mixed reality
&
(tactile and) tangible interaction

A. Bezerianos

touch interfaces

technology

frameworks

touch & multi-touch design

tables, walls, …

mobiles, watches, …

Some systems
http://billbuxton.com/multitouchOverview.html

touch interfaces

~~technology~~

~~frameworks~~

touch & multi-touch design

tables, walls, …

~~mobiles, watches, …~~

Some systems
http://billbuxton.com/multitouchOverview.html

touch interfaces

~~technology~~

~~frameworks~~

touch & multi-touch design

tables, walls,

~~mobiles, watches, ..~~

Some systems
http://billbuxton.com/multitouchOverview.html

touch screen interaction

- touch interaction
  - 1960: Single Touch
  - 1982: Multi-touch
  - 2006: Lucid touch

- touch interfaces controlled by
  - touch + widgets
  - touch + gestures
  - touch + speech
  - touch + objects

single touch

Touch screen interfaces (since ‘60)

- interaction via
  - stylus, light pens, finger, hand, …

ergonomics:

× finger stress

× “gorilla arm”

hci:

× fingernail interaction

× finger/hand occlusion

× gestures to learn

multi-touch interaction

- in real life we do actions with 2 hands or more than one finger

- multi-touch interaction allows parallel actions
- reduce task complexity of single input
- increases parallelism and reduces time
- transferred skills from real life

[Hinrichs et al., 05]

multi-touch interaction

[© DreamWorks Pictures, 02]

- but still …
  - × finger stress
  - × “gorilla arm”
- as in any finger interaction …
  - × chubby fingers, fingernail interaction
  - × screen occluded by fingers/hands
- and
  - × more gestures to learn
  - × ambiguity (think of examples)

[Ghomi et al., 13]

ergonomics

- what you can do …

ergonomics

- what you can do …
  - design fast interaction

[©DC Comics]

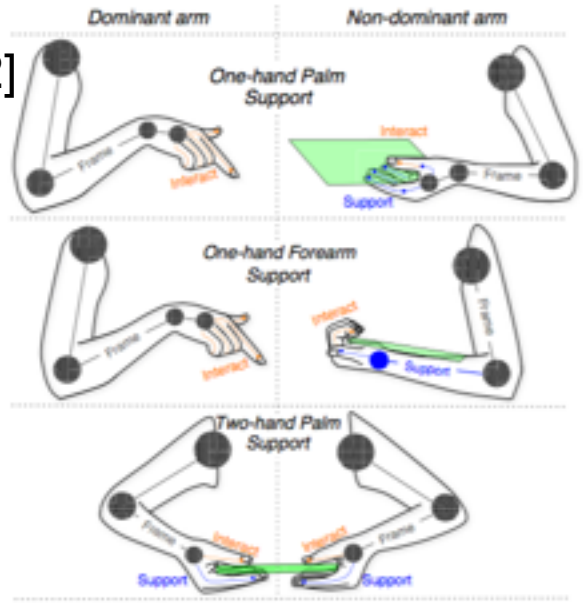
ergonomics

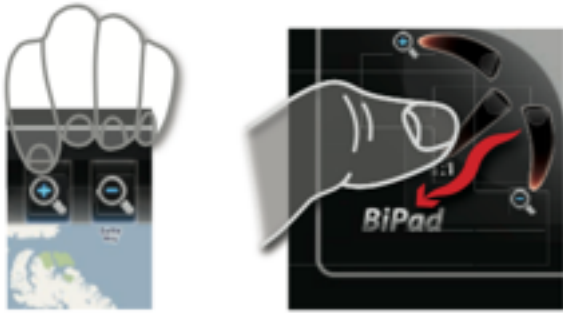
- what you can do …
  - design fast interaction
  - provide designs with hand support

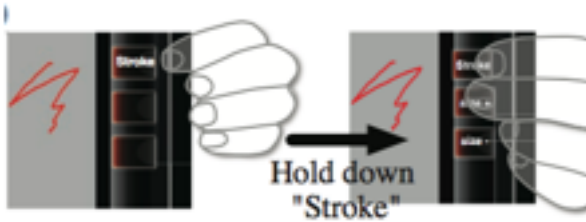
ergonomics

- what you can do …
  - design fast interaction
  - provide designs with hand support
  - rest device on hand or body

