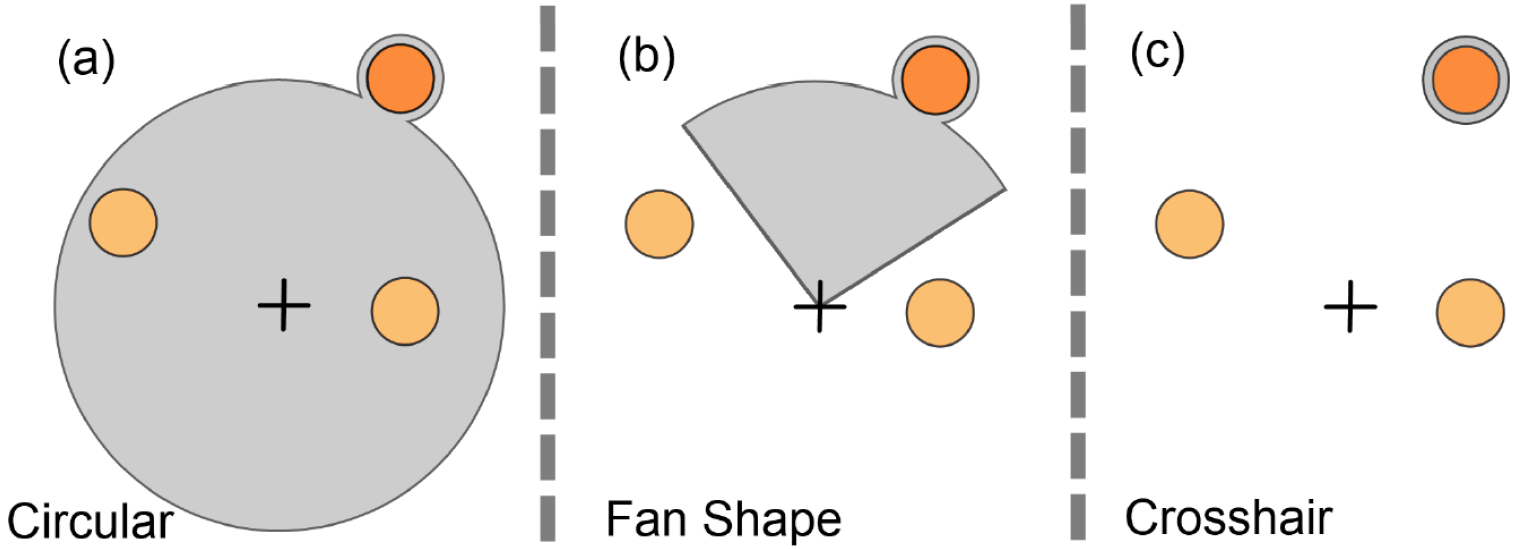
Su, Au, Lau. The Implicit Fan Cursor: A Velocity Dependent Area Cursor. CHI 2014.

Opening Angles

(MinSpan, MaxSpan)	Mean Movement Time	Error Rate
(30, 30)	1052ms	9.7%
(30, 90)	992ms	13.6%
(30, 180)	907ms	14.5%
(90, 90)	904ms	9.4%
(90, 180)	851ms	9.7%
(90, 270)	862ms	10.0%

Su, Au, Lau. The Implicit Fan Cursor: A Velocity Dependent Area Cursor. CHI 2014.

