Input Devices

CS160: User Interfaces

John Canny

Assignments

- Contextual Inquiry and Task Analysis due 10/4
- Competitive Analysis due 9/29
- Individual programming assignment 3 due 9/29

XML Parsing


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  <?xml version="1.0" encoding="UTF-8" ?>
- <atom:entry xmlns="http://www.opengis.net/kml/2.2" xmlns:app="http://www.w3.org/2007/app" xmlns:atom="http://www.w3.org/2005/Atom"
    xmlns:gd="http://schemas.google.com/g/2005" gd:etag="W/"CEEHQH87cSp7I2A9Wx5WEU4.""">

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  - <atom:content type="application/vnd.google-earth.kml+xml">
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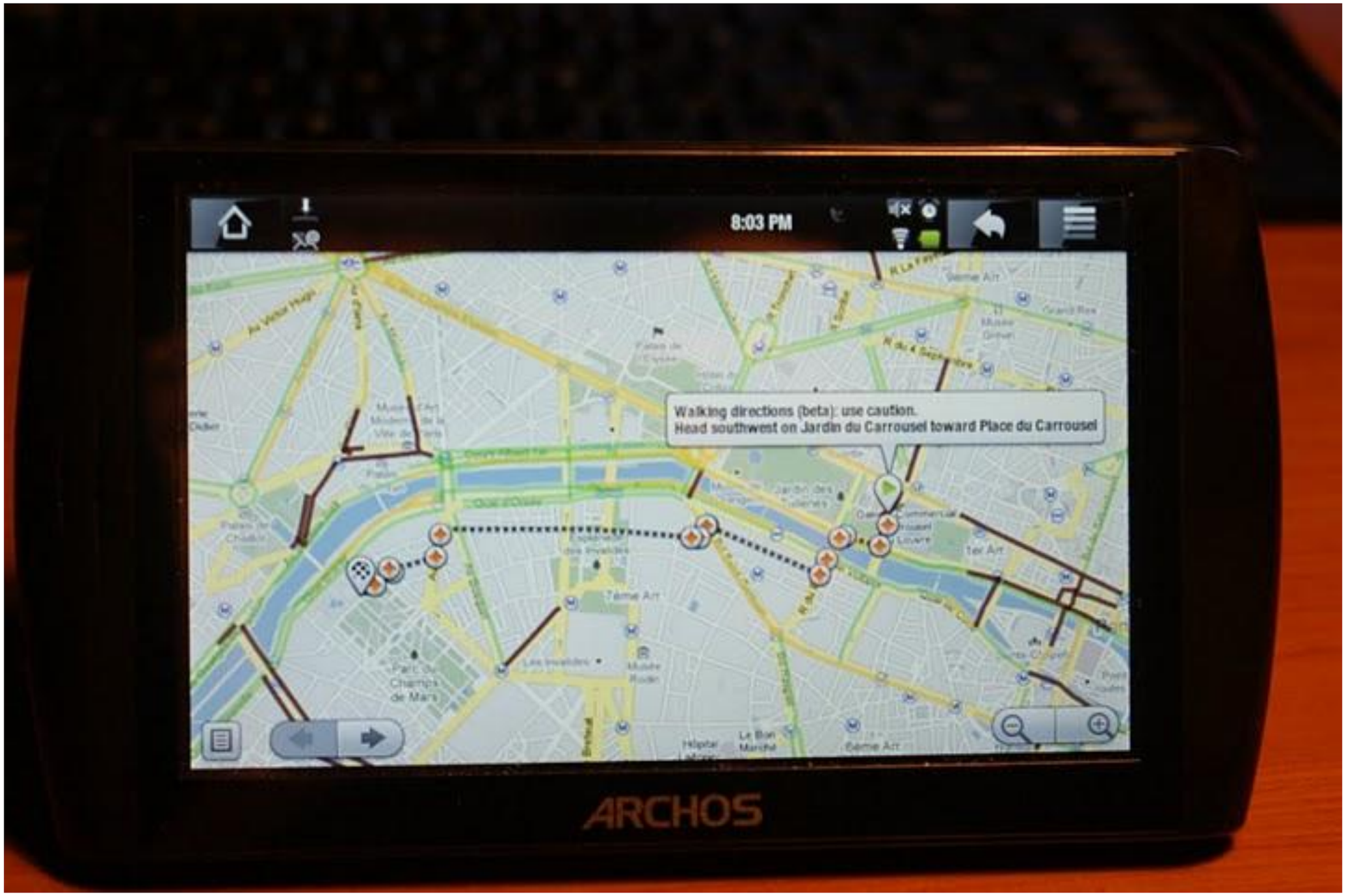

8:03 PM
Walking directions (beta): use caution.
Head southwest on Jardin du Carrousel toward Place du Carrousel
ARCHOS

Input Devices

Questions:

- What (low-level) tasks are the users trying to accomplish with an input device?
- How can we think about the space of possible input devices?
- What interaction techniques are encouraged/discouraged by a particular device?

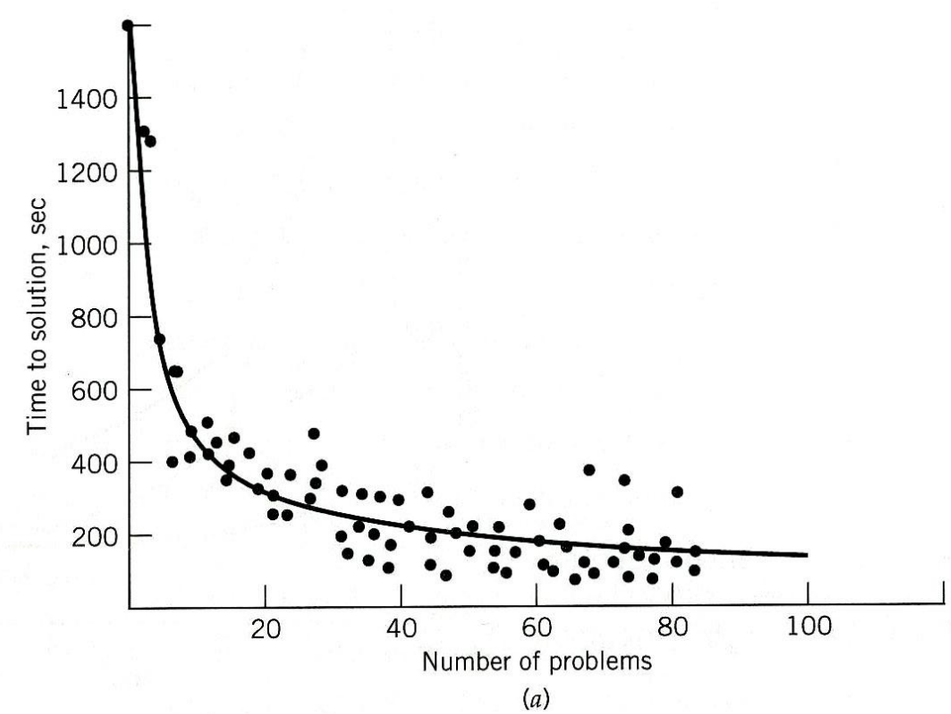
Important Tasks

- Text Entry
- Pointing/Marking
  - Target acquisition
  - Steering / positioning
  - Freehand drawing
  - Drawing lines
  - Tracing and digitizing
  - …

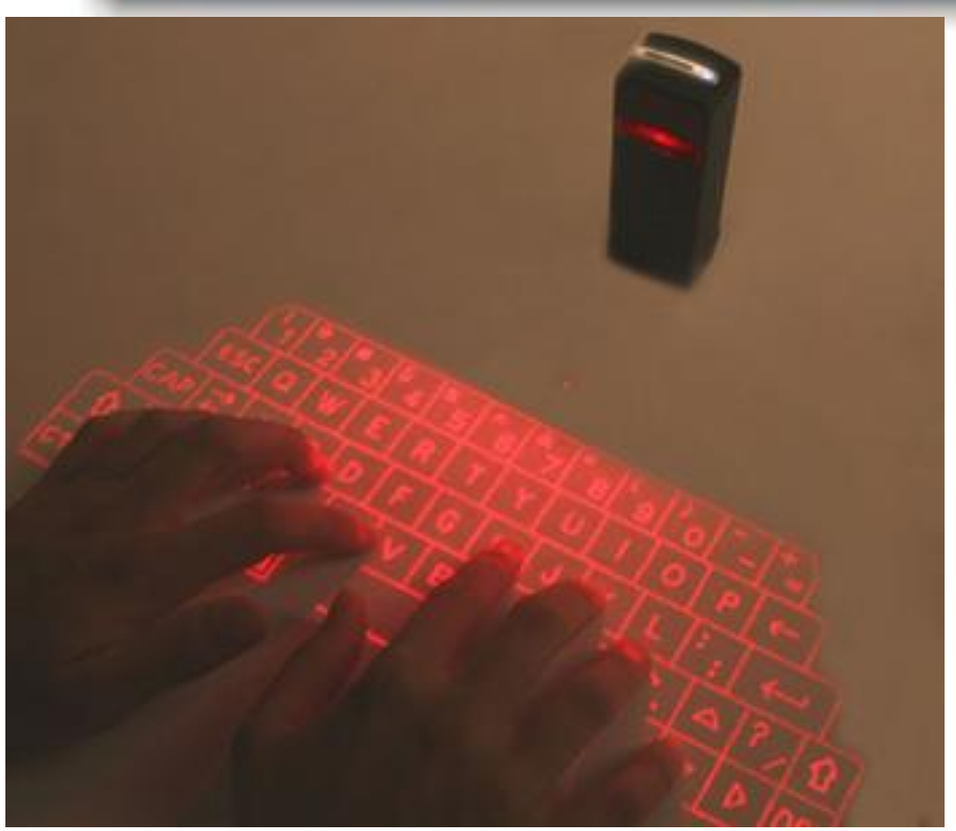
Text Entry: Keystroke Devices

- Array of Discrete Inputs
- Many variants of form and key layout
  - Can be one-handed or two
  - Wide range of sizes
  - Two-hand full keyboard is relatively standardized, Less standardization on others: Command keys, generic function keys, cursor movement, numeric keypad,...
- Use procedural memory
  - Power law of practice