e.g. BiPad [Wagner et al.,2012]
bimanual interaction
on multitouch tablets



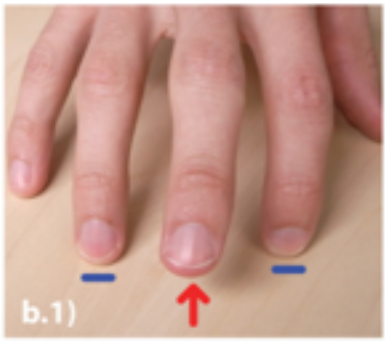


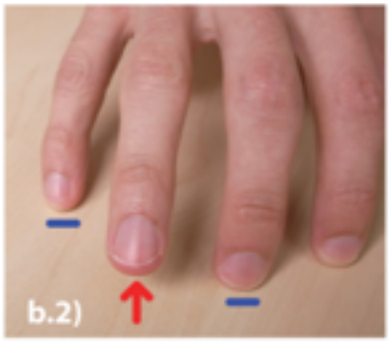


ergonomics

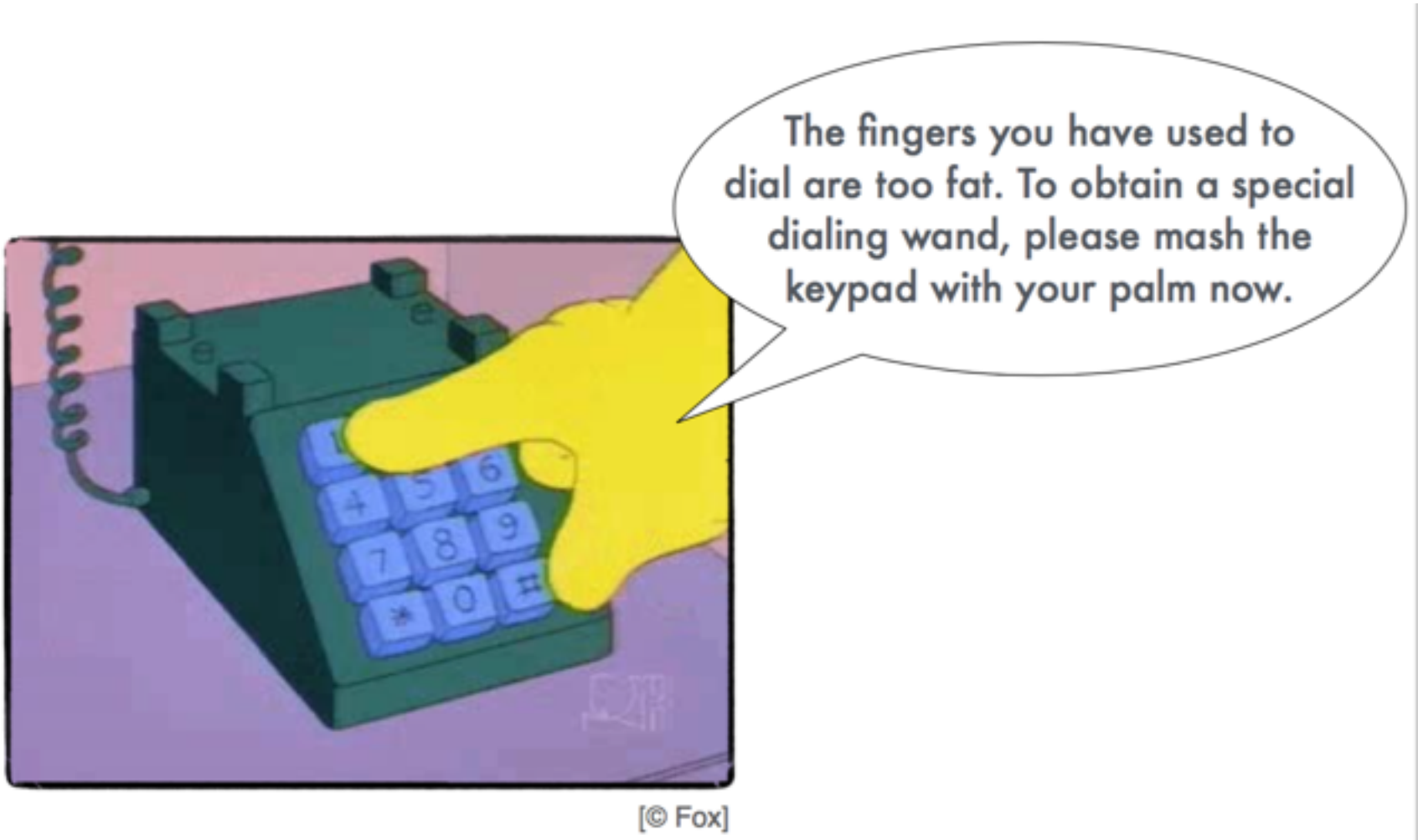
- what you can do …
  - design fast interaction
  - provide designs with hand support
  - rest device on hand or body
  - consider hand ergonomics

e.g. Arpege [Gnomi et al.,2013]
design and learning
multitouch gestures





chubby fingers



chubby fingers and target size

many studies on limits, but with different objectives

pen: 1.8mm [Ren & Moriya, 00]

fingers: from 4mm to 20-25mm

depending on studies/tasks

[Sears et al., 93], [Albinsson & Zhai, 03], [Parhi et al., 06], ...

some solutions

adapt size...

... and design big targets (Fitts' law)

but still problems

limited screen real-estate on some platforms

(mobile) size-dependant representation of data

chubby fingers

avoiding fingernail interaction (small target acquisition)

- finger sized targets

chubby fingers

avoiding fingernail interaction (small target acquisition)

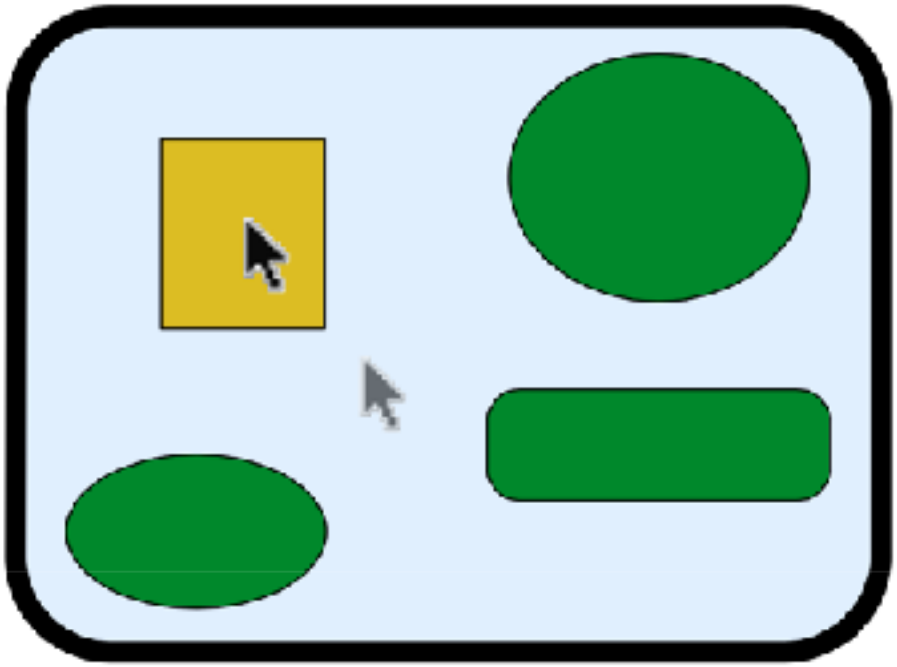
- scale display (e.g. fisheye + touch [Orwal & Feiner, 2003])
  (can be fast (e.g. time-multiplexed zoon, TapTap [Roudaut et al., 2008]
  http://youtu.be/3u9rVyC5x9E)

[Orwal & Feiner 2003]

chubby fingers

avoiding fingernail interaction (small target acquisition)

- object pointing by jumping from target to target [Guiard et al., 2004]
  requires indirect touch.



chubby fingers

avoiding fingernail interaction (small target acquisition)

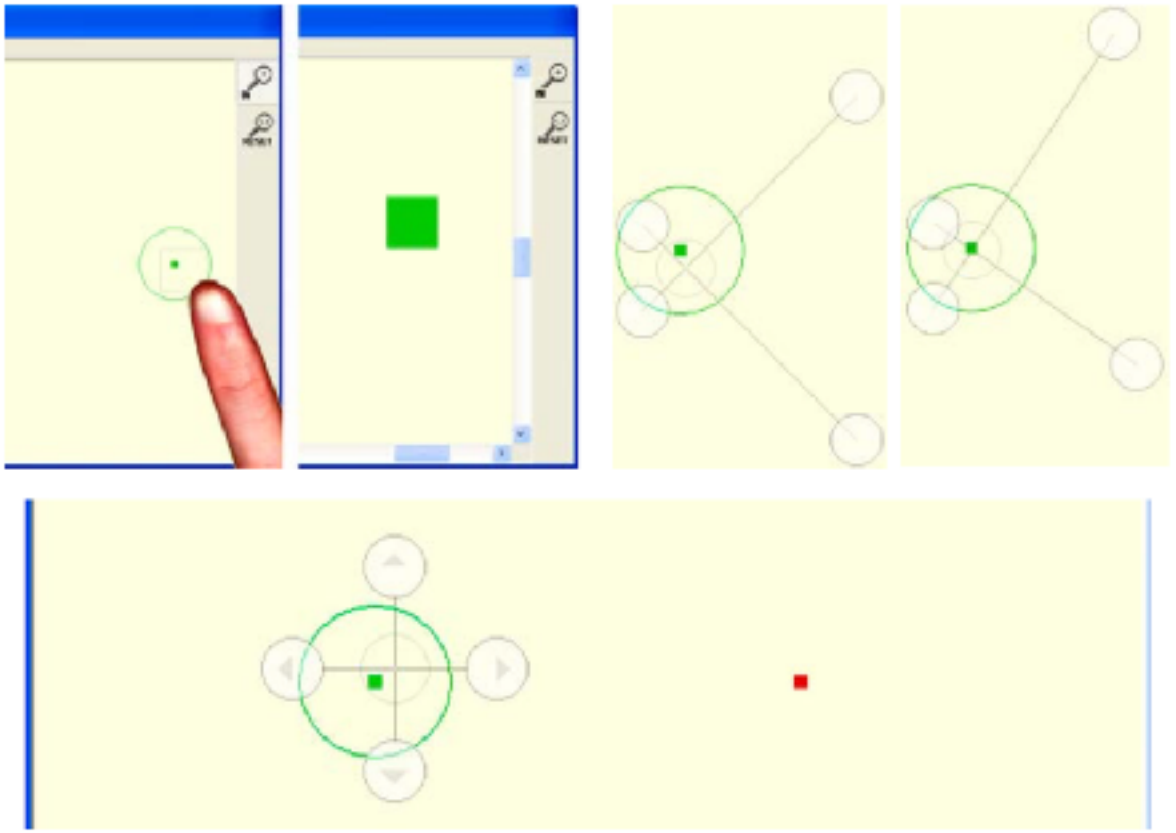
- scale motor space [Blanch et al., 2004]