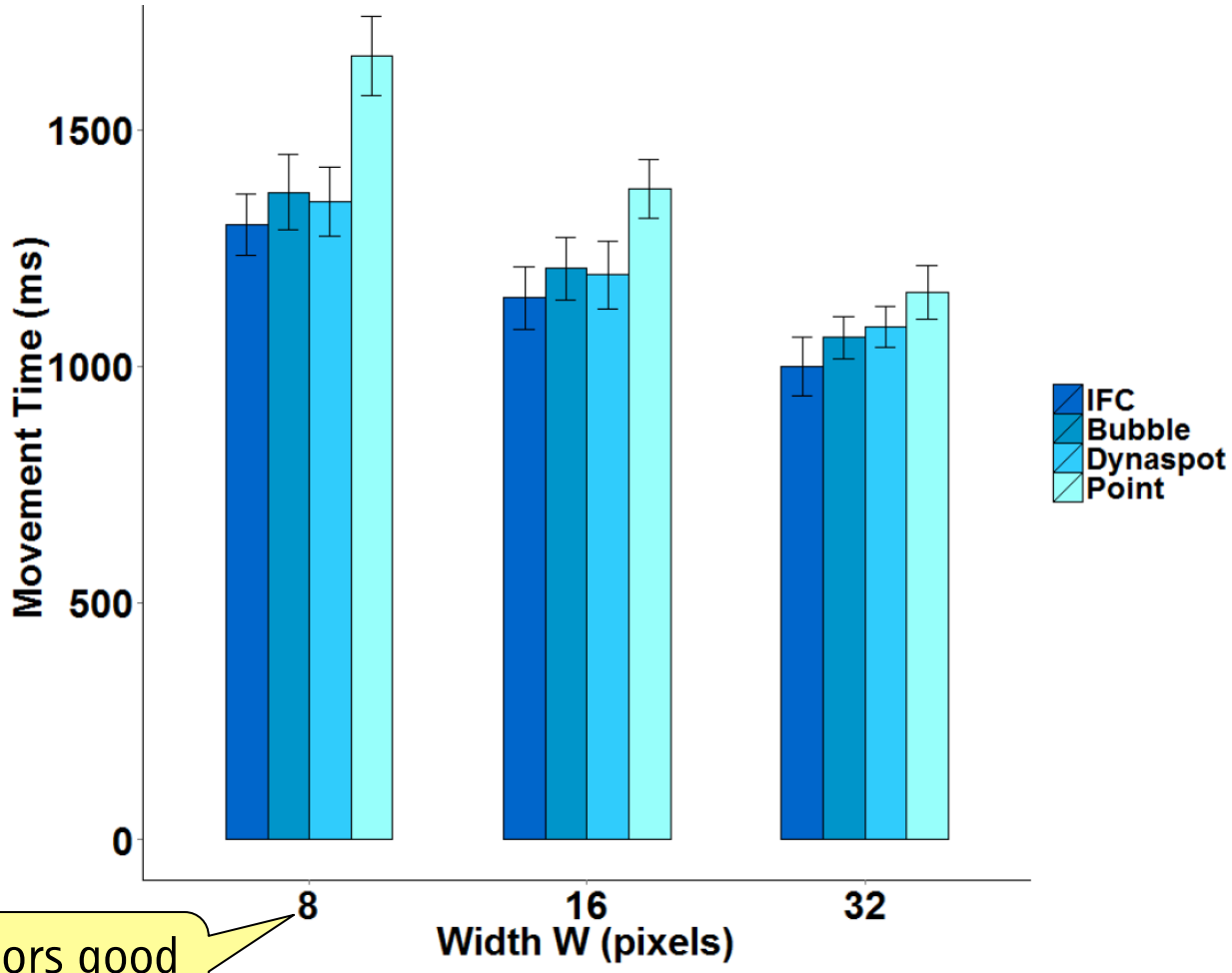
Visibility



Display Style	Mean Movement Time	Error Rate
Fan-shape	851ms	9.7%
Circular	844ms	13.6%
Implicit (Crosshair only)	819ms	7.3%

Su, Au, Lau. The Implicit Fan Cursor: A Velocity Dependent Area Cursor. CHI 2014.