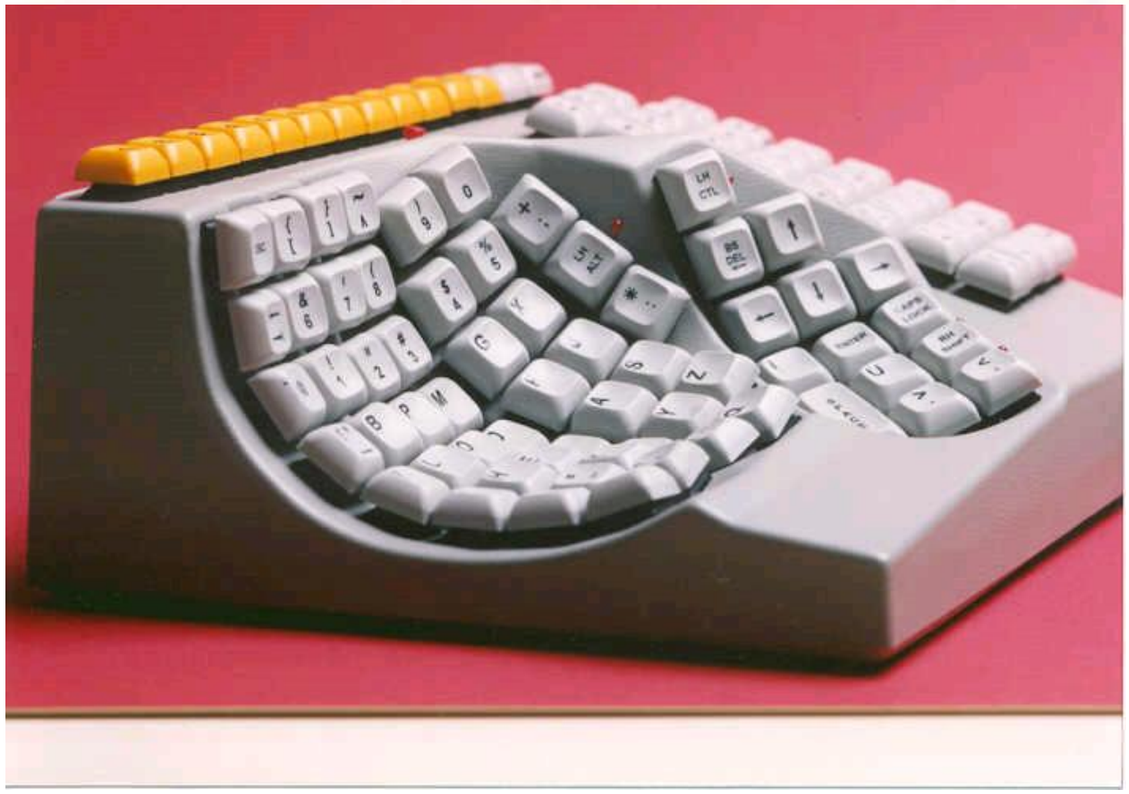
$$T_n = T_1 n^{-a} + c$$



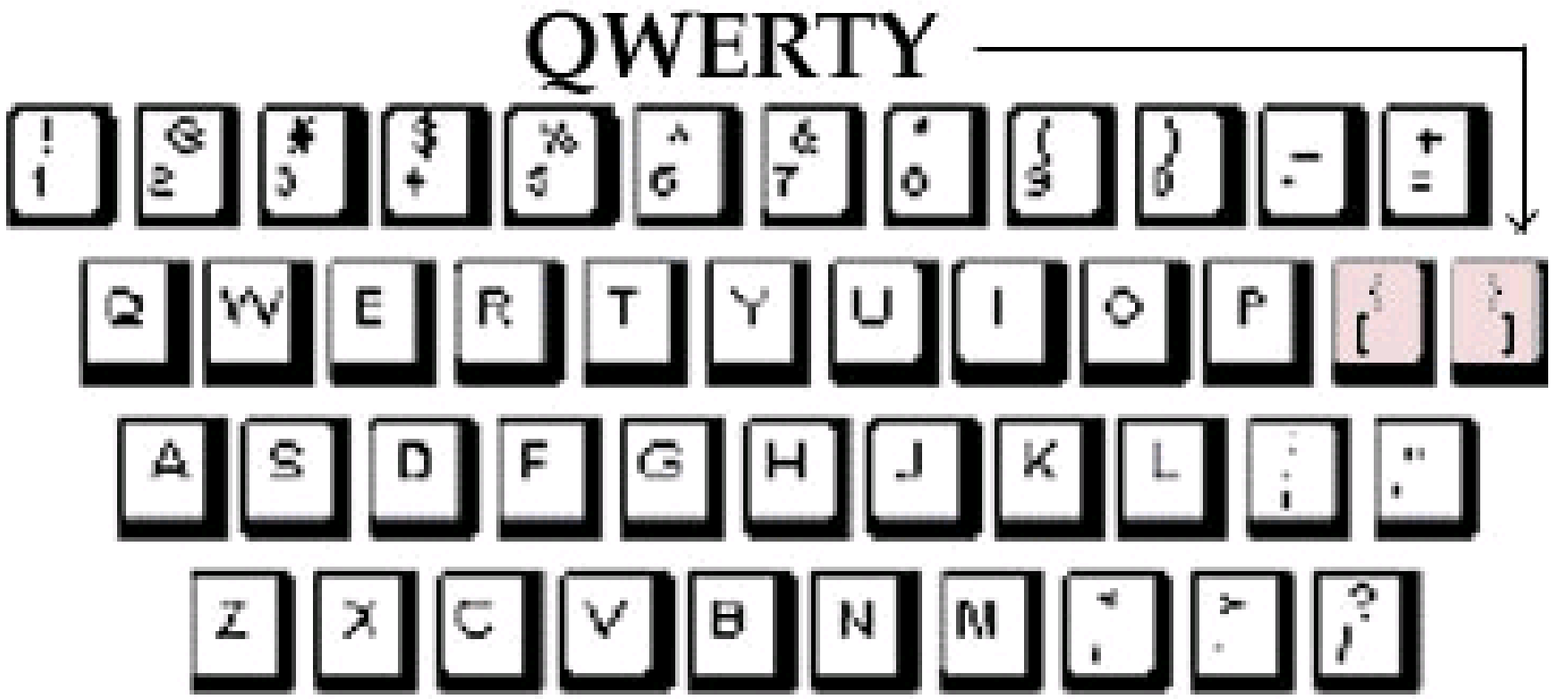
Keyboards

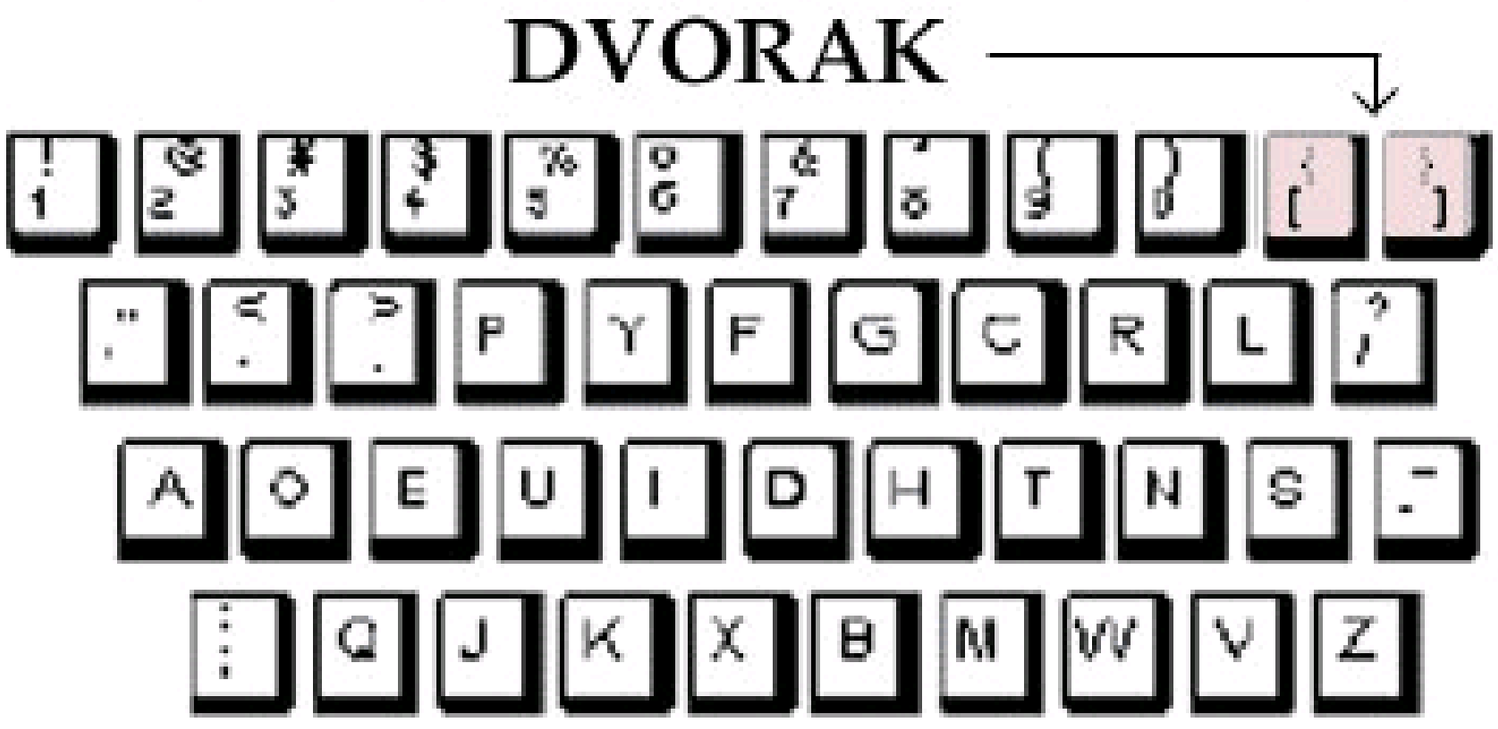



Maxim



Key Layouts


QWERTY
Q W E R T Y U I O P
A S D F G H J K L
Z X C V B N M


DVORAK
P Y F G C R L
A O E U I D H T N S
Q J K X B M W V Z

Mobile Text Entry: Keypads

- Multi-tap mappings
  - Multiple presses per letter
- Ambiguity resolution
  - One press per letter, dictionary lookup

Mobile Text Entry: Keypads

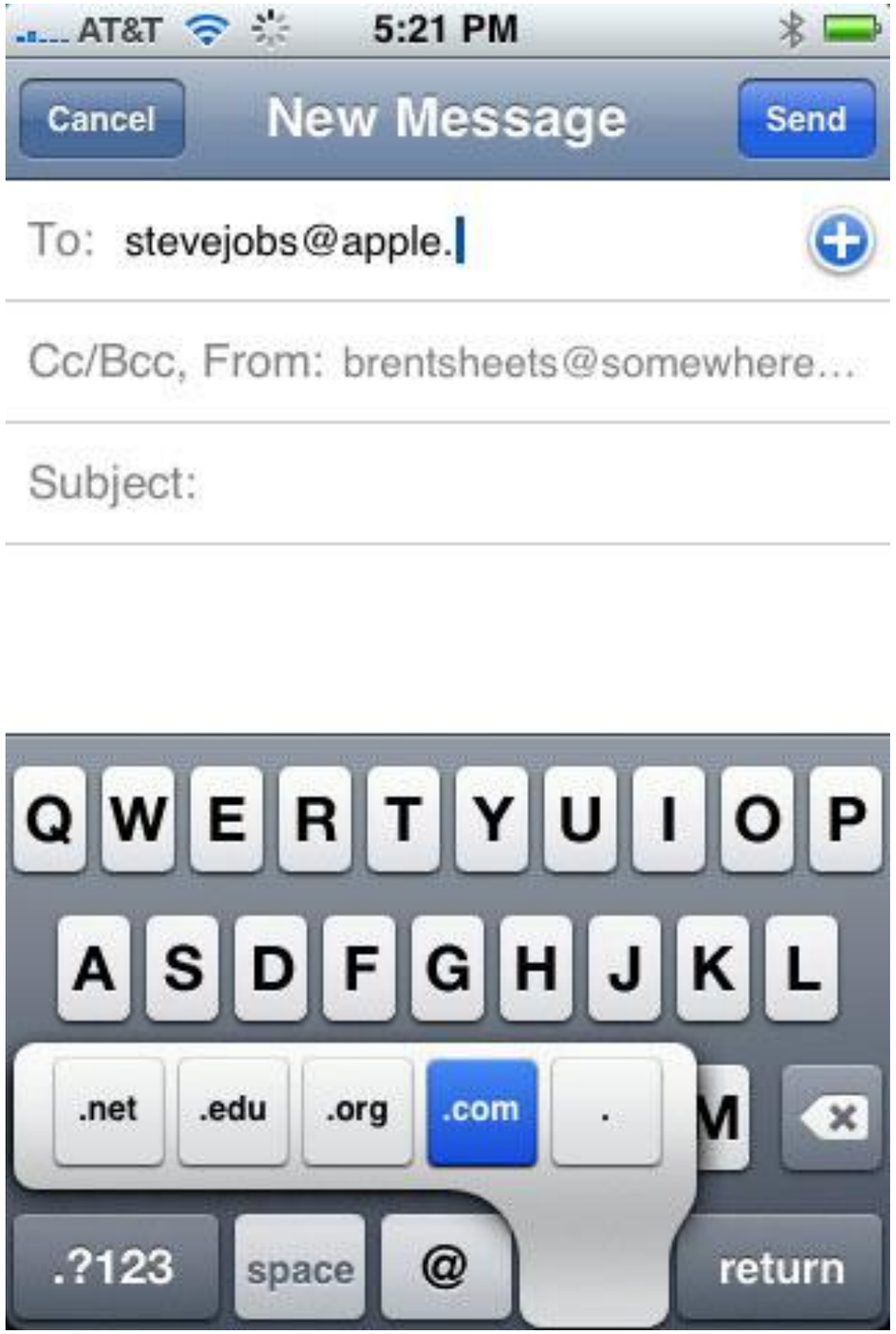
- Chording
  - Multiple keys pressed simultaneously
    2^n combinations for n keys

Twiddler2, HandyKey

Mobile Text Entry: Touch / Stylus

Soft Keyboards

- Benefits?
  Drawbacks?

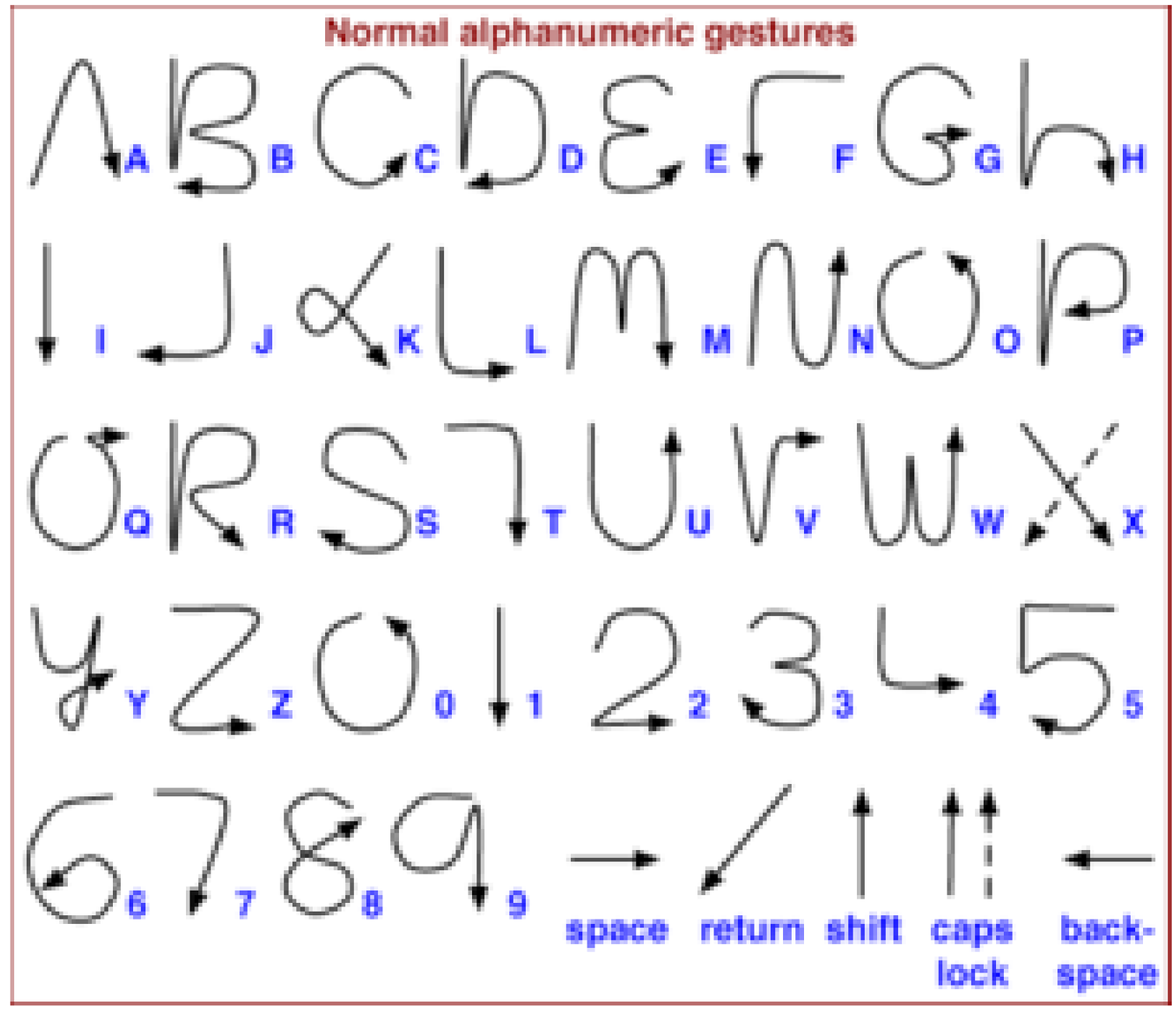


Mactoids.com

Mobile Text Entry: Handwriting Recog.

Mobile Text Entry: Touch / Stylus

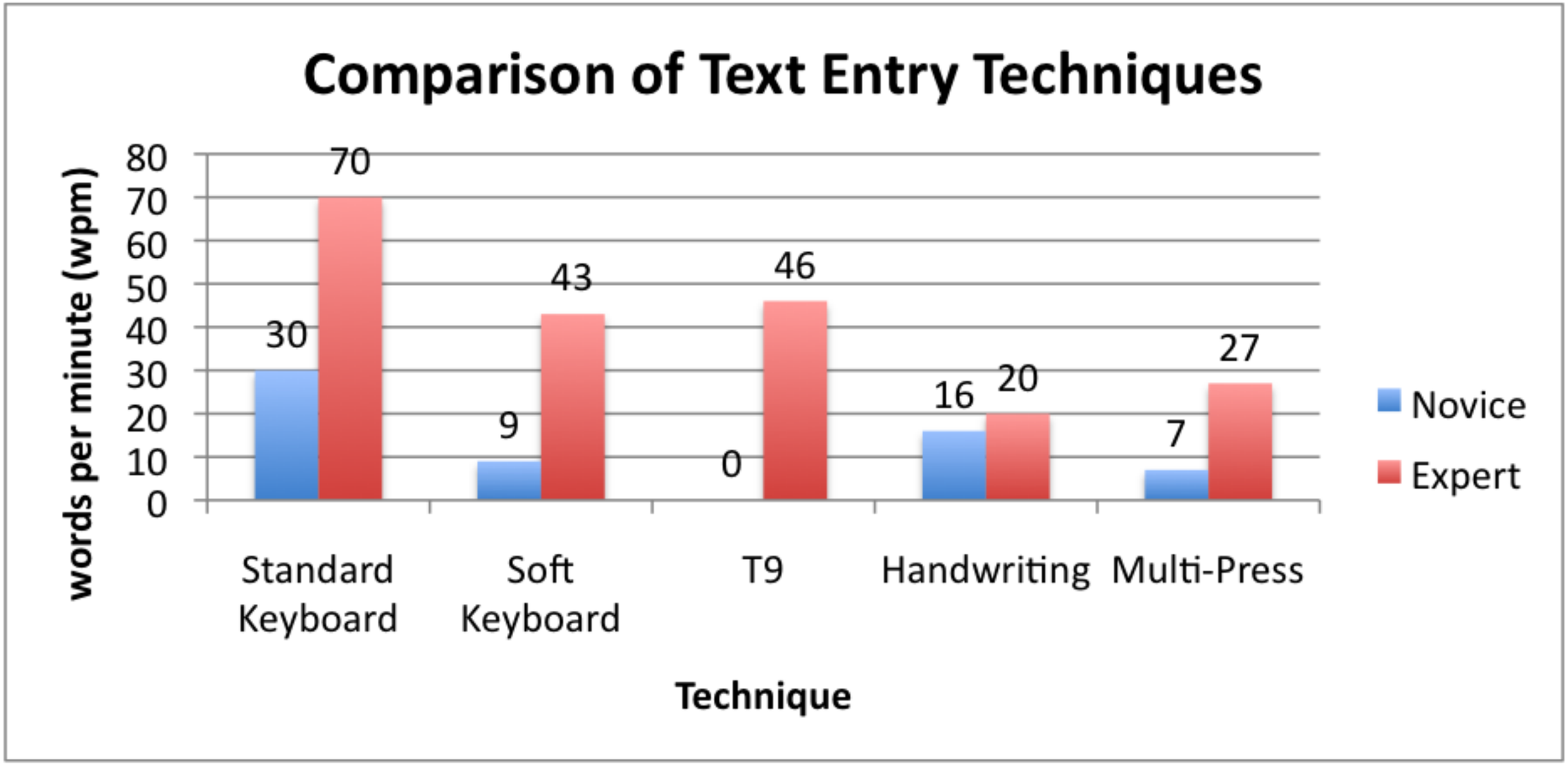
- Custom symbol sets
- improve recognition accuracy; appropriate for indirect (eyes-free) input



Mobile Text Entry: Touch / Stylus

- Stroke Entry Methods (e.g., Swype, ShapeWriter)

Which is fastest?



