Understanding & Modeling Input Devices

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Announcements

- HW3 rubric clarified

  http://hci/courses/cs147/assignments/3_discovery.html

- Google groups

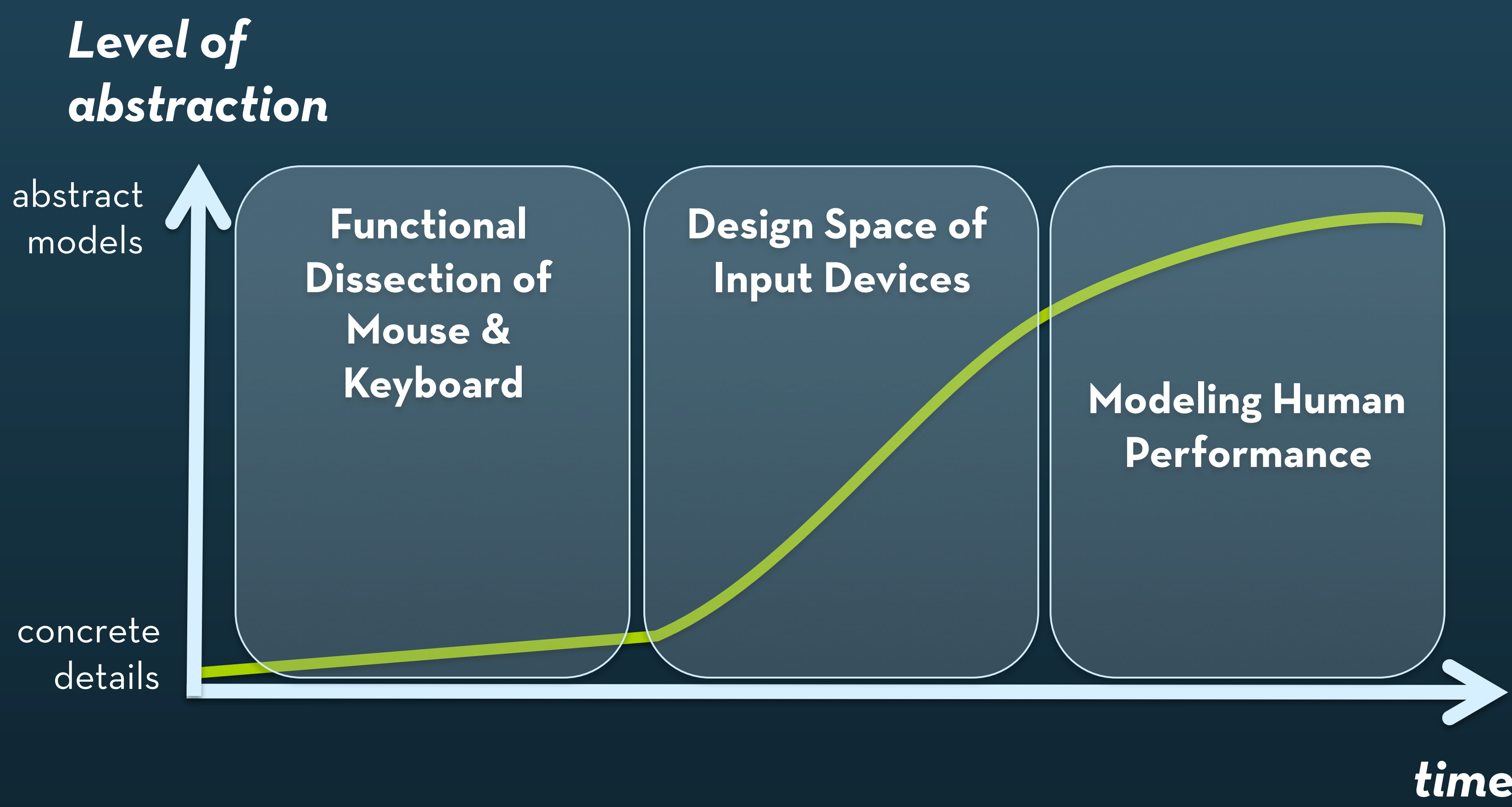
  http://groups.google.com/group/cs147-fall-2009/

  http://groups.google.com/group/cs147-tech-2009/

Questions for today

1. How do common input devices work?
2. How can we think about the larger space of all possible input devices?
3. Can we predict human input performance?
4. What about **uncommon** input devices (multitouch, tangible interfaces, ...)?
5. Will this be on the exam? Yes.

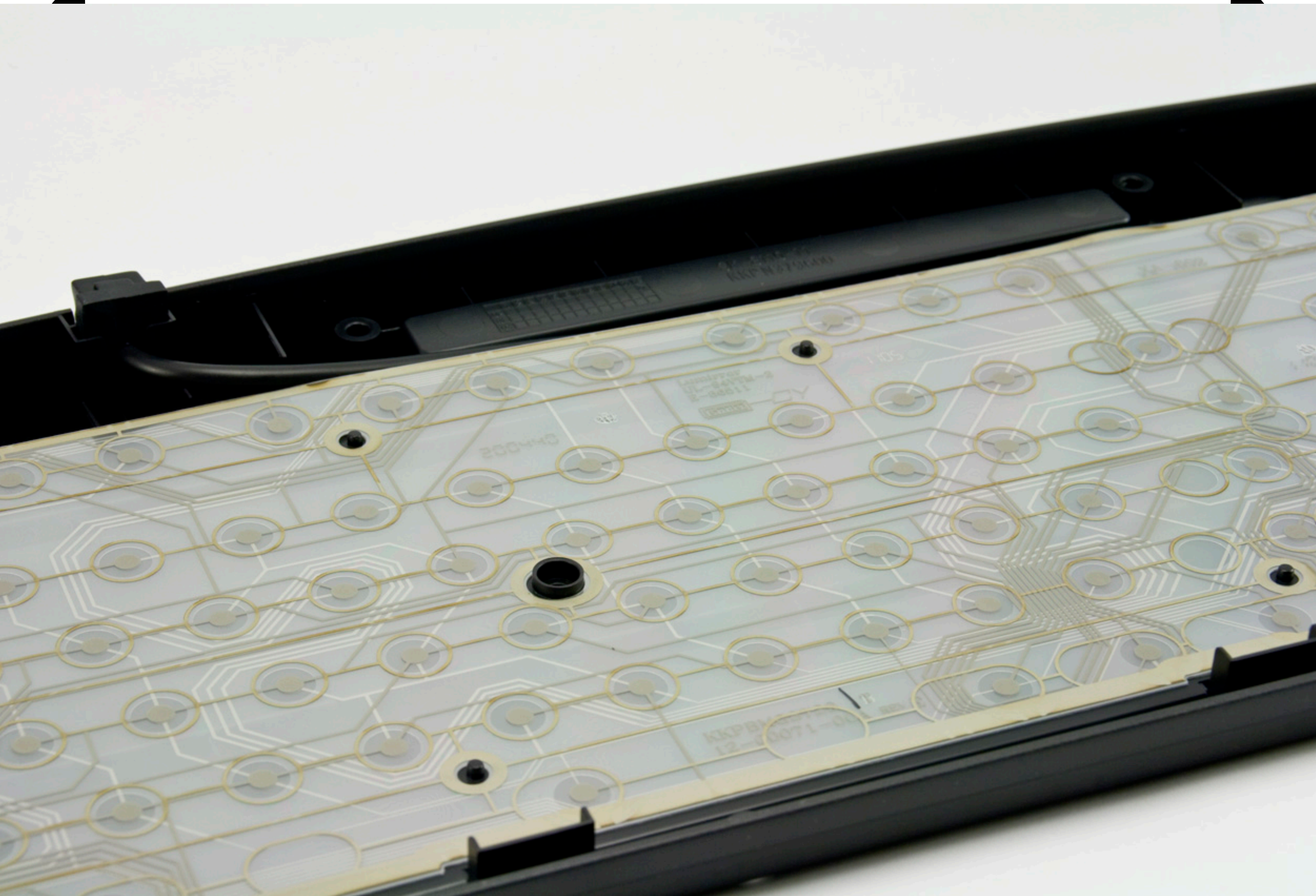
Today's lecture in graph form

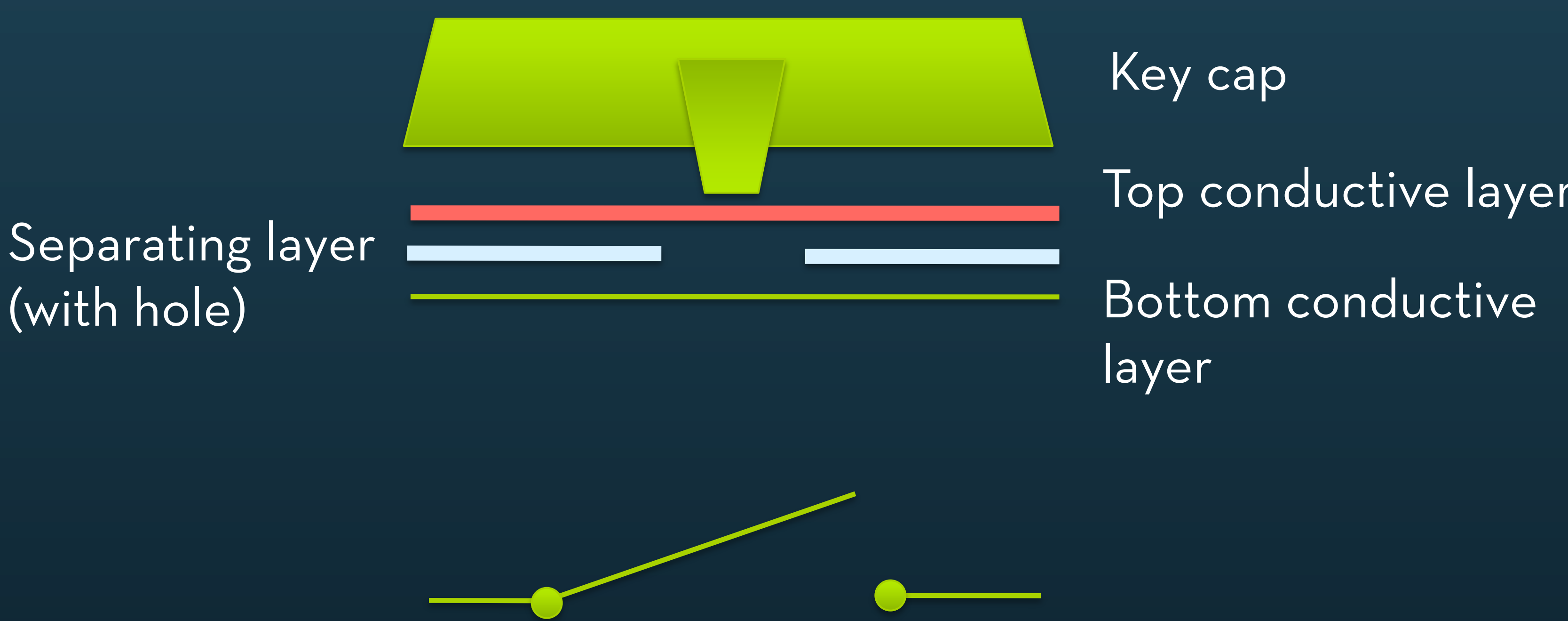


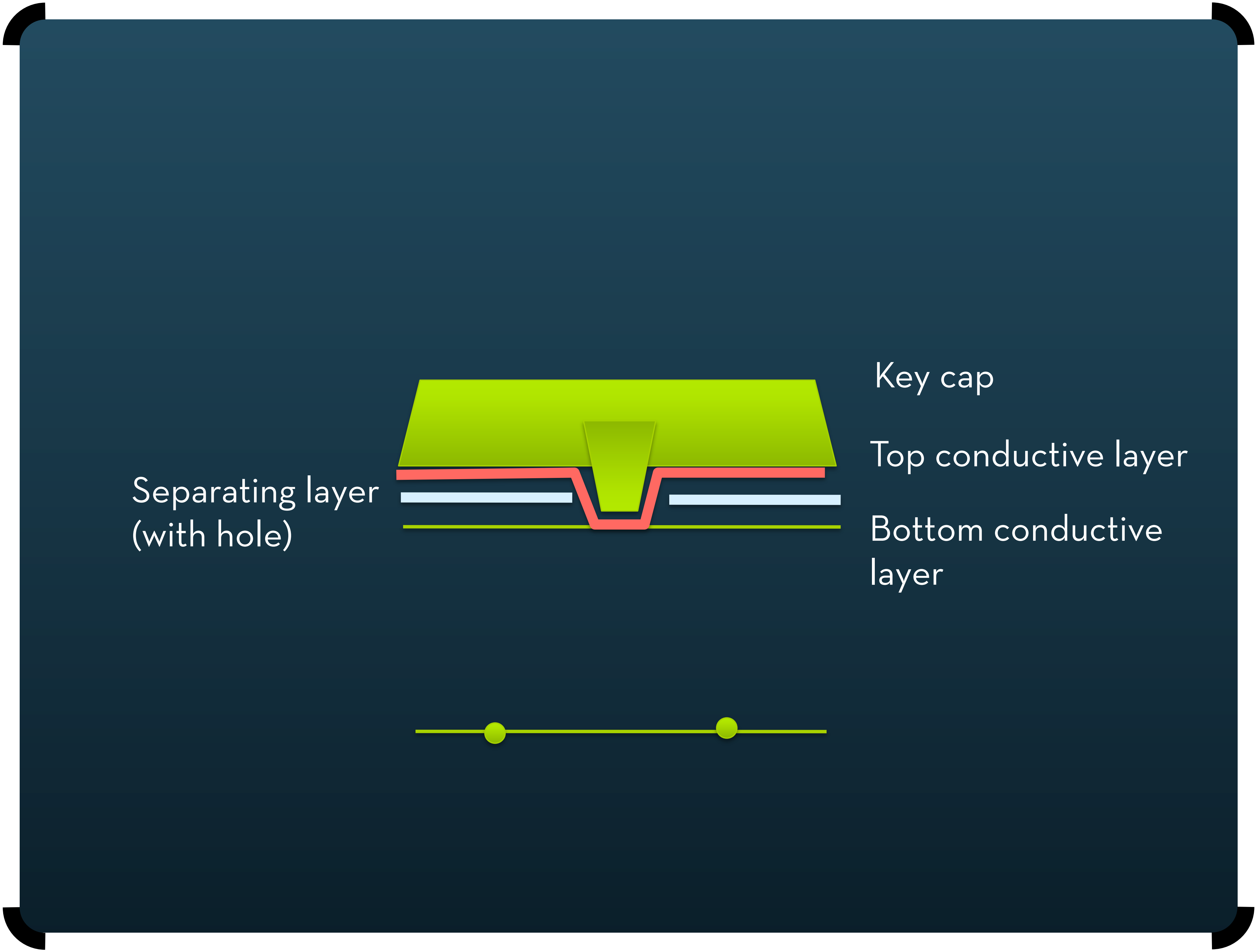
I think my keyboard is broken.

Whenever I have a few keys pressed down, some keys suddenly don’t work anymore; at other times ‘phantom’ characters appear.

What’s going on?