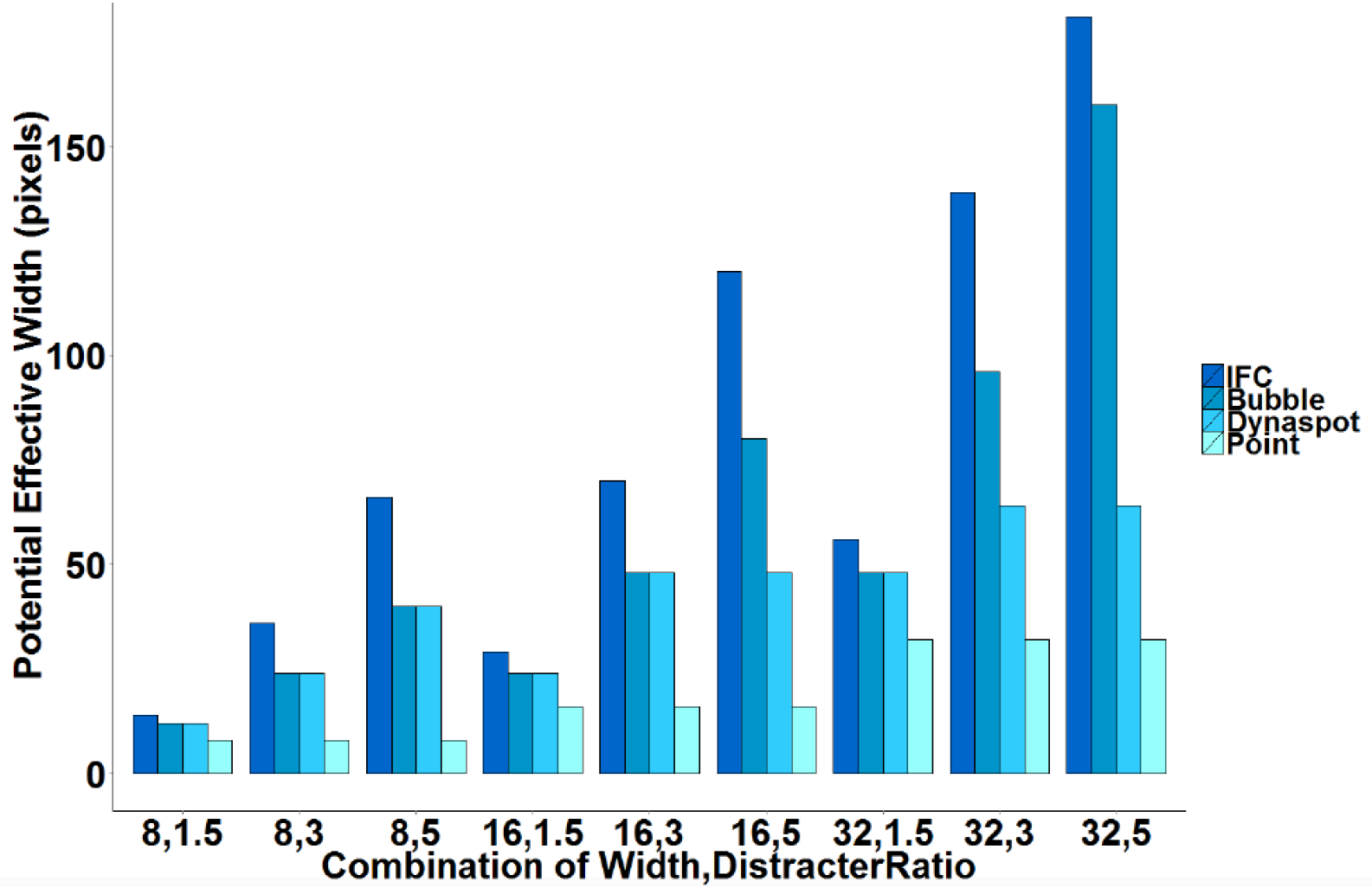
The Implicit Fan Cursor: A Velocity Dependent Area Cursor



Area cursors good for small targets

Su, Au, Lau. The Implicit Fan Cursor: A Velocity Dependent Area Cursor. CHI 2014.

