Mobile Interaction

Eric Lecolinet

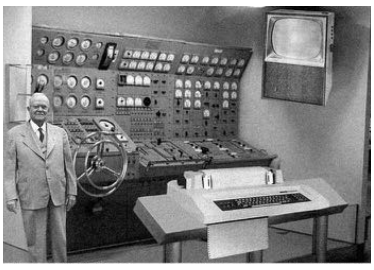
LTCI - Télécom ParisTech - DIVA Group

http://www.telecom-paristech.fr/~elc

Mobile Interaction

Eric Lecolinet
LTCI - Télécom ParisTech - DIVA Group
http://www.telecom-paristech.fr/~elc

Half a century of evolution



1954: teletype

1984: WIMP model
desktop metaphor

2007: multitouch,
sensors

- **smarter**
- **smaller**
- **more mobile**
- **closer to the body**
- **will eventually vanish?**

Early Mobile Devices

1946: first commercial mobile phone service

- ATT, for vehicles

1948: the transistor was invented

- beginning of miniaturization

1960s: mobile radio telephone

1973: Hand held mobile phone

Evolution: Personnal Digital Assistants (PDA)

1980: Radio ShackTRS-80 Pocket Computer

1984: Psion Organizer: first handheld computer

1993: Apple Newton

1996: Palm Pilot

1996: Windows CE

2000: Windows Mobile Pocket PCs

Evolution

Black Berry & Windows Mobile in 2007 vs.2009

- output:
  - larger screen, higher resolution
- input:
  - keyboard + joystick, then resistive then capacitive touchscreen
  - the keyboard has disappeared!

Evolution

iPhone (June 2007) and modern mobile devices

Output:

- high resolution screen
- audio
- vibrator

Input:

- no physical keyboard!
- capacitive touchscreen
  - interaction with fingers
  - multitouch
- sensors

Pointing: touchscreen vs. desktop

Direct vs. indirect input

- **direct**: on-screen pointer = input position
  - **direct** : touchscreen
  - **indirect**: mouse, trackpad, graphics tablet
- **direct** => same device for input & output
- but the opposite is **not true!**

Pointing: touchscreen vs. desktop

Direct vs. indirect input

- **direct**: on-screen pointer = input position
  - **direct** : touchscreen
  - **indirect**: mouse, trackpad, graphics tablet
- **direct** => same device for input & output
- but the opposite is **not true!**

Absolute vs. relative movement

- **absolute**: "consistent" mapping between input and output
  - touchscreen, graphics tablet
  - "consistent" not necessarily 1 to 1!
- **relative**: maps dispacement in input space
  - mouse, trackpad

Pointing: touchscreen vs. desktop

Direct vs. indirect input

- **direct**: on-screen pointer = input position

Absolute vs. relative movement

- **absolute**: "consistent" mapping between input and output
- **relative**: maps dispacement in input space

Usually

- touchscreen = **direct** + **absolute**
  => **no cursor**

But

- touchscreen can be **indirect**, and even **relative!**
- touchpad can be **absolute!**

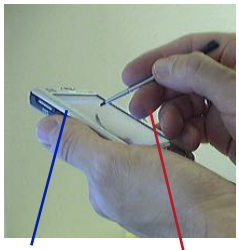
Fat finger problem

Direct => **occlusion**

Direct + Absolute => **lack of precision**

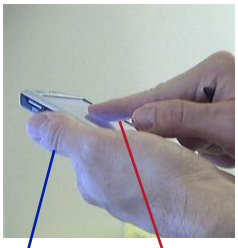
=> targets should be **large** (>= 9.2mm [Parhi 06])

=> can be improved with better **technology** [Holz 10]



unique contact point

remove hand from screen



ambiguous contact point

finger occludes target

From [Vogel et al. CHI 07]