Key cap
Top conductive layer
Separating layer (with hole)
Bottom conductive layer

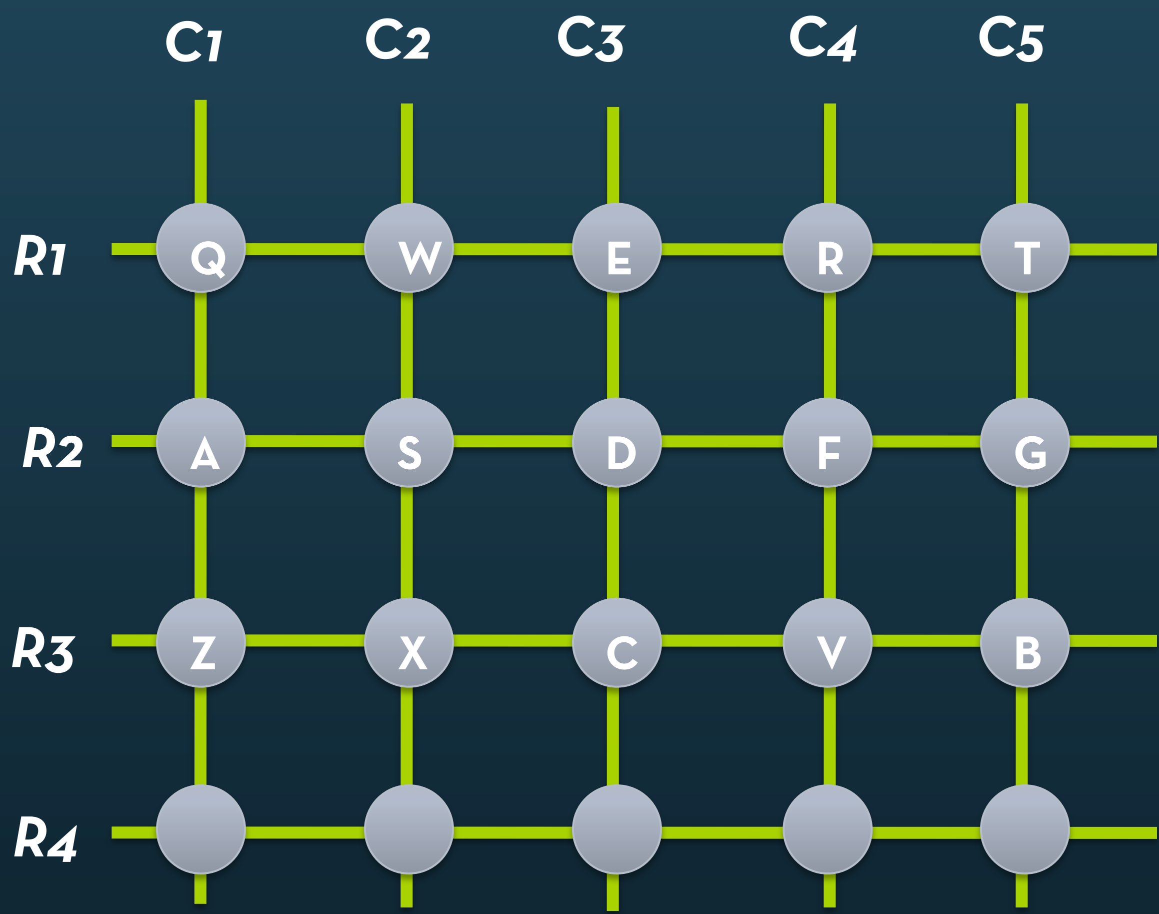

Key cap
Top conductive layer
Separating layer
(with hole)
Bottom conductive
layer

