Input Devices

text input, positional input, (and gestural)

MacBook Wheel (The Onion)
- https://youtu.be/9BnLbv6QYcA

iPod Wheel

Dimensions to Classify Computer Input

- Sensing Method
  - mechanical (e.g. switch, potentiometer)
  - motion (e.g. accelerometer, gyroscope)
  - contact (e.g. capacitive touch, pressure sensor)
  - signal processing (e.g. computer vision, audio)
- Continuous vs. Discrete
- Degrees of Freedom (DOF)

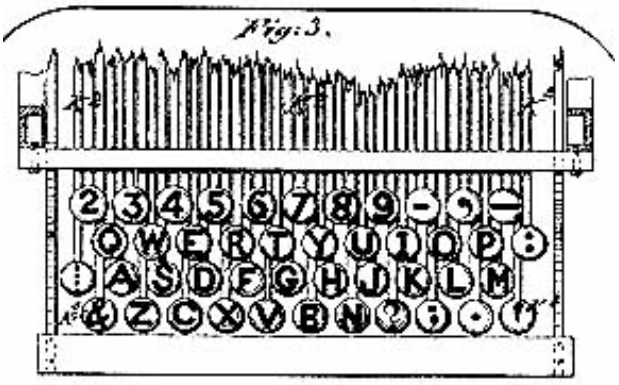
Specific vs. General Input Devices

- Specific input devices optimized for specific tasks
  - Problems?
- General input devices adapted to many task
  - Problems?

The keyboard

Typewriters and QWERTY

- QWERTY not designed to slow typing down → designed to space “typebars” to reduce jams and speed typing up



1874 QWERTY patent drawing


THE FIRST COMMERCIAL TYPEWRITER
MODEL 1 REMINGTON, SHOP NO. 1.

http://www.daskeyboard.com

Perceived Qwerty Problems

- common combinations require awkward finger motions. (eg: tr)
- common combinations require a jump over home row. (eg: br)
- common combinations are typed with one hand. (e.g. was, were)
- most typing with the left hand
- about 16% of typing uses lower row, 52% top row, 32% home row

DVORAK

- Alternative layout for two-handed keyboard

Dvorak

Qwery

Dvorak Typing Movement Optimizations

- Letters should be typed by alternating between hands
- For maximum speed and efficiency, the most common letters and digraphs should be the easiest to type. Thus, about 70% of keyboard strokes are on home row.
- The least common letters should be on the bottom row, which is the hardest row to reach.
- The right hand should do more of the typing, because most people are right-handed.

Qwerty vs. Dvorak

- Corrections … ?
  - Problems are frequently perceived versus actual, and are based on a naïve model of typing
  - Example: When you leave the home row, it can be good to stay off the home row
- Speed differences?
  - In studies, sometimes DVORAK a bit faster, sometimes QWERTY a bit faster
  - This implies *no significant difference*
  - http://home.earthlink.net/~dcrehr/whyqwert.html

August Dvorak

Mechanical Design of Keyboards

- To increase portability of devices, keyboards are frequently downsized: low-profile keys, smaller keys
- All interfere with typing
- Much more significant problem than Dvorak vs Qwerty keyboards

“Virtual” Keyboards

- Touch screen or other flat surface
- Problems:
  - small keys reduce accuracy
  - no mechanical feedback makes it hard to tell if key was pressed
  - no tactile feedback makes it hard to find the home row
  - resting of hands difficult
- Advantage:
  - portable, no extra hardware
  - customizable keys (e.g. new language, symbols, emojis)
  - customizable layout or functionality (e.g. swipe, thumb layout)