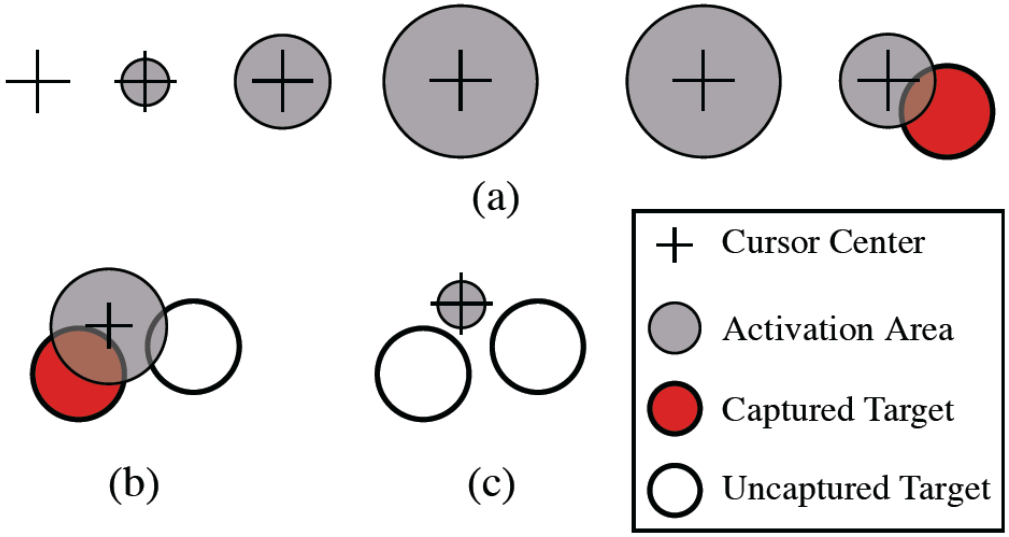
Enlarge Effective Target Width Beyond Voronoi Cells



Su, Au, Lau. The Implicit Fan Cursor: A Velocity Dependent Area Cursor. CHI 2014.

DynaSpot: Speed-Dependent Area Cursor

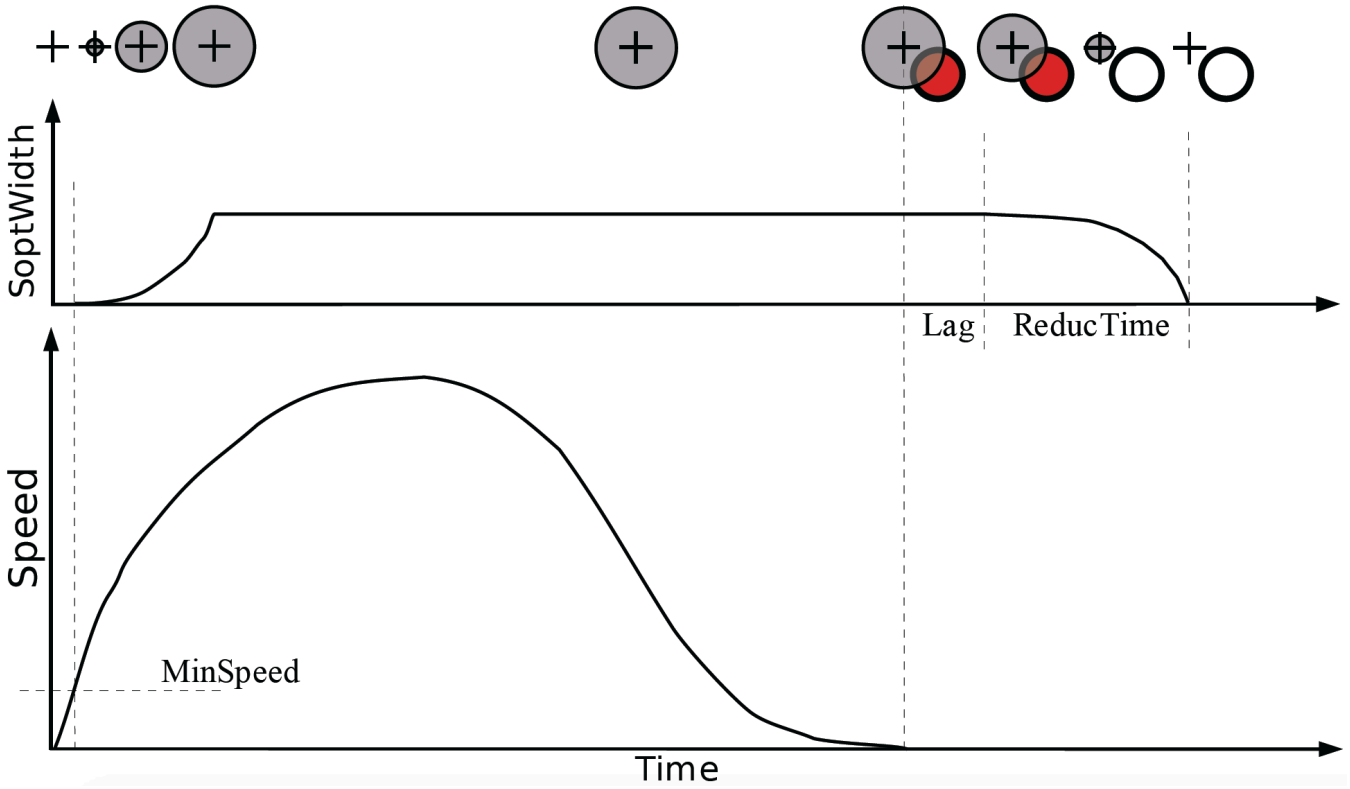
- Issues with simple area cursors
  - How to point in empty space?
  - How to select objects in rectangular regions?
- DynaSpot: Size of activation area depends on movement speed



