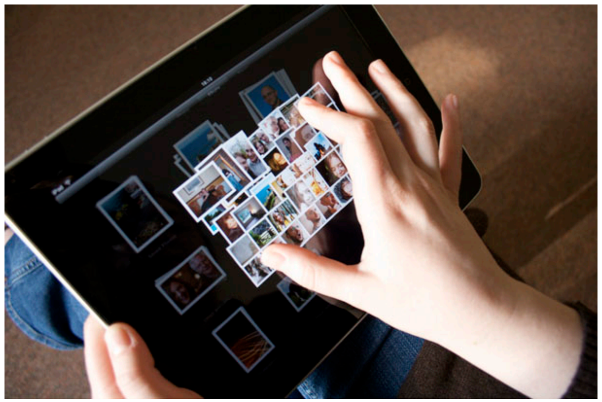
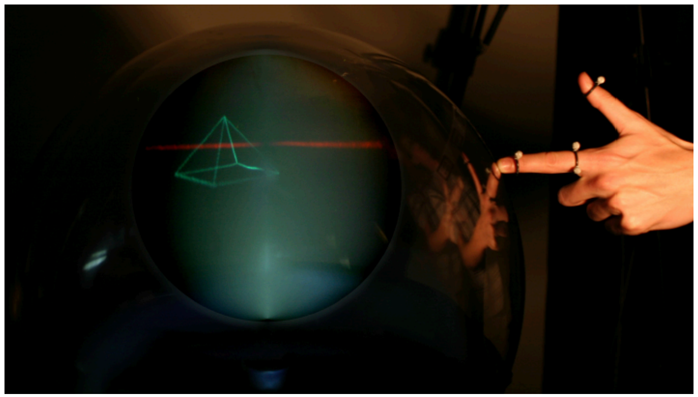
Input: pointing devices, input-output mappings, multi-touch and mid-air interaction

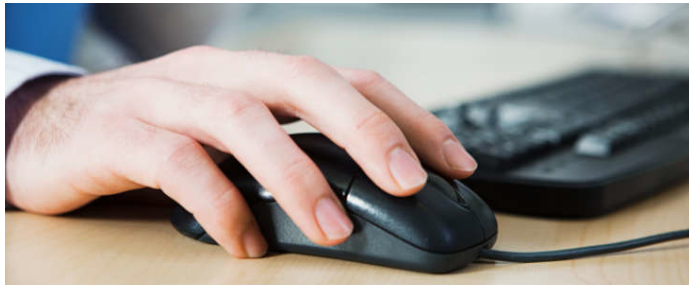
(complete set of slides)

Input devices vs. Finger-based input

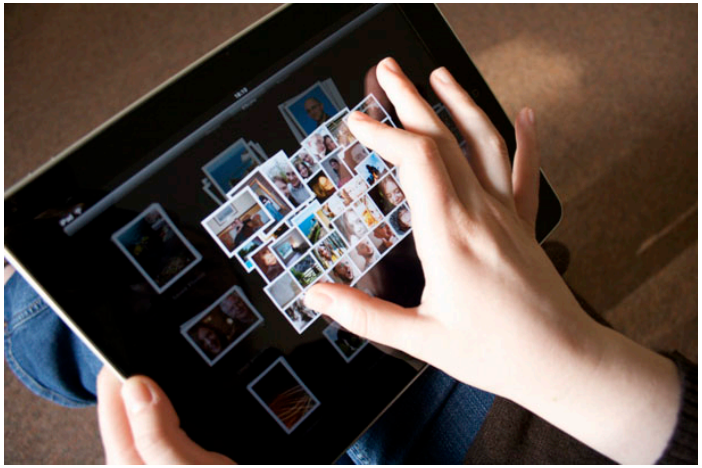




Indirect vs. Direct pointing



Indirect: The position of the cursor is controlled by the device



Direct: Fingers manipulate visual objects directly on the screen

Absolute vs. Relative pointing

Absolute: 1-to-1 mapping between input and output space

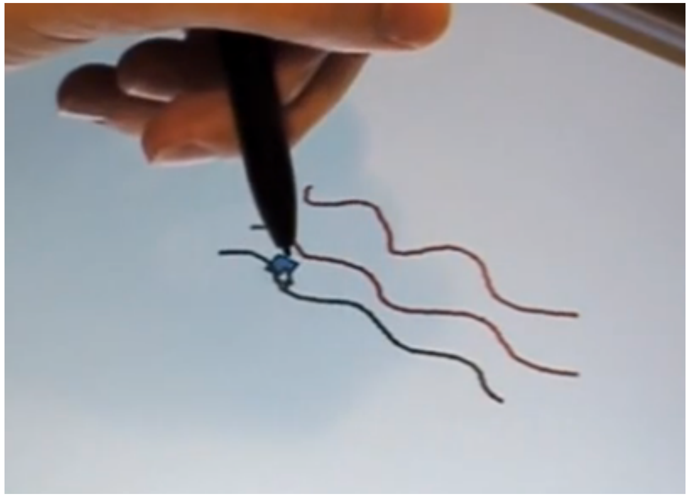
indirect

direct

Relative: Input controls the relative position of the cursor (always indirect)

Hovering mode

Tracking the position of the pointing device (e.g., the pen) or the finger from distance



Hover widgets http://www.youtube.com/watch?v=KRXfaZ8nqZM

Absolute pointing

Direct input

- Hovering feedback is not indispensable as there is a clear mapping between pen/fingers and the screen
- Main drawback: occlusion problems

Wacom Cintiq

Indirect input

- « Hovering » is indispensable: users must know the position of the cursor before starting drawing

regular graphics tablet

Relative pointing

Common devices: mouse and touchpad

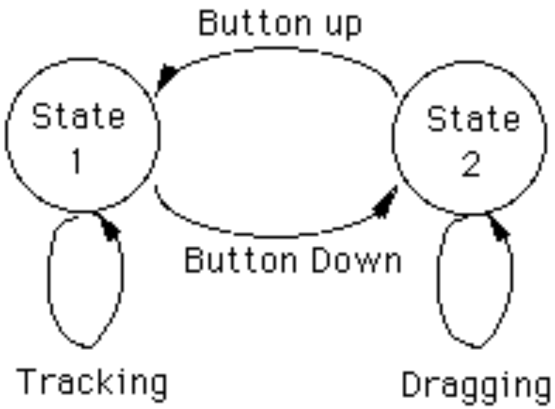
« Clutching » instead of « hovering » mode

- Lift the mouse or finger to « re-calibrate » movement
- Use of smaller input space to traverse a larger output space

How would you map the input space of the tablet to the output space of the wall?

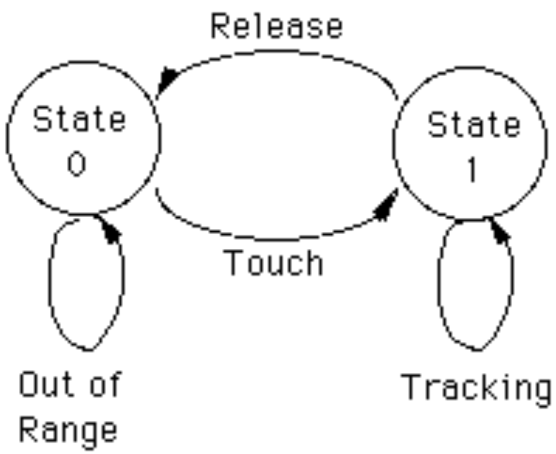
Smarties: https://www.lri.fr/~chapuis/publications/CHI14-smartiestk.mp4

Buxton's 3-state model (1990)



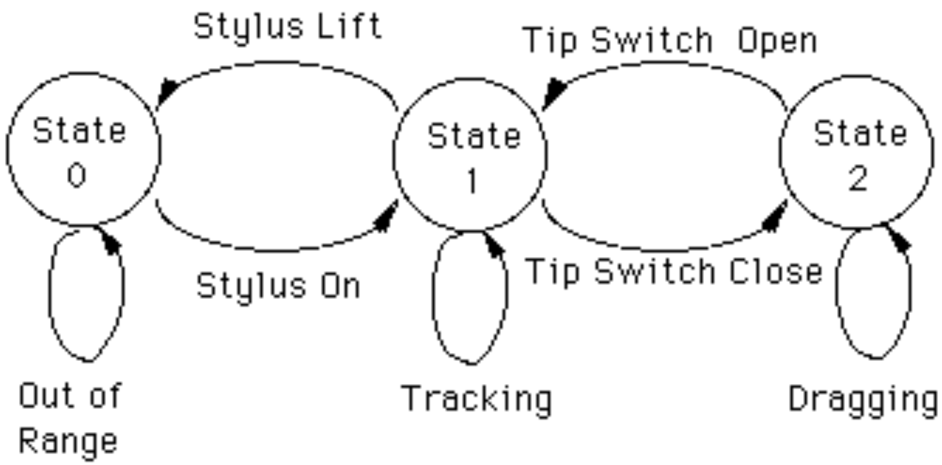
A. Two-state model for mouse

Buxton's 3-state model (1990)



B. Two-state model for a touch tablet

Buxton's 3-state model (1990)



C. Three-state model for a gaphics tablet with stylus

Relative pointing: Mappings

Position control: maps human input to the position of the cursor (or object of interest)

Examples: mouse, touchpad

Rate (or velocity) control: maps human input to the velocity of the cursor (or object of interest)

Examples: joystick, trackpoint

Trackpoint

Isotonic vs. Isometric devices

Iso*tonic* (iso-tonic = equal tension/force):
Absence of resistance, free movement

- Mouse, pen, human arms, etc.