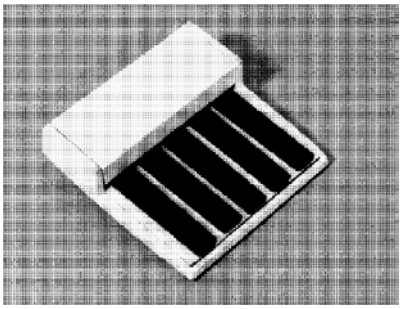

iPhone

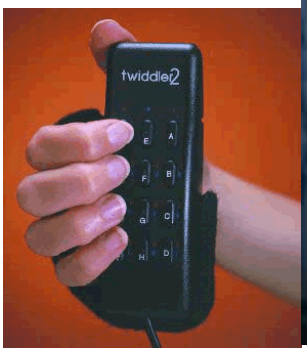

z10


iPad

Chording Keyboards

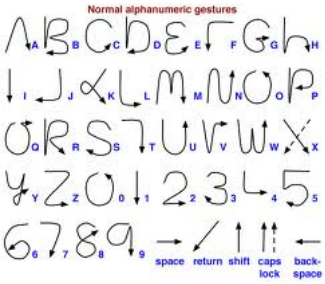
- Englebart’s NLS Keyboard
  - Multiple keys together produce letter
  - No “targeting”, potentially very fast
  - Can be small and portable
  - One handed
- Thad Starner’s Twiddler
  - for wearable computing input

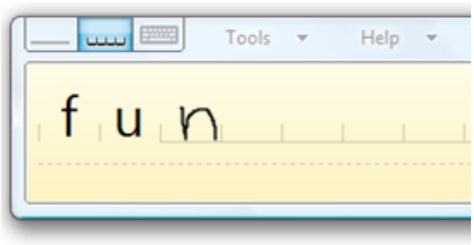




Text Recognition and Gestures

- Graffiti/Unistroke Gestures
  - map single strokes to “enter letter” commands
- Natural Handwriting recognition
  - dictionary-based classification algorithms

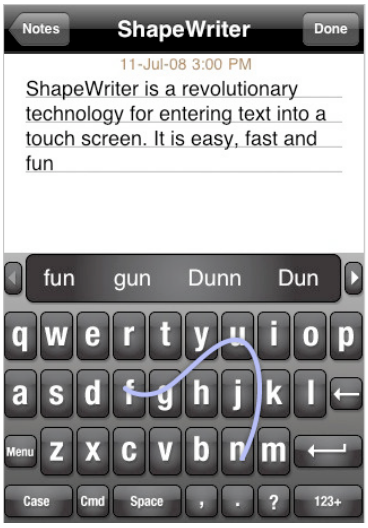




Predictive Text

- Use language characteristics to predict input
  - Given characters typed so far, what are the most likely intended words?
  - Given words typed so far, what is the most likely word to follow?
- A variation is used for T9, nine-key text entry
  - Given an ambiguous set of characters, what is the most likely word
- Possible Problems
  - “collisions” between common words
  - entering words not in dictionary difficult
  - hard to focus on typing and monitoring prediction

Gestural Text Input



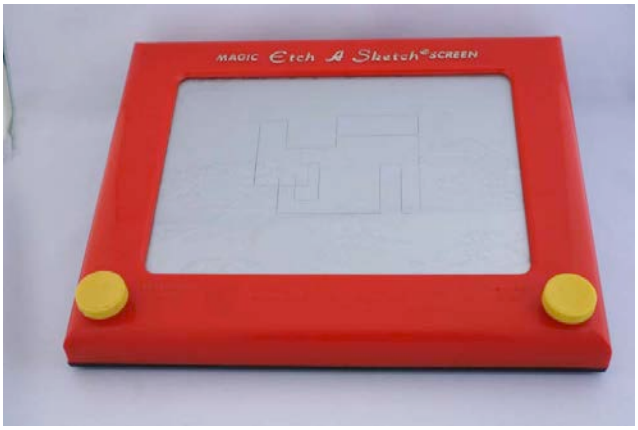
ShapeWriter
http://www.shuminzhai.com/shapewriter_research.htm