Chapuis, Labrune, Pietriga. DynaSpot: Speed-Dependent Area Cursor. CHI 2009.

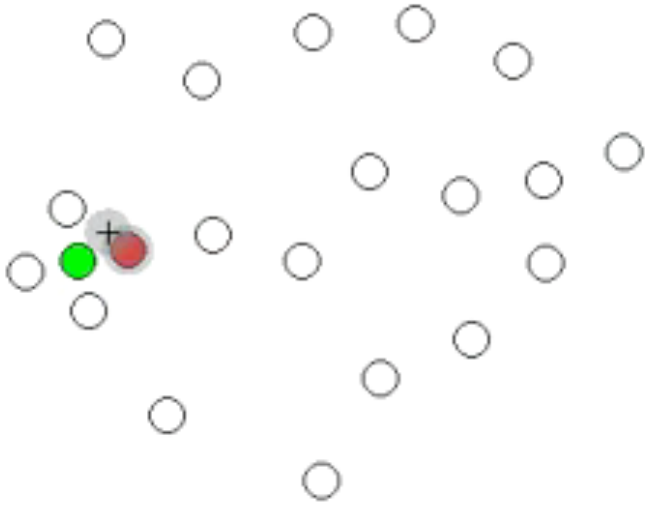
DynaSpot: Speed-Dependent Area Cursor

- Mapping movement speed to activation area



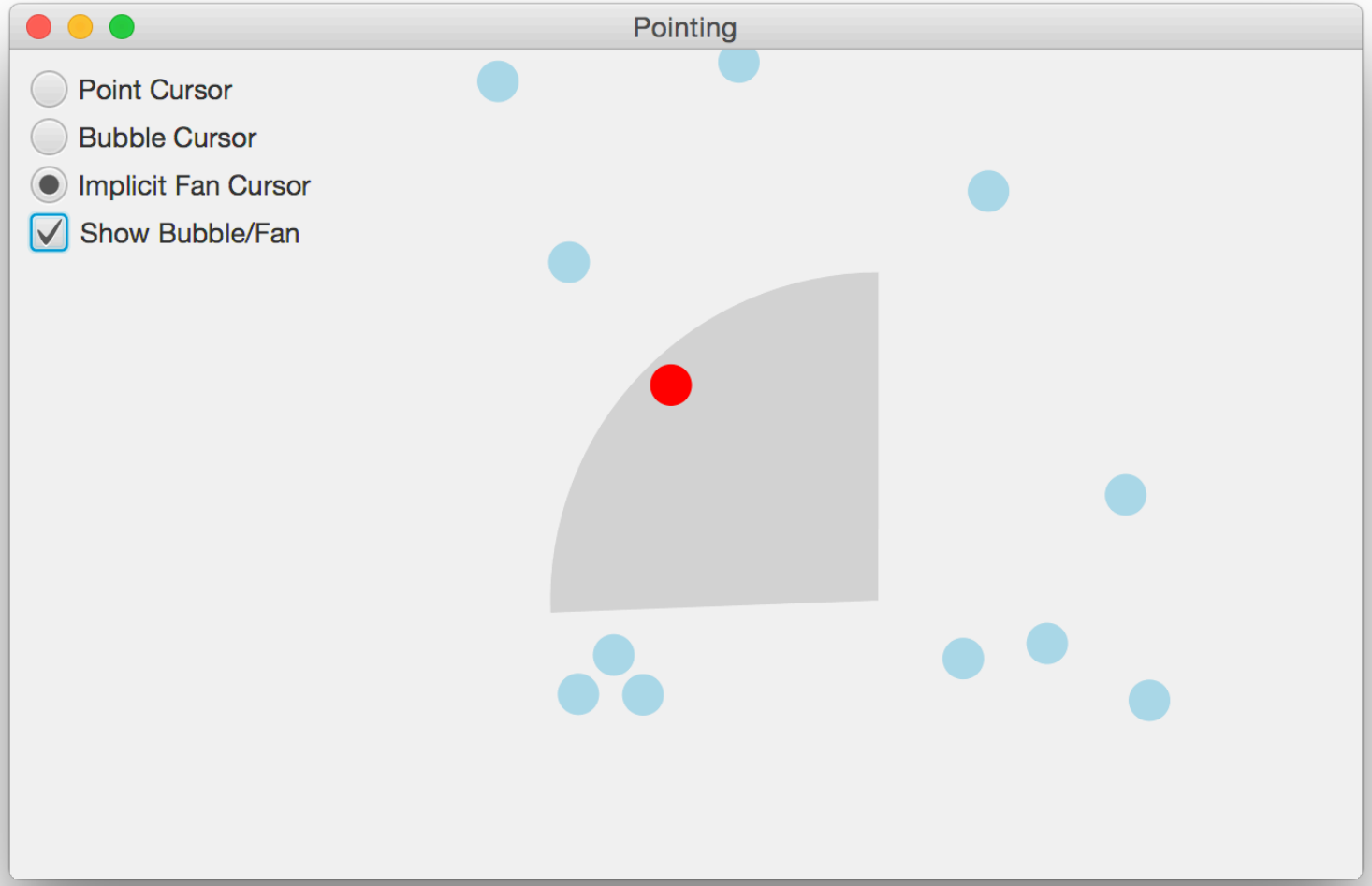
Chapuis, Labrune, Pietriga. DynaSpot: Speed-Dependent Area Cursor. CHI 2009.

DynaSpot: Speed-Dependent Area Cursor



Chapuis, Labrune, Pietriga. DynaSpot: Speed-Dependent Area Cursor. CHI 2009.

Pointing Technique Demo



Stud.IP: PointingTechniques.zip

EXPERIMENTS

Experimentation

- A central activity in HCI research
- An experiment is sometimes called a user study
- Formal, standardized methodology preferred
  - Brings consistency to a body of work
  - Facilitates reviews and comparisons between different user studies
- Research methodology
  - Empirical
  - Experimental

MacKenzie: Human-Computer Interaction - An Empirical Research Perspective.

What is Research?

- Research is…

  Investigation or experimentation aimed at the discovery and interpretation of facts, the revision of accepted theories or laws in light of new facts.