02V0
REV:C

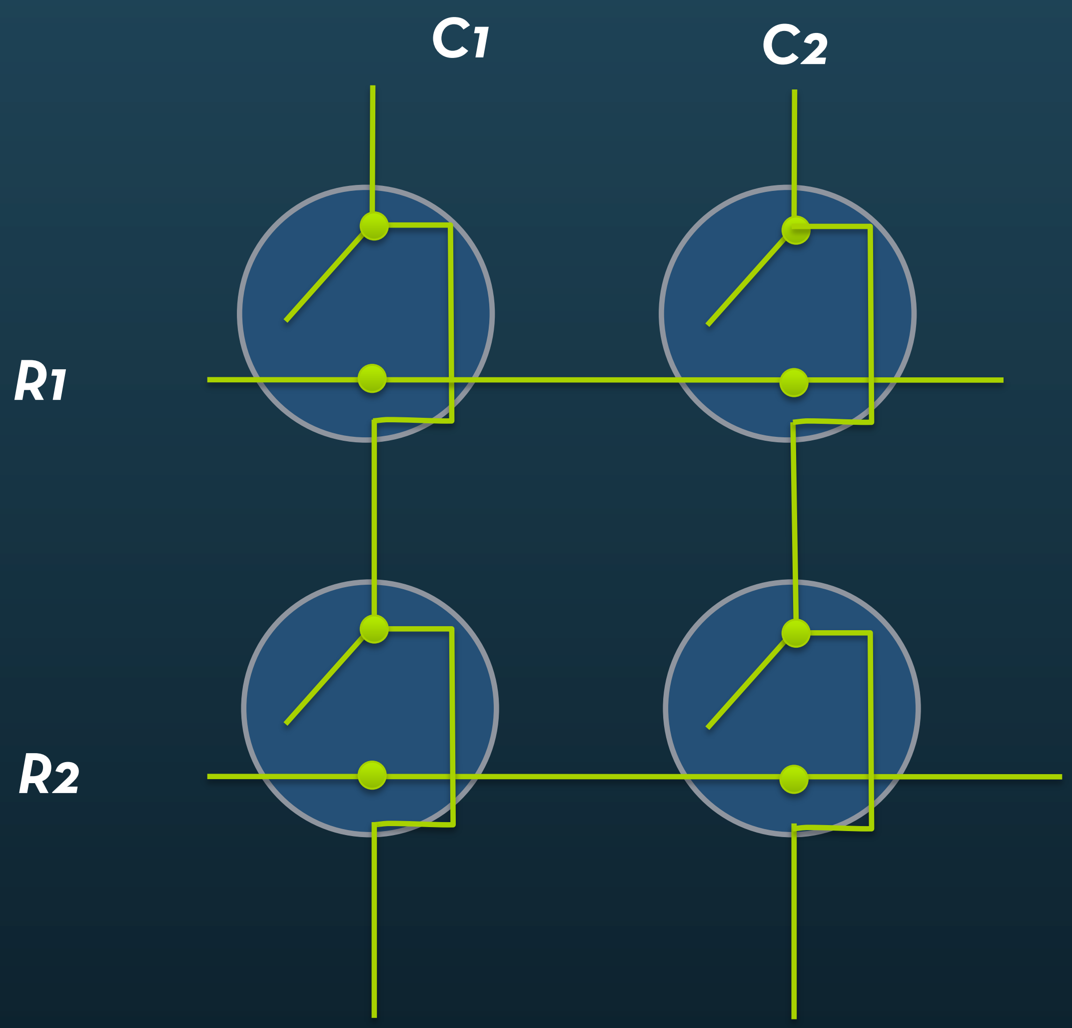
Row/Column Scanning

9 lines

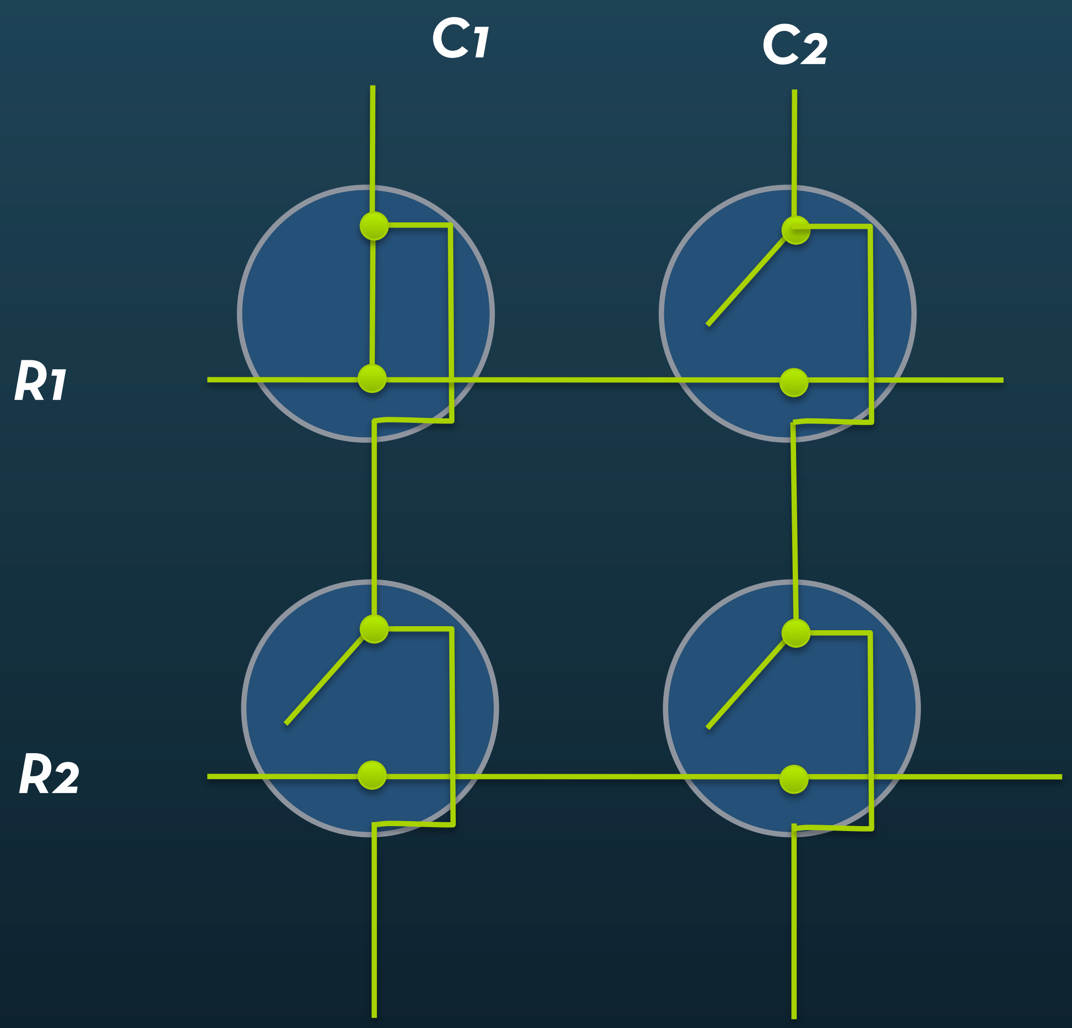
20 keys



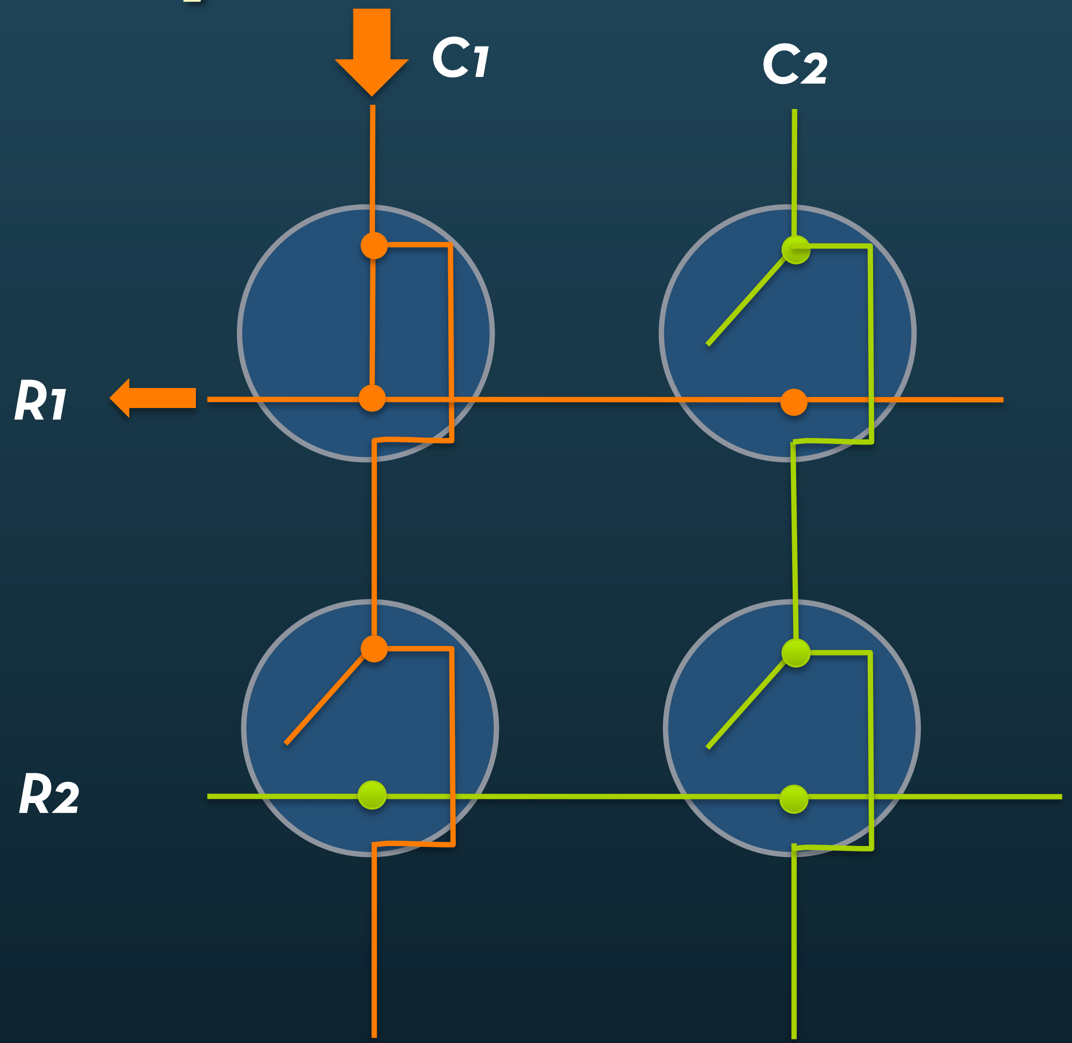
Closeup



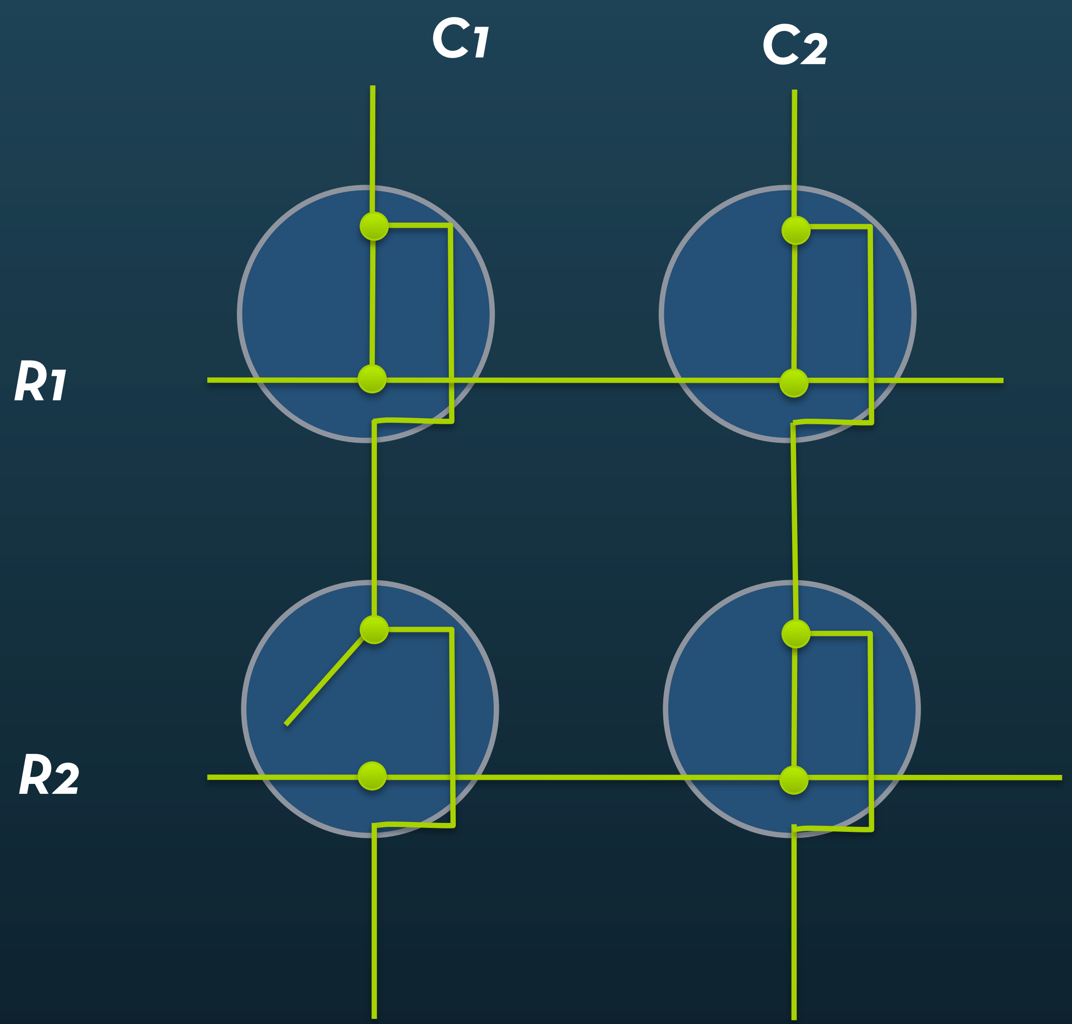
One Key Down



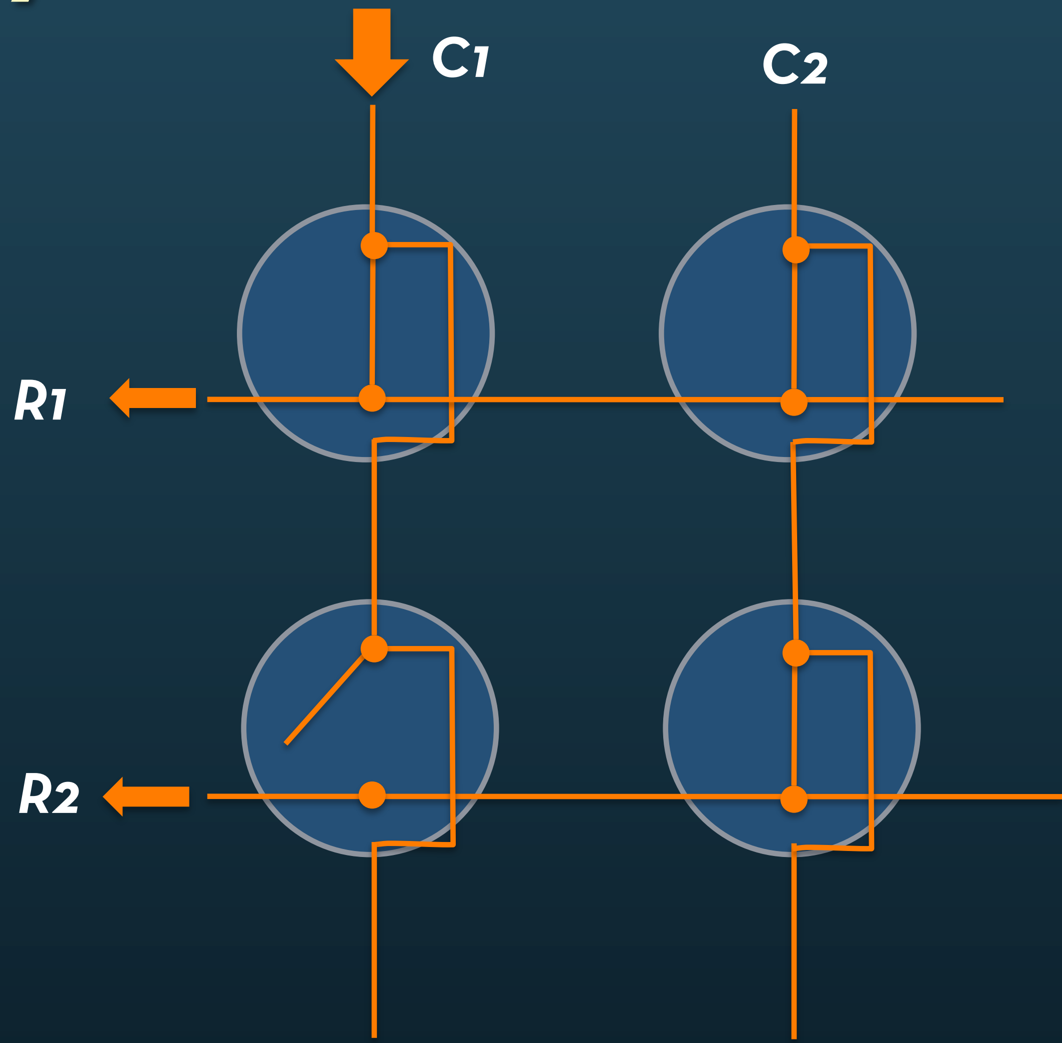
One Key Down



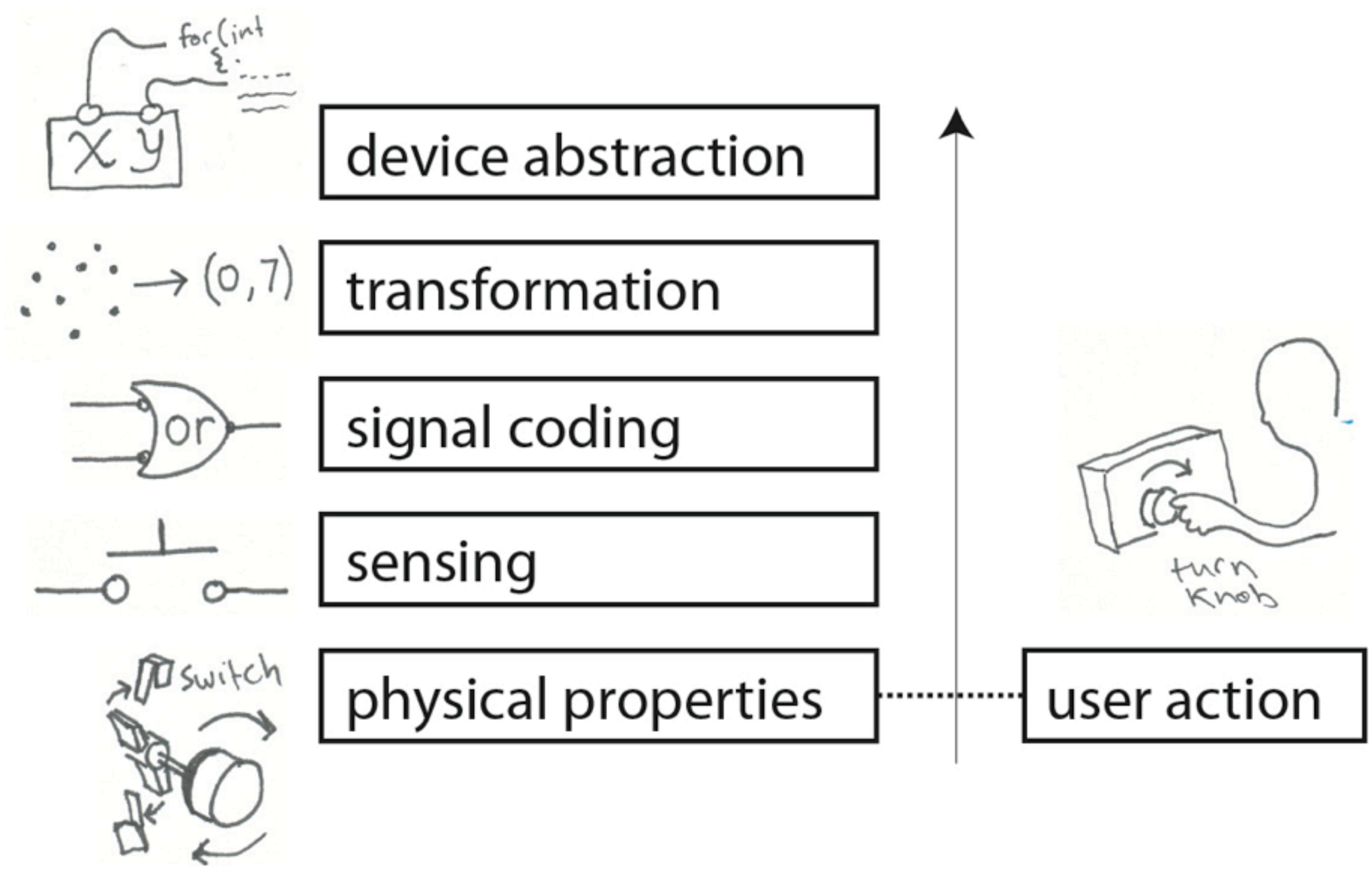
3 Keys Down



3 Keys Down



A Layered Framework



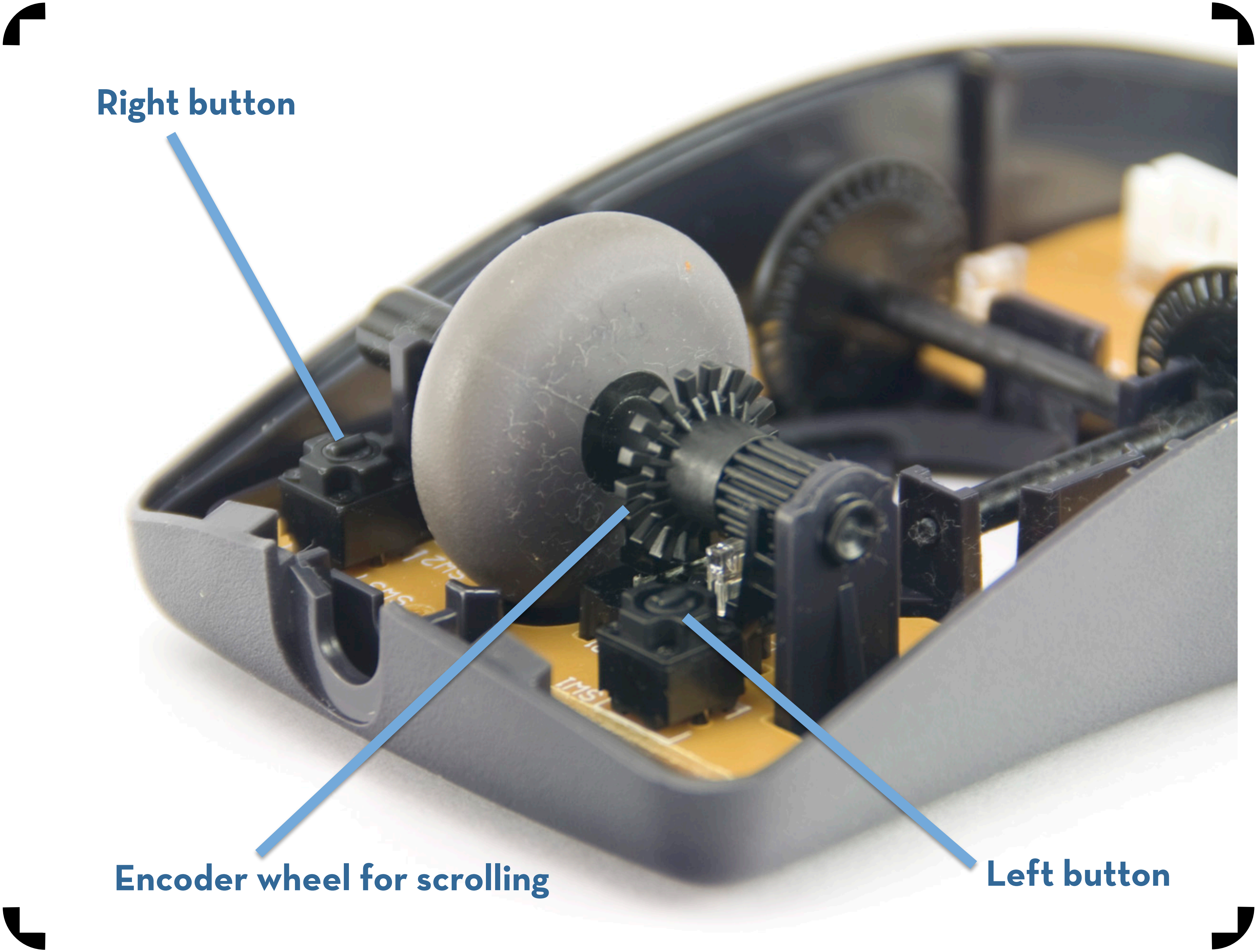
From: Hartmann, Follmer, Klemmer: Input Devices are like Onions