Figure 12: Scroll-bar redesign
(a) original version. (b) new version: visual space (what it looks like) and (c) motor space (what it feels like when interacting with it).

chubby fingers

avoiding fingernail interaction (small target acquisition)

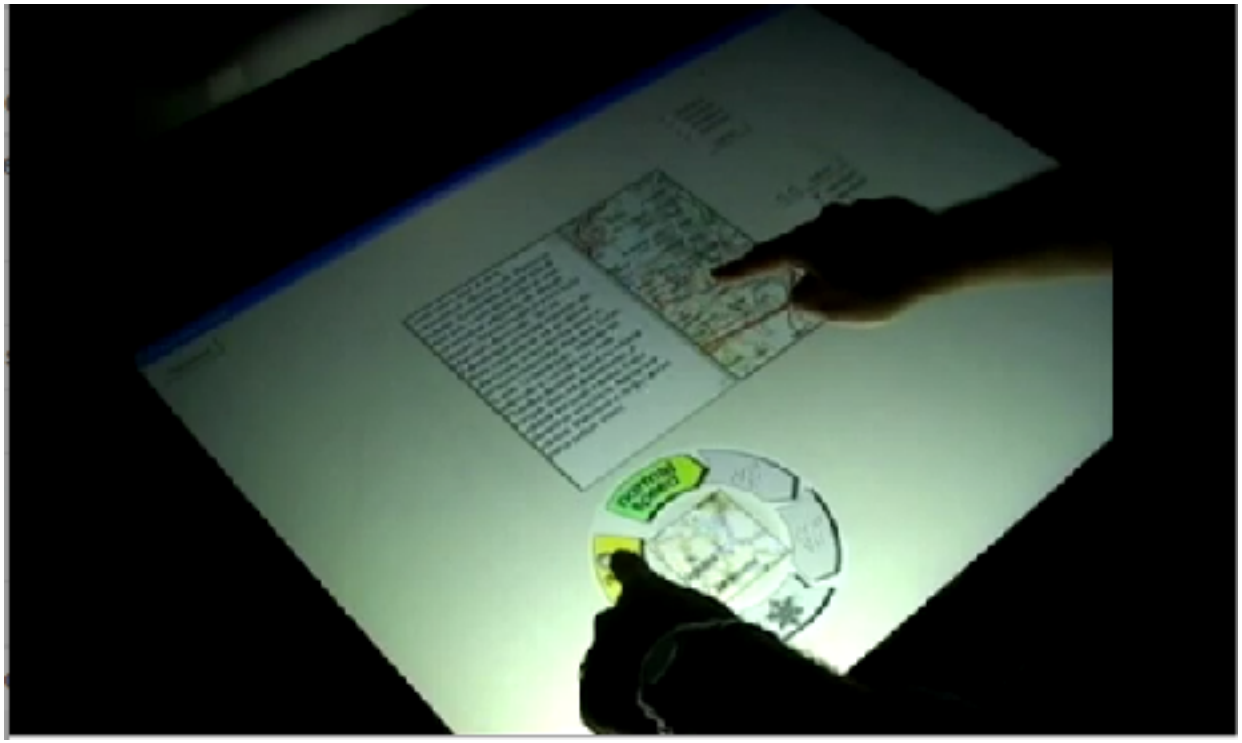
- use interaction widgets [Albinsson & Zhai, 2003]



chubby fingers

avoiding fingernail interaction (small target acquisition)

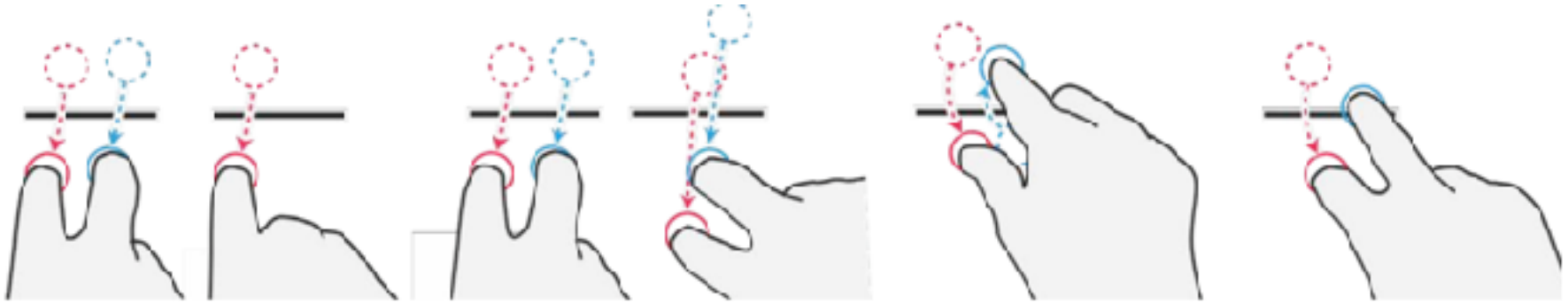
- use multitouch selection [Benko et al., 2006] http://youtu.be/XUy2bQpavc4



chubby fingers

avoiding fingernail interaction (small target acquisition)

- use sliding targets [Moscovich, 2009] http://youtu.be/k-bbgS8vUto
  or crossing (studied with direct touch [Luo & Vogel, 2014])