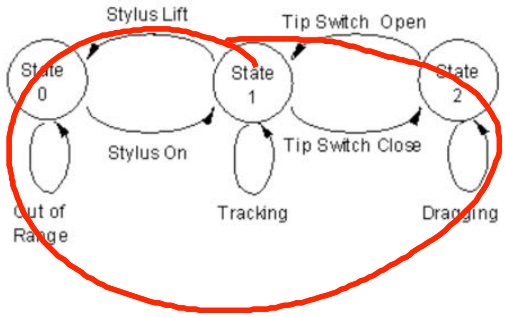
Interaction states: touchscreen vs. desktop

Desktop: 3 states or more

- mouse in air
- mouse on the surface
- button pressed

==>

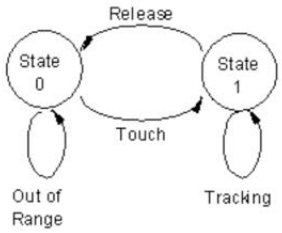
- **moving** != **dragging**
  => position can be precisely adjusted
- hover mode: tootips



Buxton 3 state model, 1990

Touchscreen: 2 states

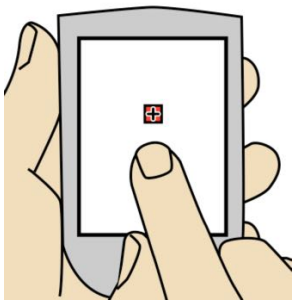
- **touching == pressing** mouse button
- => pointing performed **"in the air"**



Strategies: Offset cursor

Offset cursor [Potter et al. 88, Sears et al. 91]

- cursor at a **fixed position** from finger
- *absolute but indirect*
  - better occlusion & precision but **slower**
  - bottom area not accessible

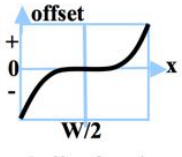


From [Vogel et al. CHI 07]

Adaptative offset cursor [Huot et al. 06]

- **variable horizontal offset**
- *absolute but not 1 to 1*
  - distant objects easier to reach
  - requires training

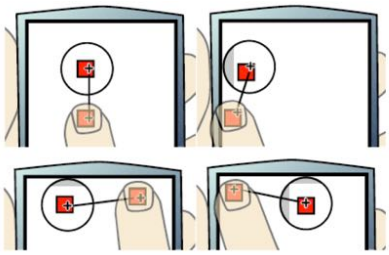
$$\delta x = \frac{\left(x - W/2\right)^3}{W * \lambda}$$



Strategies: Cursor on demand

Shift [Vogel et al. 07]

- **cursor after a delay + magnification**
- *absolute & indirect + delay*
- **data aware**: delay depends on target size
  - 3x faster than Offset cursor (for 3mm targets)



Commercial devices (iPhone, etc.)

- similar but **data agnostic**
- **delay** or double touch

Strategies: Object pointing

ThumbSpace [Karlson 07]

- **overview + object** pointing
- indirect, absolute?
- distant objects easier to reach

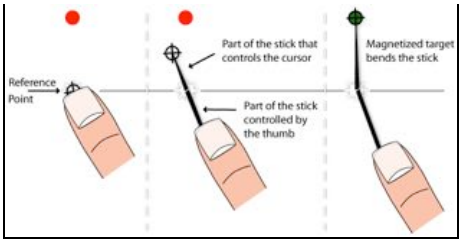
Starburst [Baudisch 08]

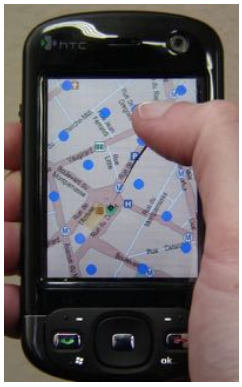
- Voronoï diagrams

Strategies: Telescopic cursor and zooming

MagStick [Roudaut et al. 08]