Iso*metric* (iso-metric = equal measure):
Absence of movement, resistance as we press

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- Mouse, pen, human arms, etc.

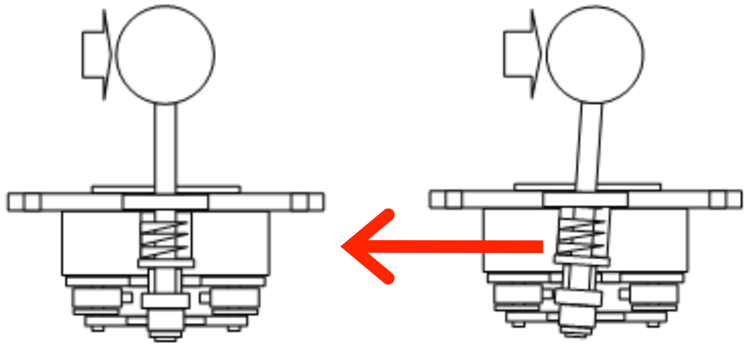
Iso*metric* (iso-metric = equal measure):
Absence of movement, resistance as we press

Elastic: Resistance increases with movement

- Joystick, trackpoint

Elastic/Isometric devices

There is a neutral position



As we apply force, an opposing force develops

Self-calibration: I we free the device, the opposing force bring the device to its neutral position

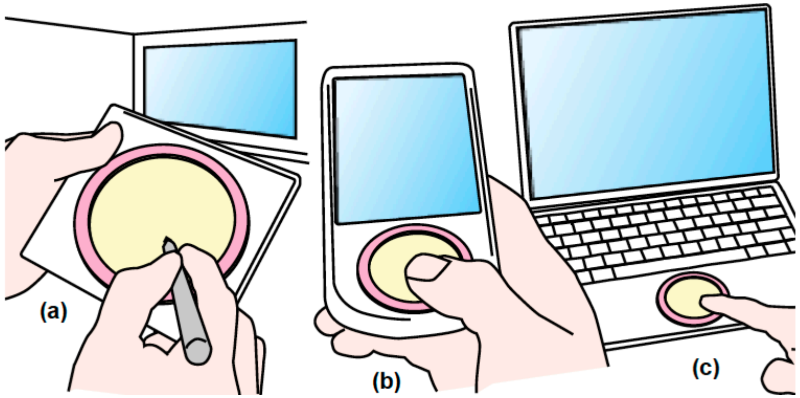
General principles

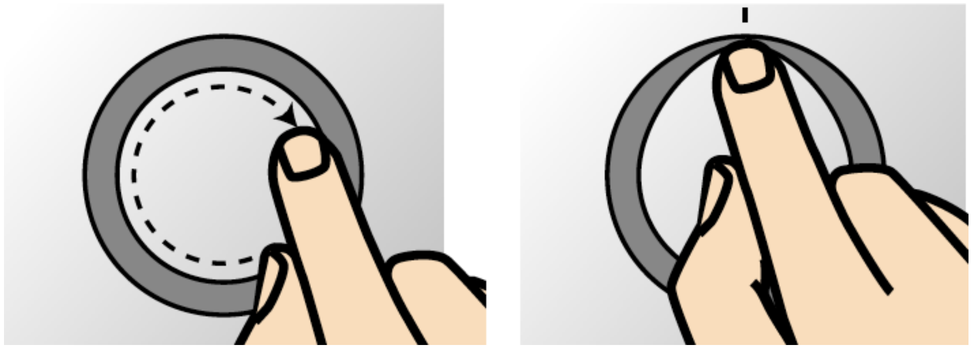
Isotonic devices (e.g., mouse) most appropriate for position control

Elastic/isometric devices (e.g., joystick) most appropriate for rate (velocity) control

Mixed control (Casiez et al., 2007)

How can we increase the input space of a trackpad to reduce clutching: trackpad + trackpoint





Position control

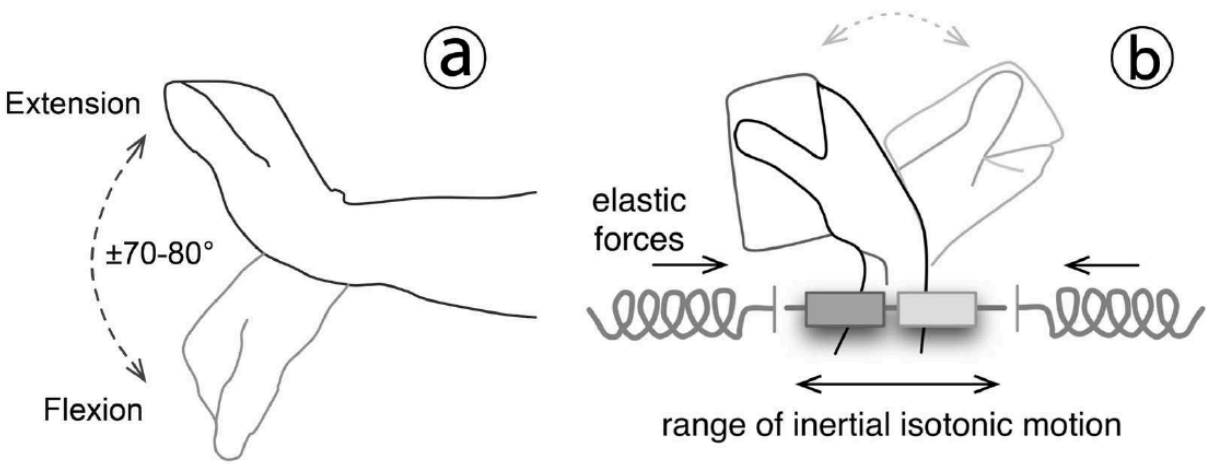
Velocity control

RubberEdge http://www.youtube.com/watch?v=kucTPG_zTik

Mixed control

The wrist as a mixed-control device (Tsandilas et al. 2013)

- position control around the neutral wrist position
- rate control near extemes angles

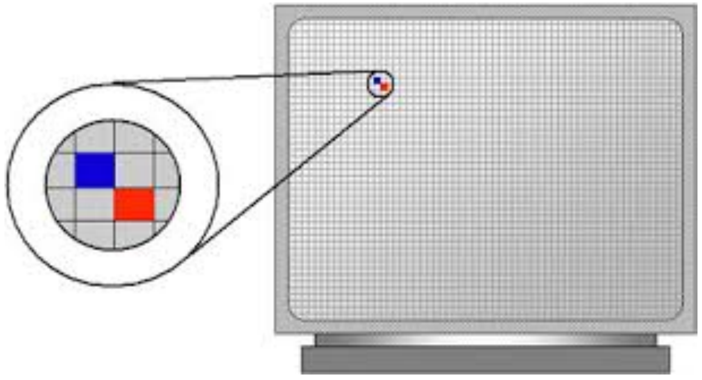


No need for clutching

Output resolution

Dots per Inch (DPI)

For screens where dots are pixels, we use the term Pixels per Inch (PPI)



Input resolution (isotonic devices)

Input resolution often measured in **counts per inch (CPI)**

- Also refered to as Dots per Inch (DPI)

A modern mouse: 400 to 10000 CPI

- Detection of displacements between 64μm and 2.54μm (about the size of a bacterium)

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« Useful » resolution: 200-400 CPI (Aceituno et al. 2013)

- Maximum resolution that users can benefit from

Control-Display (CD) gain

$$CD_{gain} = V_{pointer} / V_{device}$$

$V_{pointer}$: velocity of cursor
V_{device} : velocity of input device

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$$CD_{gain} = V_{pointer} / V_{device}$$