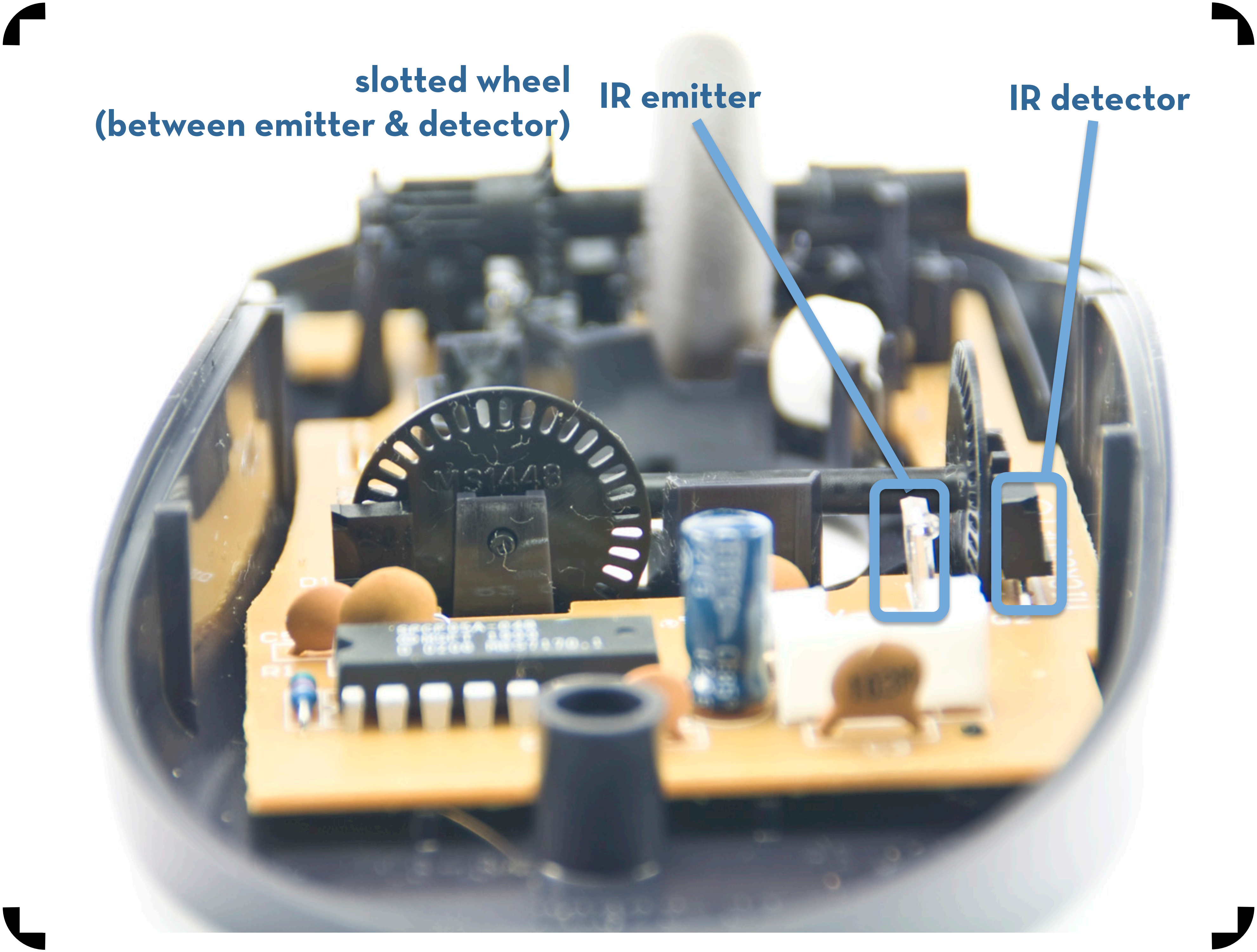
Mouse. Engelbart and English ~1964

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

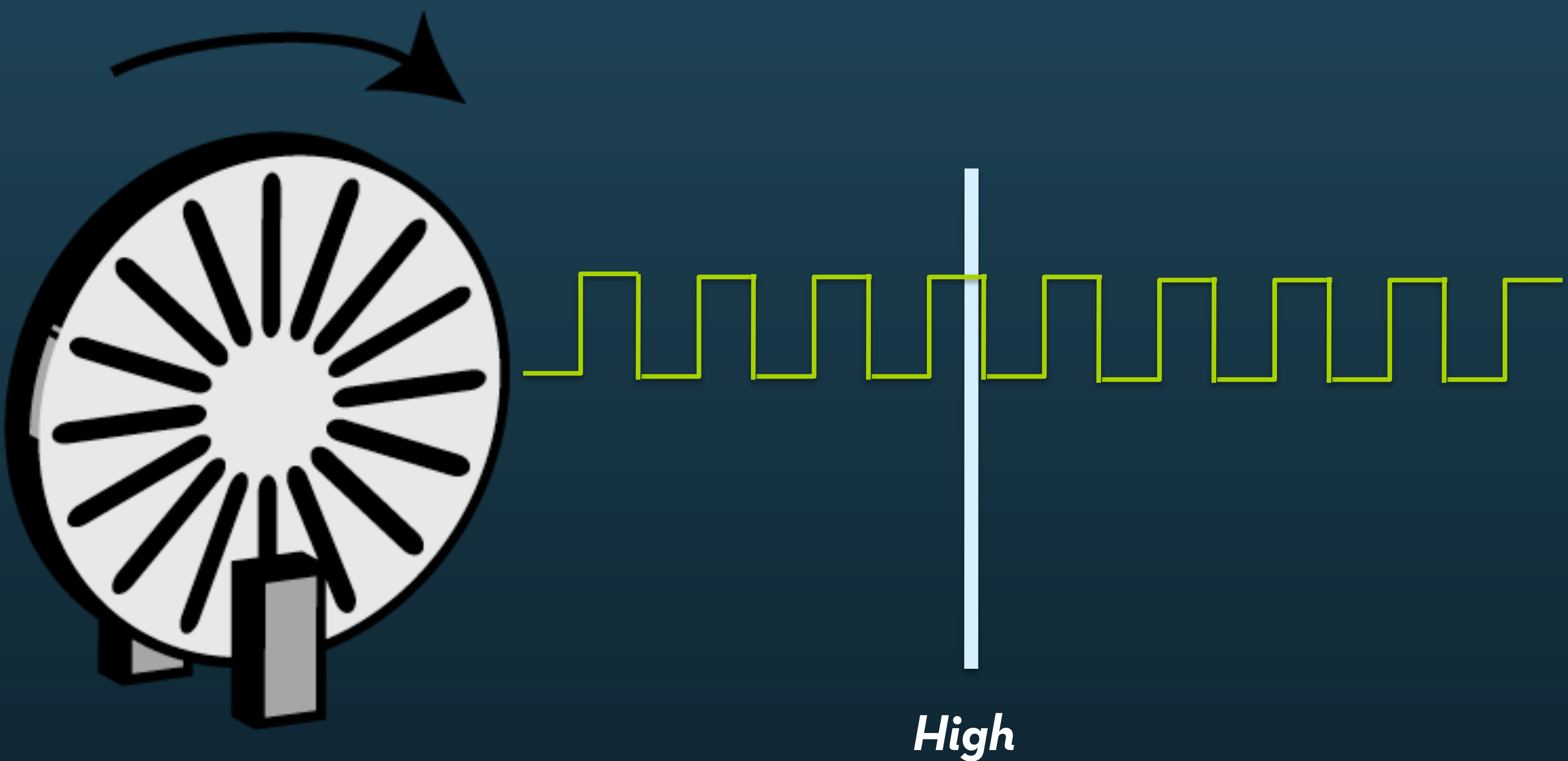

DELL
by Microsoft


SPCP05A-04B
©MSFT 1999
0 0208 MBS7170.1
94V-0
CCTC4
R2
U1
R1
C3
C6
D2
D3
Q2

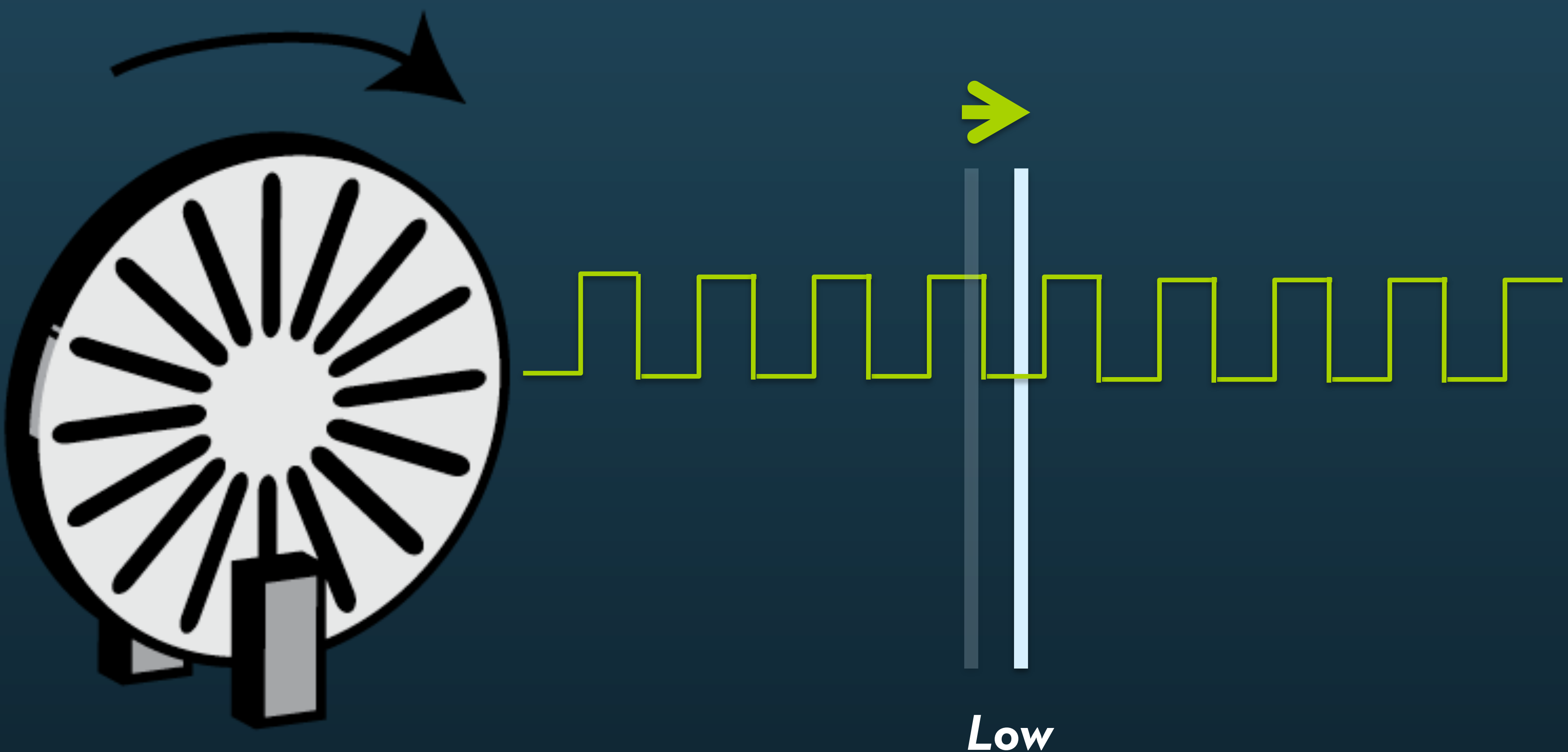

Right button
Encoder wheel for scrolling
Left button


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

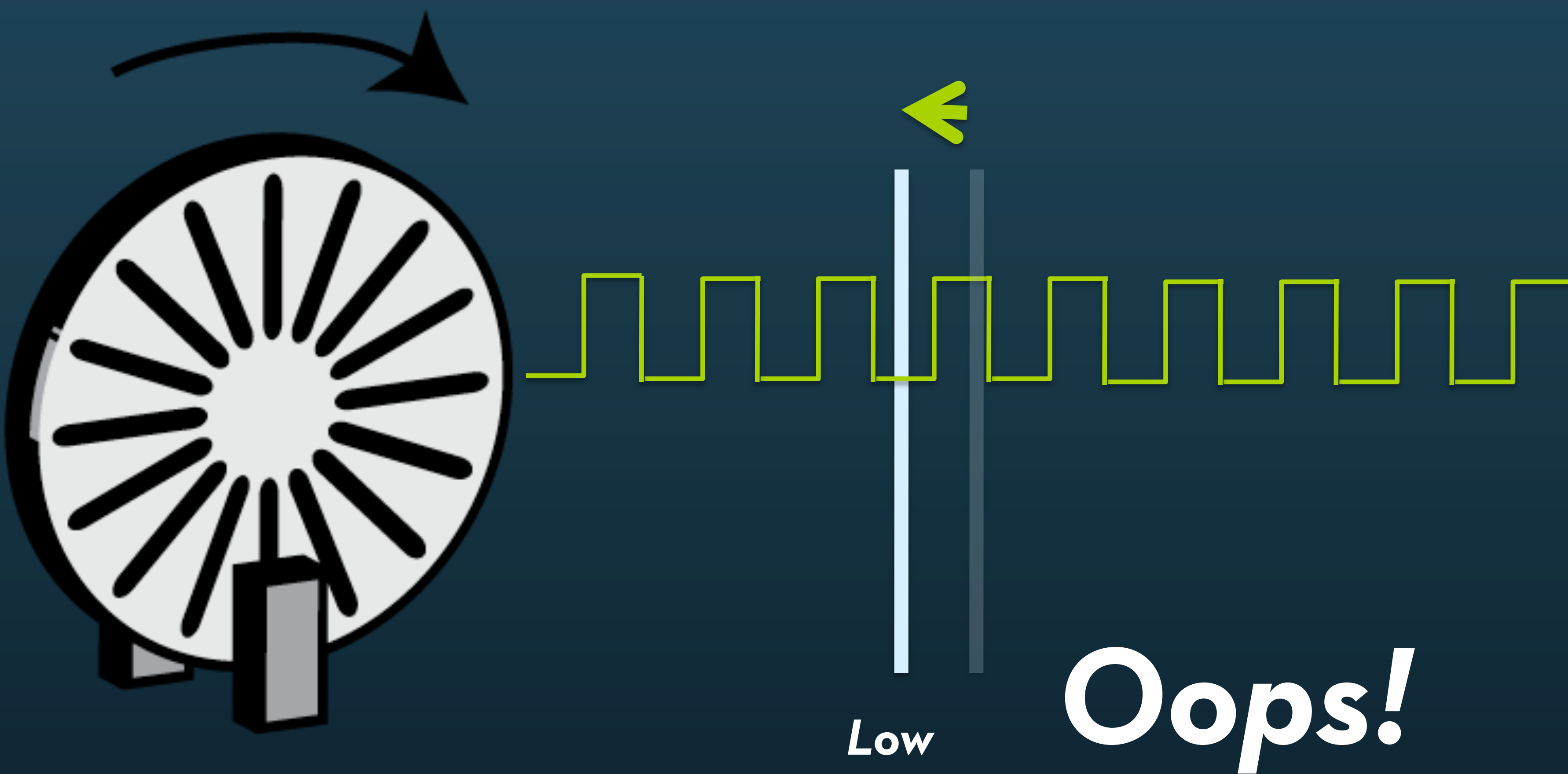
Sensing: Rotary Encoder



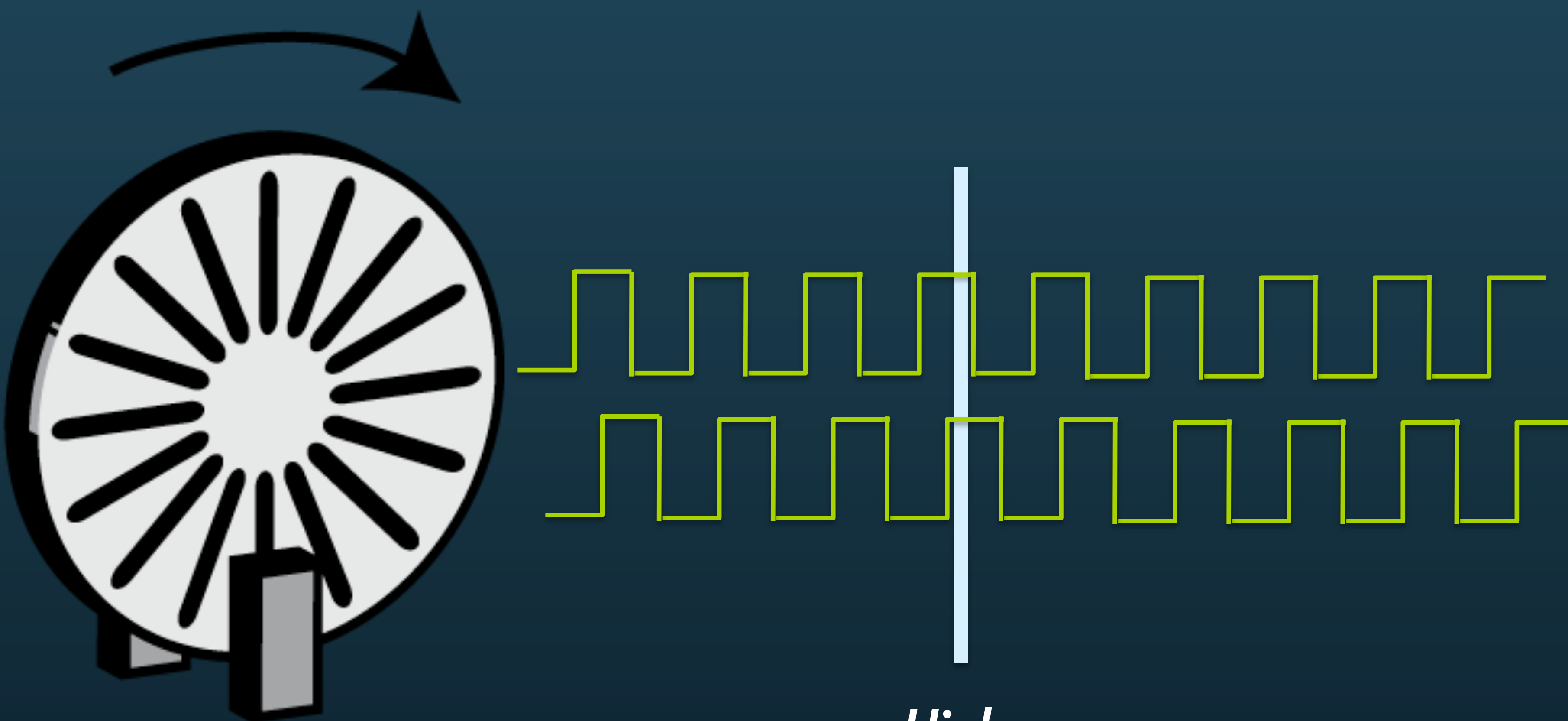
Sensing: Fwd Rotation



Sensing: Backwd Rotation



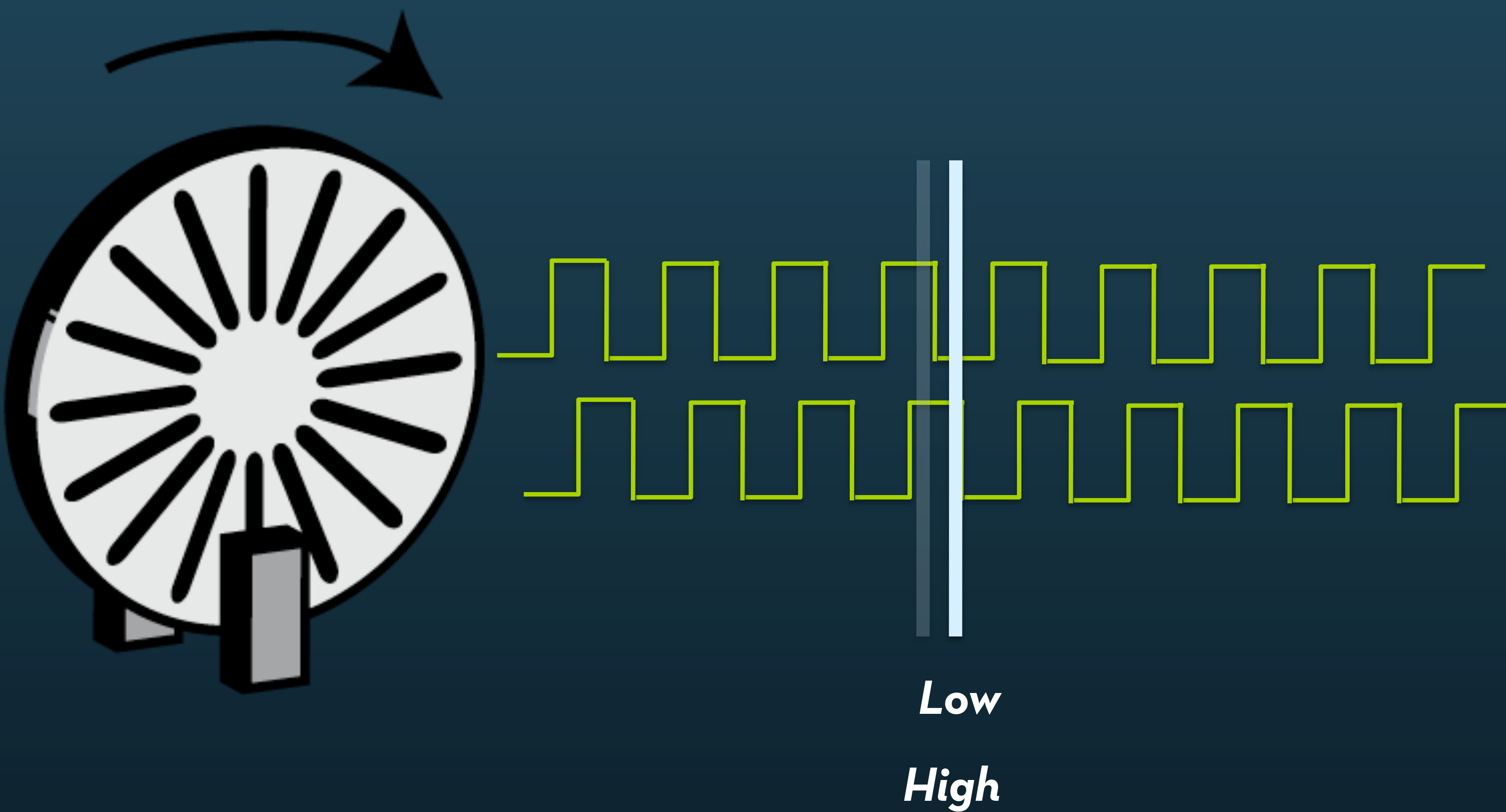
Solution: Use two out-of-phase detectors