8Pen Keyboard
http://www.8pen.com/

Text Input Expert-User Input Rates

Device	Input Rates
Qwerty Desktop	80+ WPM typical, record: 150 WPM for 50 minutes
Qwerty Thumb	60 WPM typical with training (Clarkson et al., CHI 2005)
Soft Keyboards	45 WPM
T9	45 WPM possible for experts (Silverberg et al., CHI 2000)
Gestural	~30 WPM 8Pen, ShapeWriter claims 80 WPM (expert)
Handwriting	33 WPM (Wilkund et al., Human Factors Society, 1987)
Graffiti 2	9 WPM (Koltringer, Grechenig, CHI 2004)

Positional Input



Etch-A-Sketch
http://youtu.be/hq3Et9gOISI

Skedoodle
http://youtu.be/ic1rbFGhJ8g

Images from http://research.microsoft.com/en-us/um/people/bibuxton/buxtoncollection/browse.aspx

http://www.pdp8.net/tek4010/tek4010.shtml

Tektronix 4010

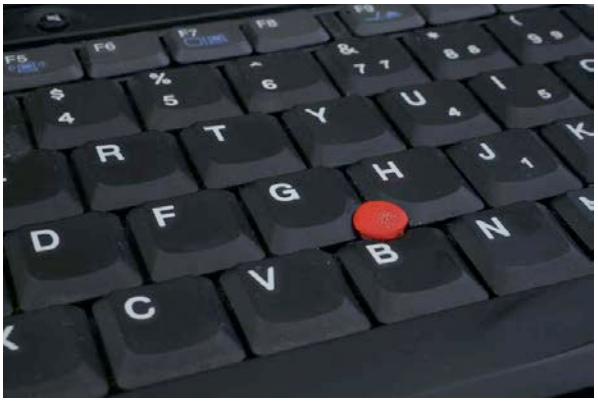
From Buxton, et al, *Human Input to Computer Systems: Theories, Techniques, and Technologies* (not yet published)

Properties of Positional Input Devices

- Absolute vs. Relative Positioning
  - touchscreen = absolute
  - mouse = relative
- Direct vs. Indirect Contact
  - direct = touchscreen
  - indirect = mouse
- Force vs. Displacement Sensing
  - (most) joysticks = force
  - mouse = displacement
- Position vs. Rate Control
  - (most) joysticks = rate
  - mouse = position
- Dimensions Sensed
  - 1 = dial, 2 = mouse, 3 = Wiimote

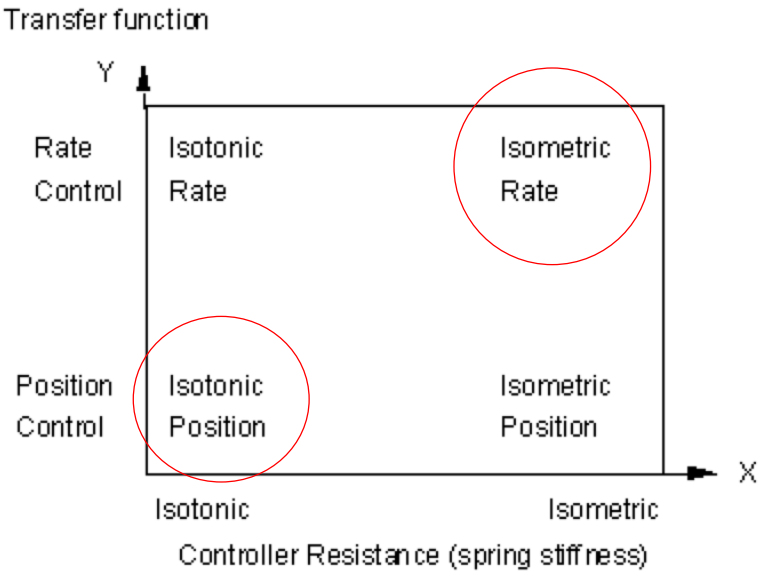
Force vs. Displacement Sensing

- (also called “isotonic” vs. “isometric” sensing)
- elastic isometric devices vs. “pure” isometric