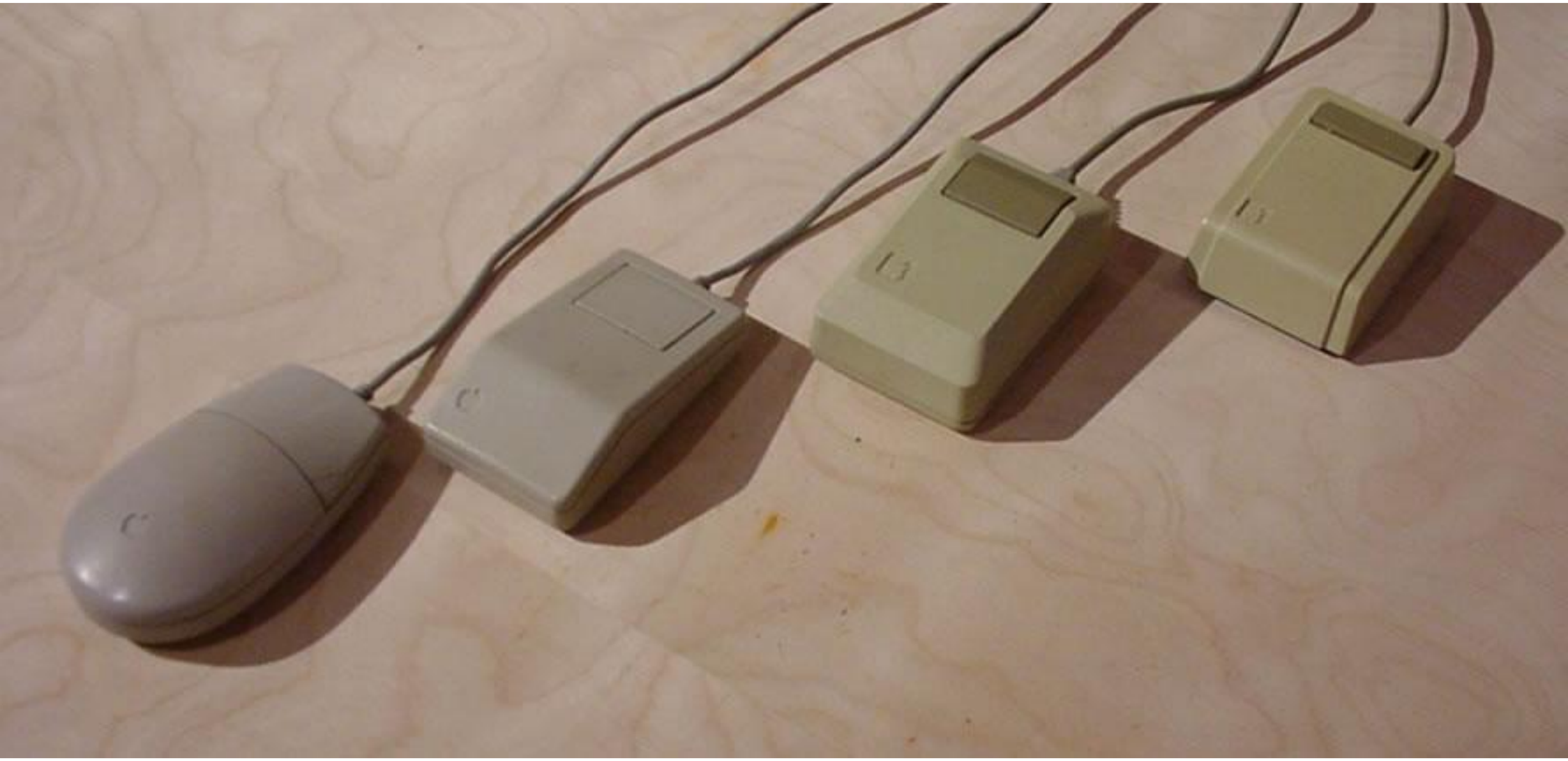
What about Speech Recognition?

- Dictation is faster than typing (~100 wpm)

What about Speech Recognition?

- Dictation is faster than typing (~100 wpm), BUT:
  - Speech is different from written language:
    Speaking in well-formed, complete, print-ready sentences is cognitively challenging
  - High cost of correcting errors through speech channel alone
  - Social awkwardness?