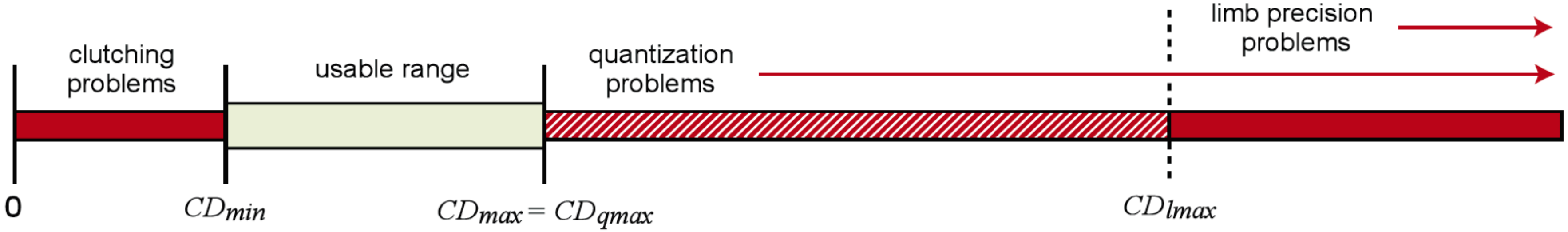
$V_{pointer}$: velocity of cursor
V_{device} : velocity of input device

$CD_{gain}=1$
When the mouse moves 1cm, the cursor also moves 1cm

$CD_{gain}< 1$
The cursor moves slower than the mouse: Better precision

$CD_{gain} > 1$
The cursor moves faster than the mouse: Faster, less clutching

Range of usable CD gains



from Casiez et al. (2008)

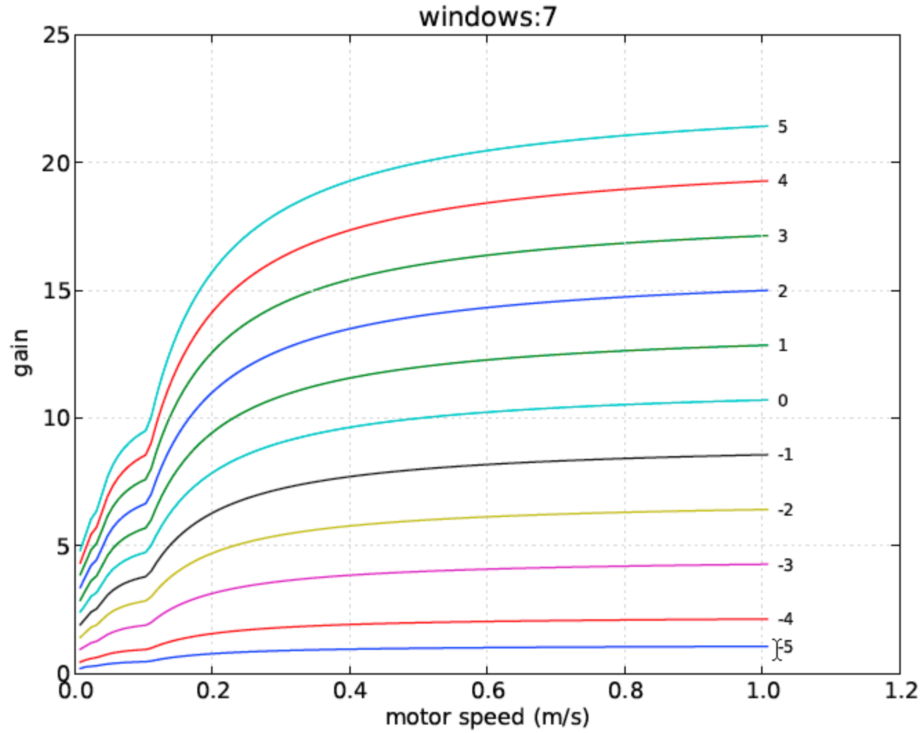
Pointer acceleration

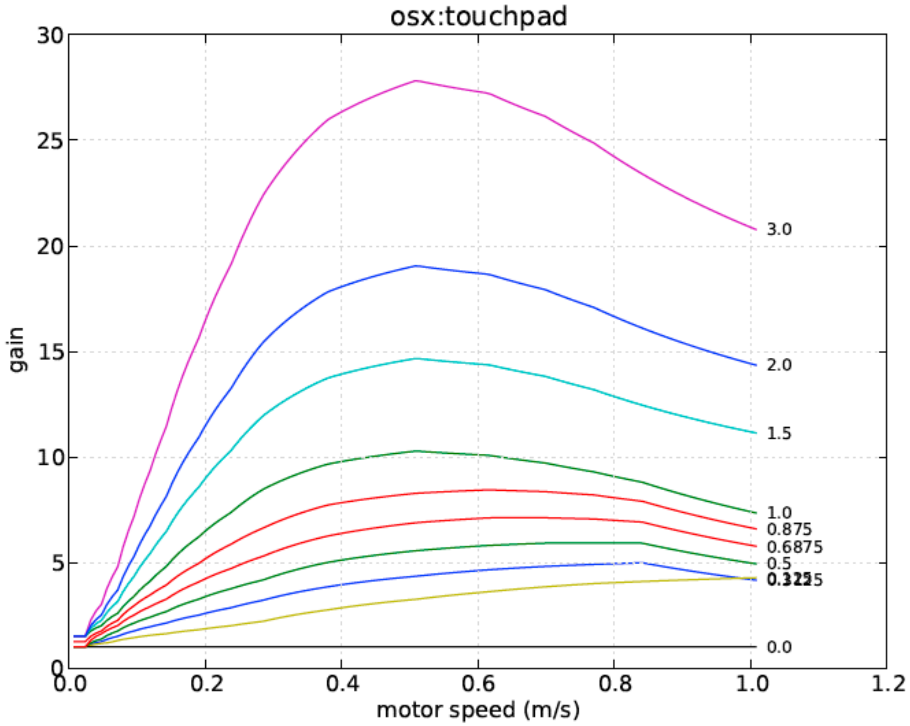
The CD gain is not constant but changes as a function of the speed of the device

- The faster I move the device, the faster the cursor (acceleration)
- Slow movements cause the CD gain to decrease: better precision