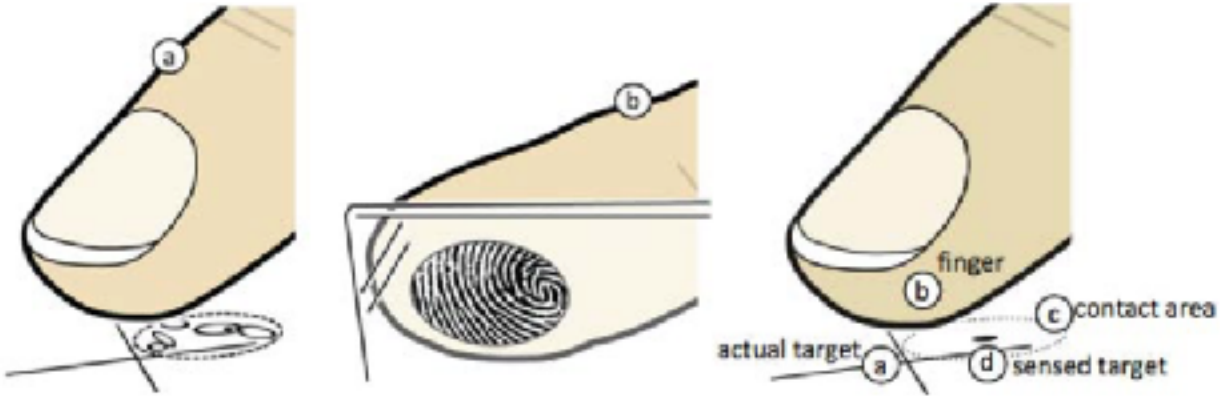


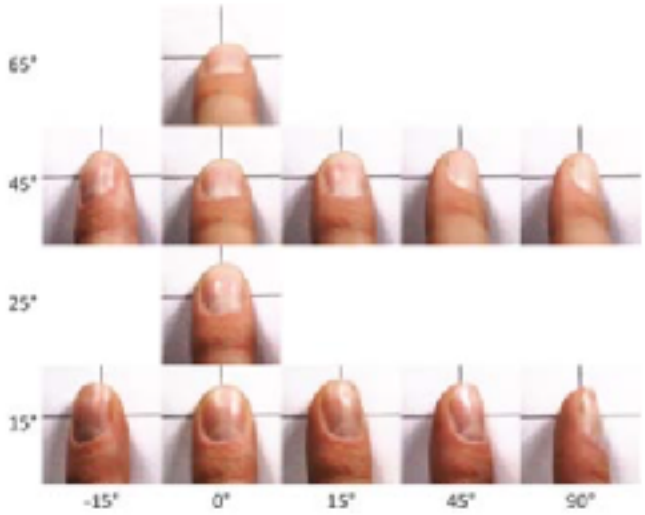
[Luo 2014]

chubby fingers

avoiding fingernail interaction (small target acquisition)

- modelling touch input (e.g. [Holz & Baudisch, 2010, 2011])





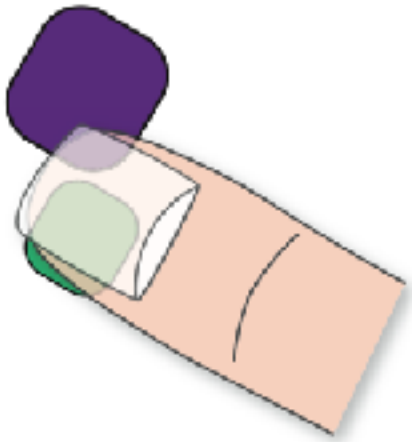
[Holts & Baudisch 2010, 2011]

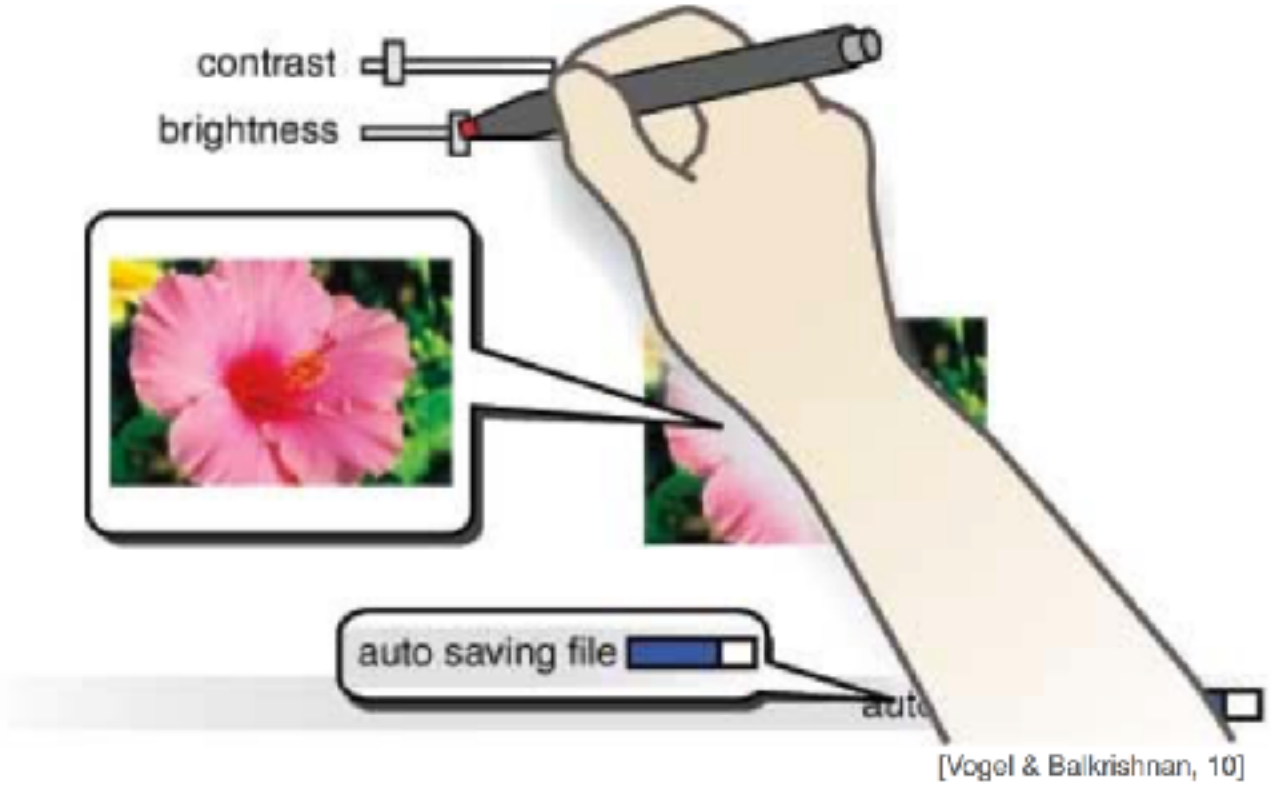
chubby fingers

avoiding fingernail interaction (small target acquisition)

- finger sized targets
- scale display [Orwal & Feiner, 2003] (can be fast [Roudaut et al., 2008])
- object pointing [Guiard et al., 2004]
- scale motor space [Blanch et al., 2004]
- use interaction widgets [Albinsson & Zhai, 2003]
- multi-finger precision techniques [Benko et al., 2006]
- use sliding targets [Moscovich, 2009] or crossing
- modelling touch input [Holz & Baudisch, 2010, 2011]

finger and hand occlusion





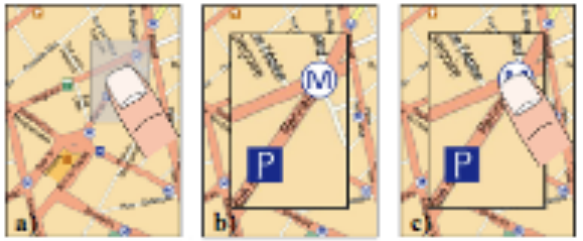
[Vogel & Balkrishnan, 10]

occlusion

avoiding occlusion

- using display scaling again ([Orwal & Feiner, 2003], [Roudaut et al., 2008])