Position vs. Rate Control Transfer Function

- force sensing (isometric) should be mapped to rate
- displacement (isotonic) sensing should be mapped to position

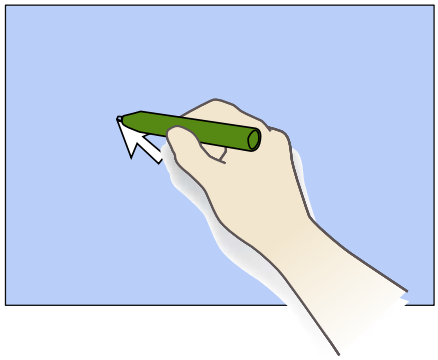


Absolute vs. Relative Position

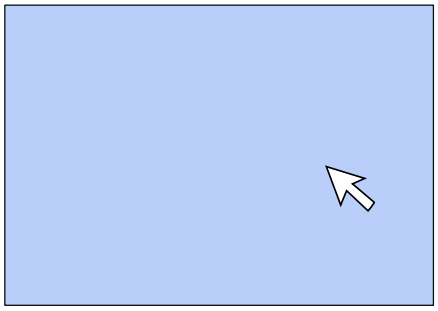
- Absolute position is a direct mapping of input device position to a display input position
  - Examples?
- Relative position maps changes in input device position to changes in display input position
  - Examples?
- To make relative position work, you need a “clutch”

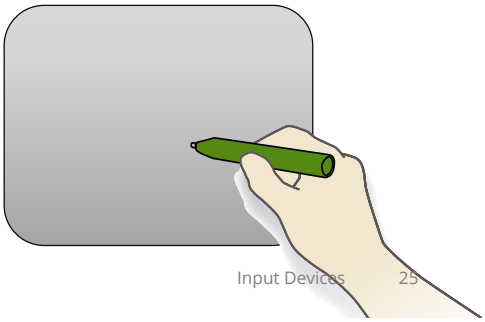
Direct vs. Indirect

Absolute Direct



Relative Indirect

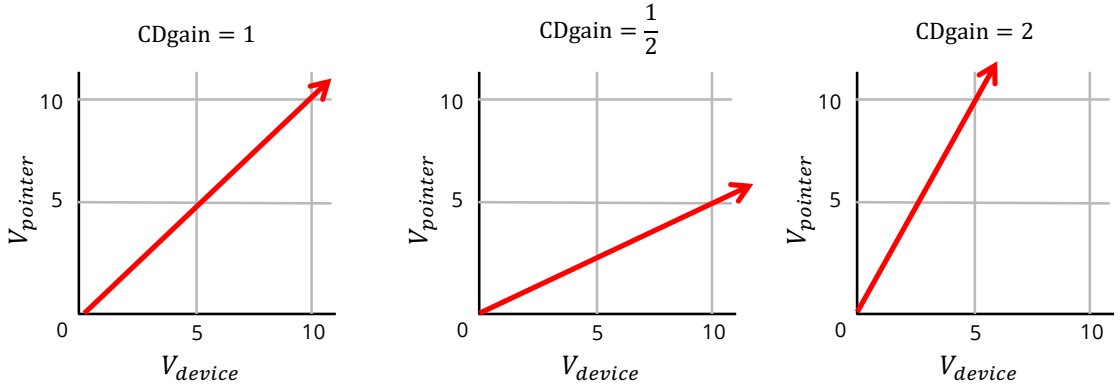




Control-Display Gain (CD Gain)