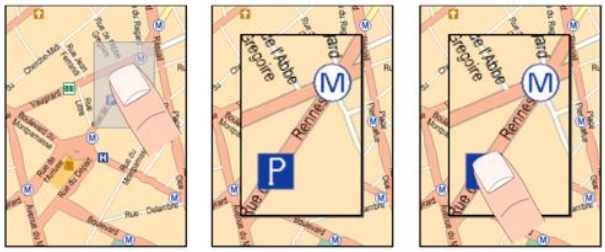
- **telescopic stick :**“magnetized” cursor
- fast and distant objects easier to reach



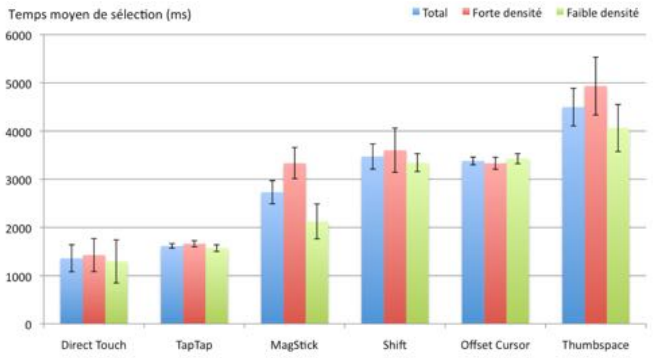


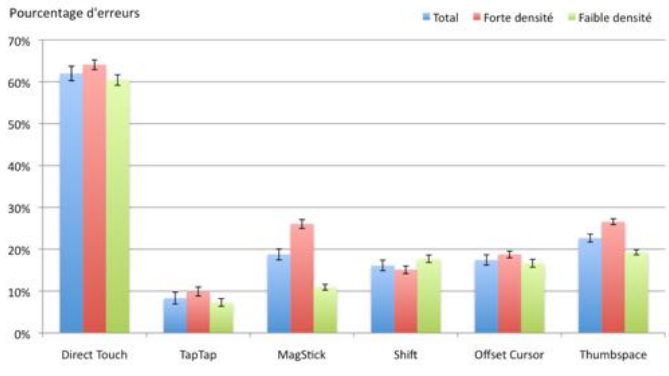
TapTap [Roudaut et al. 08]

- double tap with **automatic magnification**
- **very fast** but always active



Comparison



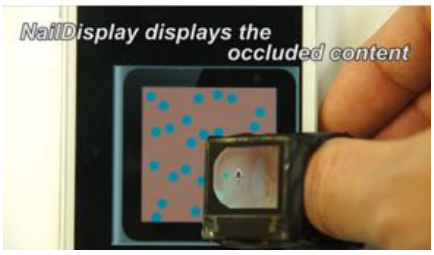


Other Strategies

Fingerprints: [Holz et al. 10]
- better touch model => better accuracy

Back-of-device touch input: NanoTouch [Baudisch et al. 09]

NailDisplay [Su et al. 13]



Gestures: Escape [Yatani et al. 08]
- directional gestures select small targets

Hover Cursor: [Osberg et al. 15]
- hover sensing over a touchscreen

Pre-Touch Sensing for Mobile Interaction

Ken Hinckley, Seongkook Heo, Michel Pahud, Christian Holz, Hrvoje Benko, Abigail Sellen, Richard Banks, Kenton P O'Hara, Gavin Smyth, William Buxton

https://www.youtube.com/watch?v=Y4KQVNpWu-s

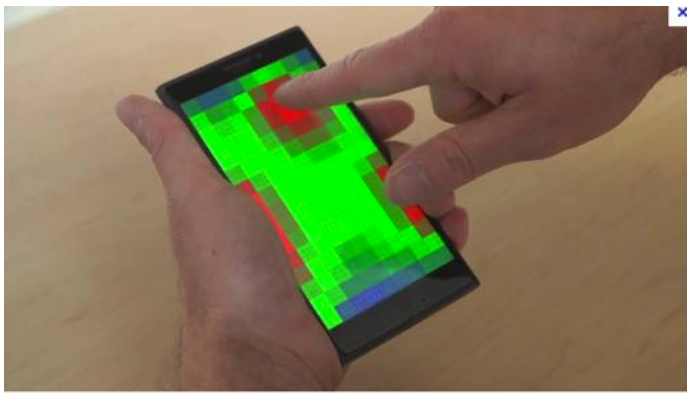
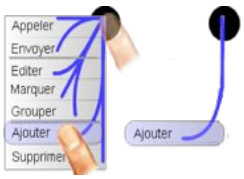