[Orwal & Feiner, 2003]

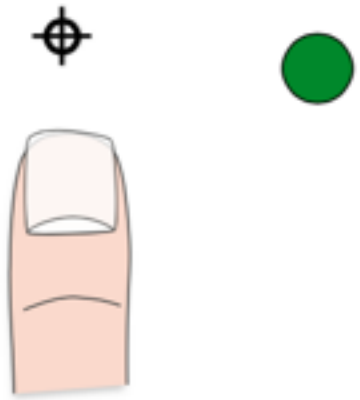


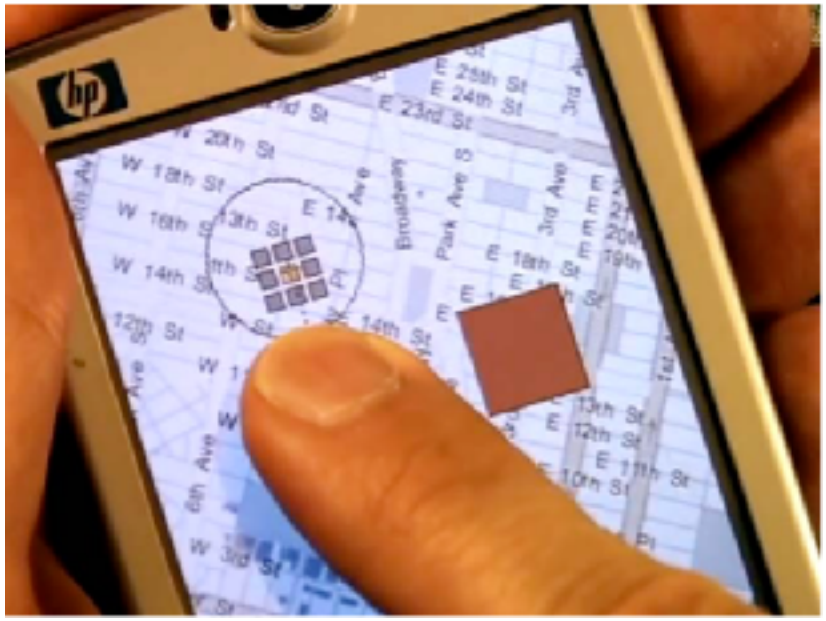
[Roudaut et al., 2008]

occlusion

avoiding occlusion

- offset cursor or displace content ([Potter 1988], Shift [Vogel 2007])

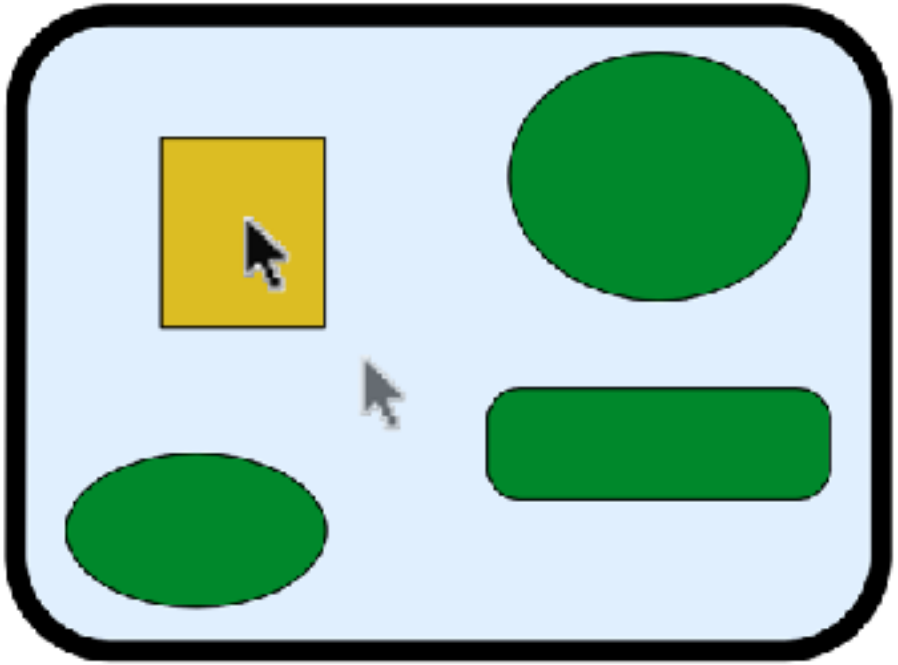




occlusion

avoiding occlusion

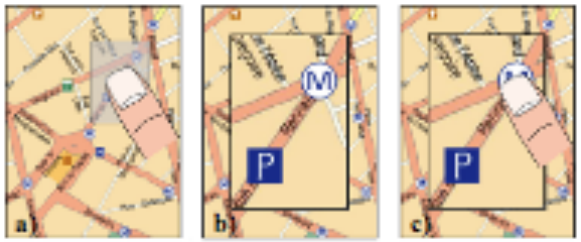
- object pointing techniques again [Guiard 2004]



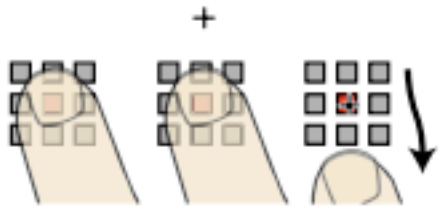
occlusion

avoiding occlusion

- using display scaling [Orwal, 2003], [Roudaut 2008])
- offset-cursor [Potter 1988] or
  displace area under touch visually [Vogel 2007]
- object pointing techniques [Guiard 2004]