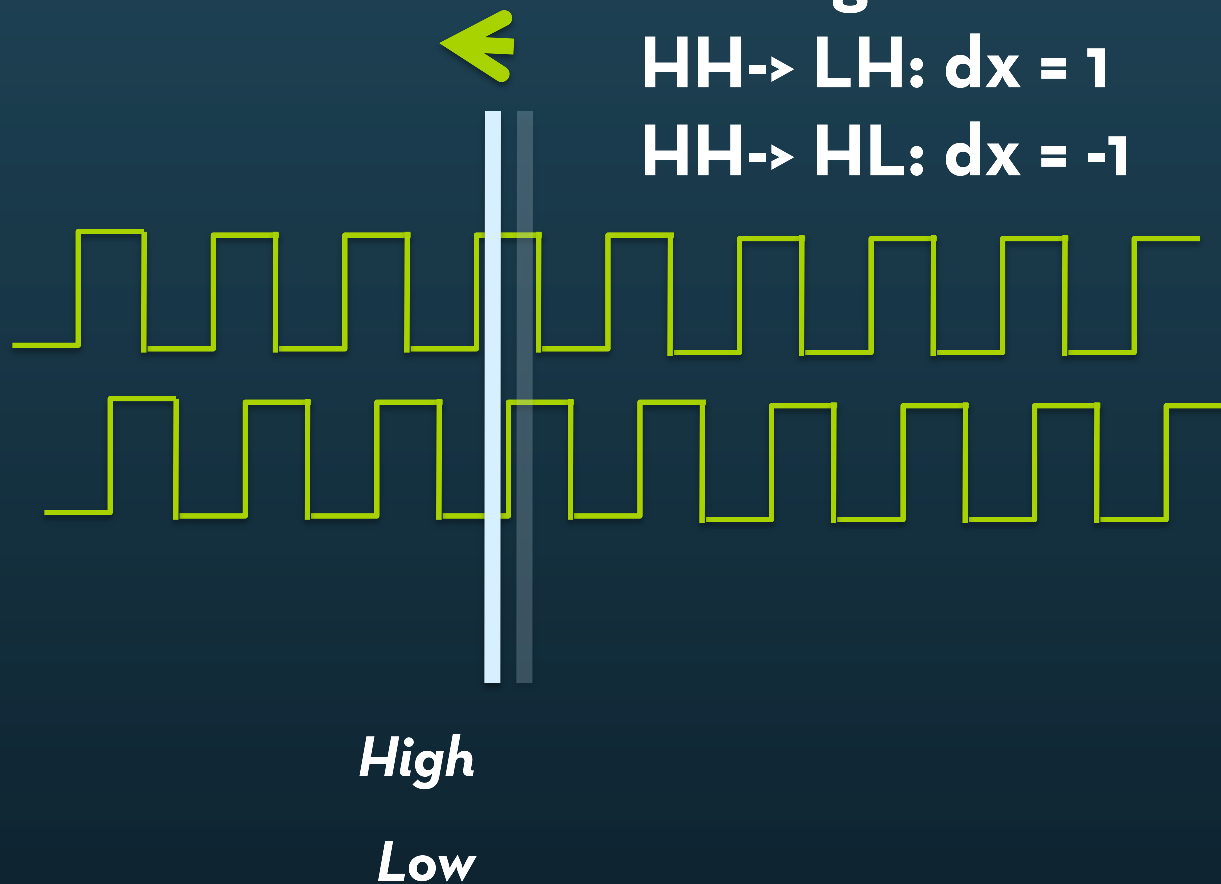
High

High

Sensing: Rotary Encoder



Sensing: Rotary Encoder



Coding:

HH-> LH: dx = 1

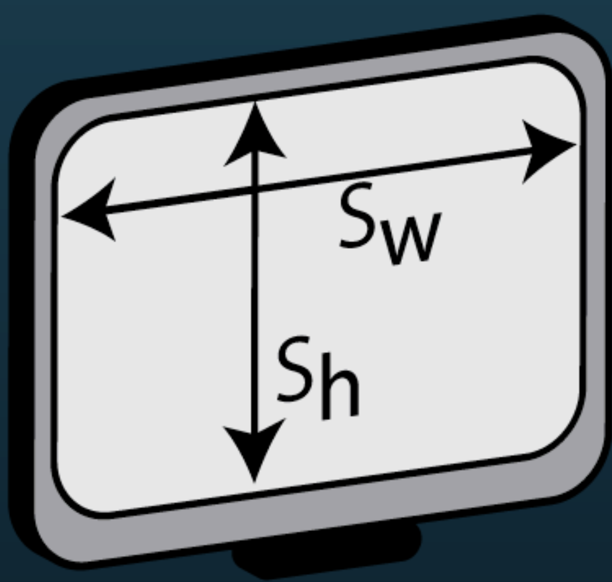
HH-> HL: dx = -1

Transformation

$$cx_t = \max(0, \min(sw, cx_{t-1}+dx*cd))$$

$$cy_t = \ldots$$

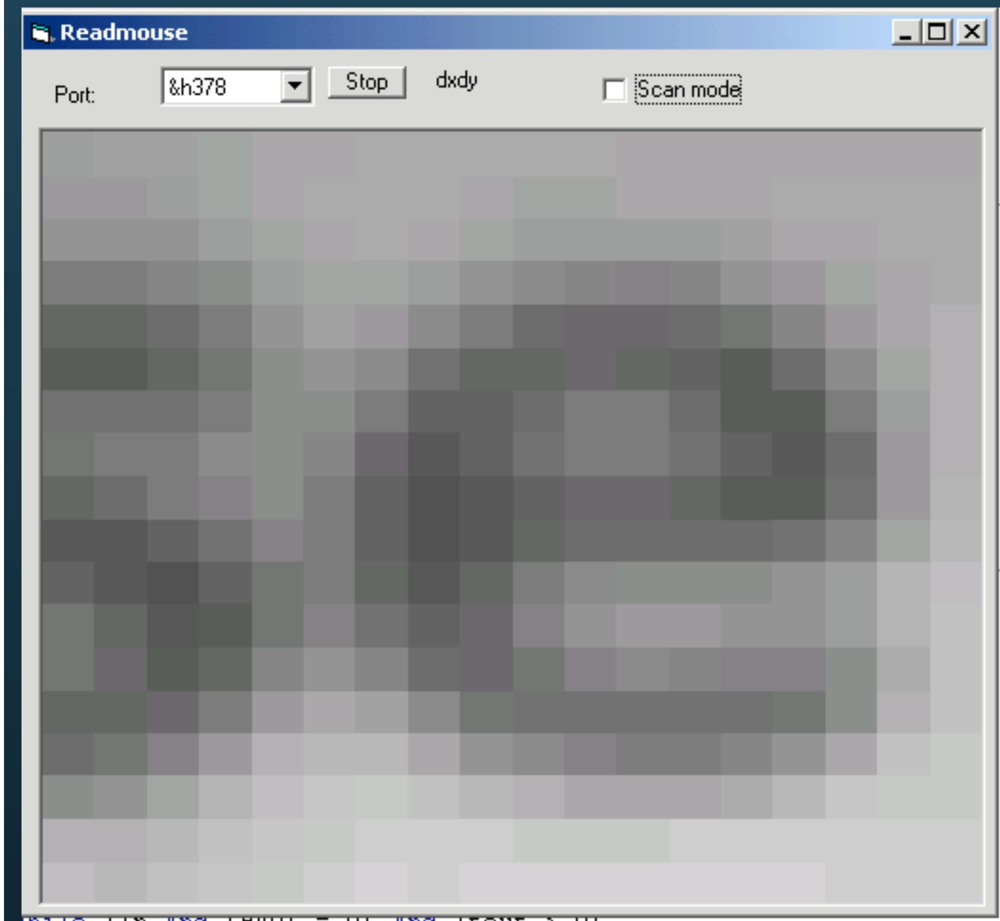
cx_t: cursor x position in screen coordinates at time t
dx: mouse x movement delta in mouse coordinates
sw: screen width
cd: control-display ratio

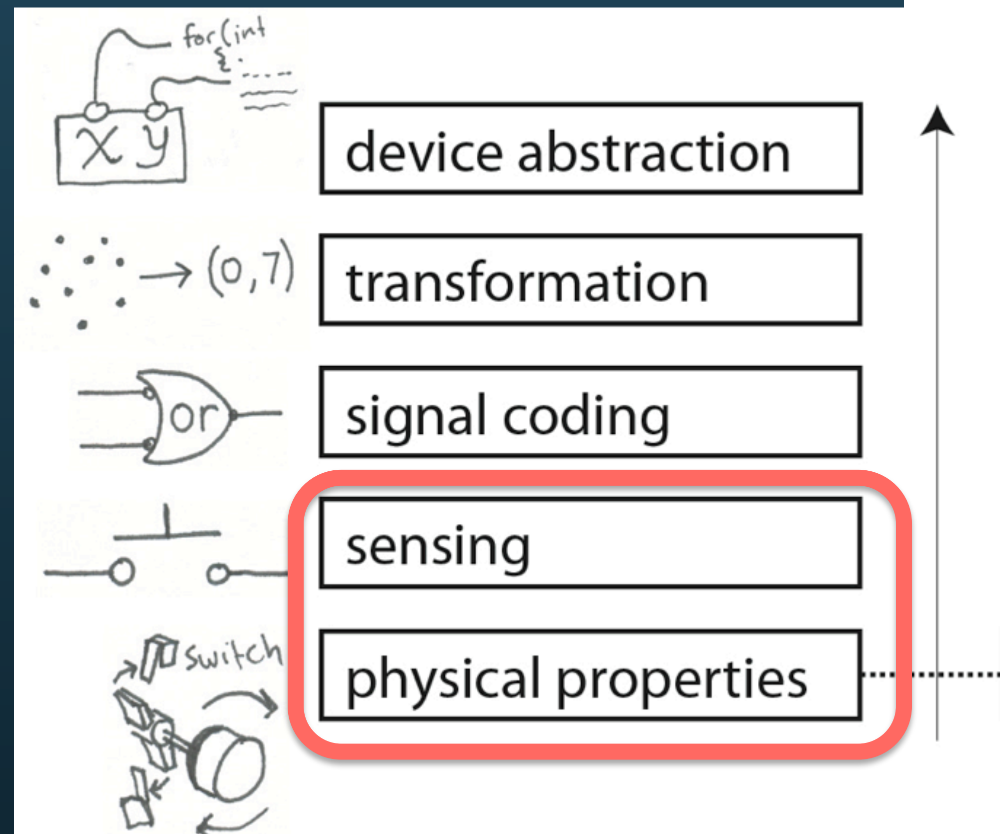


Device Abstraction

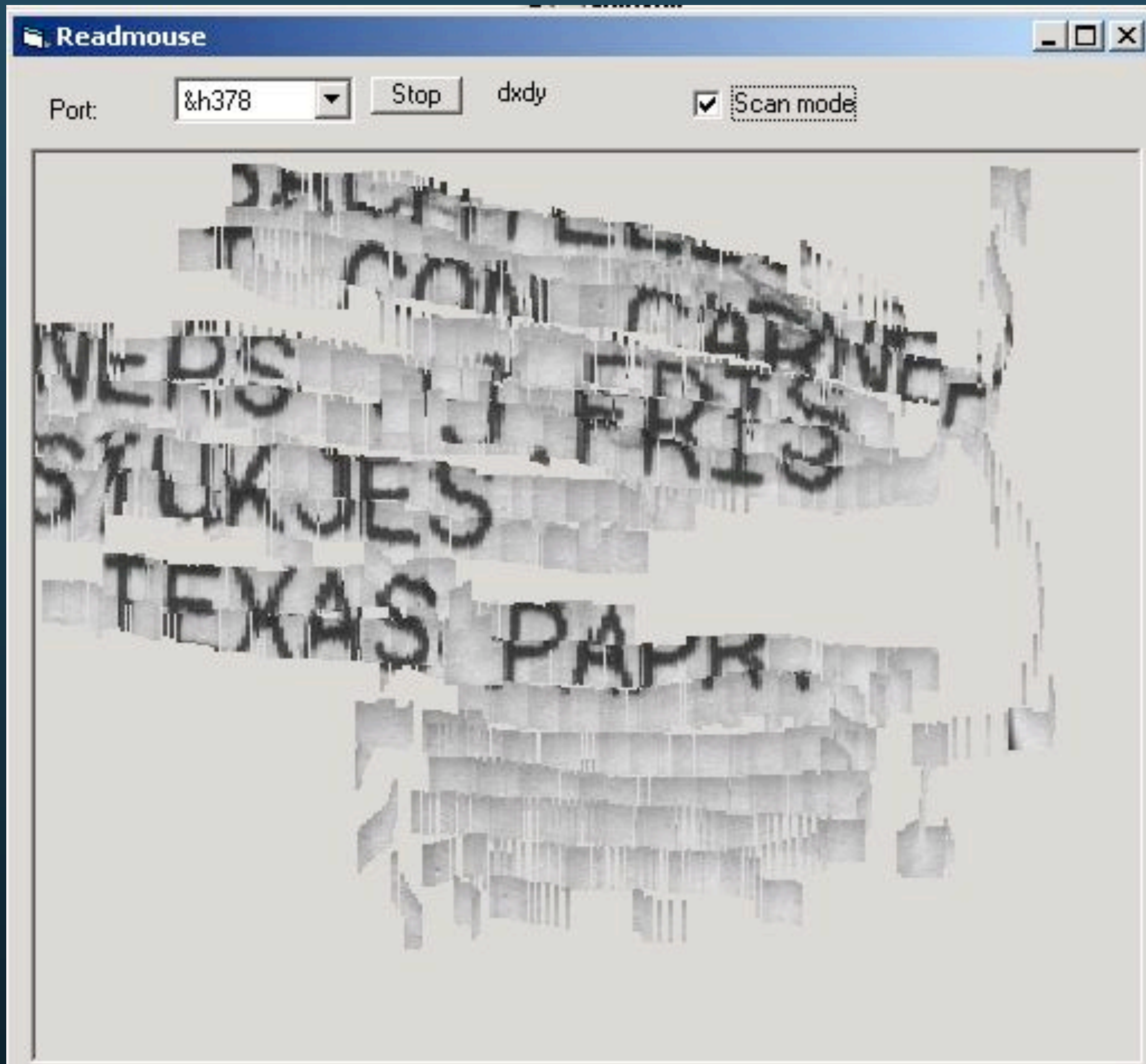
- Click, DoubleClick, MouseUp, MouseDown, MouseMove …

What about optical mice?