Acceleration functions

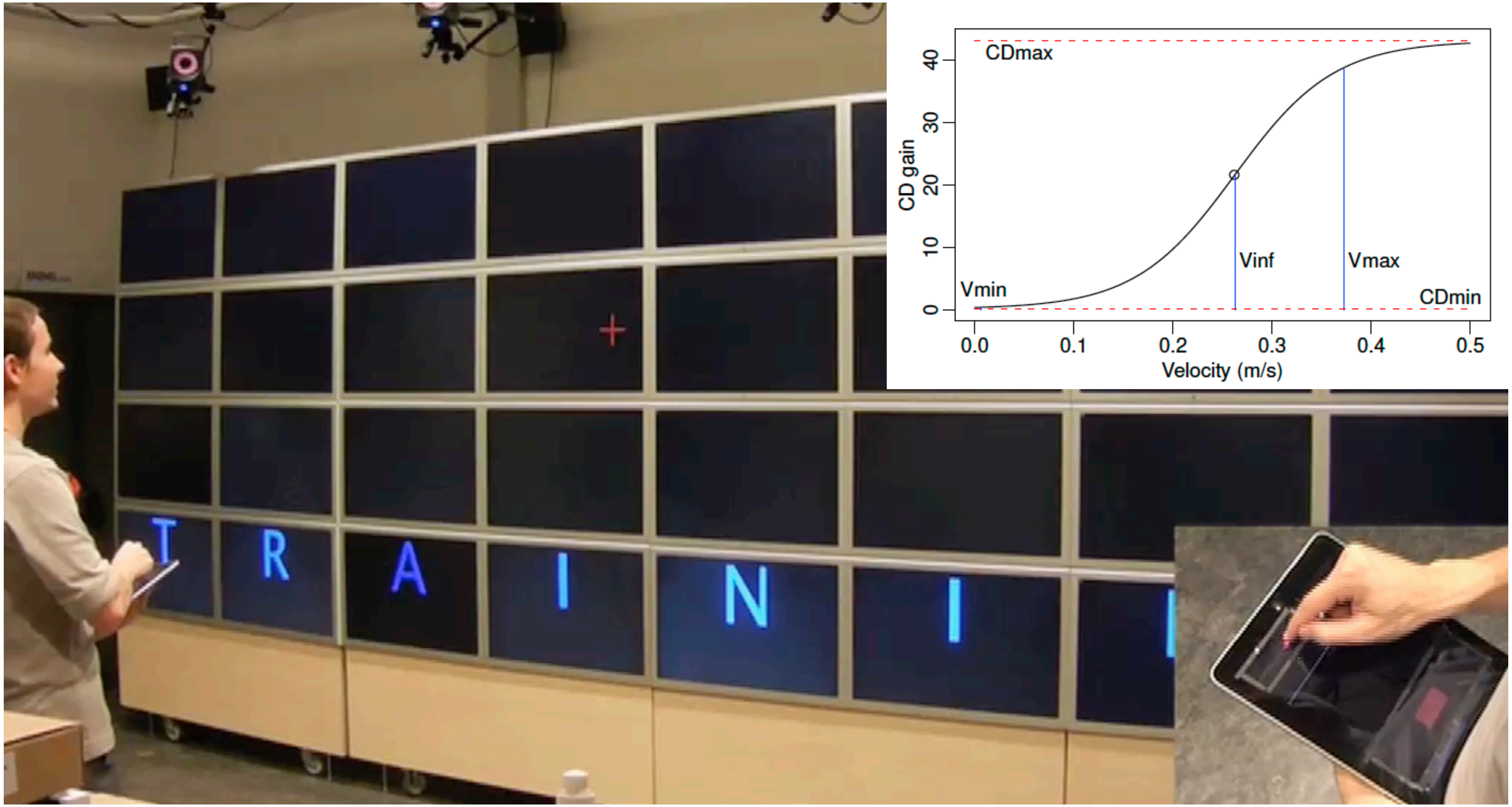
Also known as transfer functions





from Casiez and Roussel (2011)

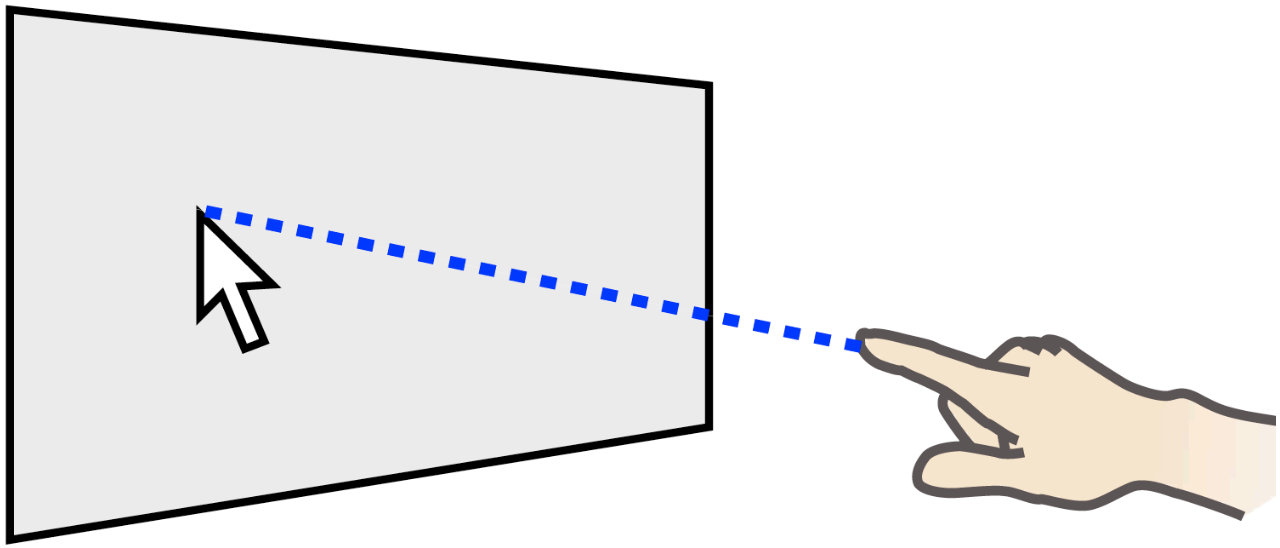
Nancel et al. (2013) found that with a good acceleration function, users could be very accurate and fast acquiring targets on a large high-resolution display even when the available input space was very small



Laser pointing – RayCasting

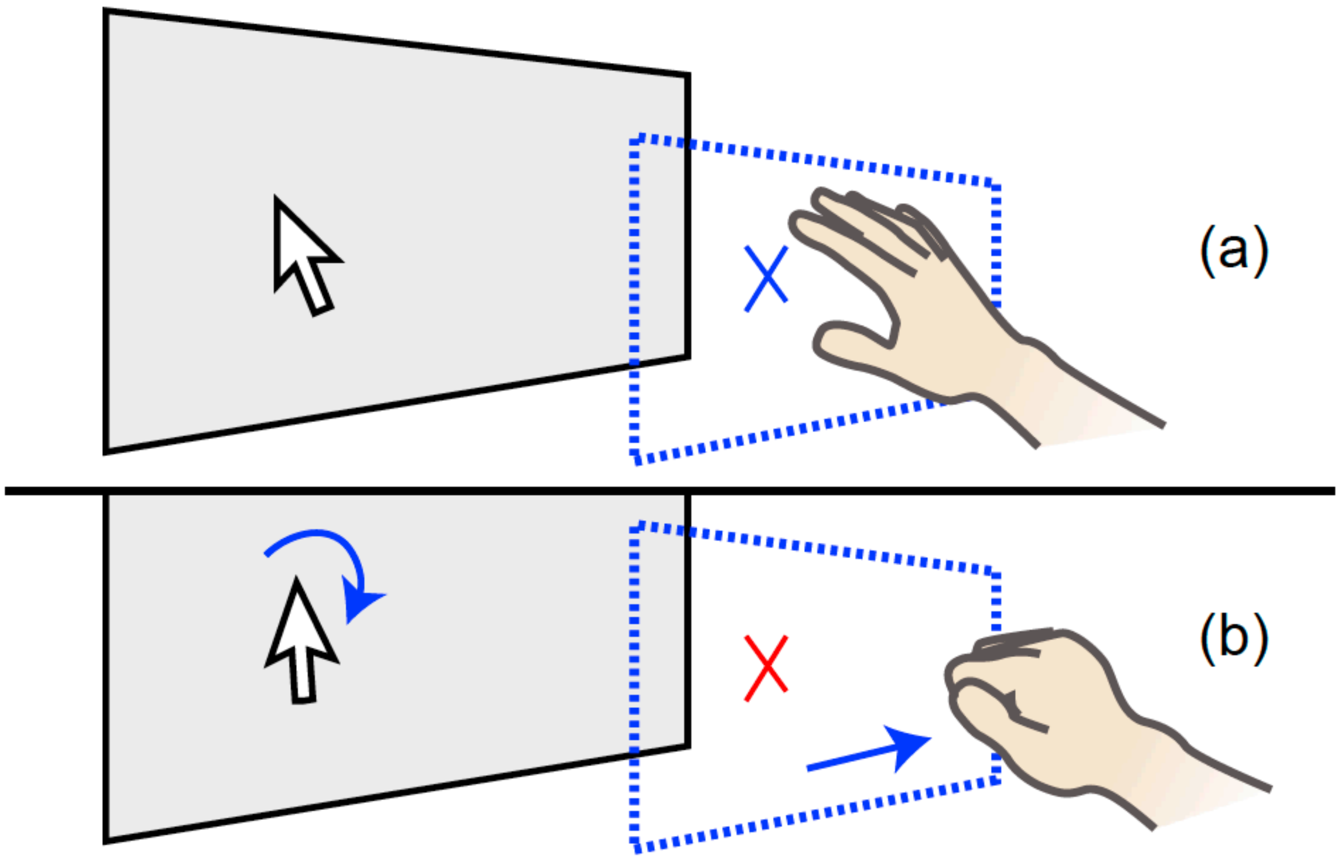
Main strength: Natural, as the device or hand points directly to the target

Drawback: Sensitive to hand tremor and tracking precision. Depending on the distance of the user, small hand movement can cause large displacements, inappropriate for accurate pointing from distance