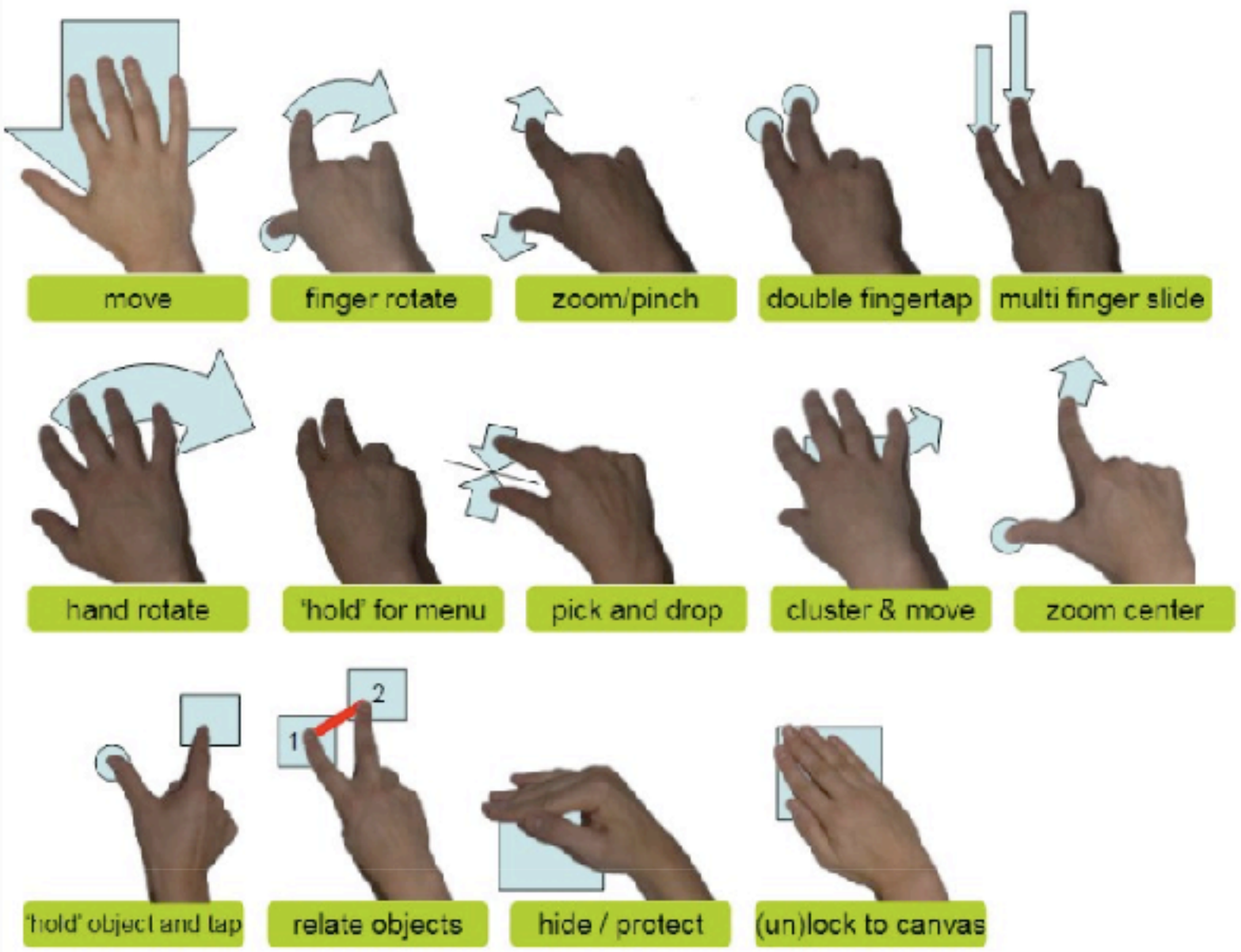
[Roudaut et al., 2008]



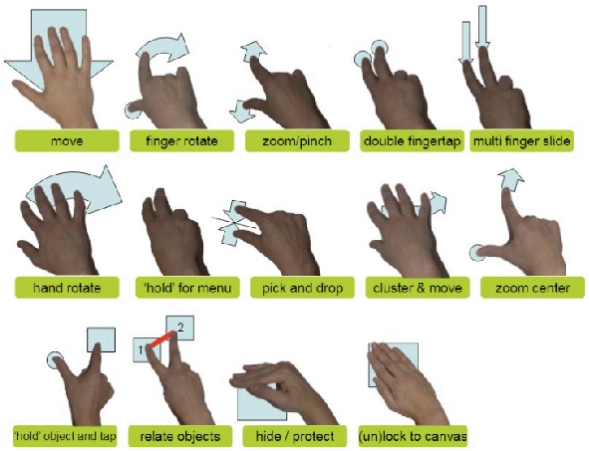
[Vogel et al., 2007]

http://youtu.be/kkoFIDArYks

(multi-touch) gestures



(multi-touch) gestures



- alternative to buttons and widgets
  provide discrete and continuous actions
- more expressive than button clicks
  using expressive power of the hand (skills, DOF, …)

- no standards, but vendor specific
- hard to discover how to do them (no affordances)
- hard to learn how to perform them correctly
  complex gestures and large vocabularies

videos

[Wu 2003]
http://www.dgp.toronto.edu/~ravin/videos/uist2003_tabletop.mpg

[Agarawala 2006]
Bumptop http://youtu.be/6jhoWsHwU7w

multi-touch gestures

Solution: gesture previews

- overlay with visual feedback
- show what gestures can be performed
- shows when others can join (collaborative gestures)
- indicates meaning of gestures
  - previews don’t limit expert users
  - increases detection rate, reduces learning curve

gestures learning …

Solution: gesture previews

- progressive feedforward: OctoPocus [Bau 2008]
- complex tutorial guides: ShadowGuides [Freerman 2009]
- metaphors: Gesture Play [Bragdon 2010]
- hand physiology and chords: Arpege [Ghomi 2013]
- and even user defined gestures [Woobrock 2009]

videos

OctoPocus [Bau 2008]
http://vimeo.com/2116172

ShadowGuides [Freerman 2009]
http://www.dustinfreeman.org/research/papers/tabletop2009_shadowguides.mpg

Gesture Play [Bragdon 2010]
http://youtu.be/-RF4NsLpEi8

Arpege [Ghomi 2013]
http://youtu.be/dGxeHjGp9kE

large multi-touch interfaces

why?

when?

how?

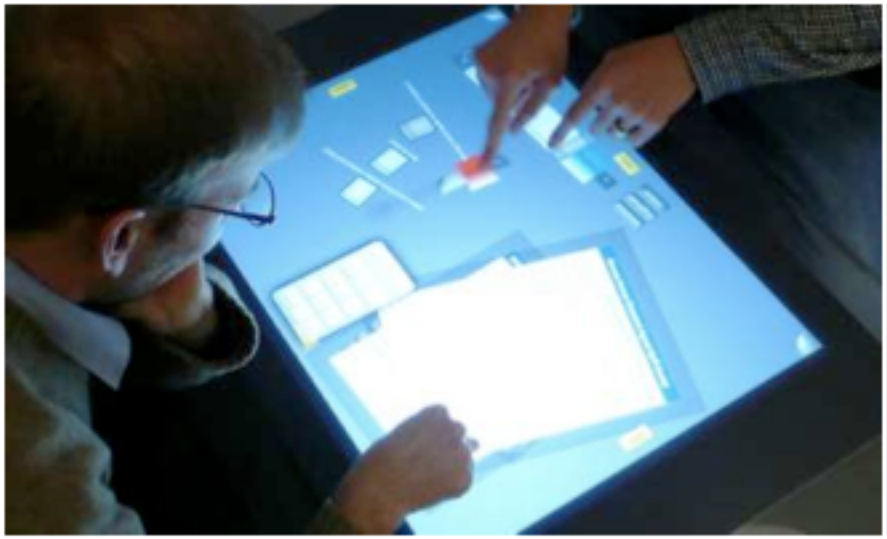
why large multi-touch surfaces?

- digital equivalents to desks or walls
- direct interaction with environment
- multiple people
- desktop screens are often too small
- new contexts

Picture from [McGee, 2001]

multi-touch large display

- > 50 inch diagonal
- surface as main interface
- several simultaneous inputs



[P. Isenberg, 2010]

[T. Isenberg, 2008]

when table vs. wall?

Microsoft Surface

Perceptive Pixels

equal participation tasks vs. presentation??