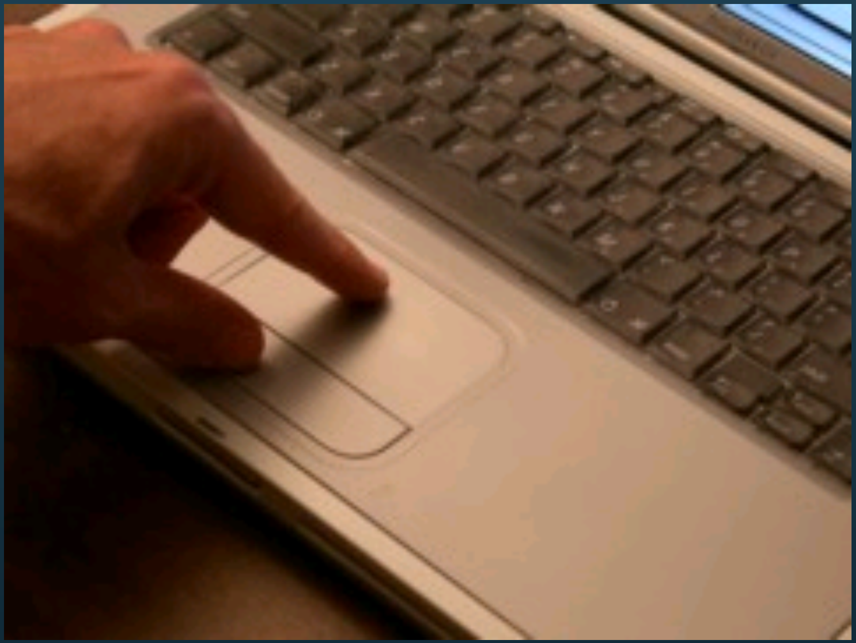


Source: http://spritesmods.com/?art=mouseeye



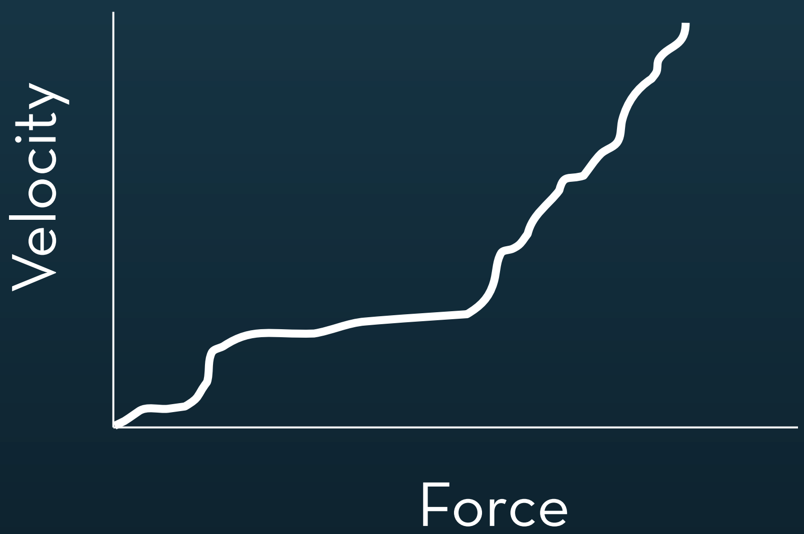
Source: http://spritesmods.com/?art=mouseeye

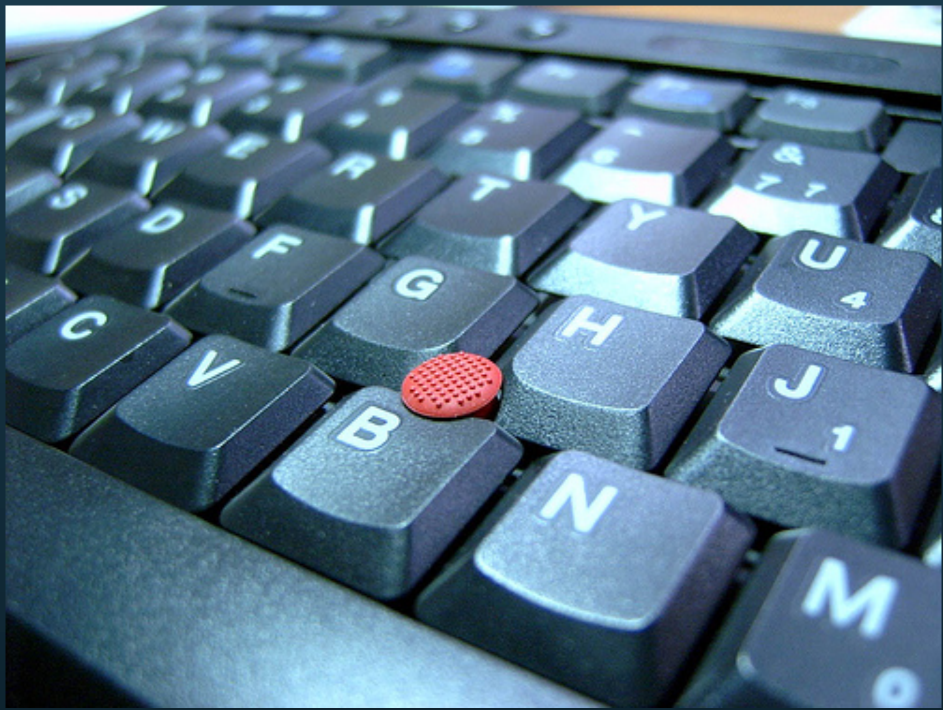
Trackball, Trackpad



Trackpoint

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





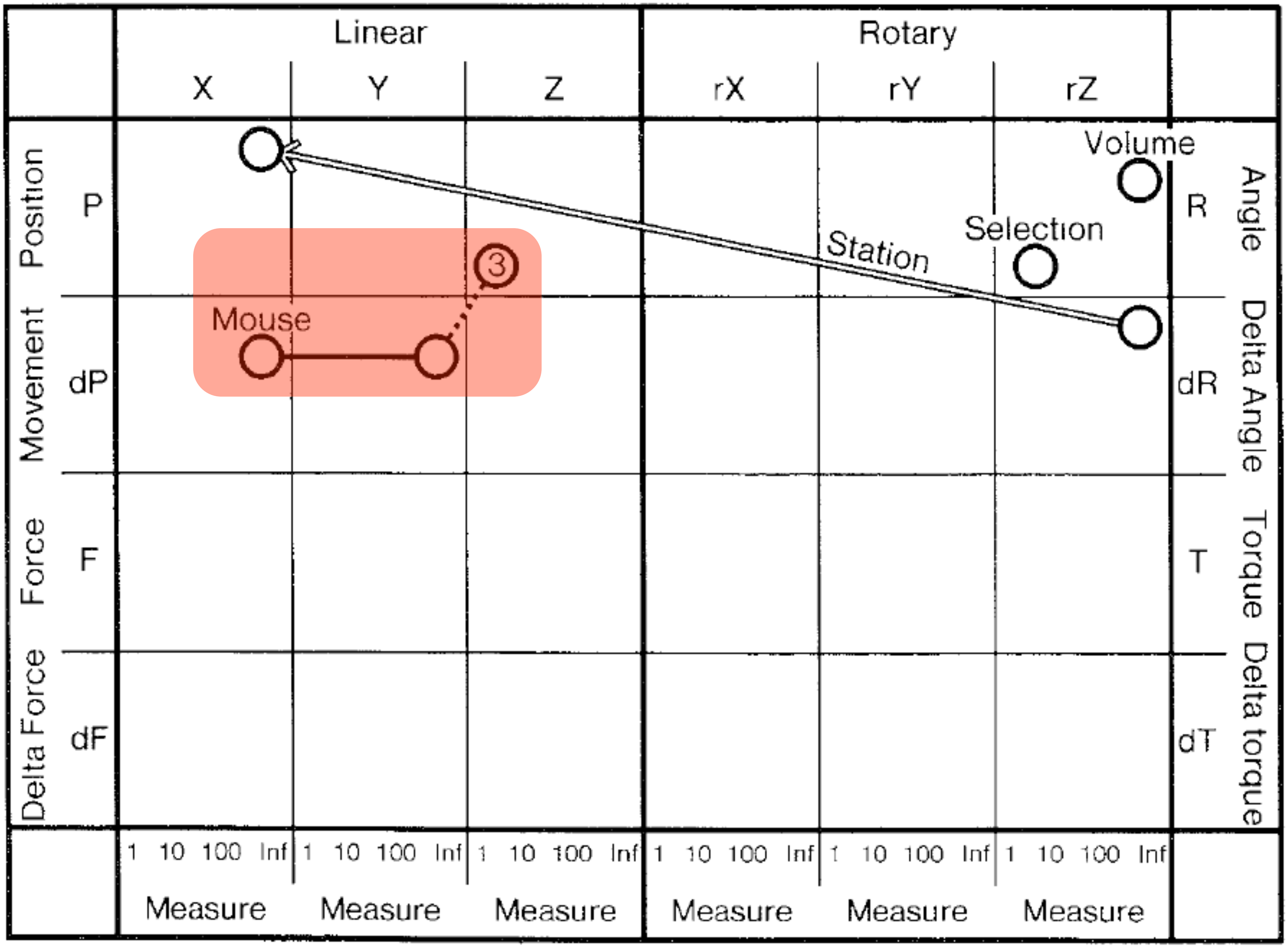
Joysticks

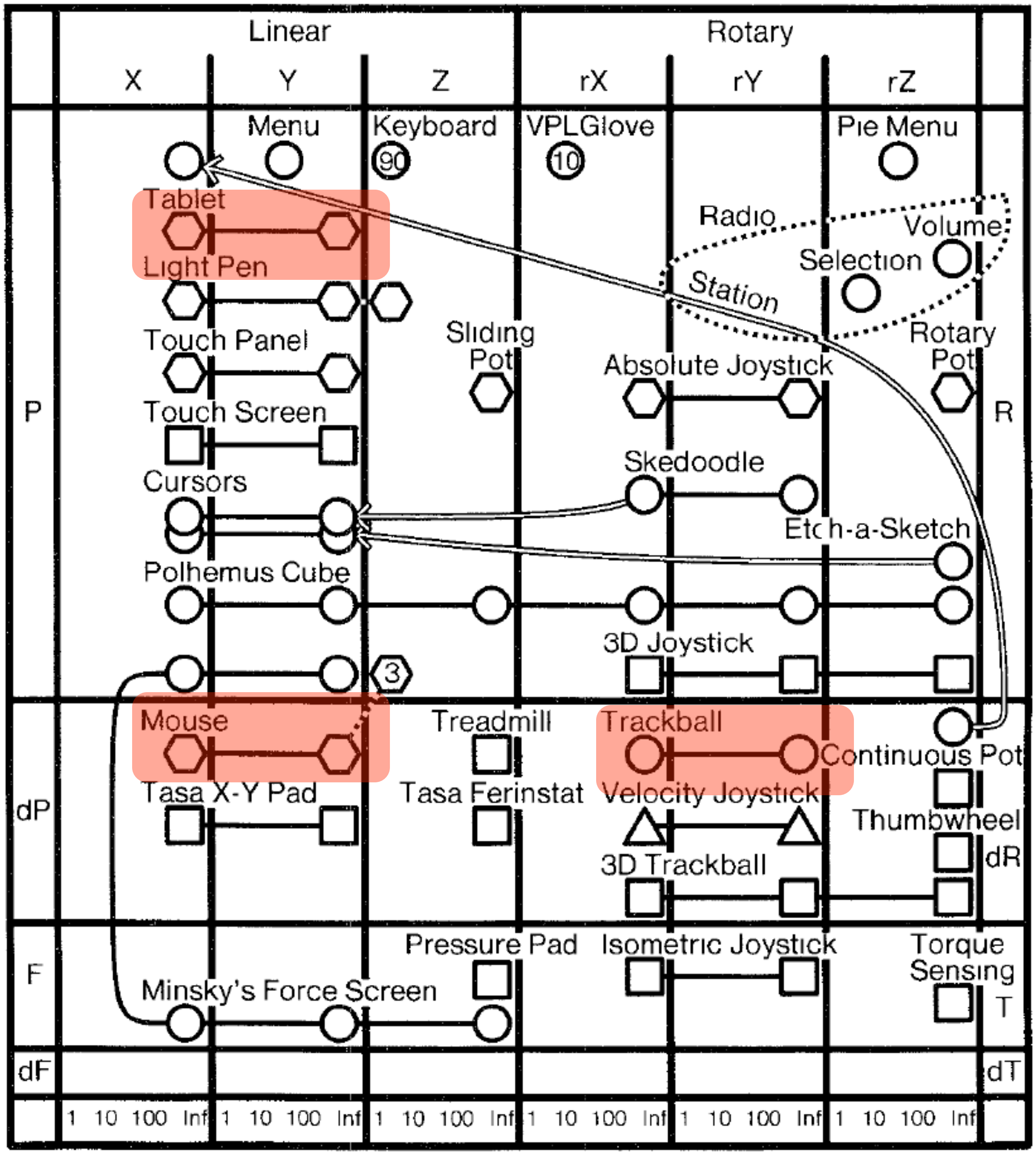
A design space of input devices…

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 TOIS* 9, 2 (Apr. 1991), 99-122.**


Linear
Rotary
X
Y
Z
rX
rY
rZ
Position
P
Movement
dP
Force
F
Delta Force
dF
Angle
R
Delta Angle
dR
Torque
T
Delta torque
dT
Volume
Selection
Station
Mouse
3
1 10 100 Inf
Measure

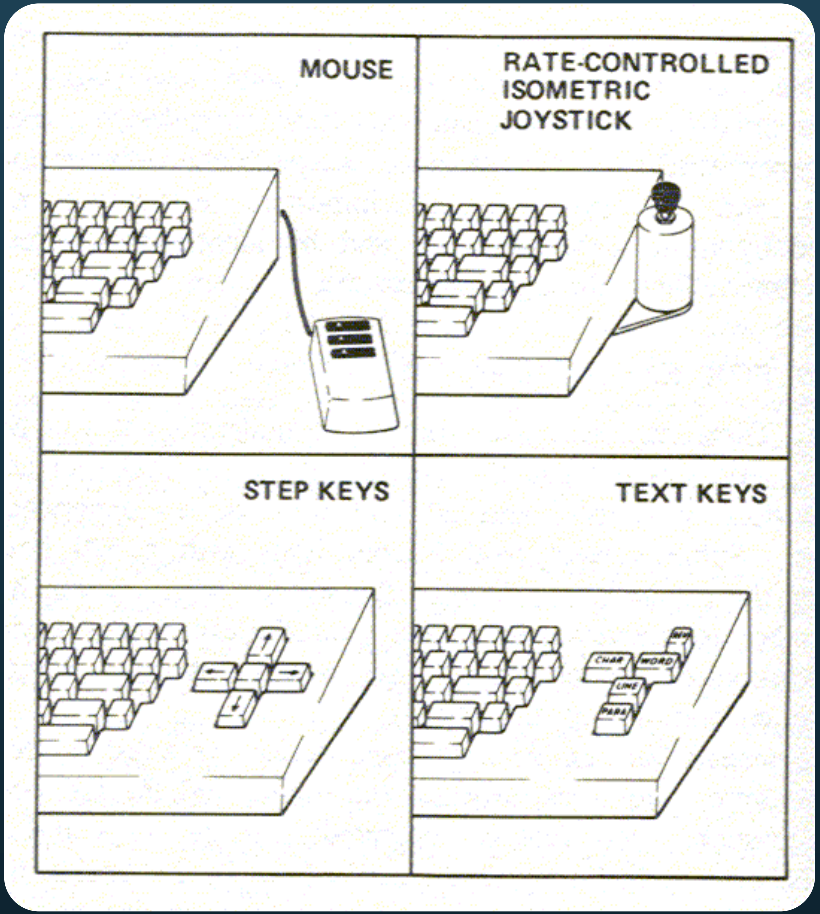

Linear
Rotary
X
Y
Z
rX
rY
rZ
Menu
Keyboard
90
VPLGlove
10
Pie Menu
Tablet
Radio
Volume
Selection
Light Pen
Station
Touch Panel
Sliding Pot
Rotary Pot
Absolute Joystick
P
R
Touch Screen
Skedoodle
Cursors
Etch-a-Sketch
Polhemus Cube
3D Joystick
3
Mouse
Treadmill
Trackball
Continuous Pot
Tasa X-Y Pad
Tasa Ferinstat
Velocity Joystick
dP
Thumbwheel
3D Trackball
dR
Pressure Pad
Isometric Joystick
Torque Sensing
F
Minsky's Force Screen
T
dF
dT
1 10 100 Inf
1 10 100 Inf
1 10 100 Inf
1 10 100 Inf
1 10 100 Inf
1 10 100 Inf

Which is faster?