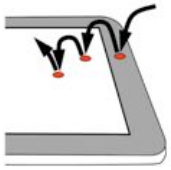
Figure 7. Our *calm web browser* reveals interactive affordances in a nuanced way that feathers off with the finger contours.

Gestures = a large resource deposit

Morphology

- Dimensionality (2D, 3D)
- Multitouch
- Shape
- Kinematics, temporal patterns
- Bumps
- With or without friction
- Pressure / pseudo-pressure
- etc.

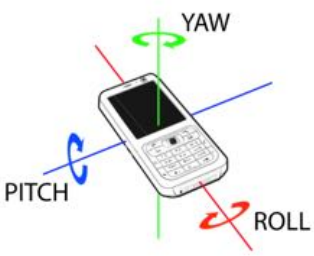




Gestures = a large resource deposit

Frame of reference

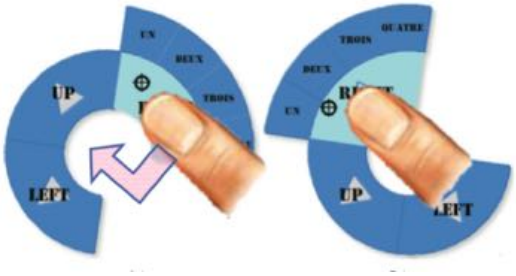
- 2D gestures:
  - movements **on** the device
    - on the screen
    - on the sides/back/bezels..
- 3D gestures
  - movements **around** the device
  - movements **of** the thevice
    - 3 translations
    - 3 rotations



Pie menus and Marking menus

Pie menus

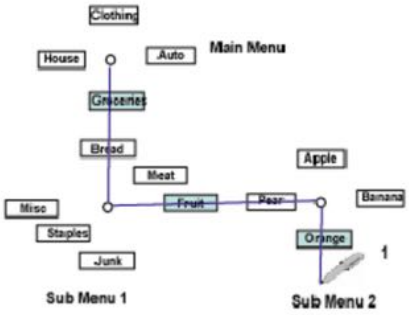
- straight lines
- no expert mode



Thumb Menu [Huot et al. 07]

Marking menus

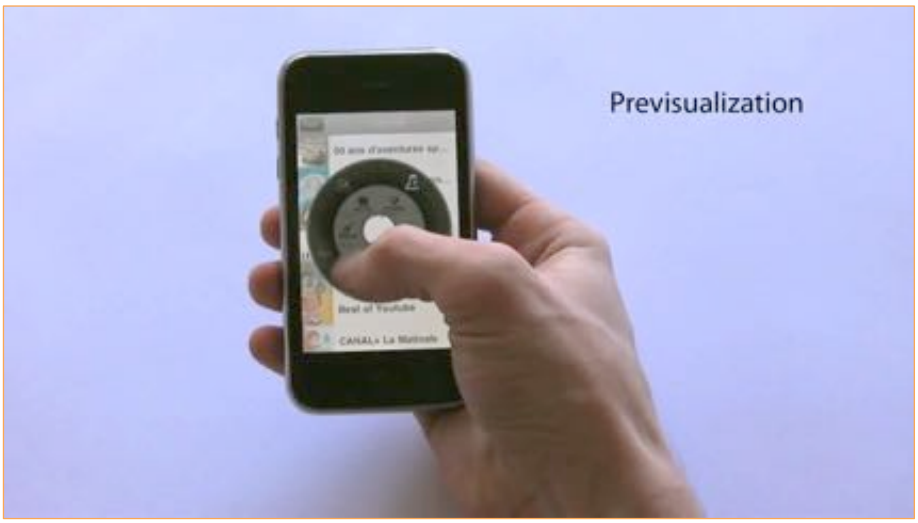
- expert mode
- N levels: "zig-zag" marks (too large)