According to [Rogers, 2004]. But since then we have seen equal participation on walls, e.g. [Liu, 2015]. It depends on task & technology

how?

- Tabletop challenges

how?

- Tabletop challenges
  - × all touch challenges +

× orientation (menus, text)
× reach
× privacy & sharing
× user identification and conflicts

how?

tabletop challenges

dealing with orientation

MS surface

how?

tabletop challenges

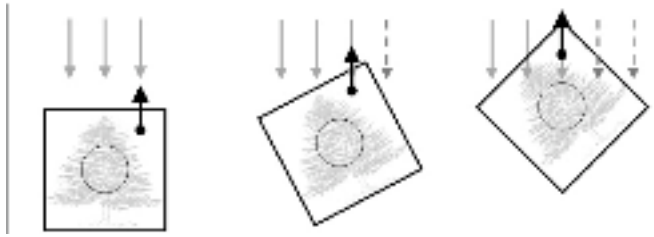
MS surface

dealing with orientation

- fix orientation
- allow multiple copies (e.g. [Wu 2003])
- adjust automatically (e.g. Occlusion aware menus [Brandl 2009])
- let the user decide (e.g. draw orientation [Leithinger 2007])
- combine automatic and user adjustment (e.g. [Dragicevic 2007])
- make object rotation easy (e.g. RnT [Kruger 2005])

[Brandl 2009]

[Leithinger 2007]



[Kruger 2005]

videos

[Brandl 2009]
http://youtu.be/1ursnHWyPgs

long Pentable video [Leithinger 2007]
http://www.leithinger.net/files/pentable_video.wmv

how?

tabletop challenges

reach

how?

tabletop challenges

reach

- throw / flick (e.g. [Reetz, 2006])
- radar views (minimap, dollhouse, …
  http://youtu.be/f1Pceuot16I

- direct vs. indirect interaction (e.g. [Parker 2006])

image: Parker et al., 2006

how?

tabletop challenges

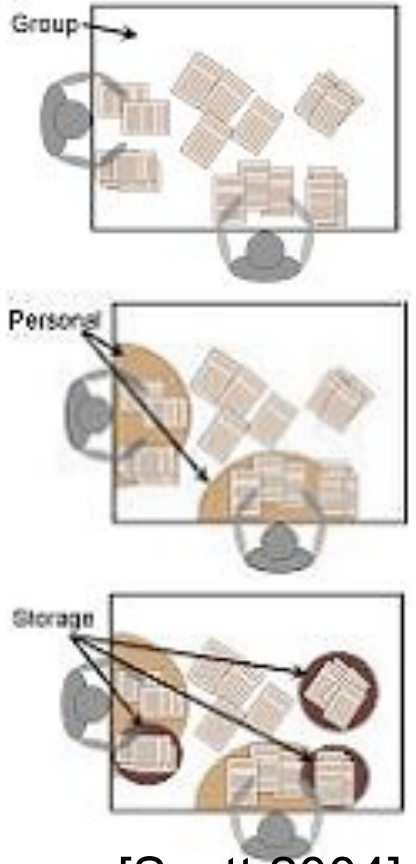
privacy & sharing

how?

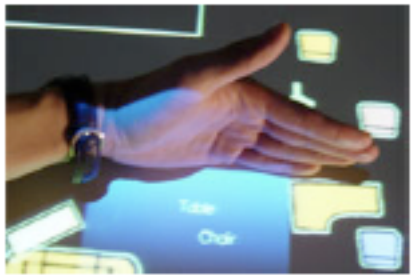
tabletop challenges

privacy & sharing

- ease sharing (e.g. with flicking)
- respect and support territories
  - personal, group, storage [Scott 2004]
- allow privacy interactions (e.g. [Wu 2003])



[Scott 2004]



[Wu 2003]

how?

tabletop challenges

user ID and conflicts,

affects ownership and makes gestures ambiguous

how?

tabletop challenges

user ID and conflicts,
affects ownership and makes gestures ambiguous

- use technology (e.g. DiamondTouch)
- use heuristics (e.g. finger distance, temporal displacement)
- allow users to coordinate
  - using social protocols
  - enforce sharing protocols (e.g. [Morris 2004])
  - define collaborative gestures (e.g. [Morris 2006], needs ID)
- work on capacitive touch screens for handprint ID
  [Harrison 2012],[Guao 2015]

how?

- wall challenges

how?

- wall challenges
  - × all touch challenges + most of tabletop ones

× gorilla arm (discussed before)
× reach (!!)
× change blindness
× perspective distortion

how?

wall challenges

reach

how?

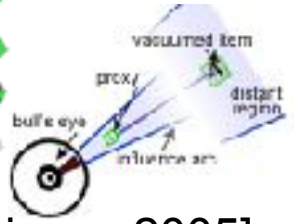
wall challenges

[Rekimoto 1997]

reach

- walking (e.g. pick-and-drop [Rekimoto 1997])
- mediators to reach
  (e.g. drag-and-pop [Baudisch 2005],
  vacuum [Bezerianos 2005])
- radar views or other lenses
- absolute vs. relative pointing
  (e.g. Hybrid Pointing [Forlines 2006])

[Baudisch 2003]



[Bezerianos 2005]

[Forlines 2006]

videos

[Rekimoto 1997]
http://www.sonycsl.co.jp/person/rekimoto/pickdrop/pd1.mpg

[Baudisch 2005]
http://www.patrickbaudisch.com/projects/dragandpop/index.html

[Bezerianos 2005]
http://youtu.be/_o8H89fAHII

[Forlines 2006]
http://youtu.be/FZmOBIg5KjM

how?

wall challenges

change blindness

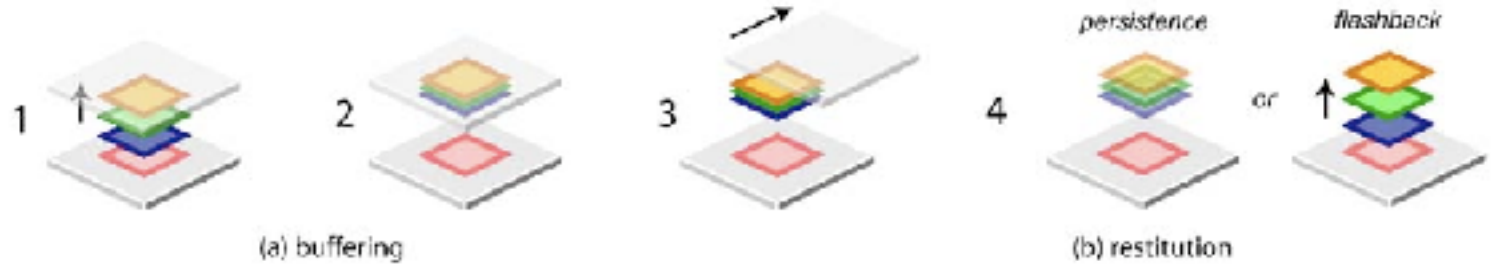
how?

wall challenges

change blindness

- do nothing
- use notifications close to the user
- store and replay (e.g. Mnemonic rendering [Bezerianos 2006])