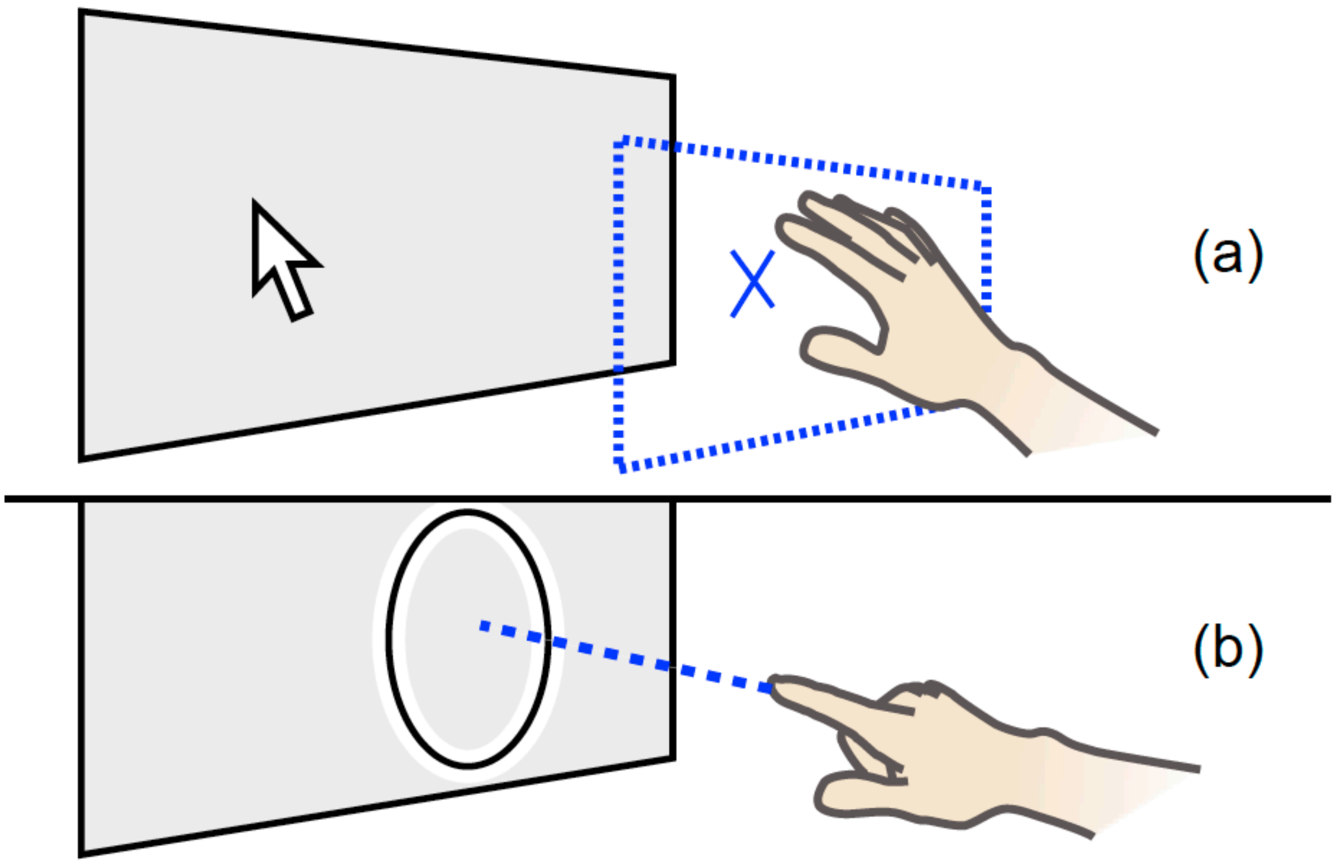
Solutions

Relative Pointing + Clutching (Vogel & Balakrishan, 2005)



Solutions

Hybrid Control (Vogel & Balakrishan, 2005)



http://www.youtube.com/watch?v=j26JQxMhBog

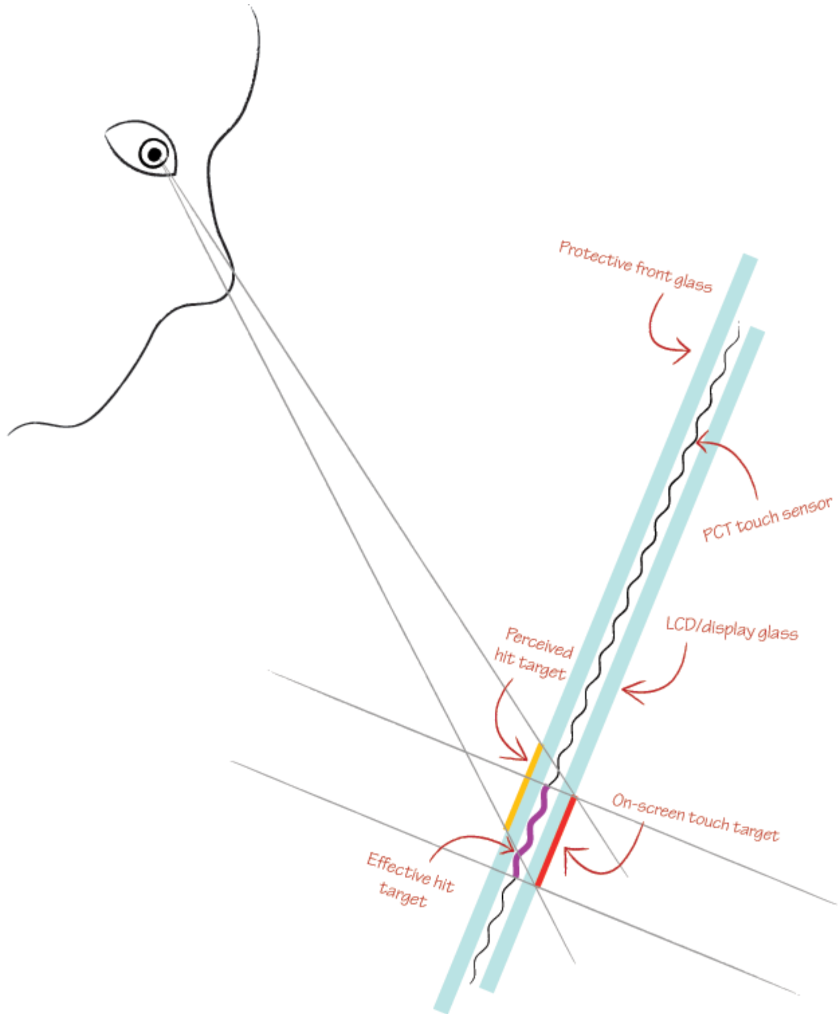
Direct input

Strengths: The user interacts directly with the objects as in the real world

Drawbacks: Lower accuracy due to occlusion, parallax, limited input resolution of the human limbs

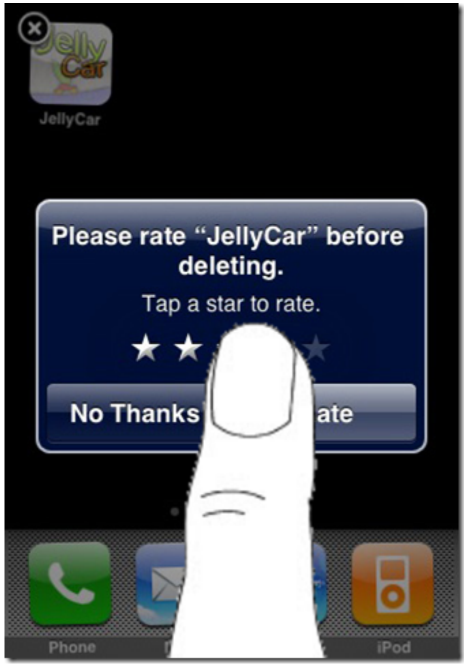
The parallax problem

Incorrect perception of where the target is

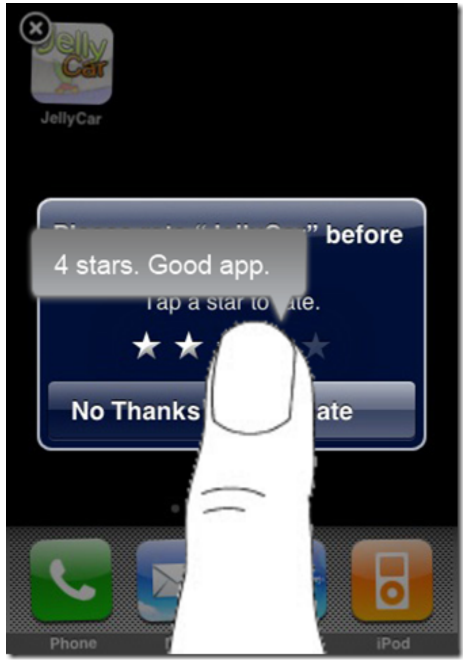


Occlusion problems

The finger covers the object of interest. Here, the letter under the users finger grows and moves upwards to reduce the problem.