Pointing Devices

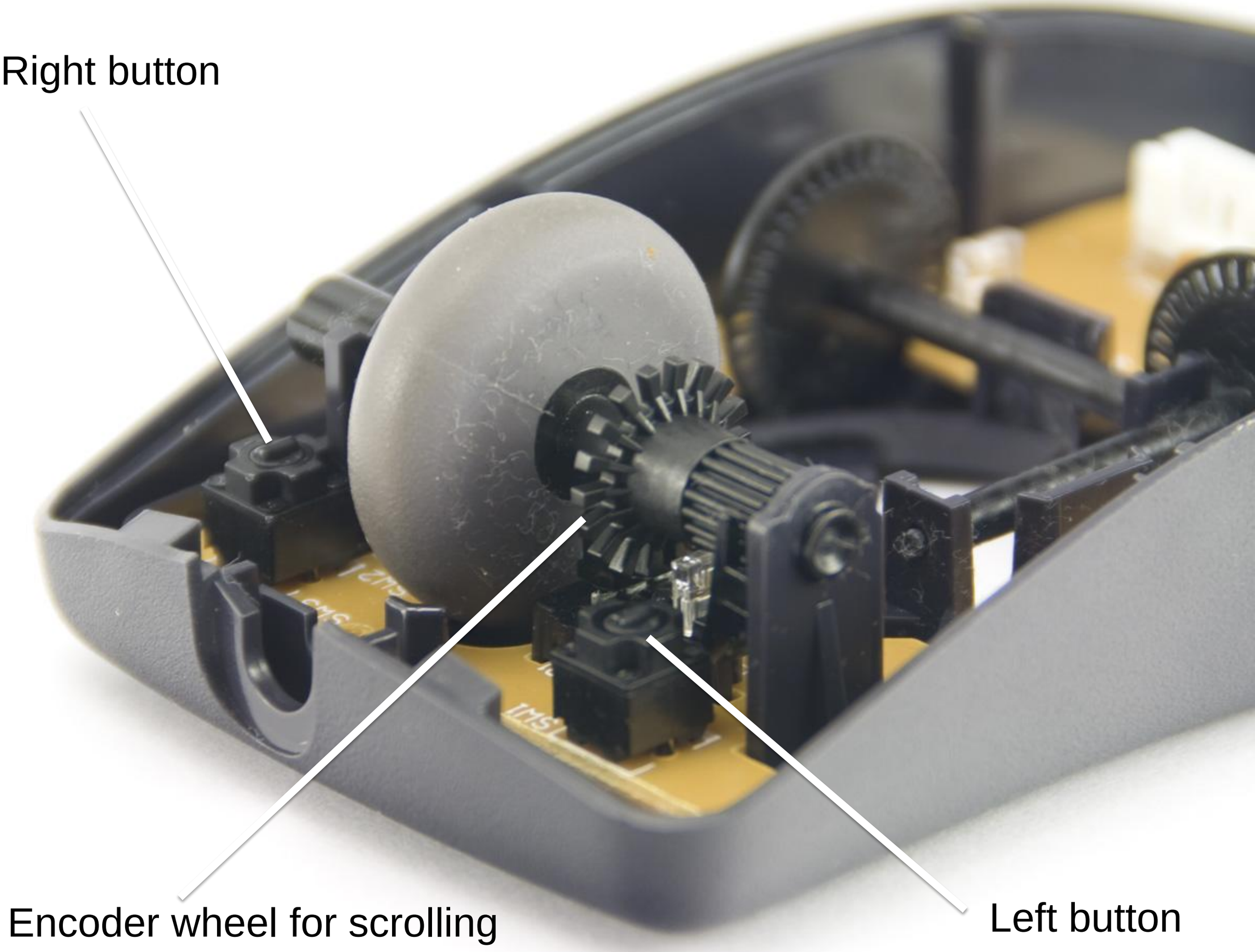


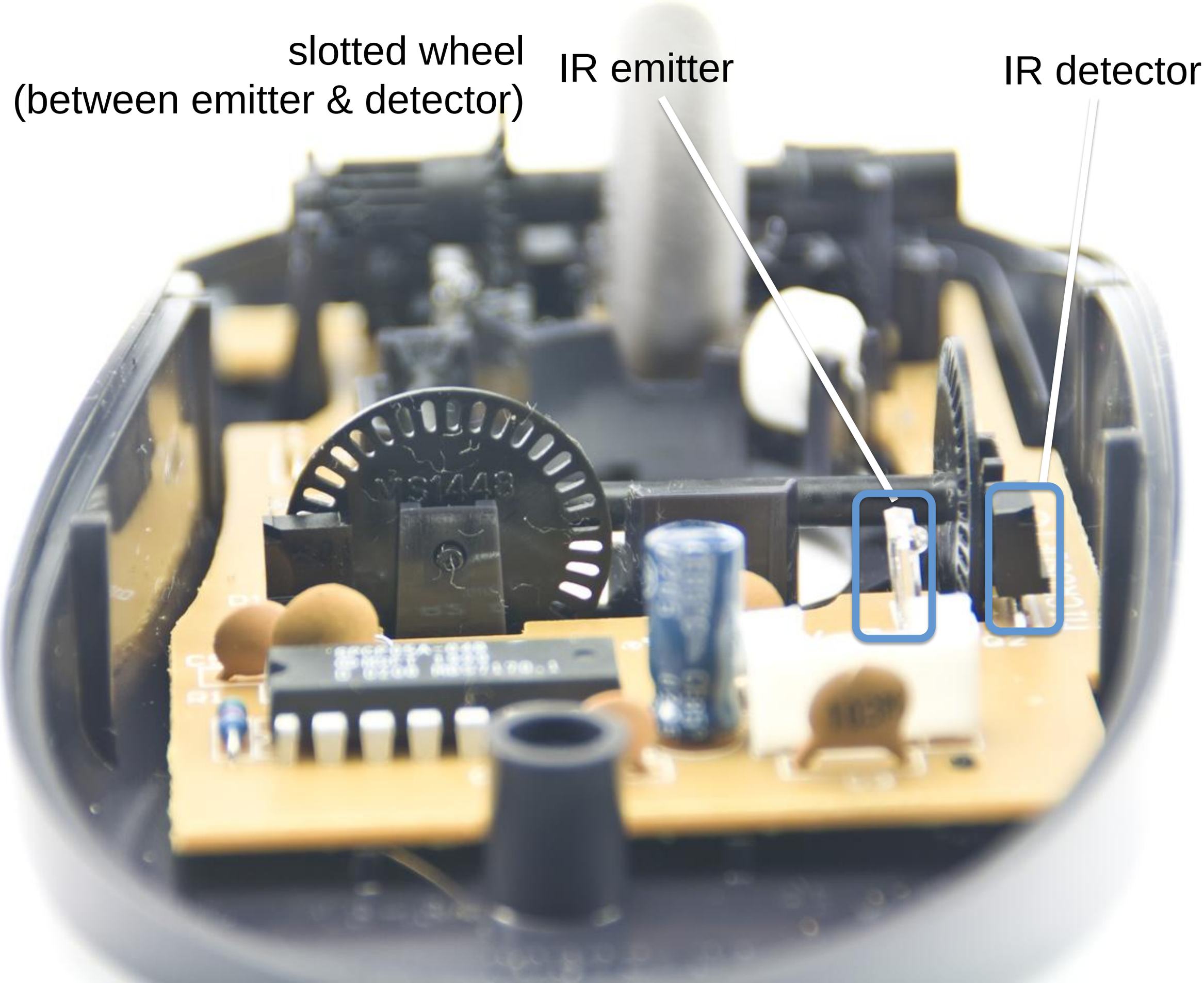
Mouse. Engelbart and English ~1964

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

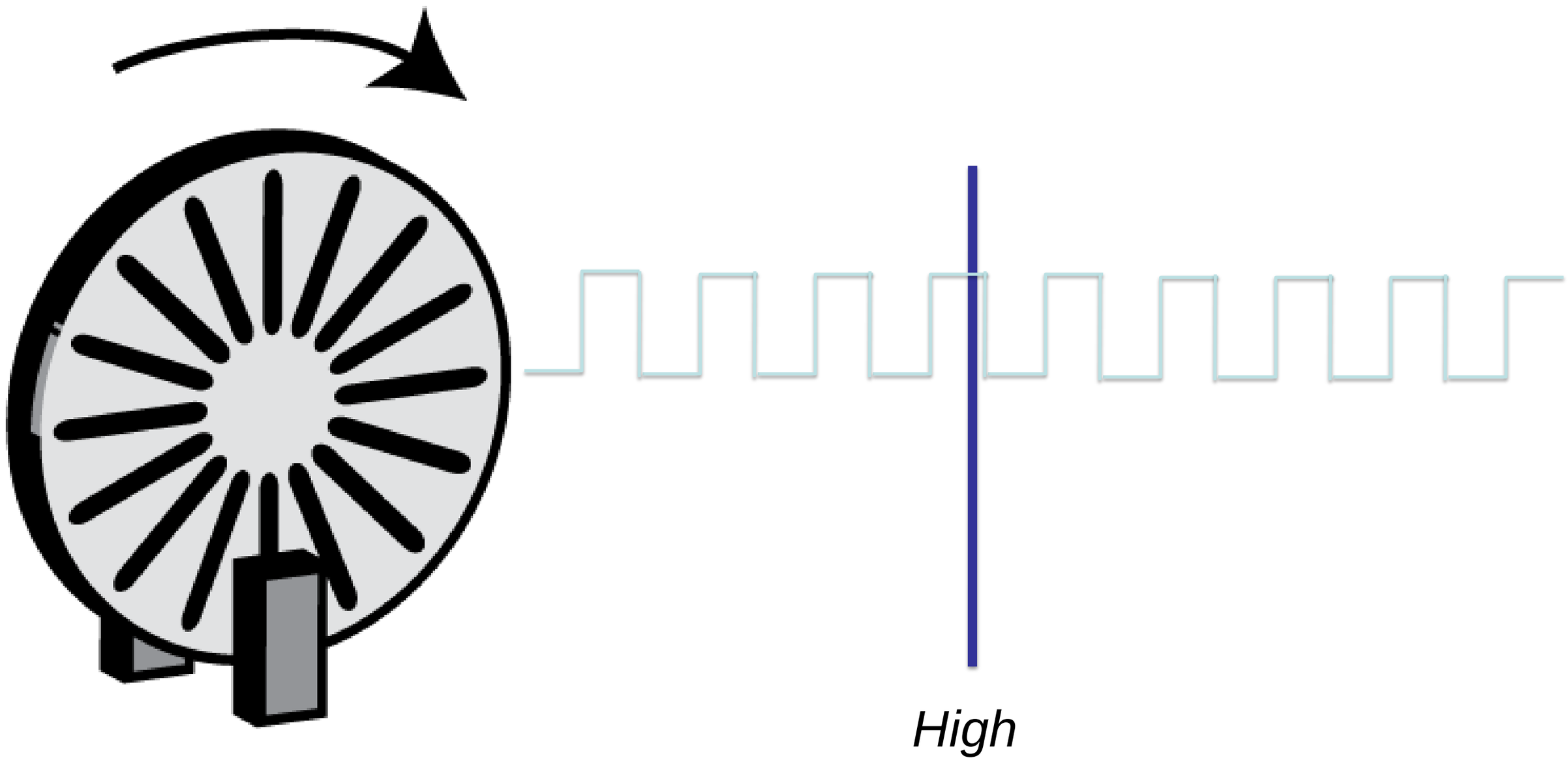

DELL
by Microsoft


D3
R2
U1
R1
C6
C3
D2
94V-0

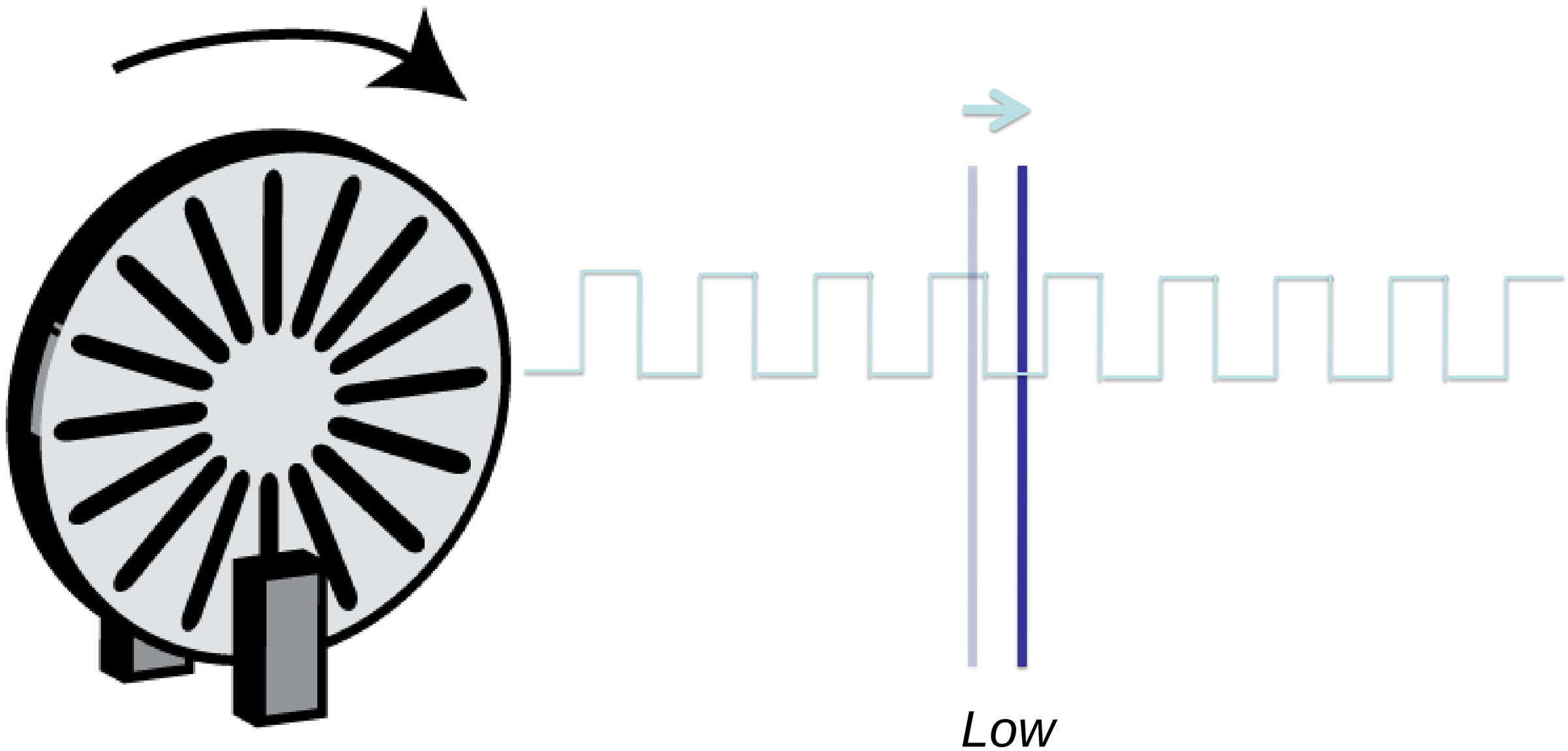

Right button
Encoder wheel for scrolling
Left button


slotted wheel
(between emitter & detector)
IR emitter
IR detector

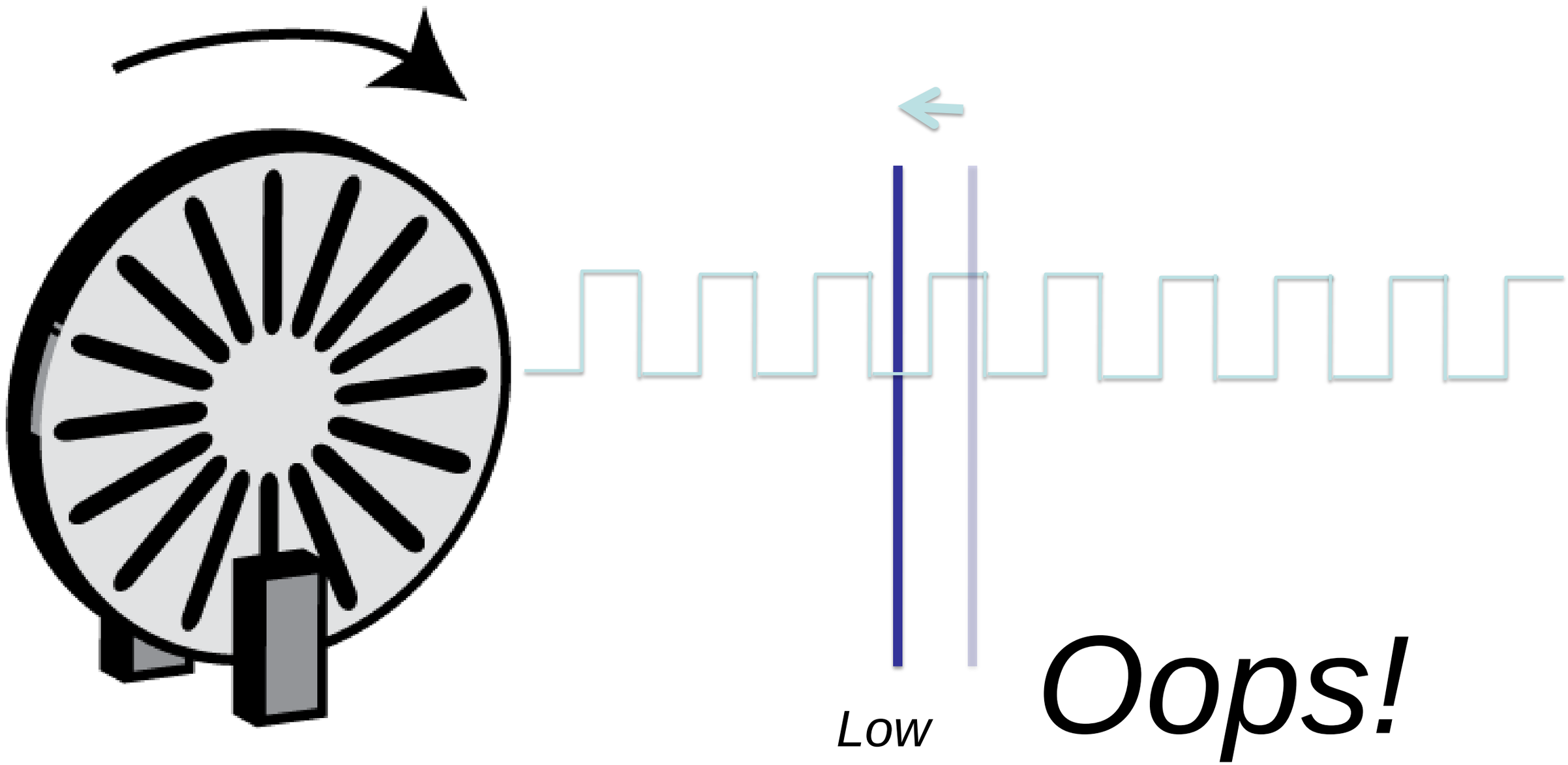
Sensing: Rotary Encoder



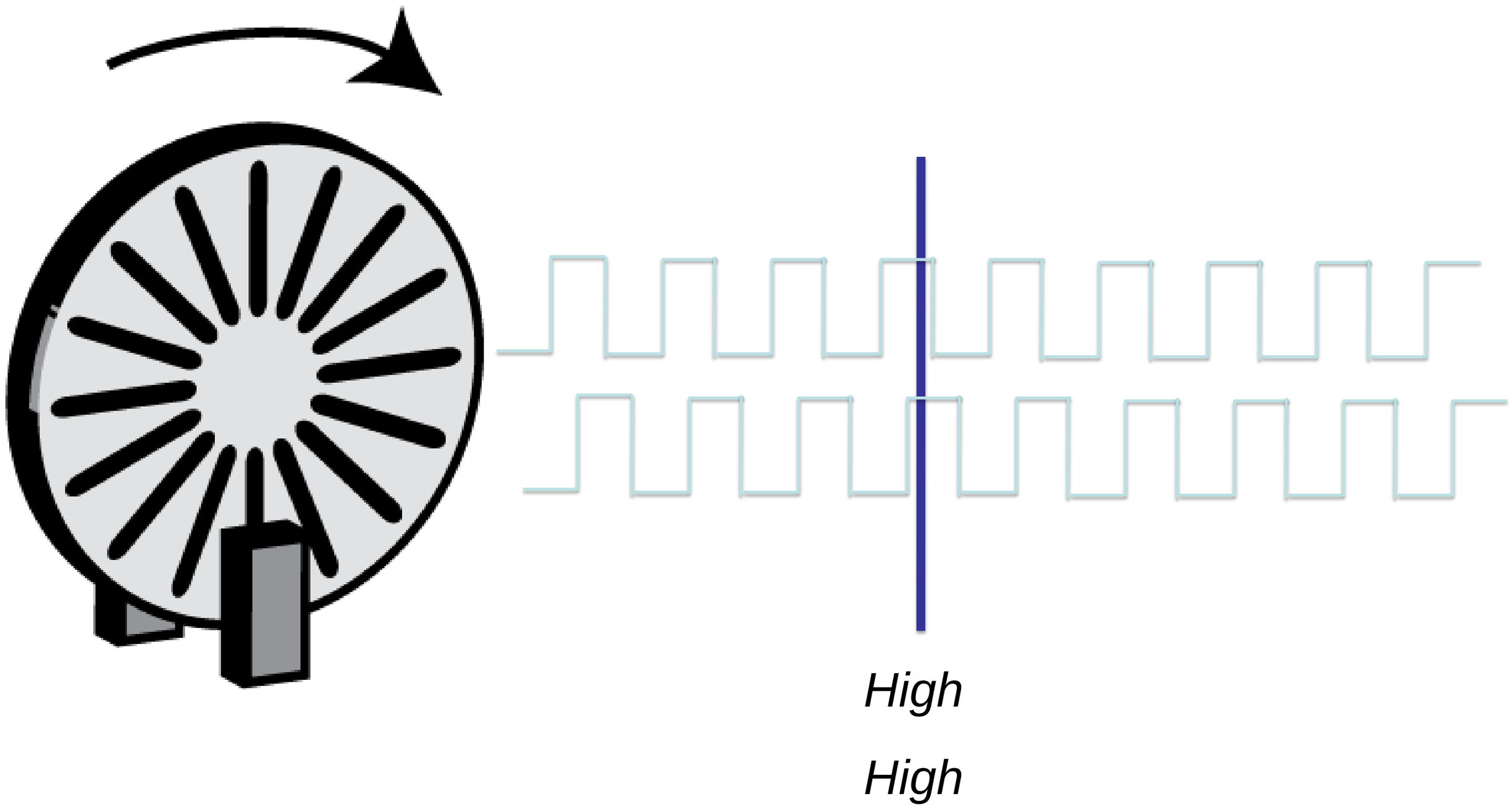
Sensing: Fwd Rotation



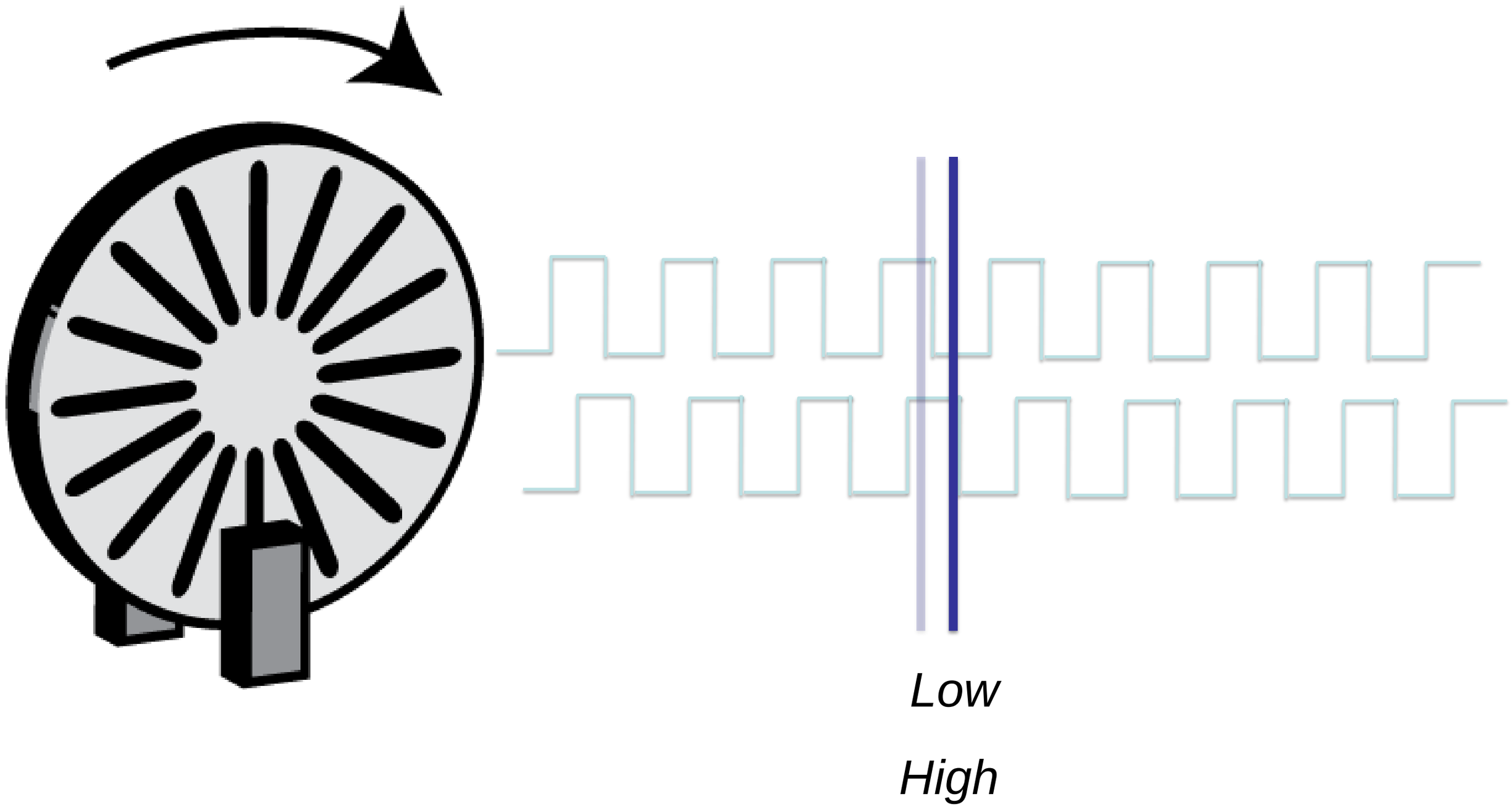
Sensing: Backwd Rotation



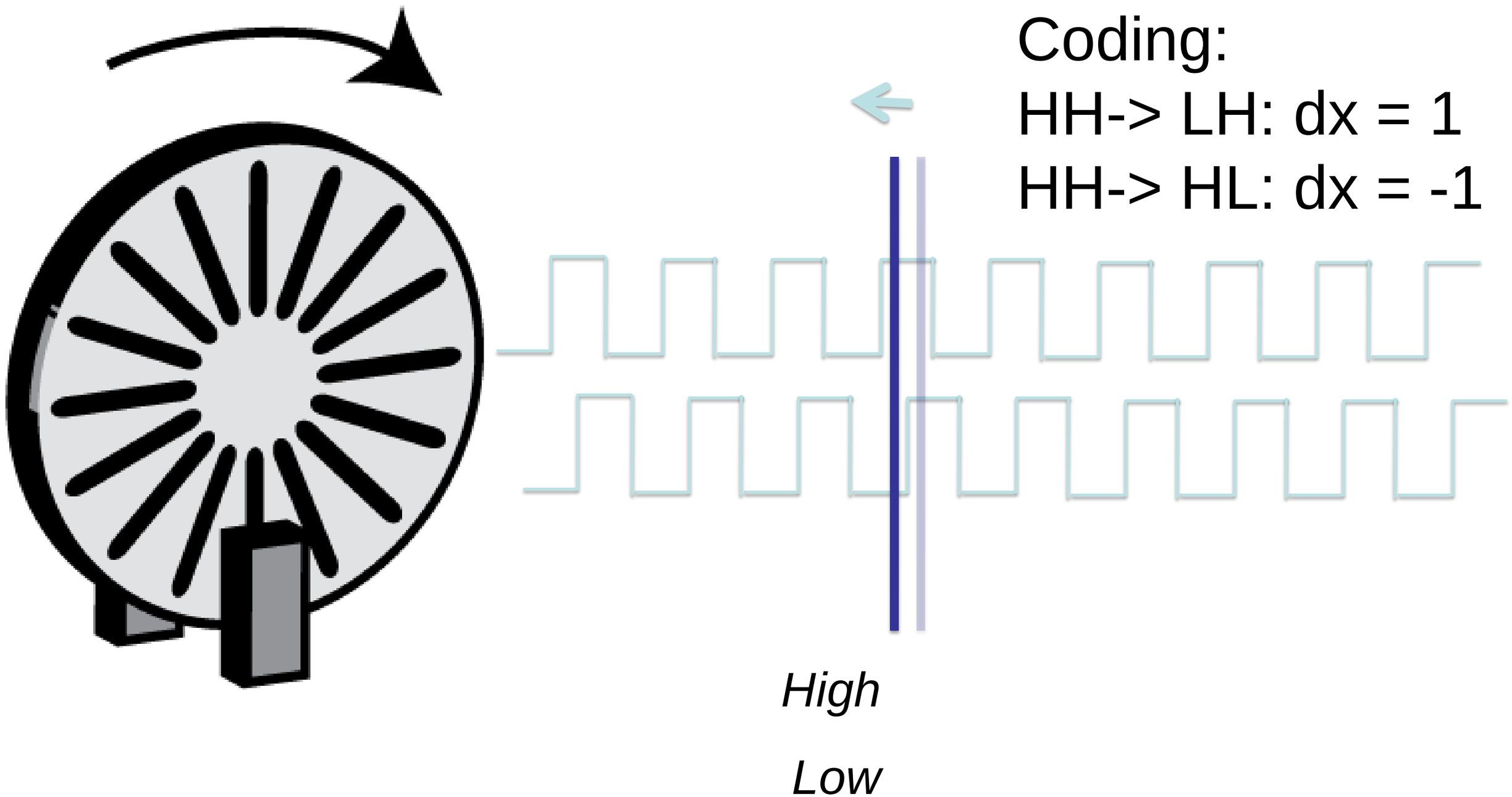
Solution: Use two out-of-phase detectors