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

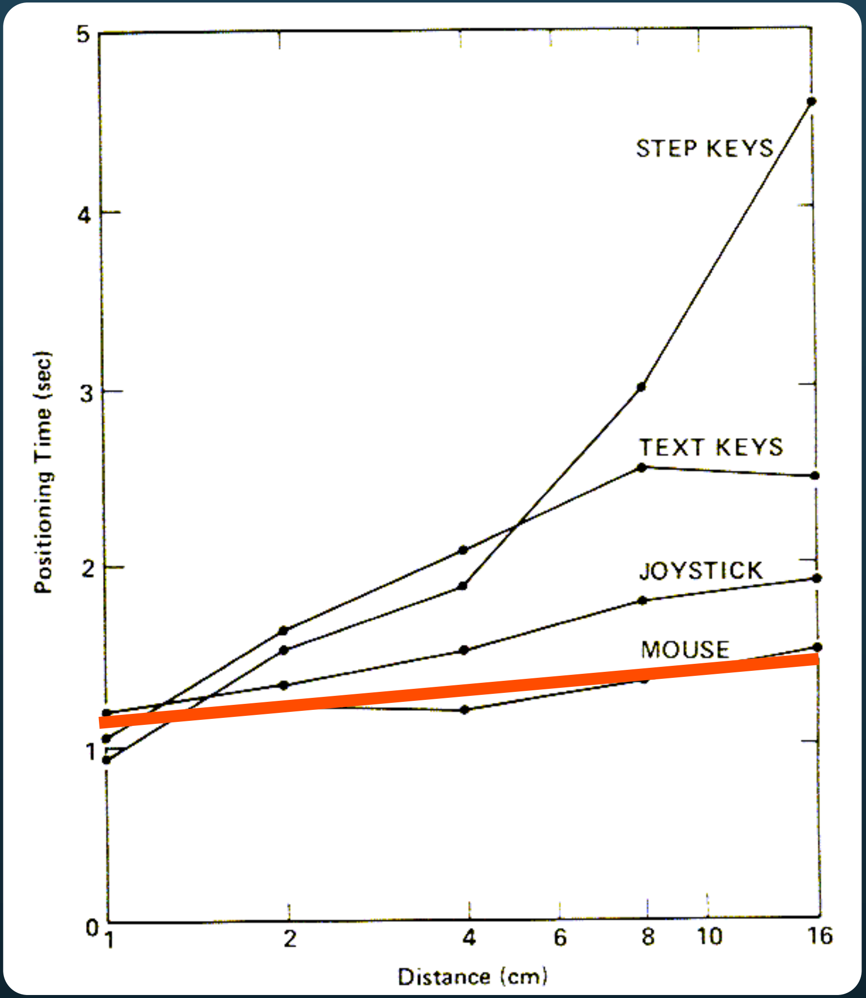
Which is faster?

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.

Exam Question Material!

Fitts' Law

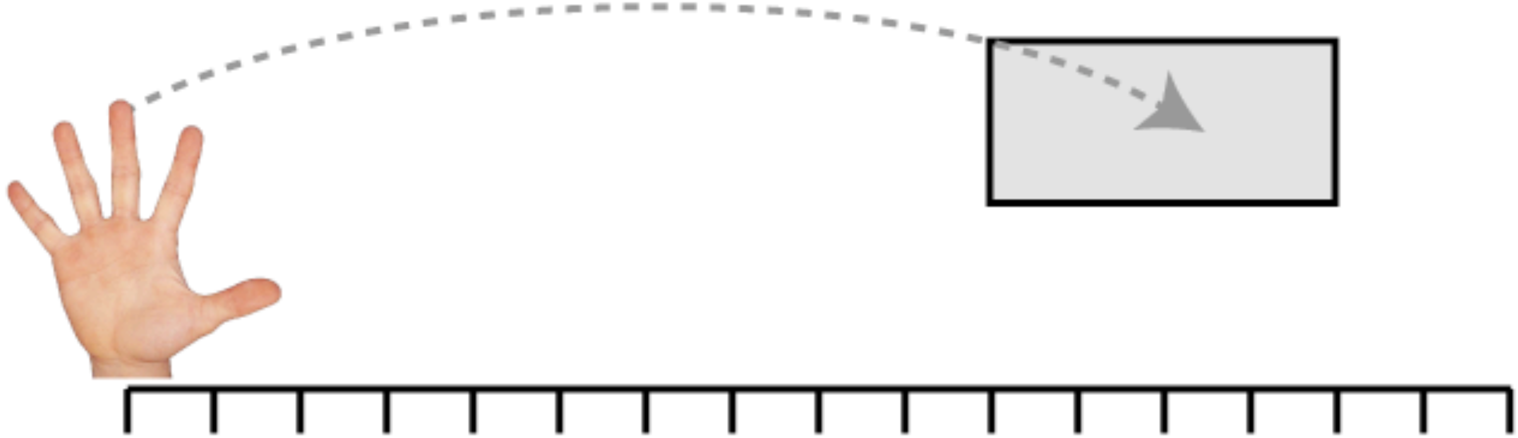
- Time T_{pos} to move the hand to target size S which is distance D away is given by:

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

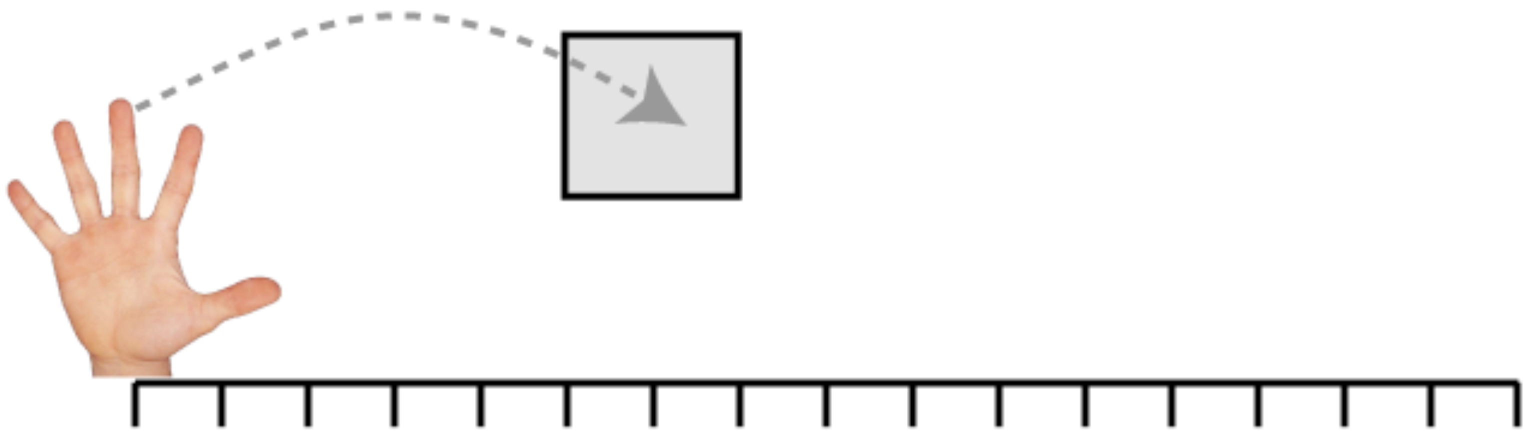
Only ***relative precision*** matters

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

S = 4, D = 12



S = 2, D = 6



Exam Question Material!

Fitts' Law

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

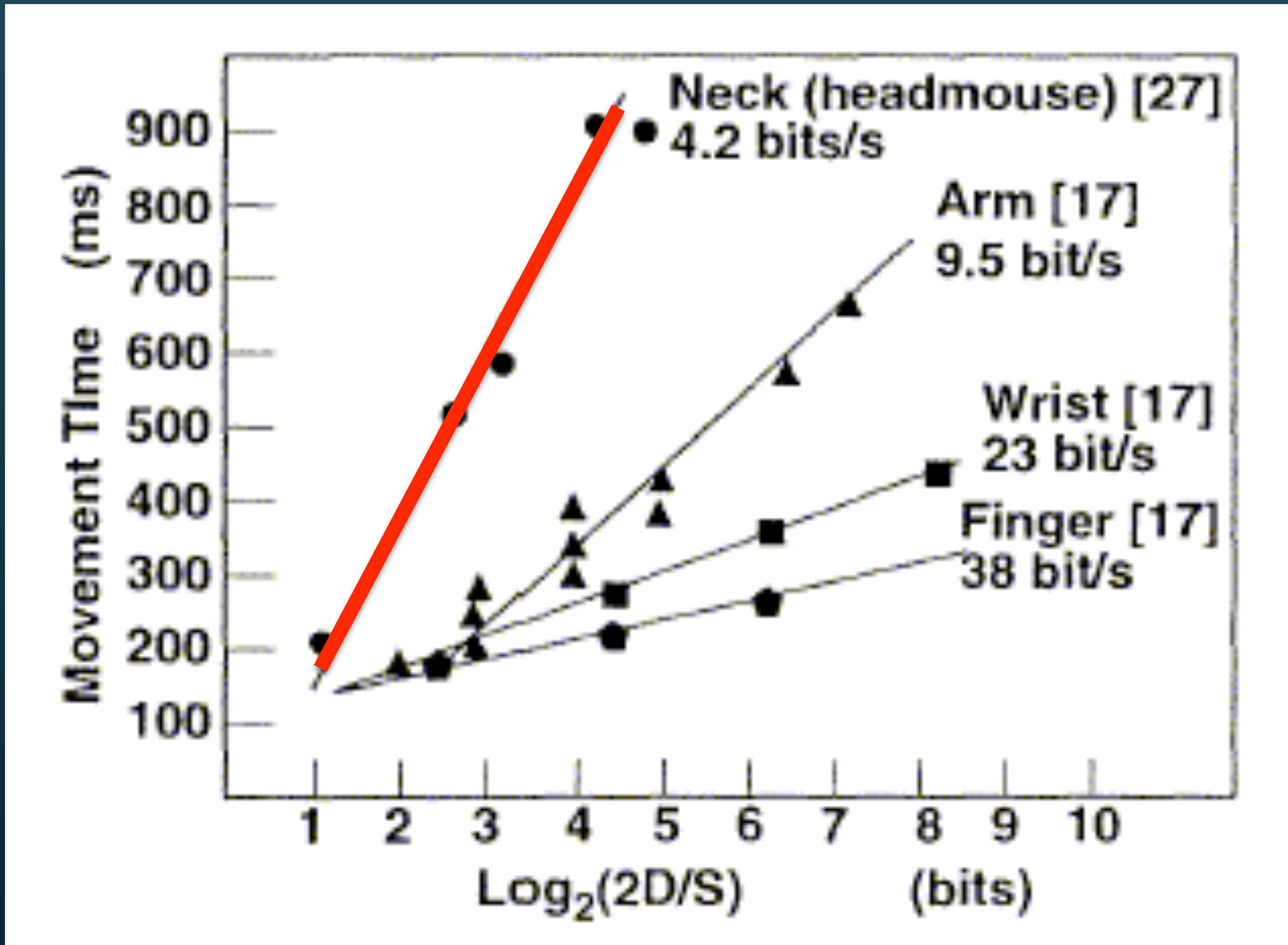
$$T_{pos} = \underbrace{a + b}_{} \log_2 (D/S + 1)$$

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

a: start/stop time
b: speed

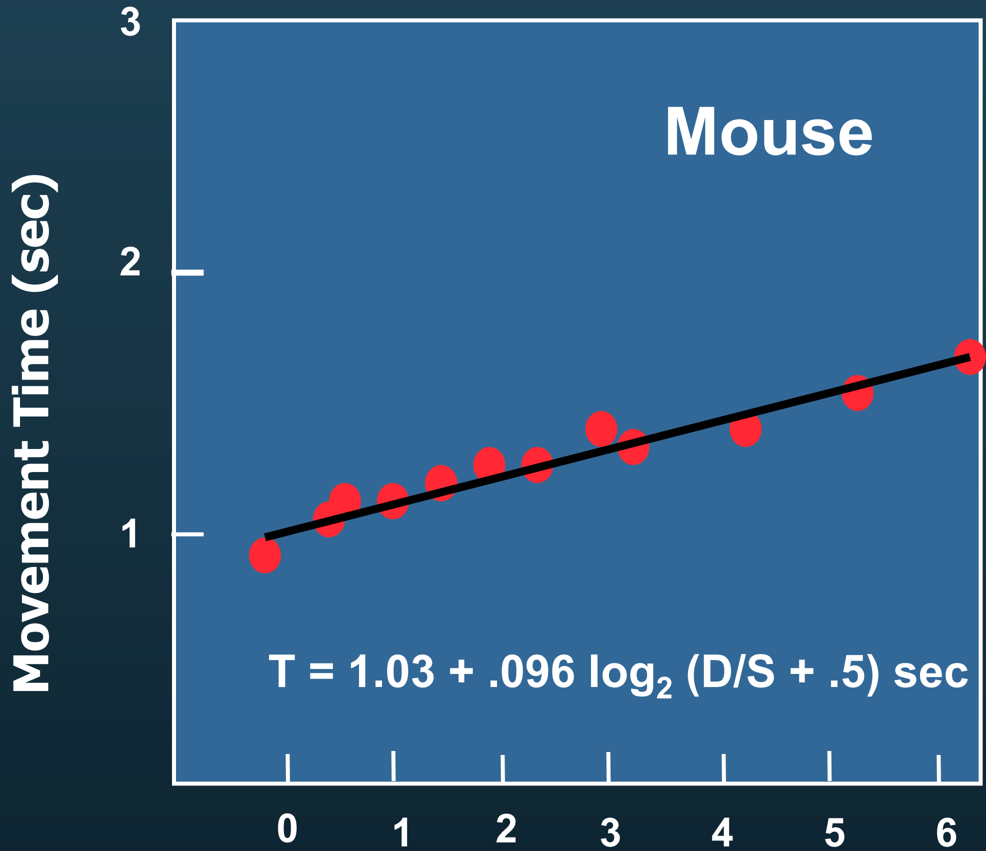
Source: Landay, James. "Human Abilities". CS160 UC Berkeley.

Bandwidth of Human Muscle Groups



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

Why is the mouse fastest?



$I_D = \log_2 \; (\text{Dist/Size} + .5)$

Why these results?