Problematic design



Better design

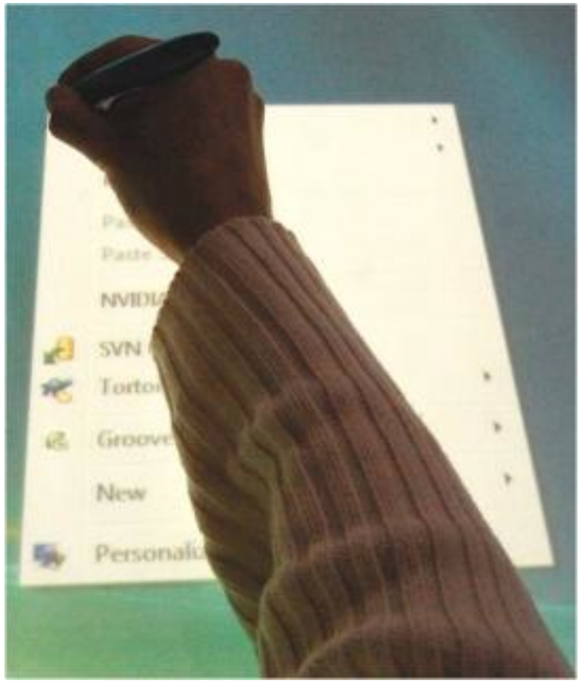
Examples from http://podlipensky.com/2011/01/mobile-usability-sliders/

Occlusion problems

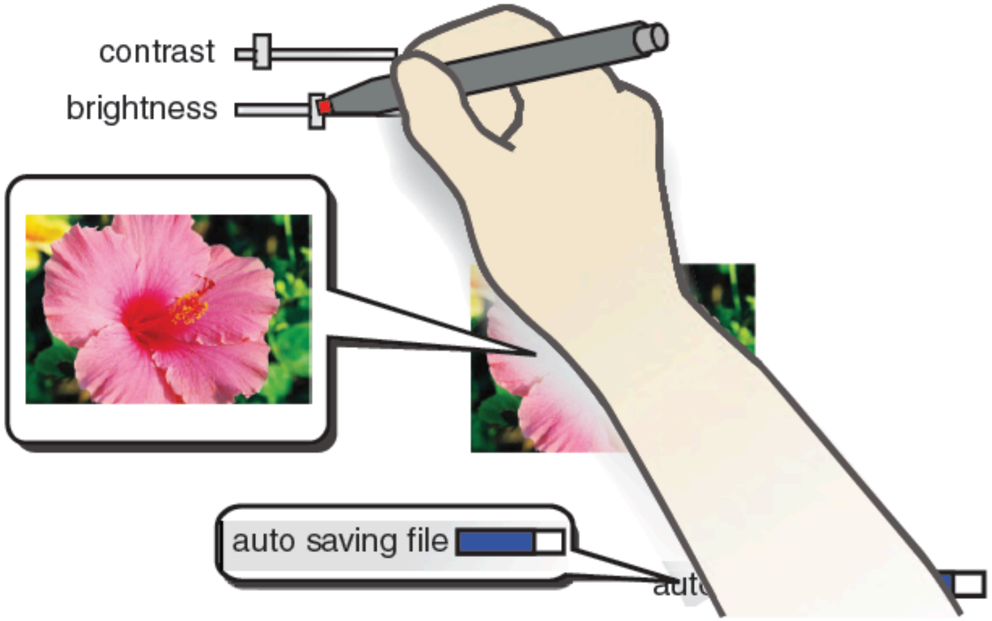
Sliding Widgets (Moshovich, 2009)
Replacing push buttons by sliding ones to reduce ambiguity due to occlusion or parallax problems (crossing-based selection)

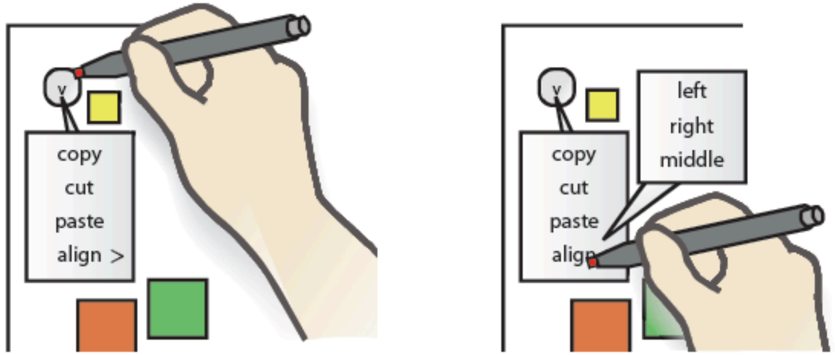
http://www.youtube.com/watch?v=Pw5nmLSYrvE

Hand occlusion

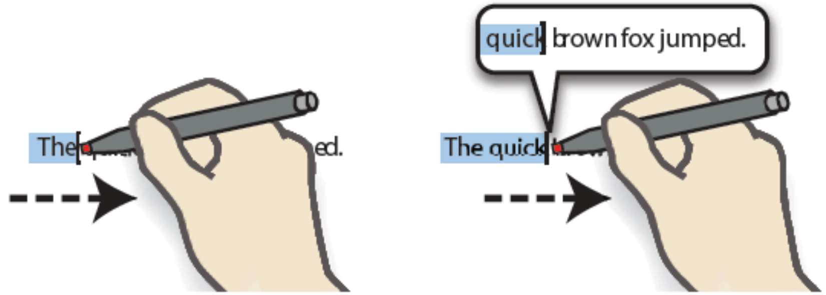


Occlusion-Aware Interfaces
(Vogel & Balakrishan, 2010)





(a) Occlusion-Aware Pop-Ups

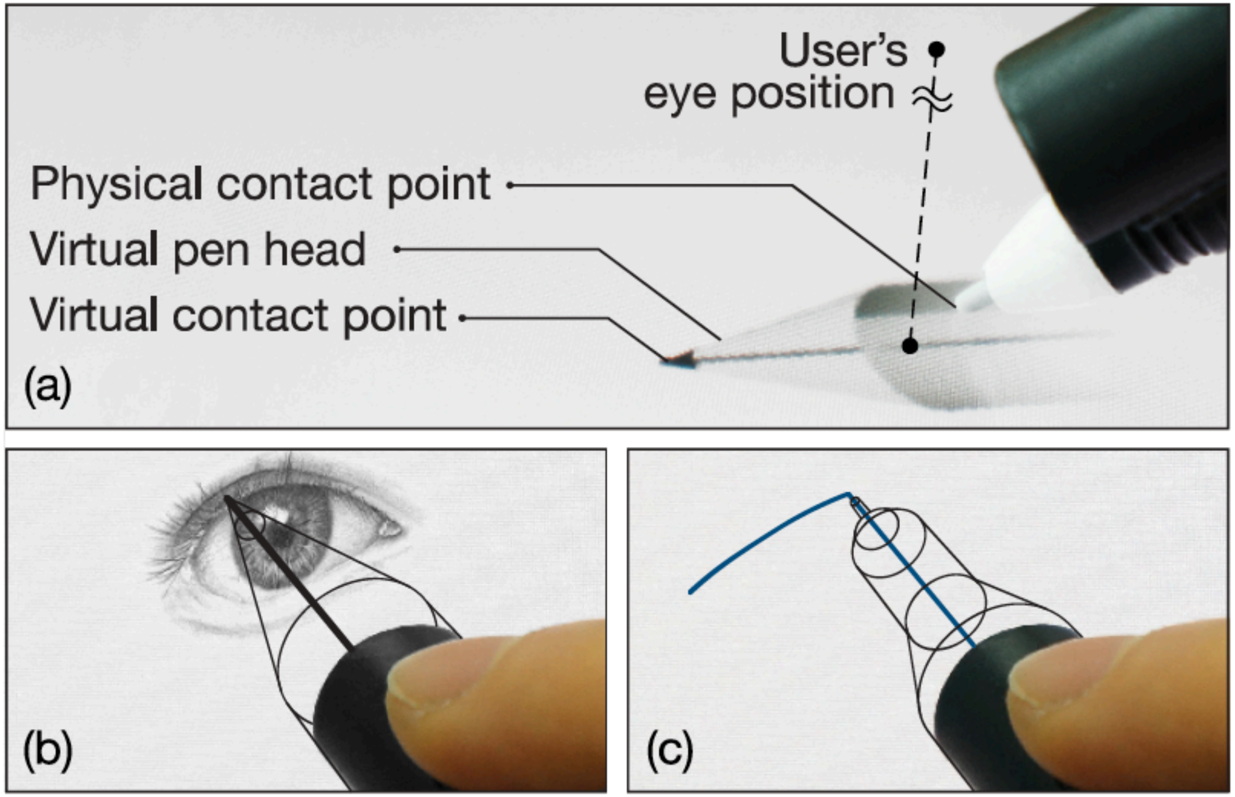


(b) Occlusion-Aware Dragging

http://www.youtube.com/watch?v=j-b9q4ZjLHo

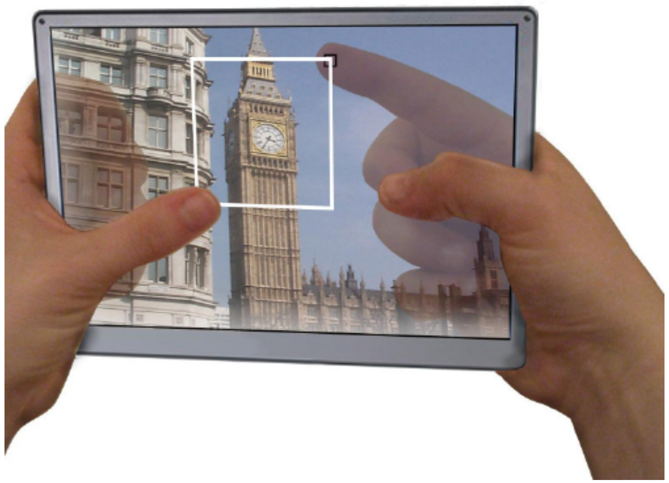
Other clever solutions

PhantomPen (Lee et al, 2012)