- Example
  - Design and conduct a user study to test whether a new interaction technique improves on an existing interaction technique
  - Cf. Snap-and-Go vs. Snap Dragging

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"Empirical" Research

- Empirical
  - Originating in or based on observation or experience
  - Relying on experience or observation alone without due regard for system or theory (i.e., don't be blinded by pre-conceptions)

- Example: Nicolas Copernicus (1473-1543)
  - Prevailing system or theory: celestial bodies revolved around the earth
  - Copernicus made astronomical observations that cut against this view
  - Result: heliocentric cosmology (earth and planets revolve around the sun)

MacKenzie: Human-Computer Interaction - An Empirical Research Perspective.

Research Must Be Published

- Publication is the final step
- Also an essential step
- Until it is published, research cannot achieve its critical goal: Extend, refine, or revise the existing body of knowledge in the field

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Peer Review

- Research submitted for publication is reviewed by peers
  - Peers: other researchers doing similar research
- Only research meeting a high standard of scrutiny is accepted for publication
  - Are the results novel and useful?
  - Does the evidence support the conclusions?
  - Does the methodology meet the expected standards for the field?
- Accepted research is published and archived
- The final step is complete

MacKenzie: Human-Computer Interaction - An Empirical Research Perspective.

DFG: Regeln guter wissenschaftlicher Praxis

Deutsche Forschungsgemeinschaft

- *„allgemeine Prinzipien wissenschaftlicher Arbeit, zum Beispiel*
  - *lege artis zu arbeiten*
  - *Resultate zu dokumentieren*
  - *alle Ergebnisse konsequent selbst anzuzweifeln*
  - *strikte Ehrlichkeit im Hinblick auf die Beiträge von Partnern, Konkurrenten und Vorgängern zu wahren*
- *Zusammenarbeit und Leitungsverantwortung in Arbeitsgruppen*
- *die Betreuung des wissenschaftlichen Nachwuchses*
- *die Sicherung und Aufbewahrung von Primärdaten*
- *wissenschaftliche Veröffentlichungen“*

http://www.dfg.de/download/pdf/dfg_im_profil/reden_stellungnahmen/download/empfehlung_wiss_praxis_1310.pdf

DFG: Sicherung und Aufbewahrung von Primärdaten

„Primärdaten als Grundlagen für Veröffentlichungen sollen auf haltbaren und gesicherten Trägern in der Institution, wo sie entstanden sind, zehn Jahre lang aufbewahrt werden."

„Ein wissenschaftliches Ergebnis ist in aller Regel ein komplexes Produkt vieler einzelner Arbeitsschritte. In allen experimentellen Wissenschaften entstehen die Ergebnisse, über die in Veröffentlichungen berichtet wird, aus Einzelbeobachtungen, die sich zu Teilergebnissen summieren. Beobachtung und Experiment, auch numerische Rechnungen, sei es als eigenständige Arbeitsmethode, sei es zur Unterstützung der Auswertung und Analyse, produzieren zunächst „Daten". […] Experimente und numerische Rechnungen können nur reproduziert werden, wenn alle wichtigen Schritte nachvollziehbar sind. Dafür müssen sie aufgezeichnet werden. Jede Veröffentlichung, die auf Experimenten oder numerischen Simulationen beruht, enthält obligatorisch einen Abschnitt „Materialien und Methoden", der diese Aufzeichnungen so zusammenfasst, dass die Arbeiten an anderem Ort nachvollzogen werden können. […] In renommierten Labors hat sich die Regel bewährt, dass der komplette Datensatz, der einer aus dem Labor hervorgegangenen Publikation zugrunde liegt, als Doppel zusammen mit dem Publikationsmanuskript und der dazu geführten Korrespondenz archiviert wird."

http://www.dfg.de/download/pdf/dfg_im_profil/reden_stellungnahmen/download/empfehlung_wiss_praxis_1310.pdf

Patents

- Some research develops into inventions
- A researcher/company may wish to maintain ownership of (profit from) the invention
- Patenting is an option
- The patent application describes
  - Previous related work
  - How the invention addresses a need
  - The best mode of implementation
- If the application is granted, the patent is issued
  - Note: A patent is a publication; thus patenting meets the must-publish criterion for research