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

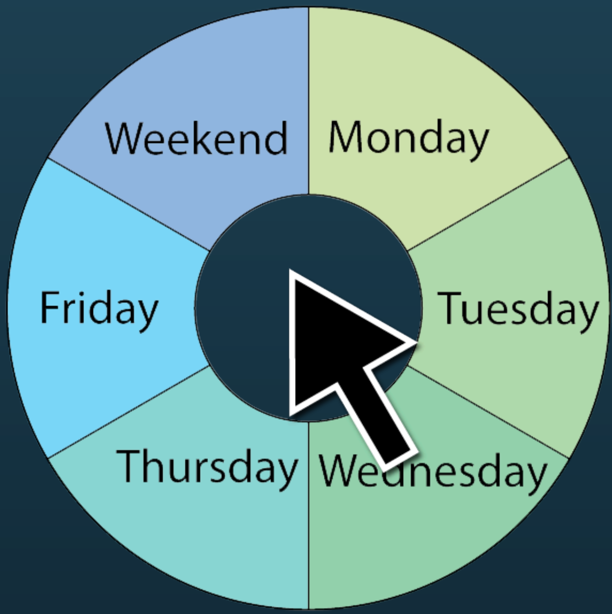
[i.e. how well can the muscles direct the input device]

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

Therefore, mouse is a near optimal device.

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

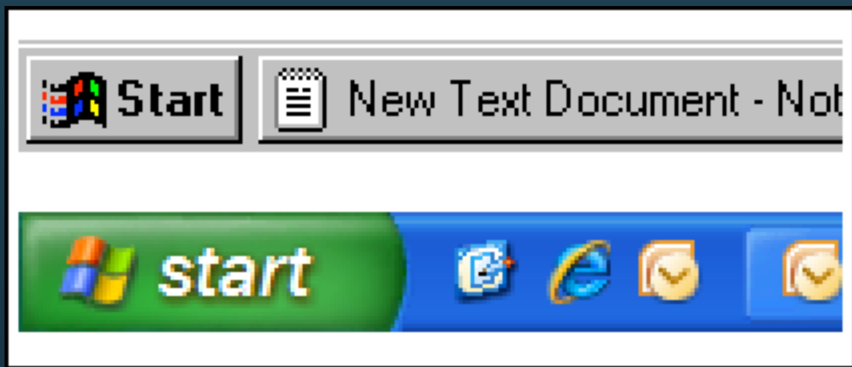
Fitts' Law Example



- 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

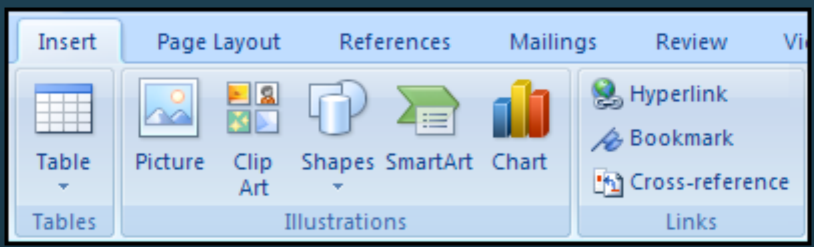


Windows 95: Missed by a pixel
Windows XP: Good to the last drop

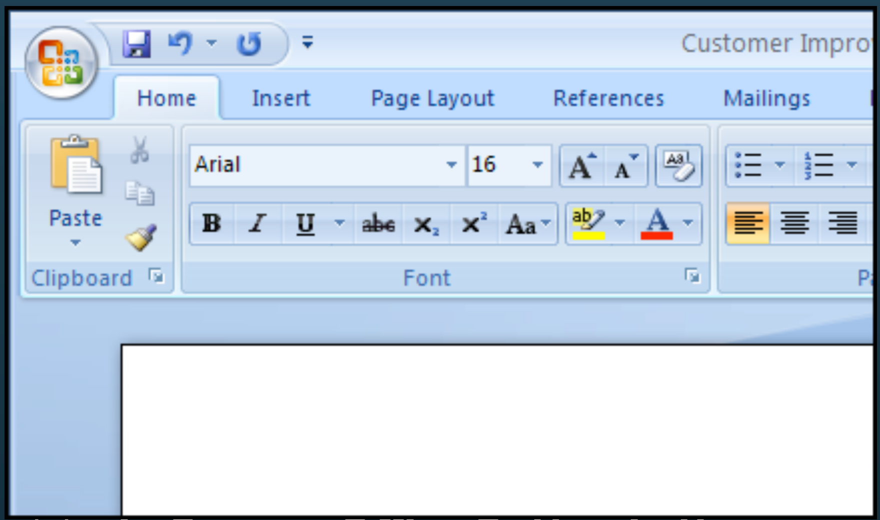
The Apple menu in Mac OS X v10.4 Tiger.

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

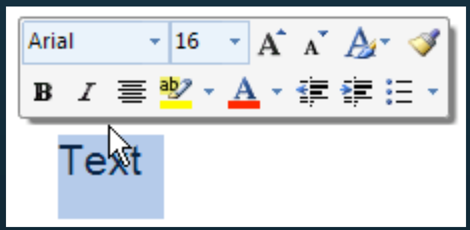
Fitts' Law in Microsoft Office 2007



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.

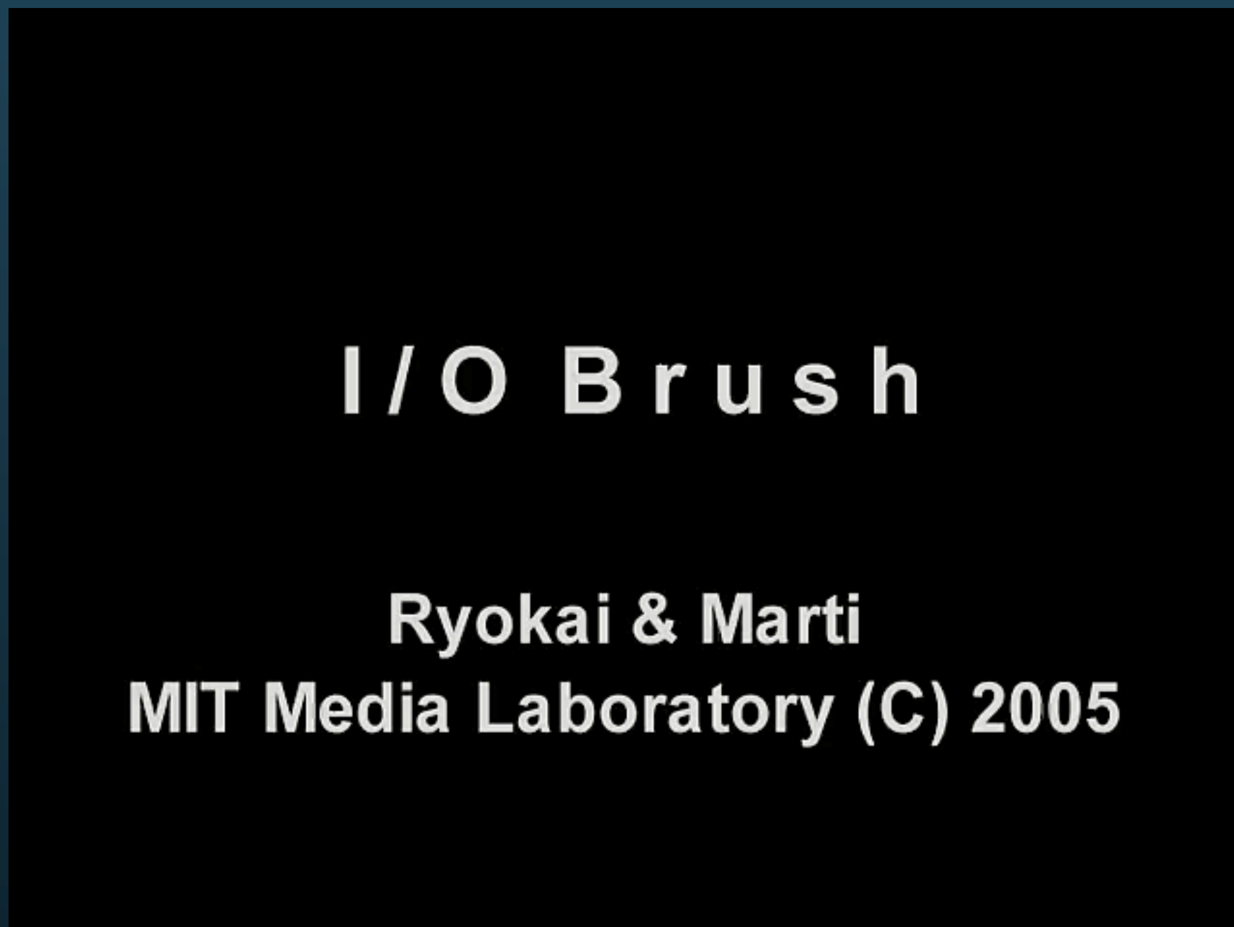
Uncommon Input Devices

- Assumptions so far:
  - Single user, working in front of a desktop PC
  - Main tasks are typing and pointing
  - Efficiency rules
- What if we change these assumptions?
  - Design for enjoyment / engagement
  - Design for multi-user scenarios

Position+Orientation: Nintendo Wii

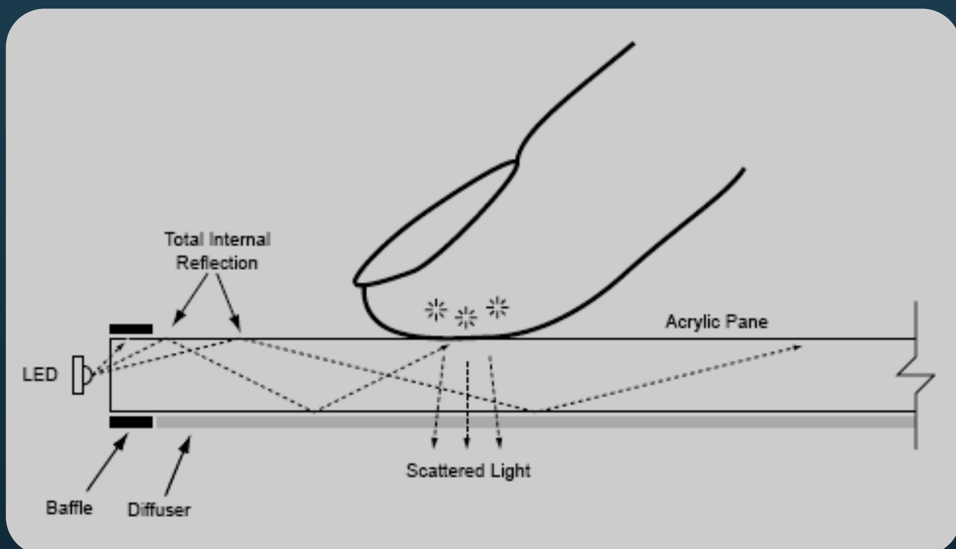
Source: Nintendo, us.wii.com

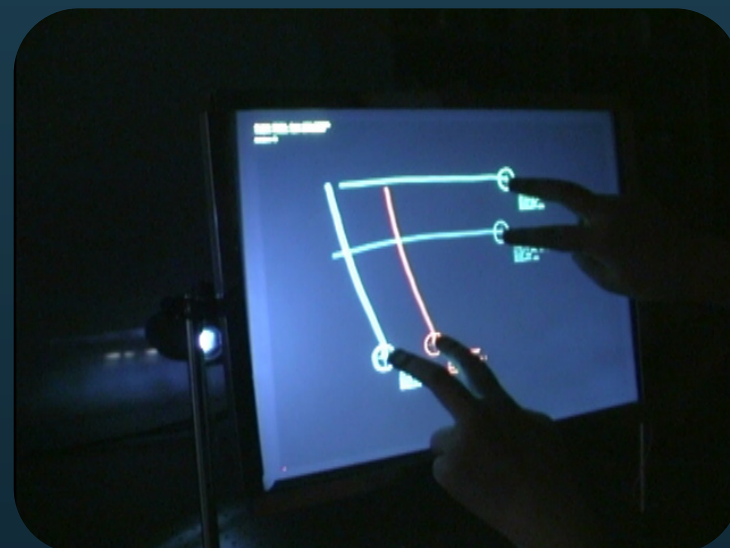
Camera-based input: IO Brush



Source: Kimiko Ryokai, http://web.media.mit.edu/~kimiko/iobrush/

Multi-touch





Jeff Han, Perceptive Pixel

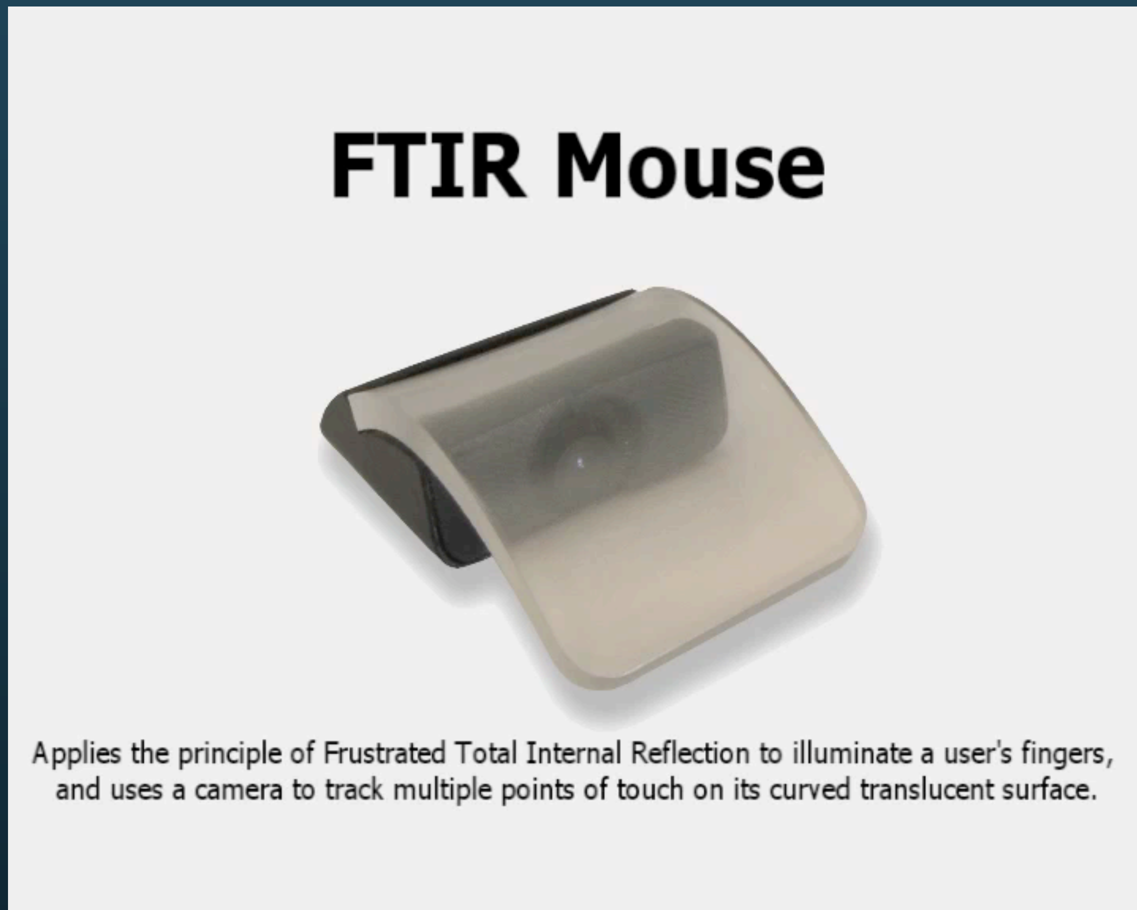
Hybrids: Devices on Tables

Hartmann, Björn, Morris, M.R., Benko, H., and Wilson, A.
Augmenting Interactive Tables with Mice & Keyboards. In Proceedings of UIST 2009.

Hybrids: Devices on Tables

Hartmann, Björn, Morris, M.R., Benko, H., and Wilson, A.
Augmenting Interactive Tables with Mice & Keyboards. In Proceedings of 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.

http://**bjoern.org**