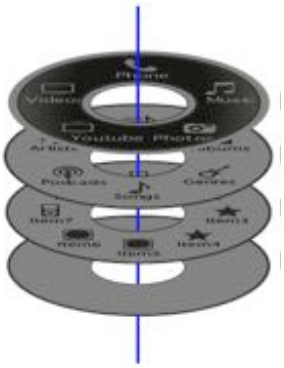


Wavelet menus

[Bailly et al. 10]

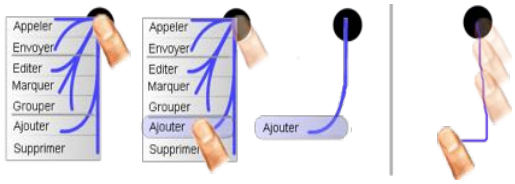
- novice mode: **inverted** rings
- expert mode: **superimposed** marks

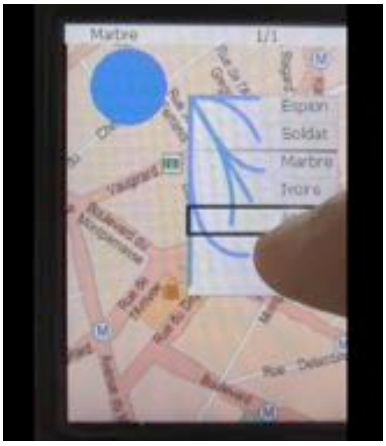




Using curvature

Leaf menus [Roudaut et al. 09]



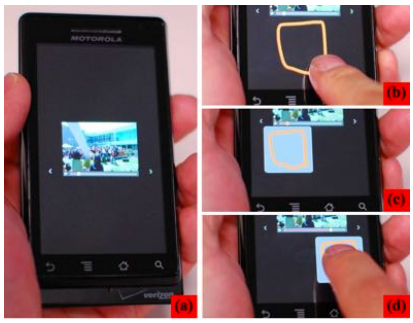


novice mode *expert mode*

Drawing & symbols

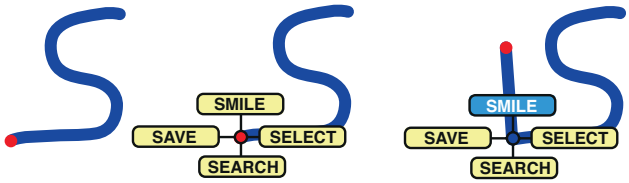
Gesture Avatar [Lu & Li 11],

- the user can draw a letter or the shape of a widget
- less errors than Shift, faster for small targets (1mm)



Augmented Letters [Roy et al. 13]

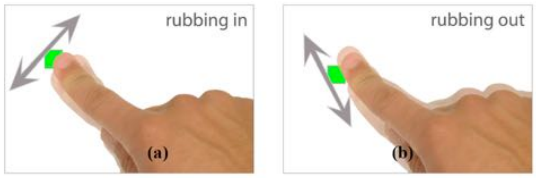
- symbols + Marking menus



Using the shape or kinematics

Rubbing gestures [Olwal et al. 08]

- to-and-fro diagonal gestures
- act as delimiters



MicroRolls [Roudaut et al. 09]

- rolling gestures of the thumb

Drag **Flick /Swipe** **Rubbing** **MicroRolls**

MicroRolls [Roudaut et al. 09]

- do not conflict with ordinary gestures
- zero tangential velocity (no friction)

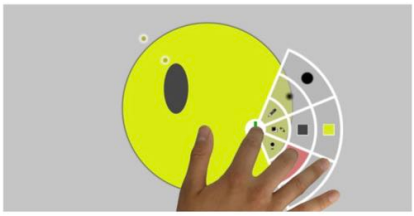
Multitouch: which fingers?