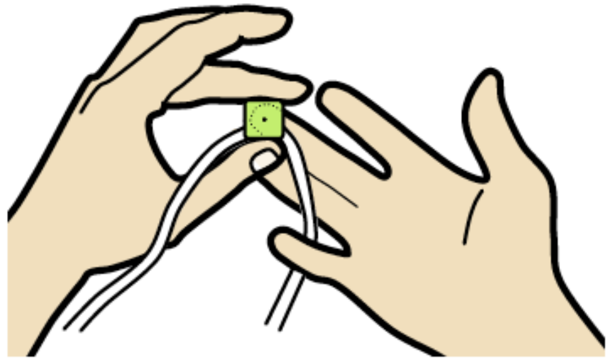


http://www.youtube.com/watch?v=r62wxK3Rma4

Other clever solutions



LucidTouch (Wigdor et al , 2007)
http://www.youtube.com/watch?v=qbMQ7urAvuc



Interaction with small touch devices
(Baudisch and Chu, 2009)

Multi-touch

Apple magic trackpad

iPad, iPhone, smartphones, tablets

Vertical public displays

Tabletops

The history of multitouch

For the long history of touch and multitouch, see Buxton’s overview page:

http://www.billbuxton.com/multitouchOverview.html

Touch points & degrees of freedom

Degrees of freedom = the number of parameters that may vary independently

Examples:

- One touch point can control the X and Y position of an object (2 degrees of freedom)

- Two touch points can control the X and Y position of an object, its rotation, and its scale (4 degrees of freedom)

Touch points & degrees of freedom

We can control more degrees of freedom

1. By adding more touch points

2. By sensing parameters other than position
   - Pressing force of a finger
   - Moving speed or acceleration
   - Size of contact point

3. By adding new input modalities
   - e.g., tilting the device while touching

Detecting fingers

Capacitive touchscreens (e.g., tablets and smartphones) do not differentiate between different fingers: they only detect contact points

Some vision-based systems (e.g., some tabletops) create a model of the whole hand, but their accuracy can be low

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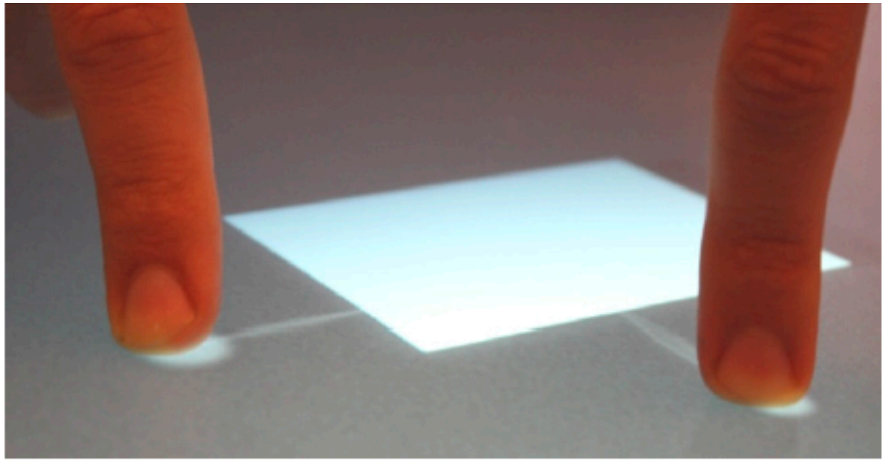
How would it be useful to differentiate between fingers?

Detection problems & feedback

Making detection visible to the user

Ripples (Microsoft Research, 2009)
http://www.youtube.com/watch?v=BXLsdhoRXF4



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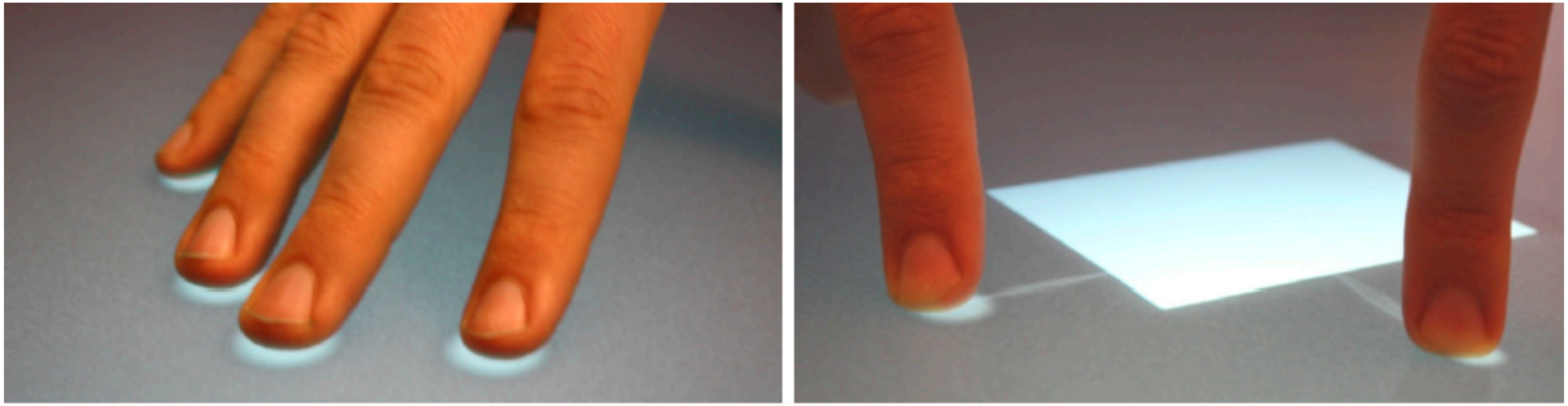


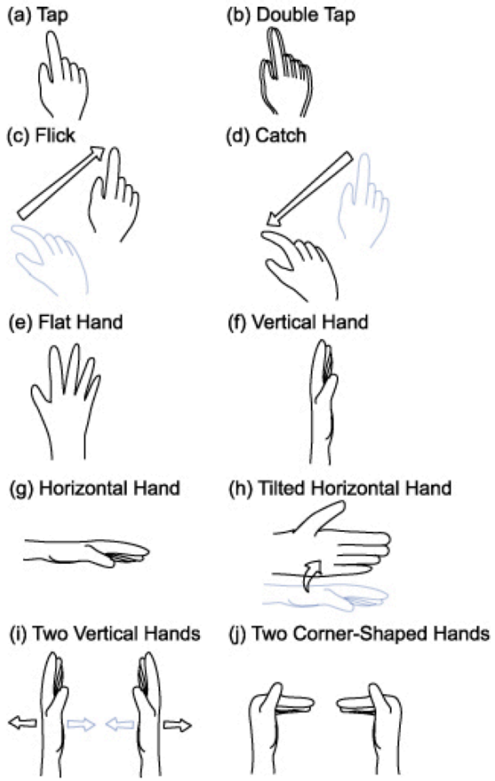
Think about other technologies where detection can be problematic, e.g., motion sensing by Kinect