Sensing: Rotary Encoder



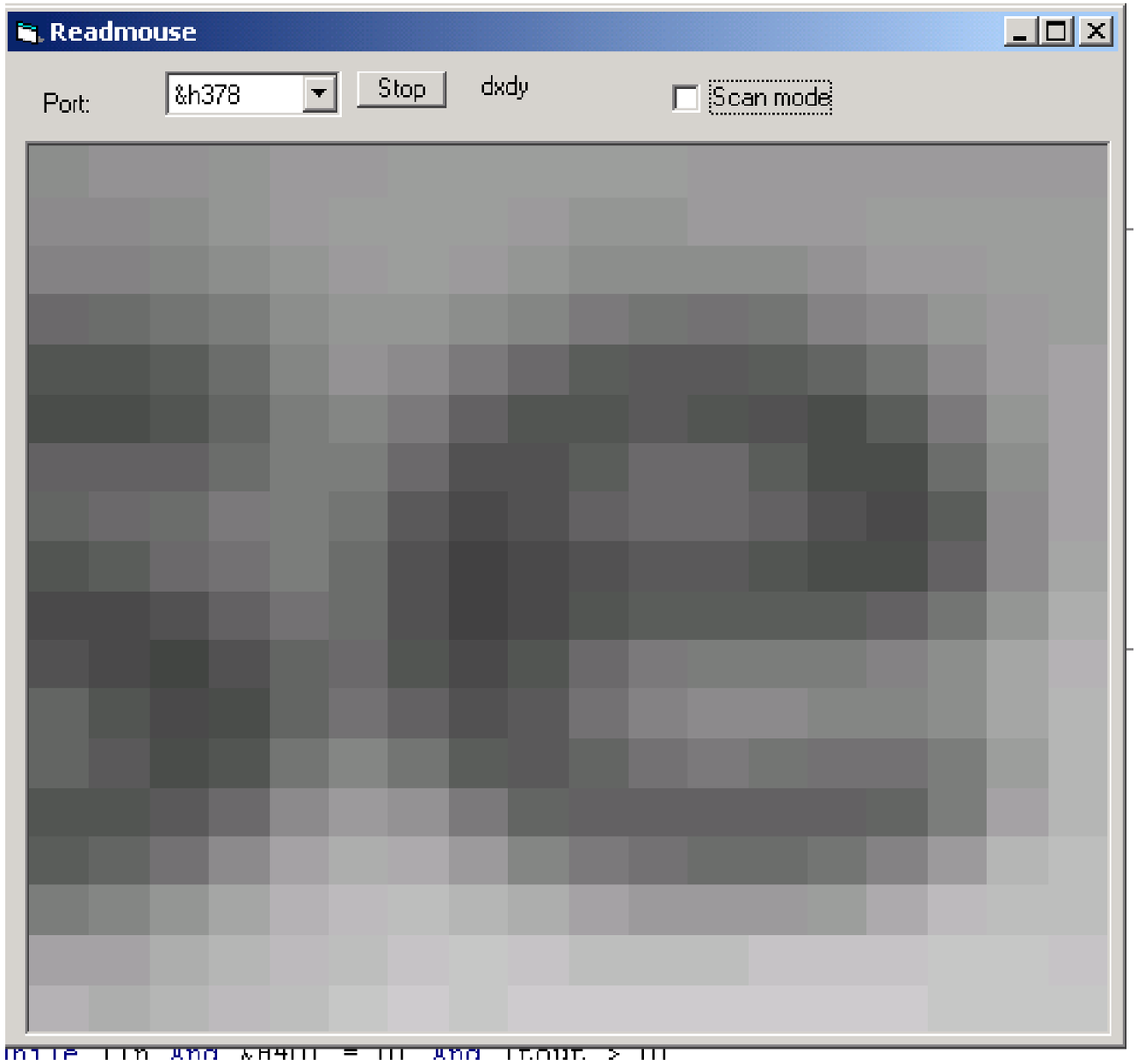
Sensing: Rotary Encoder



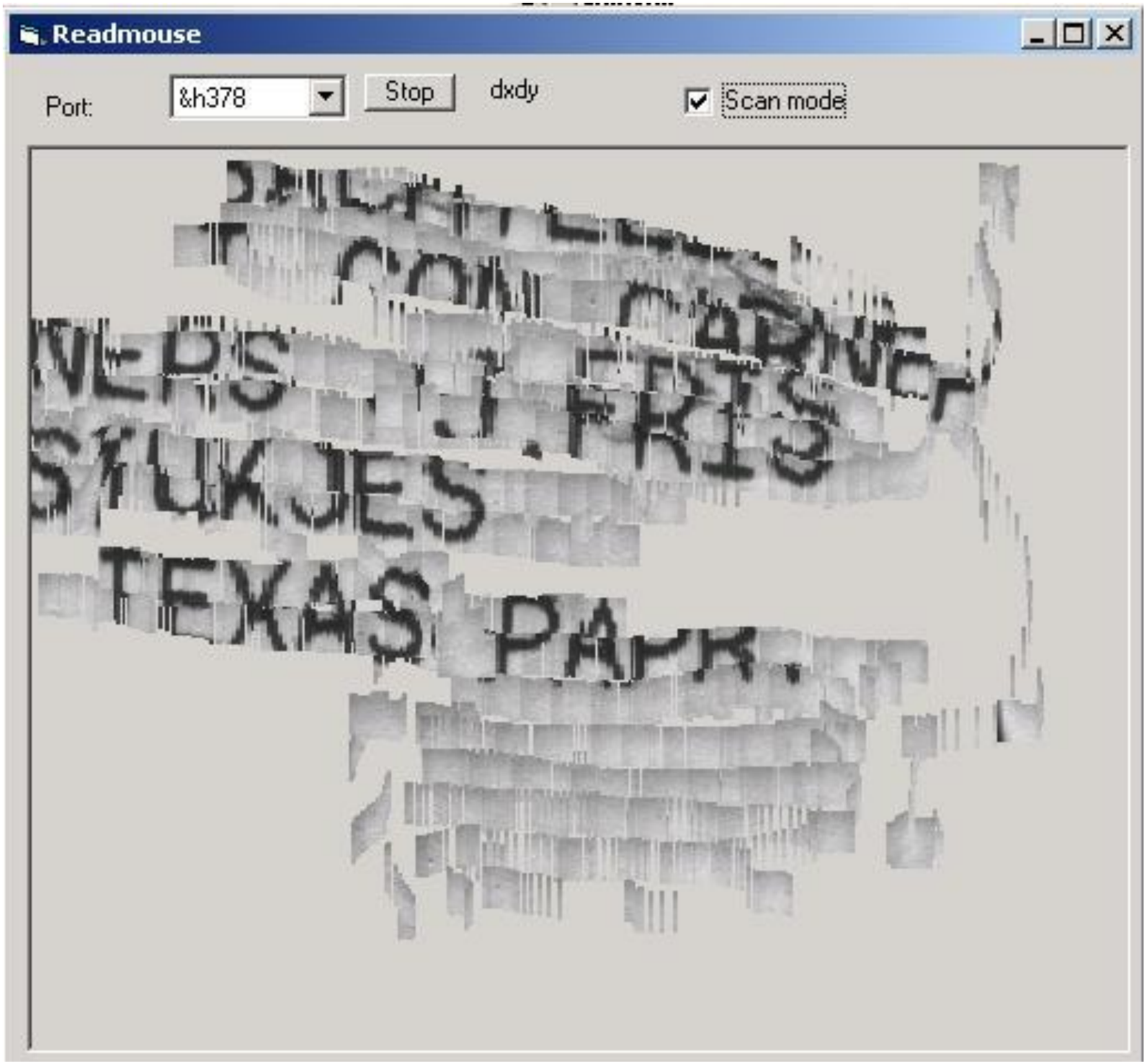
Device Abstraction

- Click, DoubleClick, MouseUp, MouseDown, MouseMove …

What about optical mice?



Source: http://spritesmods.com/?art=mouseeye



Source: http://spritesmods.com/?art=mouseeye

What is sensed?

Table I. Physical Properties Used by Input Devices

	Linear	Rotary
Position		
Absolute	Position **P**	Rotation **R**
Relative	Movement **dP**	Delta rotation **dR**
Force		
Absolute	Force **F**	Torque **T**
Relative	Delta force **dF**	Delta torque **dT**

Card, S. K., Mackinlay, J. D., and Robertson, G. G. 1991. A morphological analysis of the design space of input devices. *ACM Trans. Inf. Syst.* 9, 2 (Apr. 1991), 99-122.

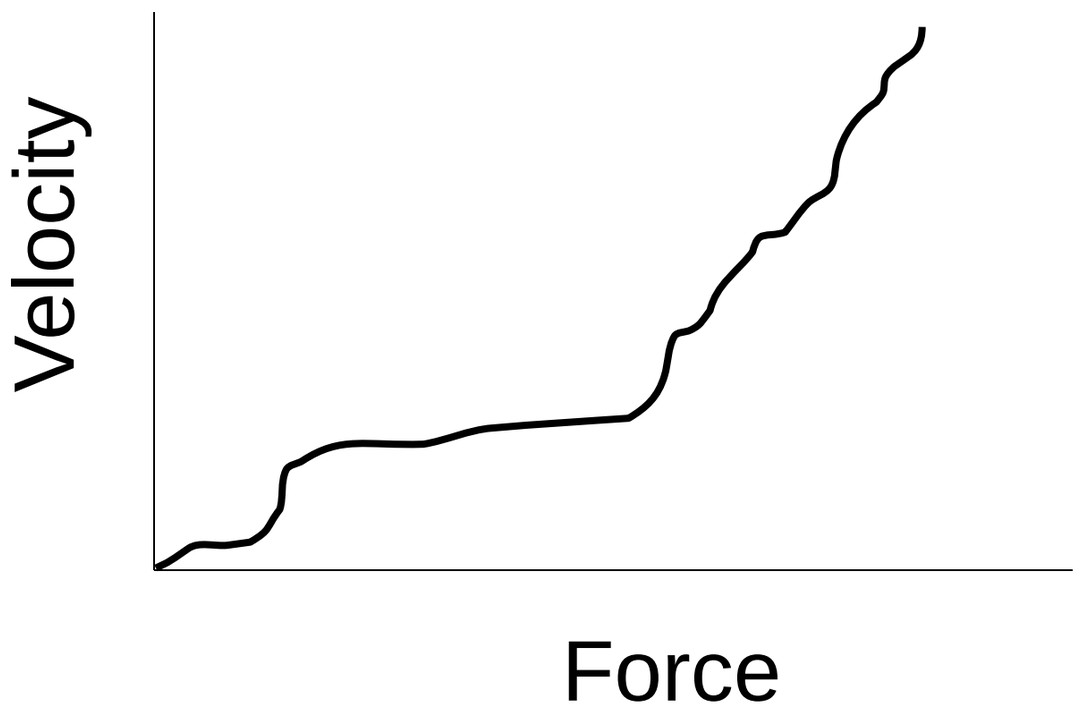
Other device properties:

- Indirect vs. Direct
  - Direct: Input and output space are unified
- C:D Ratio
  - For one unit of movement in physical space, how far does the cursor travel in display space?
  - Q: What is the C:D ratio for direct touch screen input?
- Device Acquisition Time

Trackball, Trackpad

Trackpoint

- Indirect, force sensing, velocity control
- Nonlinear transfer function



(cc) Image by flickr user tsaiid

Mobile Pointing

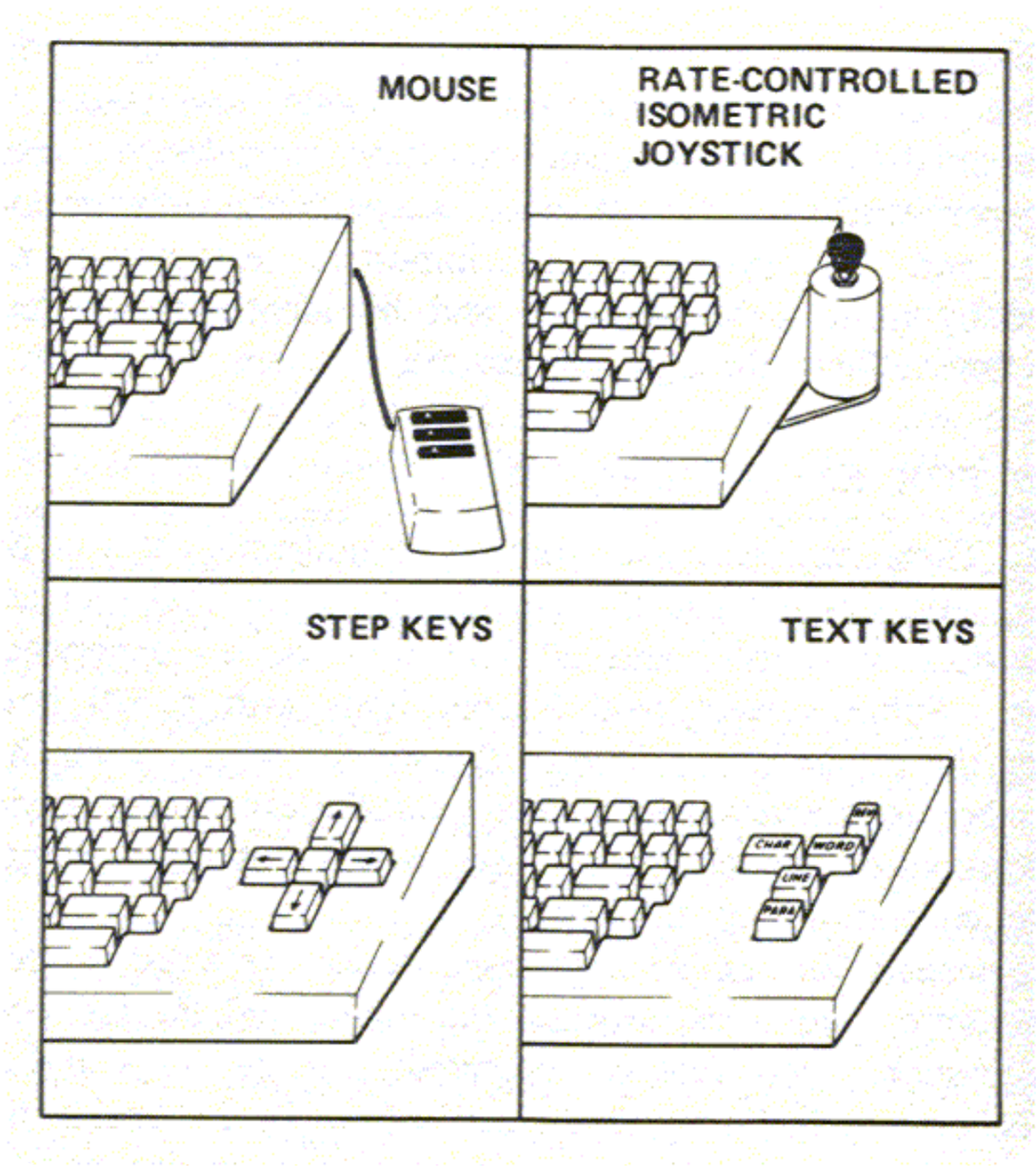
- D-Pad
  (see: arrow keys)
- Trackball
- Direct touch
  (see: Trackpad)
- Stylus

Which is faster?

Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

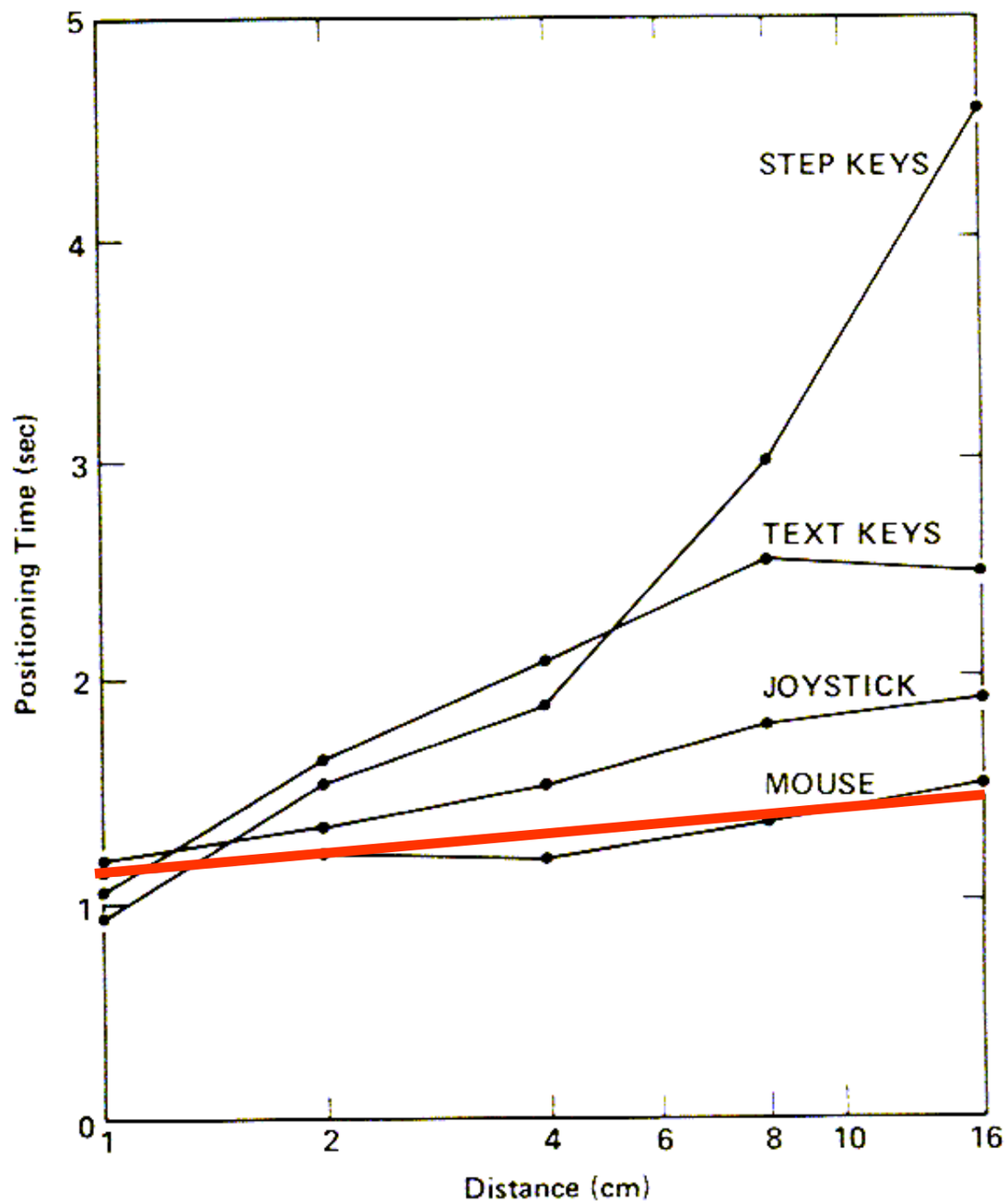
Which is faster?