Hardware based

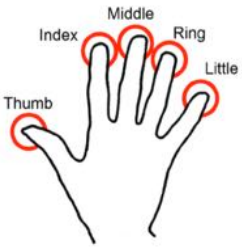
- vision-based, fingerprints [Holz et al. 10]

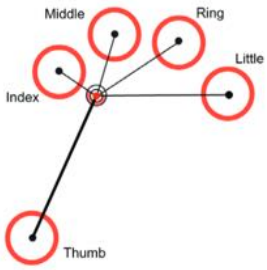
Sofware based

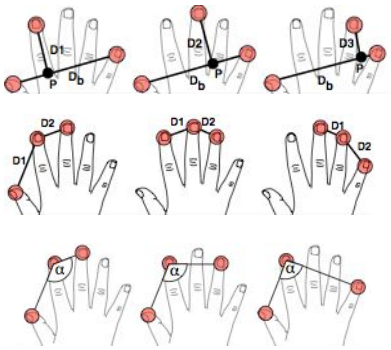
- Lift-and-stroke [Lepinski et al. 10]
- Multitouch finger registration [Au and Tai 10]
- Multi-finger Chords [Wagner et al. 14]



Multi-finger Pie Menu [Banovic et al. 11]



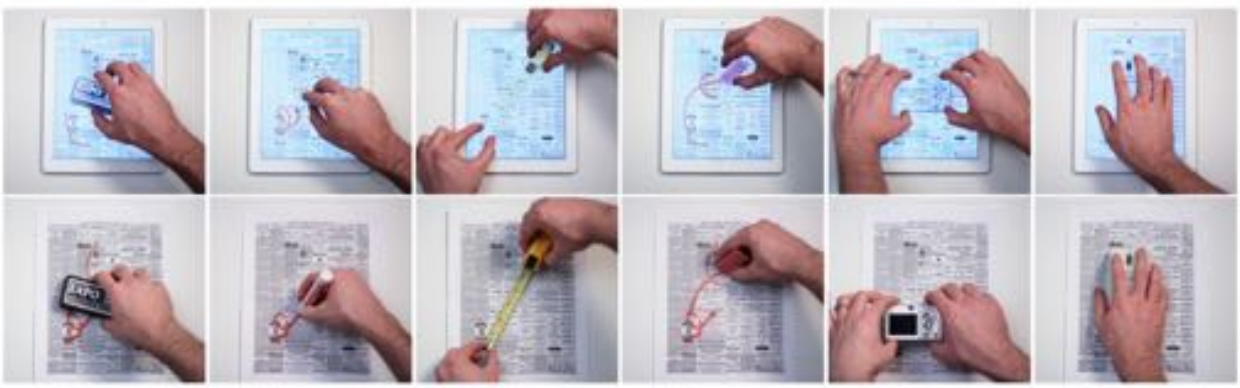




Multitouch: ways of touching

FingerSense (Queexo)

TouchTools [Harrison et al. 14]



whiteboard eraser, marker, tape measure, rubber eraser, camera, mouse, magnifying glass.