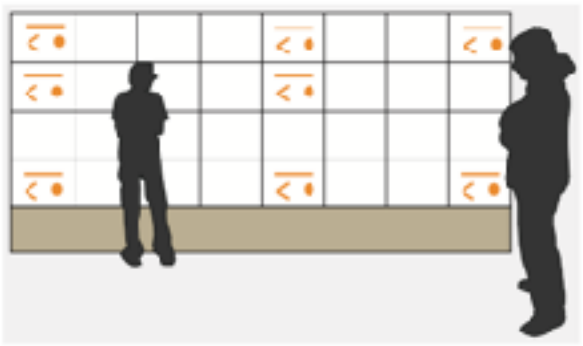
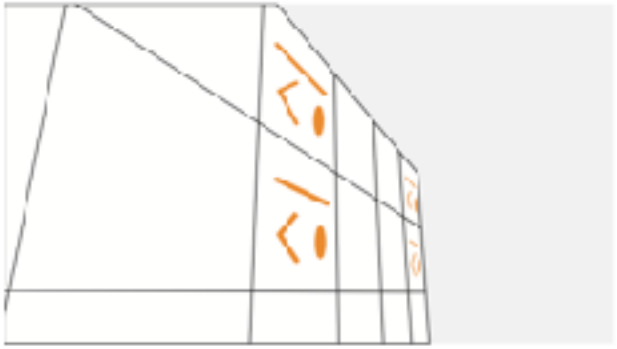
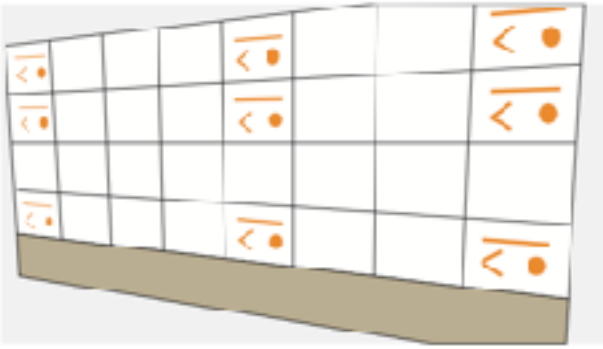
http://youtu.be/POFV4fZYz_E



how?

wall challenges

perspective distortion [Bezerianos 2012] and LCDs [Kim 2011]
affects how we view information

(but can also be useful) http://www.youtube.com/watch?v=1Oszb7AhKGA#t=15

- place important information close to user (e.g. radar)
- stand further back using remote interaction [Nancel 2011]

http://www.lri.fr/~nancel/videos/CHI_11_CamReady_GoodRes_SD.mov

wall challenges

so why not just interact from a distance?

- miss resolution and detailed work
- miss implicit zooming to change perspective
- remote techniques (e.g. laser pointers) often inaccurate or require extra devices
  - much work on this, ask if interested in references

Best: support both!

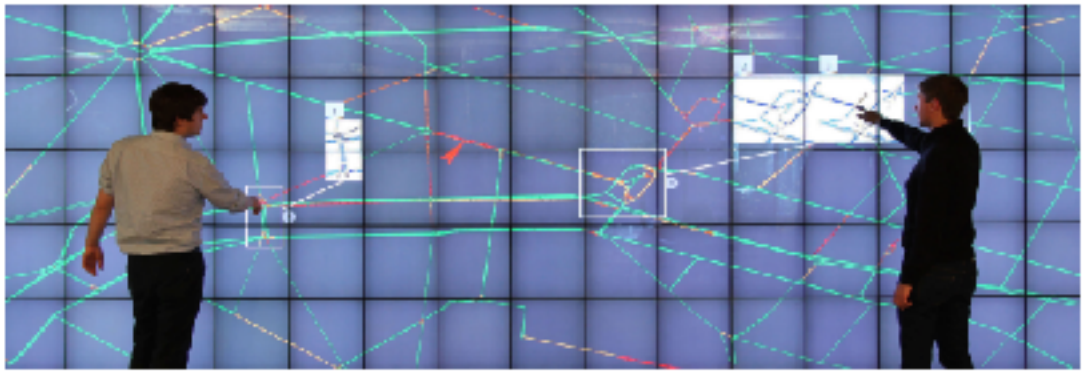
topics / trends in tables and walls

- Fundamental aspects
  - input (e.g. remote interaction [Nancel 2012], [Chapuis 2014], [Léon 2024]),
  - output (e.g. perception [Bezerianos 2012], multiple encodings [Isenberg 2013]),
  - collaboration (e.g. [Wallace 2011], [Liu 2016]), etc.
- Applications
  - scientific analysis (e.g. [Isenberg 2010], [Sultanum 2011]),
  - public displays (e.g. engagement [Müller 2012]),
  - crisis management (e.g. [Doeweling 2013], [Prouzeau 2017,2019]), etc.
- Technology and novel large displays

  (e.g. floors [Augsten 2010]) http://www.youtube.com/watch?v=spiKgkW1UmI

  but there are many more unexplored possibilities (see internship !!!)
- Modality or Device combination
  - with AR (e.g. [Reipschlager 2021] [James 2023]), etc
  - pen/touch/gesture input (e.g. [Frisch 2011]),
  - haptic and visual output (e.g. [Kim 2013]), etc.
  - with smartwatches (e.g. [Frisch 2011, Horak 2018]) or mobile phones/tablets (e.g. [Tsandilas 2015], [Chapuis 2014]), etc

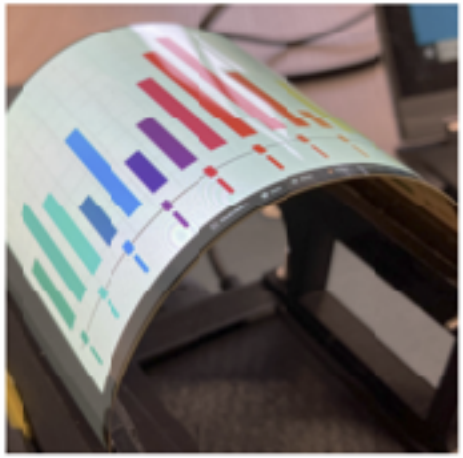
related internships (1)



Wall Displays versus Virtual Reality in Collaborative Tasks
(and many more positions in AR !!!).
https://ilda.saclay.inria.fr/jobs.html

Large wall displays are expensive to build and hard to develop for, do we really need them? This internship will investigate differences in how people collaborate around a physical wall display compared to using connected VR headsets. The goal is to understand what are the benefits / drawbacks between the two and when we should use each of these technologies.

related internships (2)


Data Visualization on Non-Planar Displays supervised by Petra Isenberg/Raimund Dachselt or Anastasia Bezerianos/Tobias Isenberg (2 positions). www.aviz.fr/Research/Jobs

These internships are part of a project that aims to escape from the “display flatland” that characterizes today’s research. It will establish foundations for how to engage with a future in which physical displays take on several different form factors and become truly embedded in our environments.

Internship 1: non-flat displays for public spaces
Internship 2: non-planar mobile devices

touch can be fun

SandCanvas [Kazi et al. 2011]
http://youtu.be/NQ9FERXWWsQ