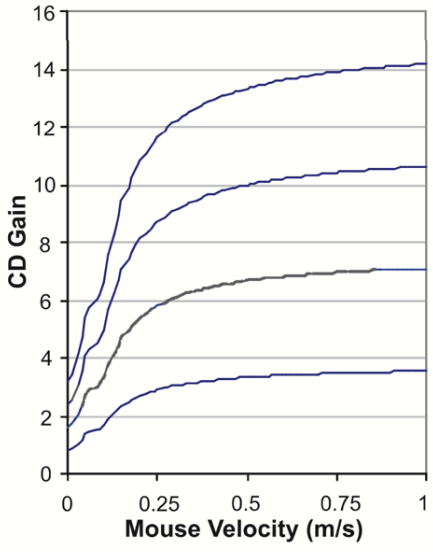
- Ratio of ***display*** **pointer** movement to **device *control*** movement
  - the ratio is a scale factor (the "gain")
  - usually expressed in terms of velocity
  - works for rate control and position control

$$\text{CDgain} = \frac{V_{pointer}}{V_{device}}$$

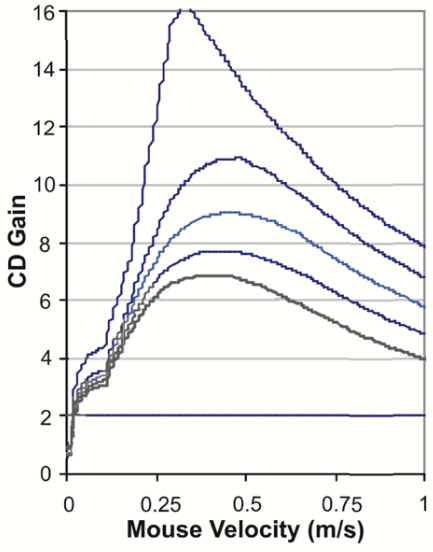


Pointer Acceleration

- Possible to dynamically change CD Gain based on device velocity

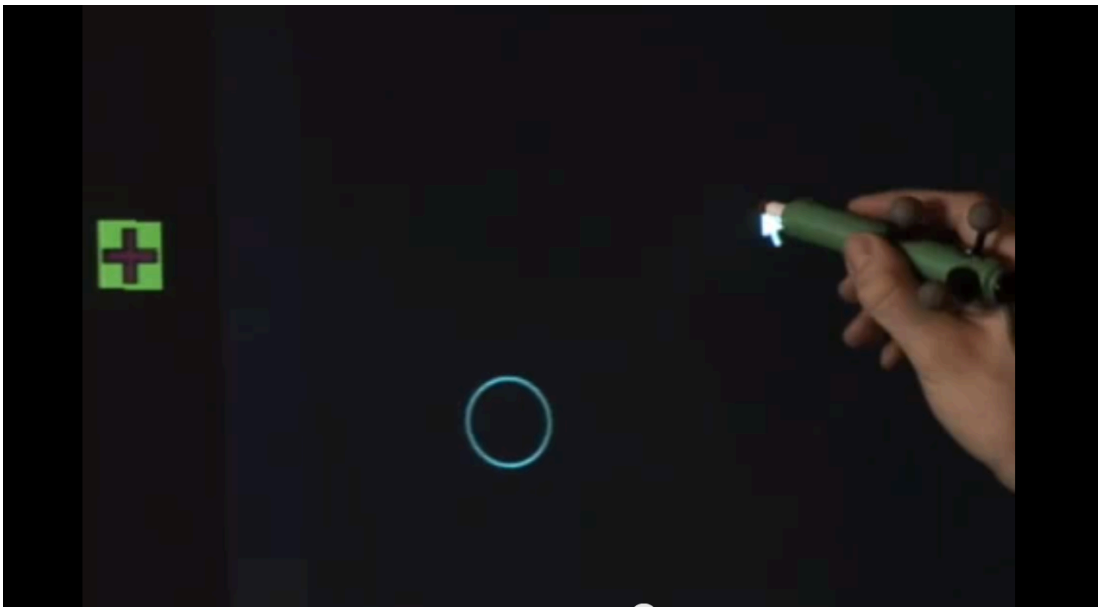