Two-handed

BiTouch / BiPad [Wagner et al. 12]

- two-handed interaction
- special zones
- taps, chords, gestures

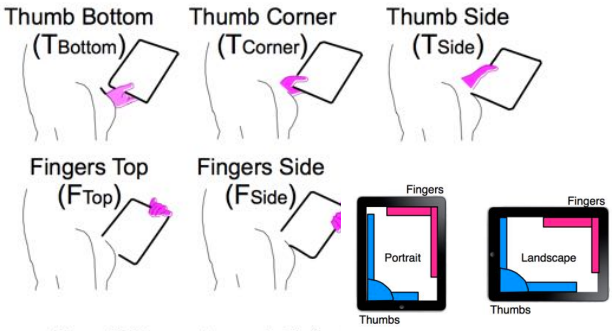
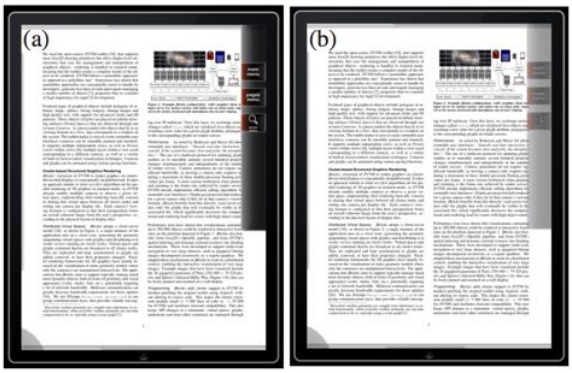


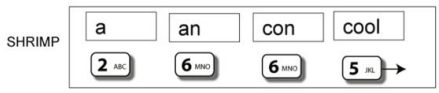
Figure 2. Five spontaneous holds (portrait orientation).



3D gestures

SHRIMP [Wang et al. 10]

– tilting the phone to disambiguate



TimeTilt [Roudaut et al. 09]

– tilt the phone to navigate between apps

3D gestures

[Baglioni et al. 11]

JerkTilts

- Avoid unintentional activation
- Auto-delimiting quick back-and-forth gestures

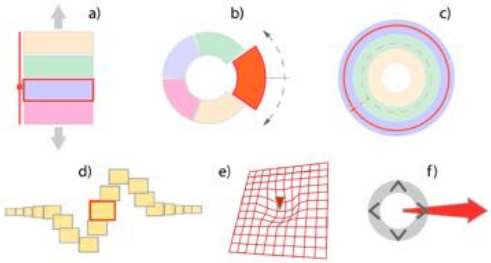
Extending the device

- Input

- Output

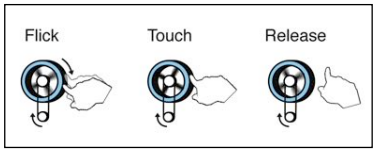
Input: Pressure and pseudo-pressure

Pressure widgets
[Ramos et al. 04]



Flick&Brake
[Baglioni et al. 11]

- Extends Flick metaphor



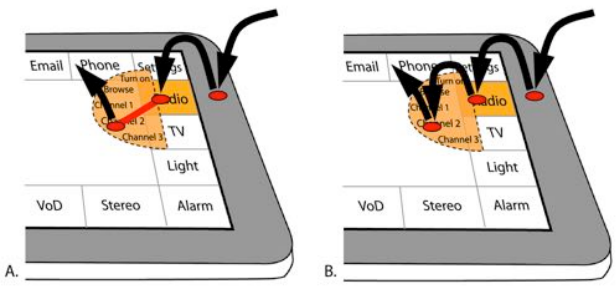
Input: Using the bezels

BezelSwipe [Roth et al. 09]

- gestures start from the bezels

BezelTap [Serrano et al. 13]

- accelerometer : **tap on the bezel** + tap or slide on the screen
- always active even in idle mode



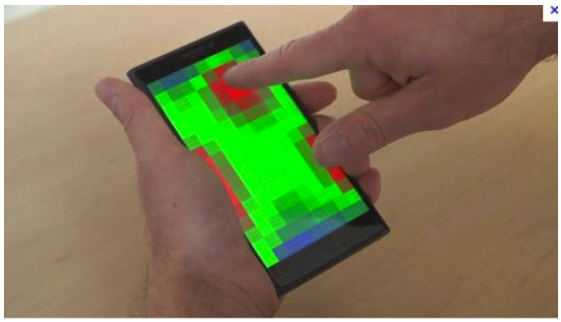
BezelTap [Serrano et al. 13]