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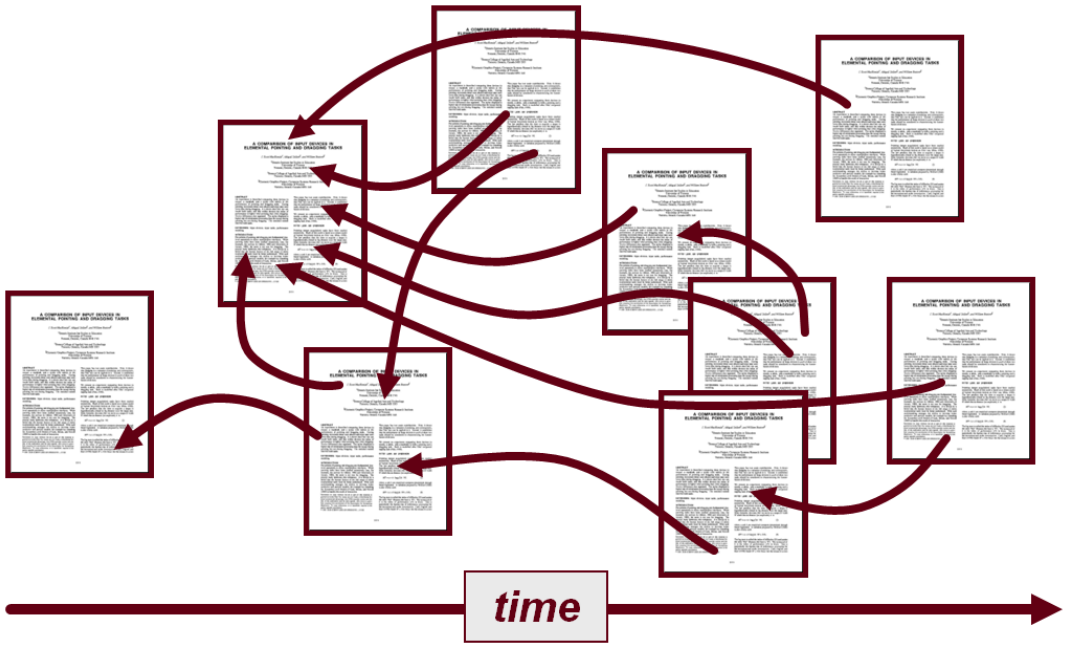
Citations, References, Impact

- Citations, like hyperlinks, connect research to other research
- Through citations, a body of research takes shape
- The number of citations to a research paper is an indication of the paper's impact

Can you spot the high-impact paper? (arrows are citations)



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Google Scholar – H-Index[1]

- Google Scholar makes citation counts easy to gather
  - Can be gathered for papers, journals, etc.
  - Can also be gathered for researchers
- H-index is a measure of the impact of a researcher
  - Rank publications by number of citations
  - H-index is the point where the rank equals the number of citations
  - Researcher with H-index n has n publications each with n+ citations

[1] *Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences, 102, 16568-16572.*

Research Must Be Reproducible

- Research that cannot be replicated is useless
- The research write-up must be sufficiently detailed to allow a skilled researcher to replicate the research if he/she desired
  - To ensure reproducibility follow a standardized methodology
- Many advances in science pertain to methodology
  - (e.g., Louis Pasteur's detailed disclosure of the methodology used in his research in microbiology)
- The most cited research paper is a "method paper"[1]
  - (see Google Scholar for the latest citation count)

[1] Lowry, O. H., Rosenbrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry, 193*, 265-275.

Research vs. Engineering vs. Design

- Researchers often work closely with engineers and designers
  - Different skills
- Engineers and designers build things, focusing on
  form (design emphasis) and
  function (engineering emphasis)
- Tension / trade-off, between form and function

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Form Trumpeting Function

- Form: Elegant – smooth, shiny
- Function: Touchpad design (or is in engineering?) has a problem
- No tactile sense at the sides of the touchpad

The fix

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Duct Tape To The Rescue

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