(b) Windows XP/Vista



(c) Mac OSX

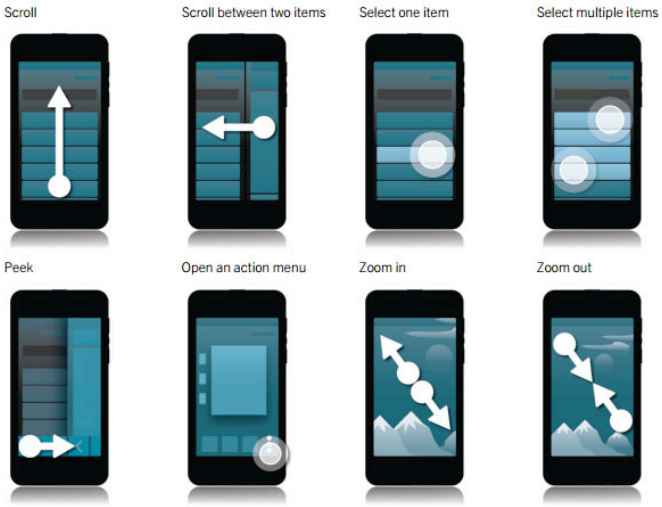
(Casiez et al. 2008)



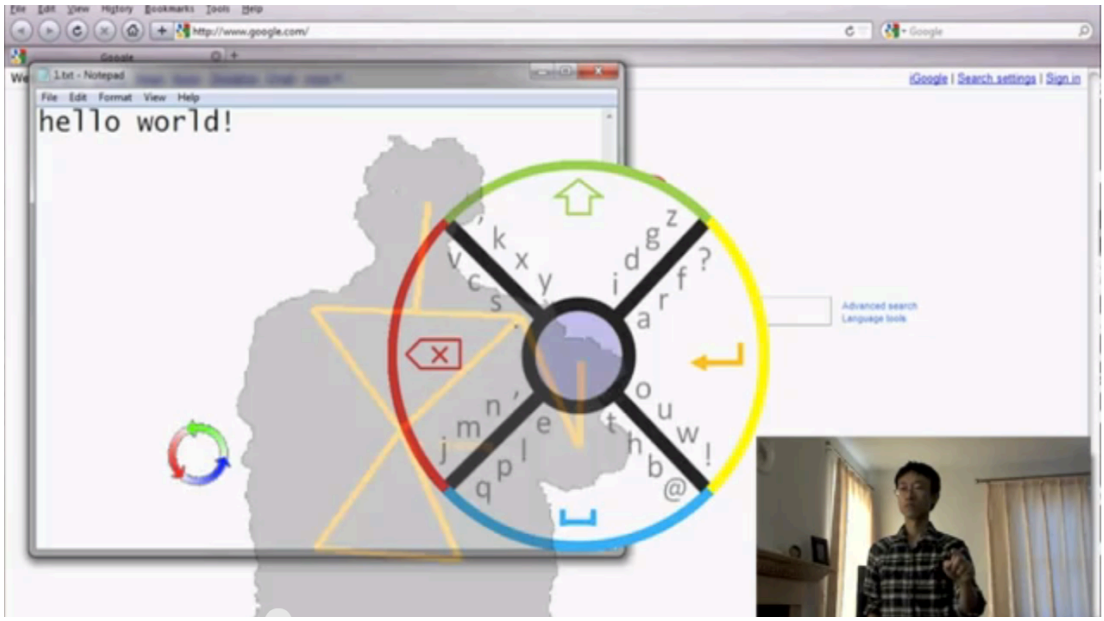
Hybrid Absolute and Relative Pointing
- http://youtu.be/FZmOBIg5KjM

Gestural Input

- Gestures map movements to commands
  - instead of pressing button, “wave your hand”
  - problems?
  - map position of body part to display input position



BB10 swipe gestures



Kinect Position and Text Input (Xie and Lio)
  - http://youtu.be/sVRRi-Z9t9M