Engelbart



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Experiment: Mice are fastest!



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Fitts' Law

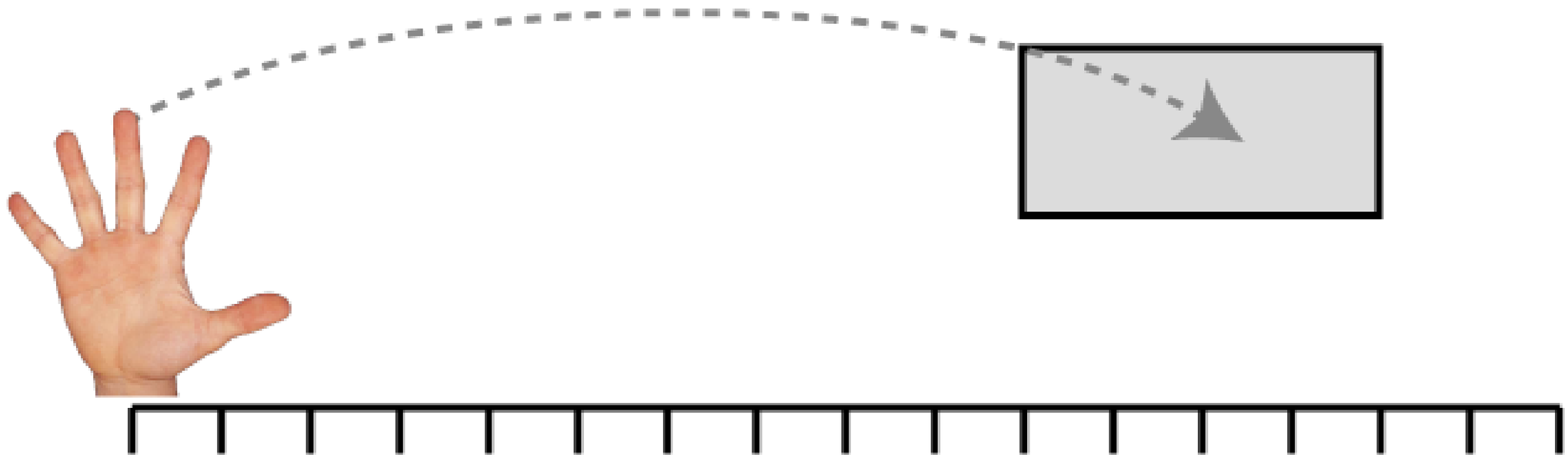
- Time T_{pos} to move the hand to target size S which is distance D away is given by:

$$T_{pos} = a + b \underbrace{\log_2 (D/S + 1)}_{\textit{Index of Difficulty (ID)}}$$

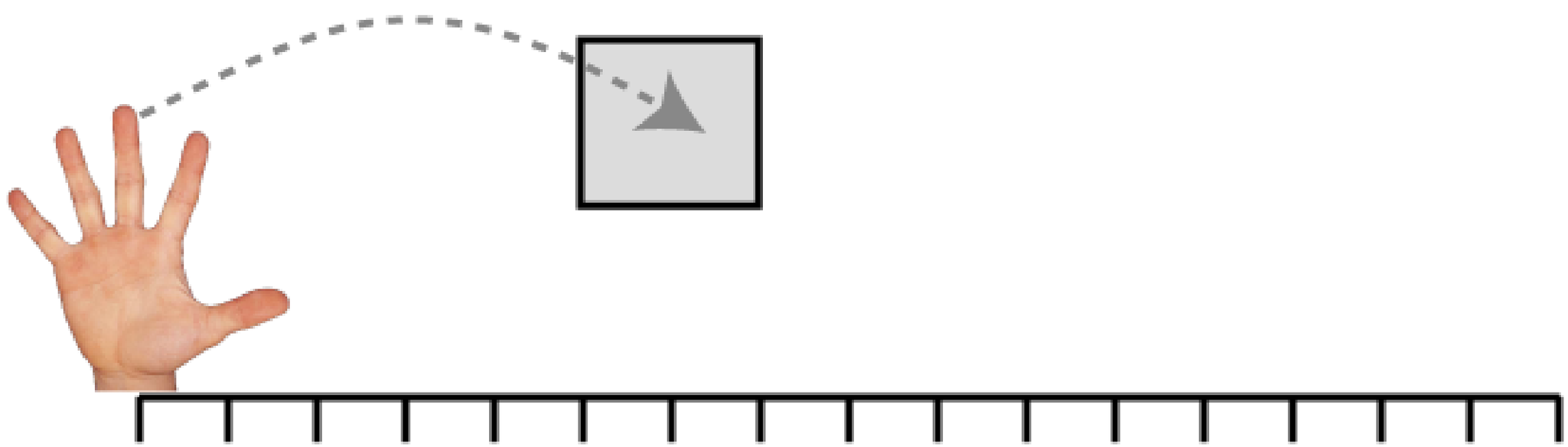
Only *relative precision* matters

Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

S = 4, D = 12



S = 2, D = 6



Fitts' Law

- Time T_{pos} to move the hand to target size S which is distance D away is given by:

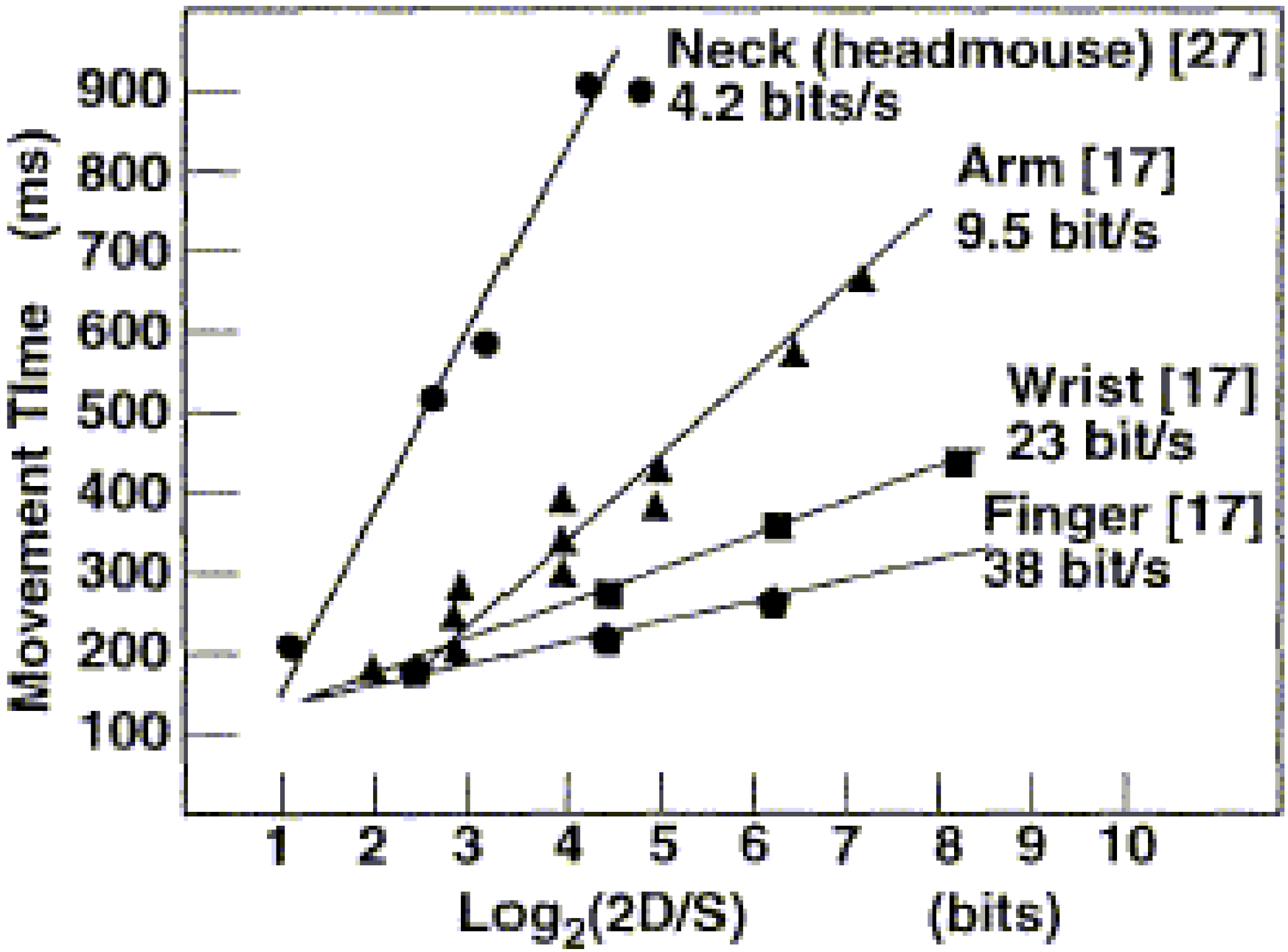
$$T_{pos} = \underbrace{a + b}_{} \log_2 (D/S + 1)$$

Device Characteristics
(bandwidth of human muscle group & of device)

a: start/stop time
b: speed

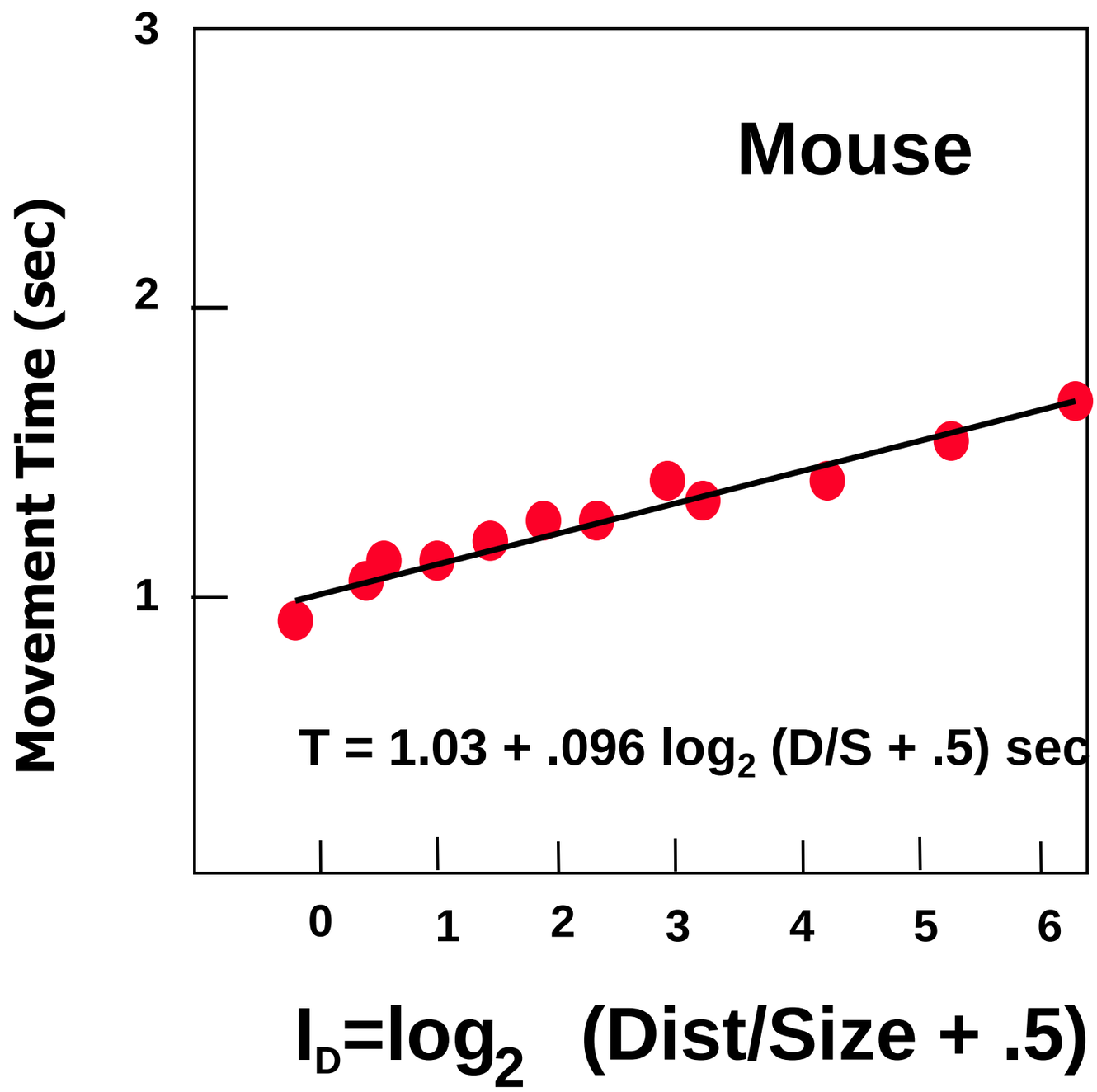
Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

Bandwidth of Human Muscle Groups



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Why is the mouse fastest?



Source: Card, Stu. Lecture on Human Information Interaction. Stanford, 2007.

Why these results?

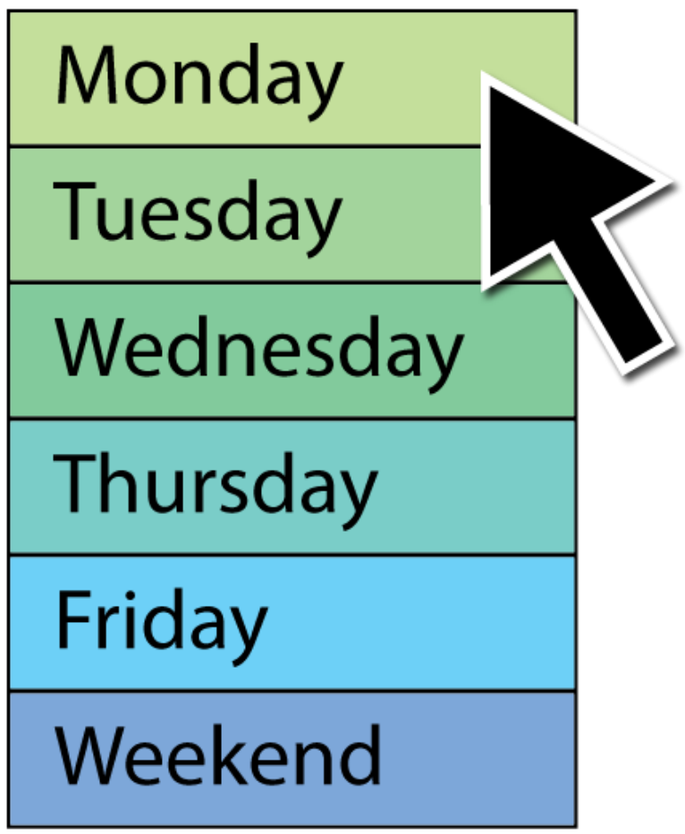
Time to position mouse proportional to Fitts' Index of Difficulty I_D.