Multi-touch: Common gestures

from http://www.mobiletuxedo.com/touch-gesture-icons/

Multi-finger interaction for multi-user tabletops

Wu and Balakrishnan, 2003

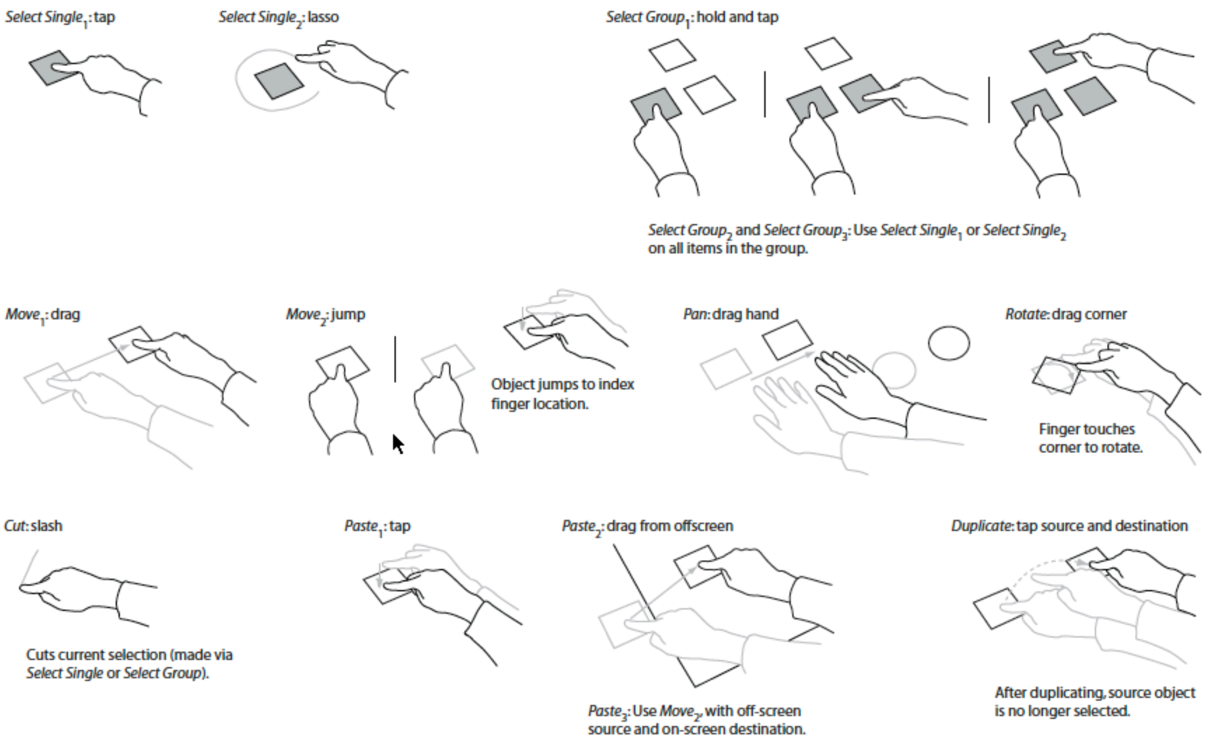


http://www.dgp.toronto.edu/research/tabletop/tabletop640x480.mpg

Gesture elicitation studies

Gesture elicitation (Wobbrock et al., 2009)

- Asking target users to create their own gesture vocabulary
- Then, define gestures based on the identified common gesture patterns



Gesture elicitation studies

Morris et al. (2010) found that peope preferred gestures defined by larger groups of end-users than gestures defined by HCI researchers

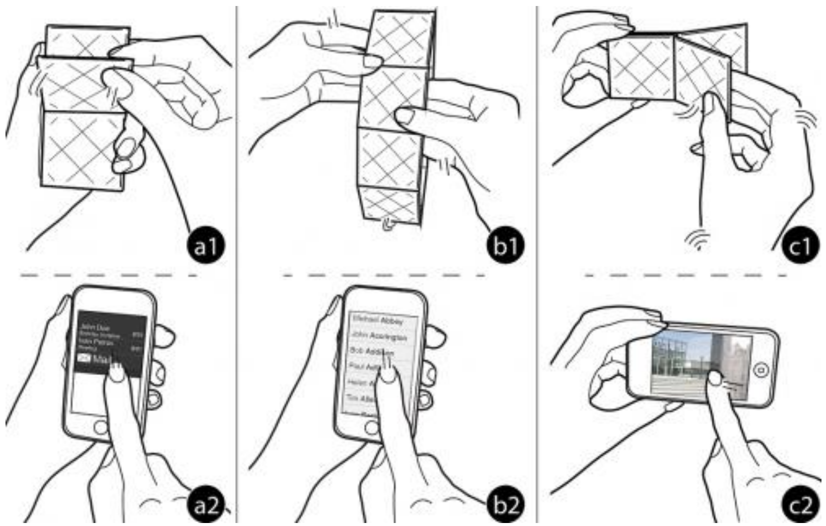
- HCI researchers proposed physically and conceptually more complex gestures than end-users

The approach has been used by other researchers for defining gestures for a wide variety of input modalities: mid-air gestures, motion gestures, folding-paper gestures, etc.

Problem of « legacy » bias: Users are often biased by their previous exposure to commercial systems.

Beyond touch

Flexible displays



Transformable displays (Ramakers et al., 2014)
http://www.raframakers.net/wiki/Main/Paddle

Programming for multitouch

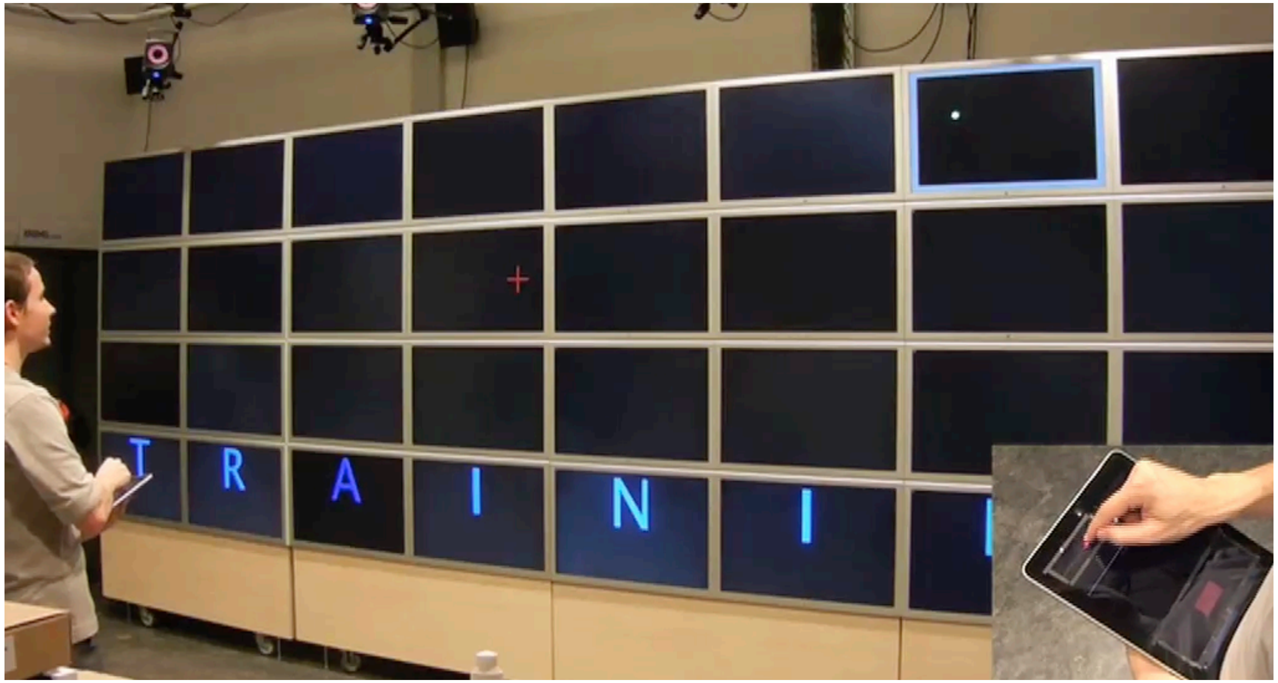
There are many platform-dependent toolkits for capturing and handling touch events

Example

- The Android SDK (based on Java) provides listeners of simple multi-finger touch events (move, down, up) and common touch gestures (tap, double tap, long press, fling, scroll)

Programming for cross-platform interaction

How do we communicate events between different devices and different platforms?



Programming for cross-platform interaction

Protocols for communicating generic events

- Open Sound Control: http://opensoundcontrol.org/introduction-osc
- IVY: http://www.eei.cena.fr/products/ivy/

Protocol for communicating multitouch events

- TUIO: http://www.tuio.org

Open Sound Control (OSC)

Initially developed for the communication between synthesizers, digital instruments, and musical software

Widely used by the music and HCI communities

Client/Server architecture, where the OSC server receives OSC messages from one or multiple OSC clients

- The server and the clients can be in different devices/platforms

Implementation for many platforms and programming languages, e.g., Java: http://www.illposed.com/software/javaosc.html

TUIO

Based on OSC: Client/Server architecture where devices can send multitouch events to interested applications

Support for a wide range of multitouch devices and platforms: http://www.tuio.org/?software