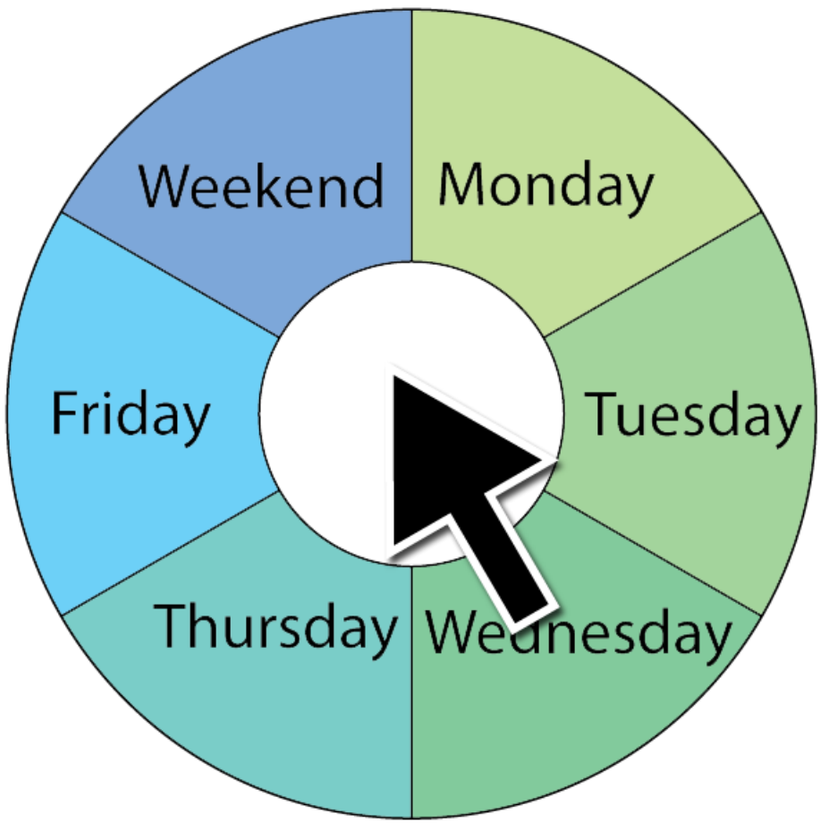
[i.e. how well can the muscles direct the input device]

Therefore speed limit is in the eye-hand system, not the mouse.

Therefore, mouse is a near optimal device.

Fitts' Law Example



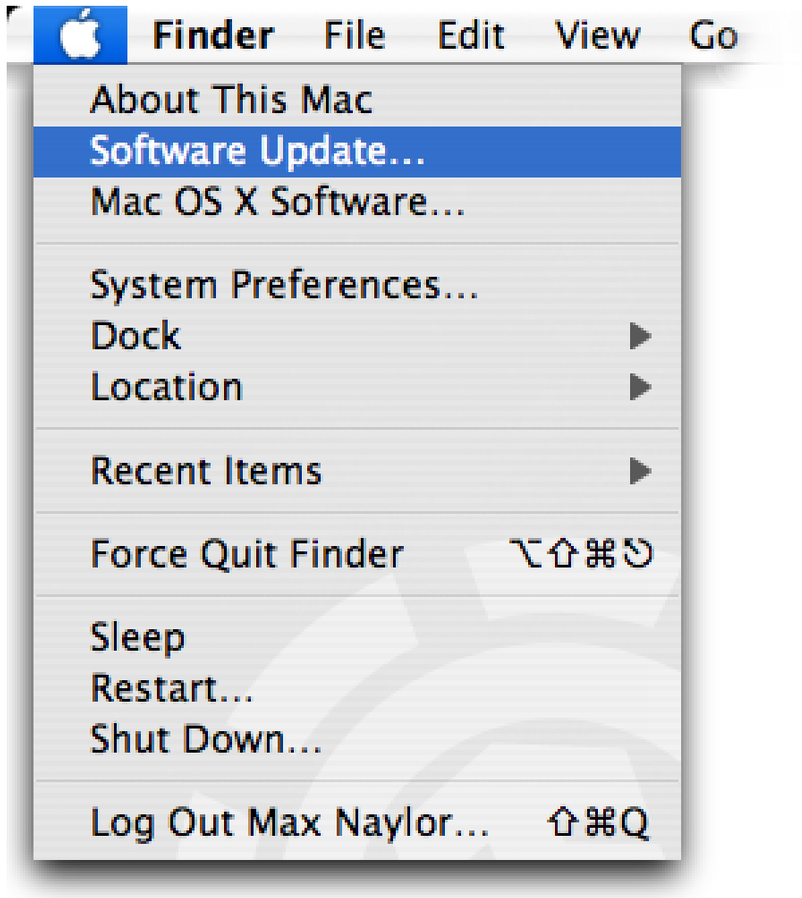


- Which will be faster on average?
  - pie menu (bigger targets & less distance)

Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

Fitts' Law in Windows & Mac OS

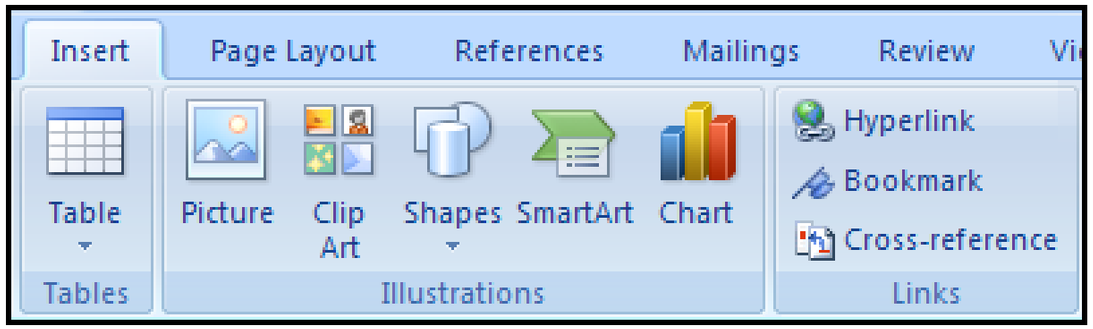
Windows 95: Missed by a pixel
Windows XP: Good to the last drop



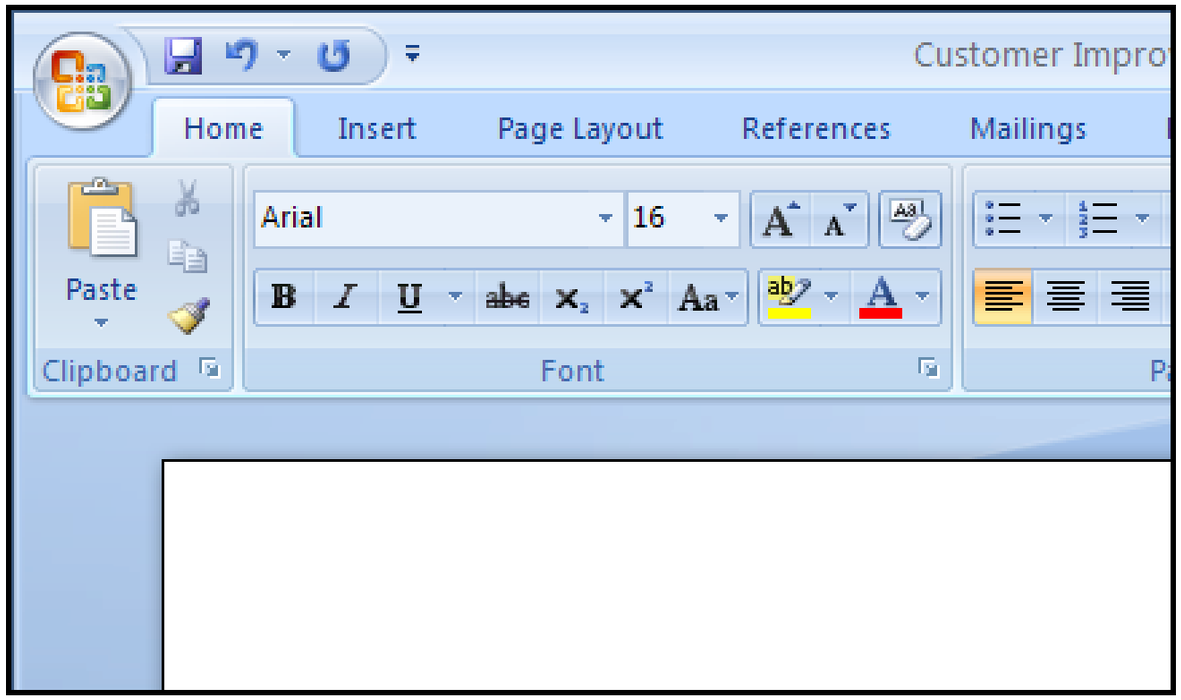
The Apple menu in Mac OS X v10.4 Tiger.

Source: Jensen Harris, An Office User Interface Blog : Giving You Fitts. Microsoft, 2007; Apple

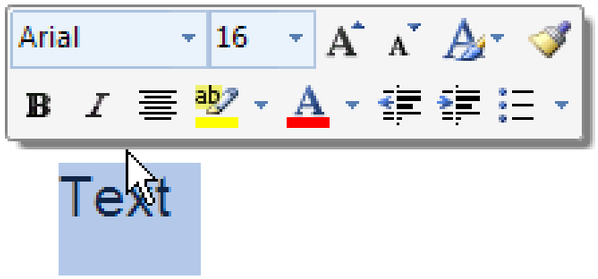
Fitts' Law in Microsoft Office 2007



Larger, labeled controls can be clicked more quickly



Magic Corner: Office Button in the upper-left corner



Mini Toolbar: Close to the cursor

Source: Jensen Harris, An Office User Interface Blog : Giving You Fitts. Microsoft, 2007.

Everything is best for something and worst for something else.

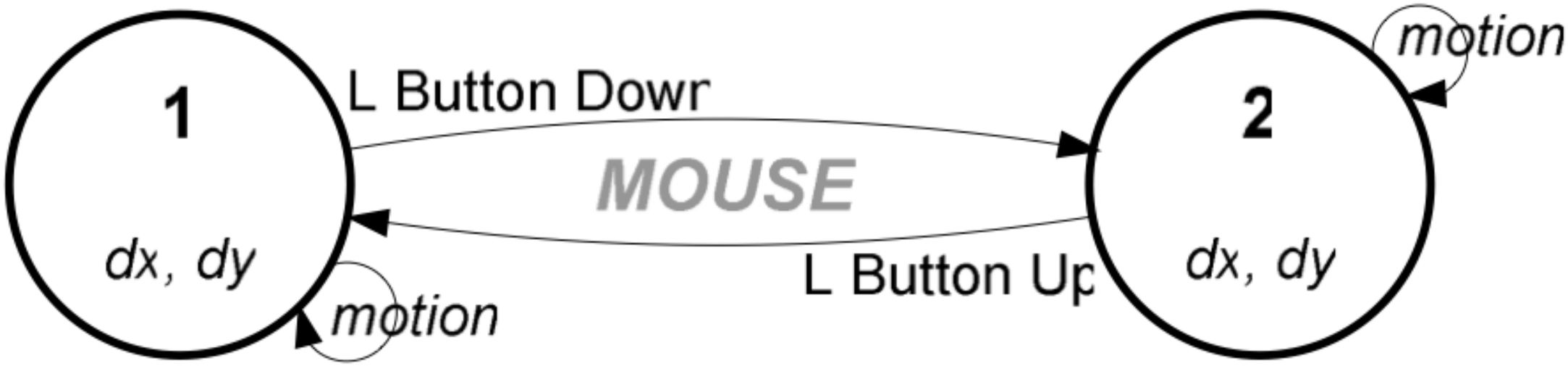
- Bill Buxton

3-State Model of Input (Buxton)

State	Description
0	*Out Of Range:* The device is not in its physical tracking range.
1	*Tracking:* Device motion moves only the cursor.
2	*Dragging:* Device motion moves objects on the screen.

(Table from Hinckley Reading)

Mouse



(Figure from Hinckley Reading)

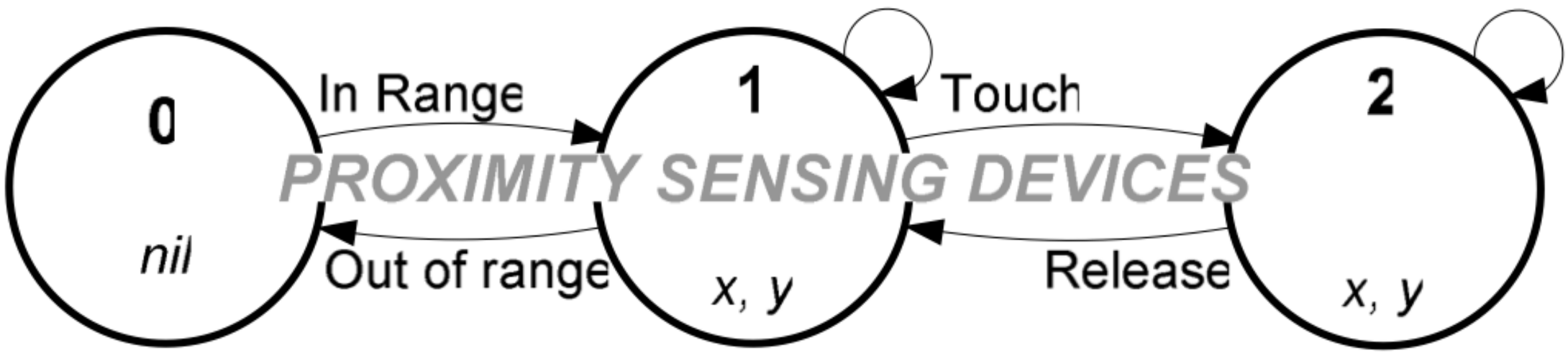
State	Description
0	*Out Of Range:* The device is not in its physical tracking range.
1	*Tracking:* Device motion moves only the cursor.
2	*Dragging:* Device motion moves objects on the screen.

Touch Screen

(Figure from Hinckley Reading)

State	Description
0	*Out Of Range:* The device is not in its physical tracking range.
1	*Tracking:* Device motion moves only the cursor.
2	*Dragging:* Device motion moves objects on the screen.

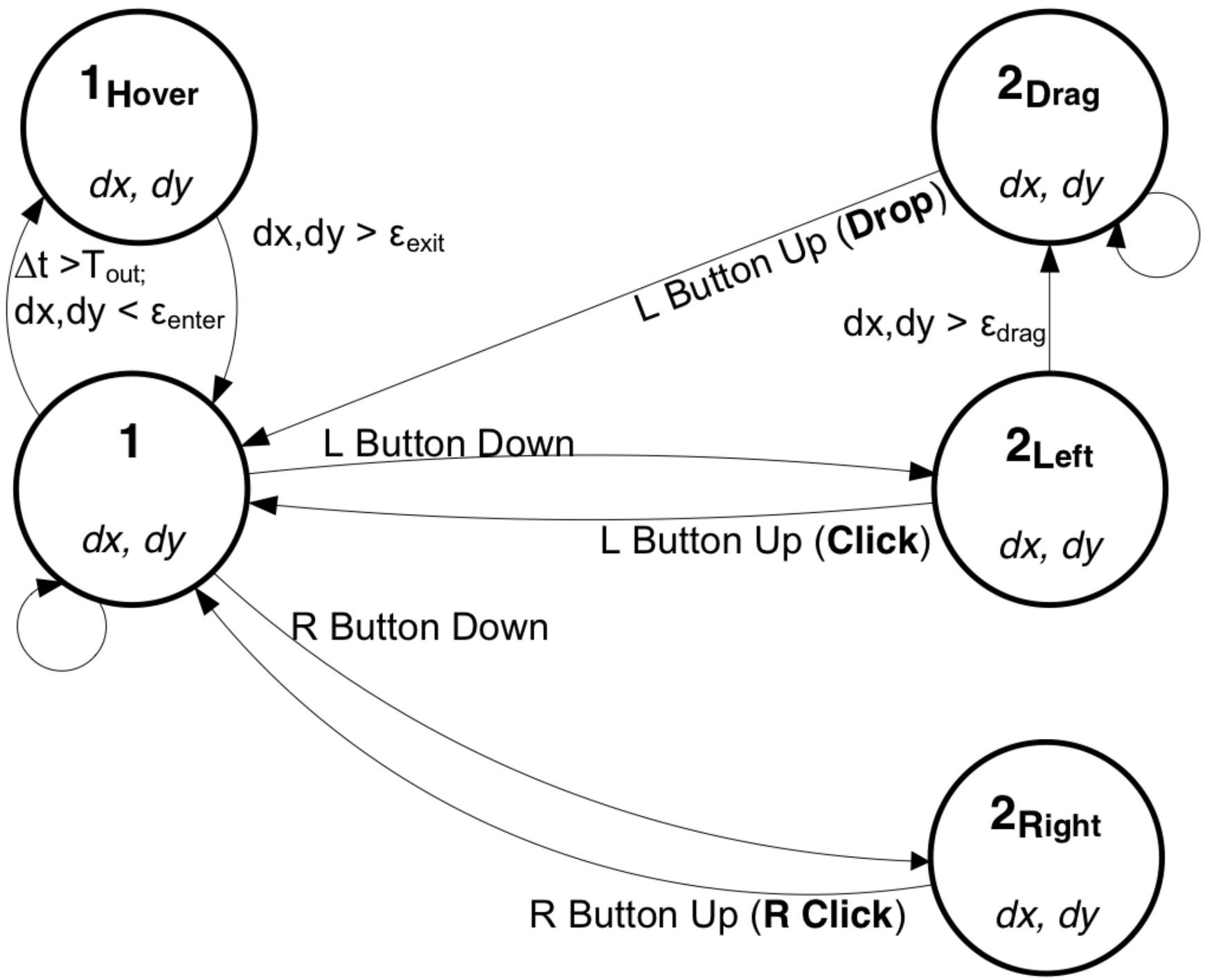
Stylus on Tablet



(Figure from Hinckley Reading)

State	Description
0	*Out Of Range:* The device is not in its physical tracking range.
1	*Tracking:* Device motion moves only the cursor.
2	*Dragging:* Device motion moves objects on the screen.

Mouse, in more detail



(Multi-) Touch

Strengths

- Direct input allows maximal screen space for mobile devices (ocular centrism).
- More degrees of freedom.
- “Virtual input devices” are adaptable.
- No extra pieces to lose or break (styli!)

Challenges

(from Buxton)

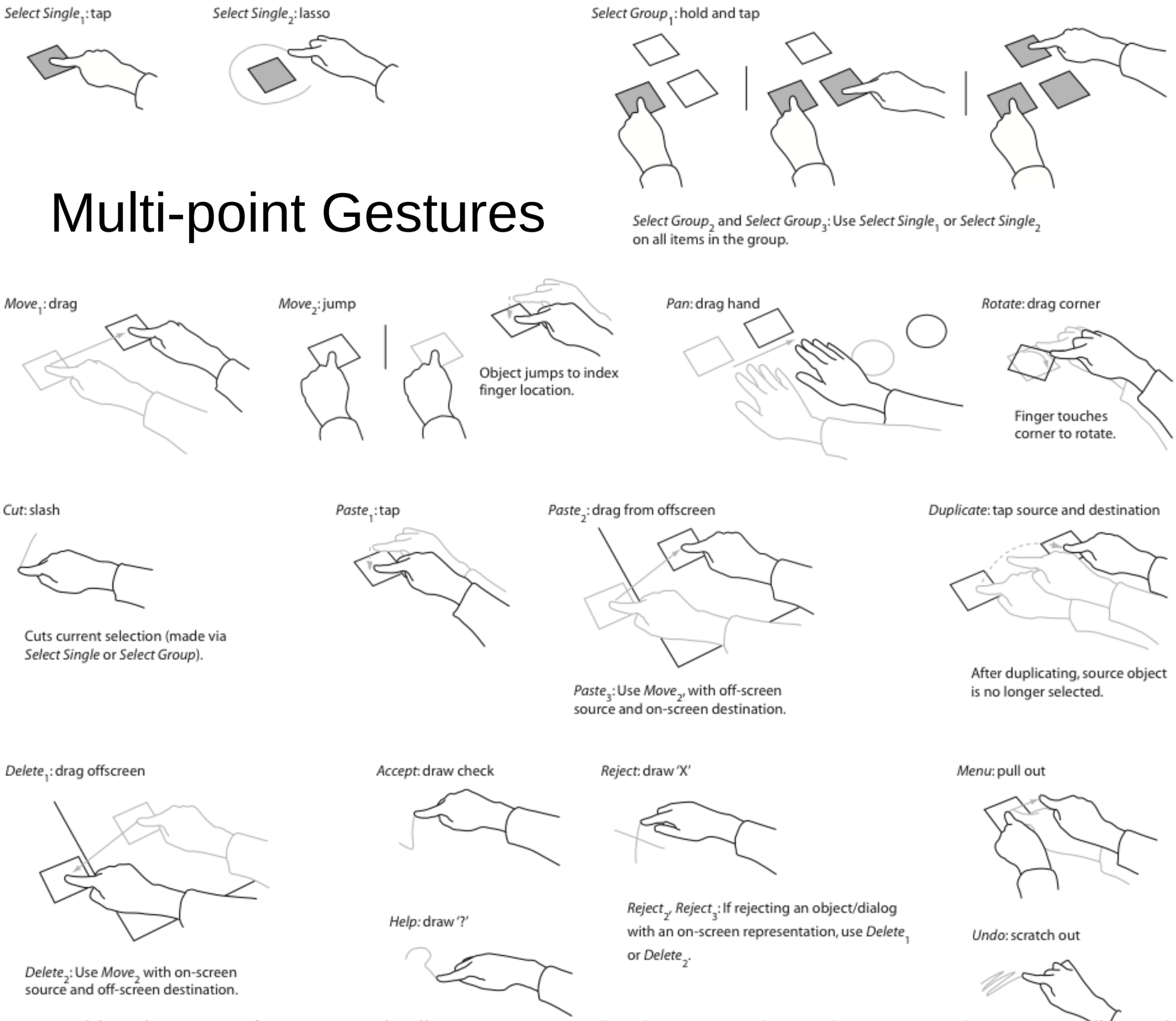
- No tactile feedback.
- Requires free use of (both) hands and eyes.
- “Fat Finger” problems – precision & occlusion

Terminology

(from Buxton)

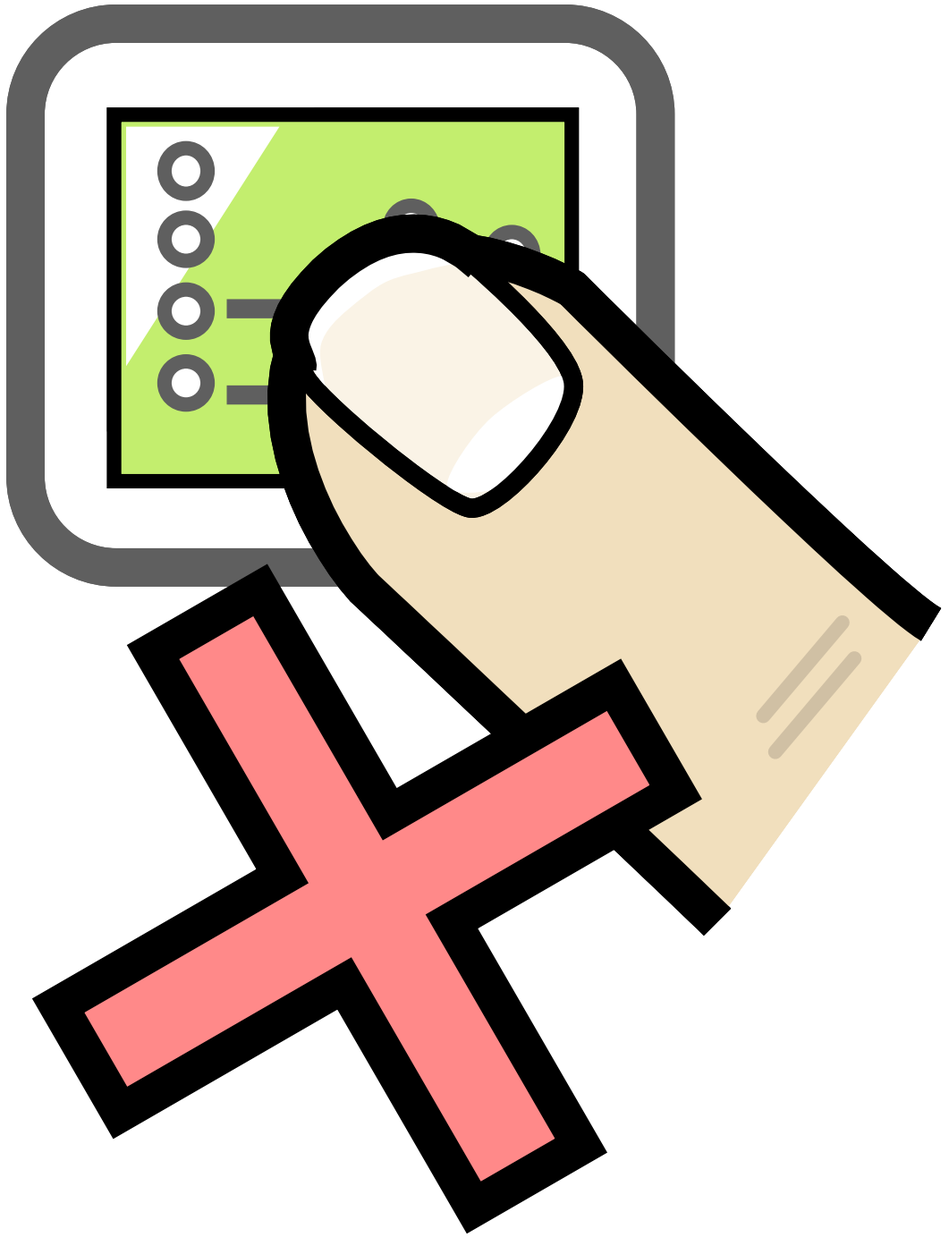
- Touch-tablets *vs* Touch screens
- Single-finger *vs* multi-finger
- Multi-person *vs* multi-touch
- Points *vs* Postures
- Hands and fingers *vs* Objects

Multi-point Gestures



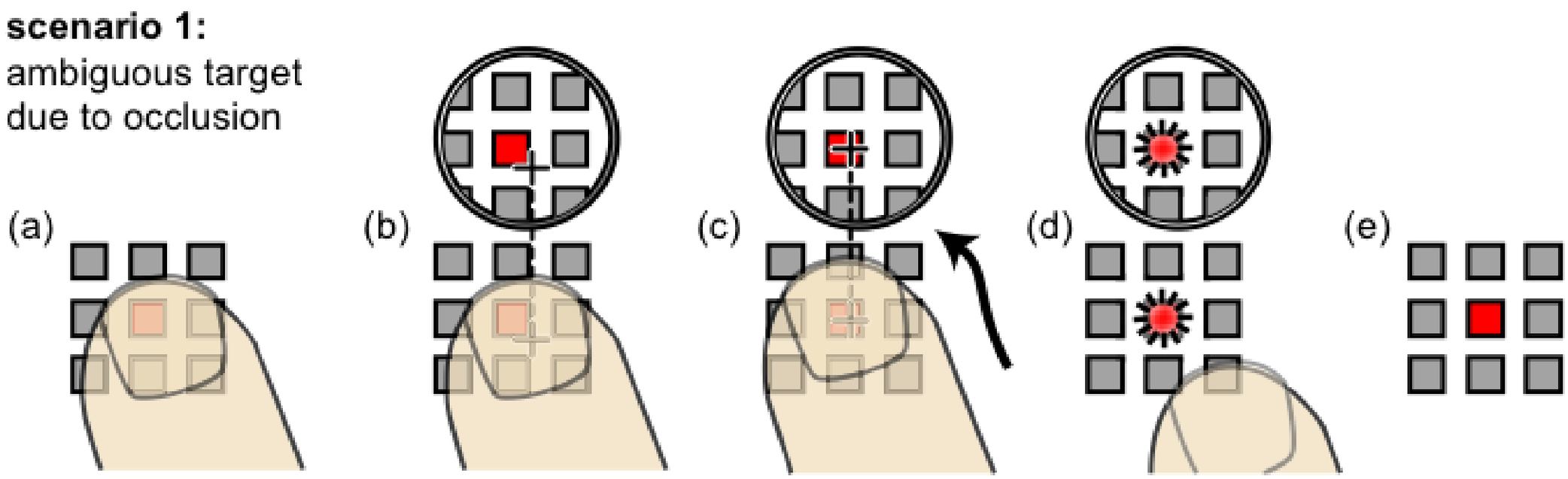
Wobbrock, J., **Morris, M.R.**, and Wilson, A. User-Defined Gestures for Surface Computing. *Proceedings of CHI 2009*, 108

The “Fat Finger” Problem



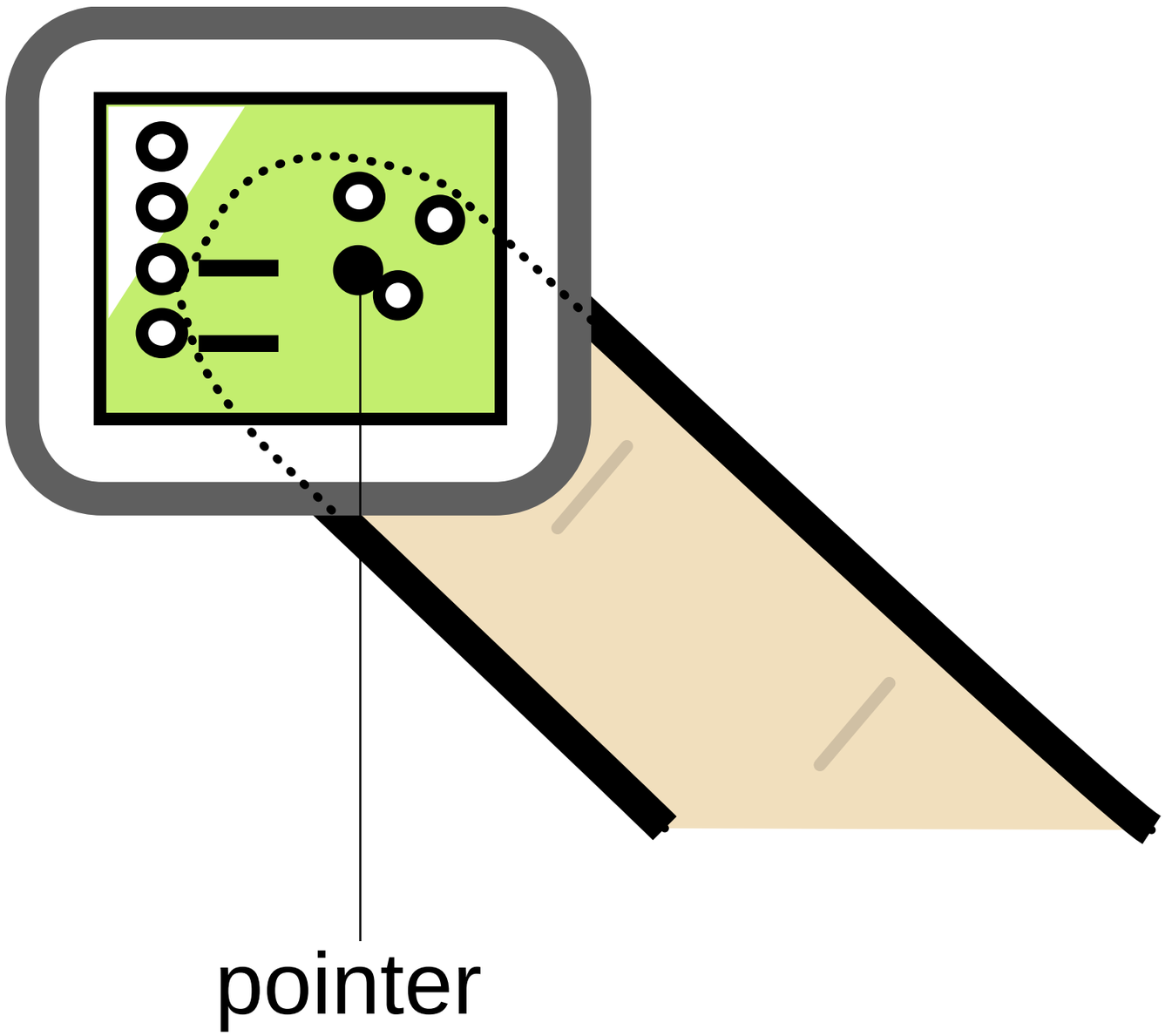
Graphics: Patrick Baudisch, nanoTouch

A Software Solution

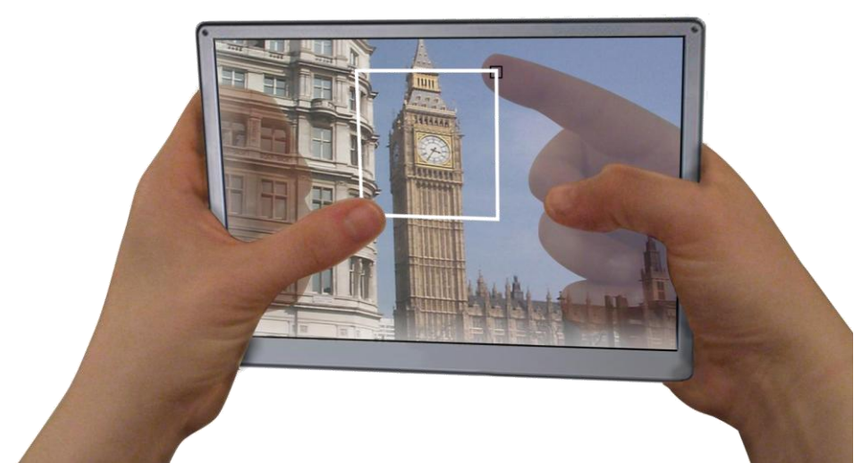


Graphics: D. Vogel, P. Baudisch - Shift

A Hardware Solution: Use the Backside



Graphics: Patrick Baudisch, nanoTouch




A
B
C


A
B
C

Hybrids: Keyboards on Interactive Tables

B. Hartmann, M. Morris, H. Benko, A. Wilson: Augmenting Interactive Surfaces With Keyboards and Mice. UIST 2009

Hybrids: Multi-touch on Mice

Mouse 2.0: Multi-touch Meets the Mouse
Nicolas Villar, Shahram Izadi, Dan Rosenfeld, Hrvoje Benko, John Helmes, Jonathan Westhues, Steve Hodges, Eyal Ofek, Alex Butler, Xiang Cao and Billy Chen.
Proceedings of UIST 2009.

Hybrids: SLAP widgets

Next Time

Model-View-Controller, Event-driven UIs

- *Basics of Event Handling.*
  Developing User Interfaces. Dan Olsen, Ch.4.
- Don’t forget to read and submit comment!