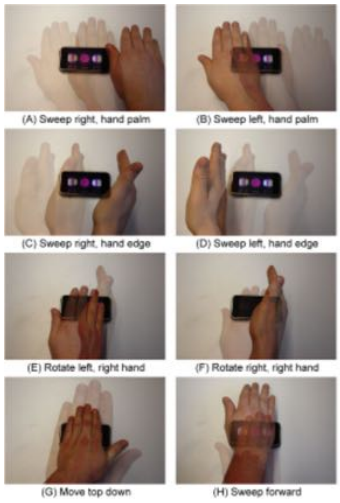
Around the bezel and the screen

HoverFlow
- IR distance sensors

HoverFlow
[Kratz, Rohs 09]

Pre-Touch sensing [Hinckley et al. 16]

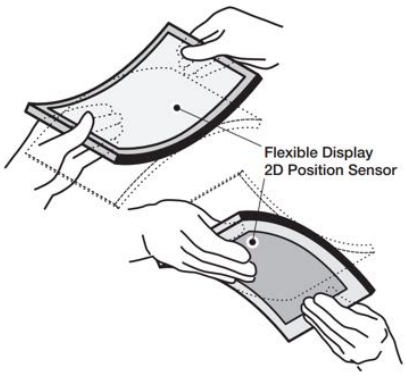


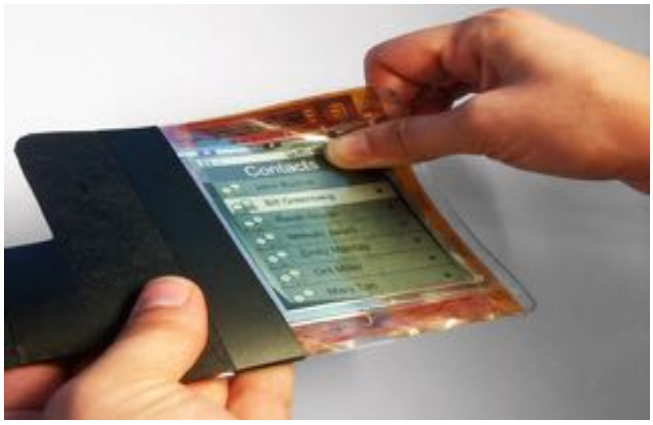


Bending the tablet

Gummi [Schwesig et al. 04]

PaperPhone [Lahey et al. 11]





Clavier projeté (Lumio)

Output: Tactile feedback and Shape changing

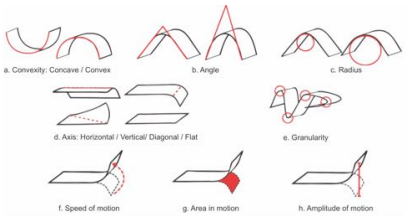
TeslaTouch [Bau et al. 10]

Haptic Edge [Jang et al. 16]

Morphees [Roudaut et al. 13]

Shapes and emotions [Strohmeier et al. 16]

TeslaTouch (Bau et al, Disney)



Clavier projeté (Lumio)

Haptic Edge Display for Mobile Tactile Interaction

Sungjune Jang, Lawrence H Kim, Kesler Tanner, Hiroshi Ishii, Sean Follmer
https://www.youtube.com/watch?v=R1lnHeWsSMU
http://www.sjjang.com/#!haptic-edge-display/a17g1

Sungjune Jang et al., CHI, 2016 (accepted)

Smartwatches, etc.

Olsen: *"If I can fit my entire PC in a cubic inch, how will I interact with it?"*

Abracadabra

- use of the (larger) space around a (very small) device
- magnets

Abracadabra [Harrison et al. 09]

Nenya [Ashbrook et al., 11]
- micro-interactions with a ring

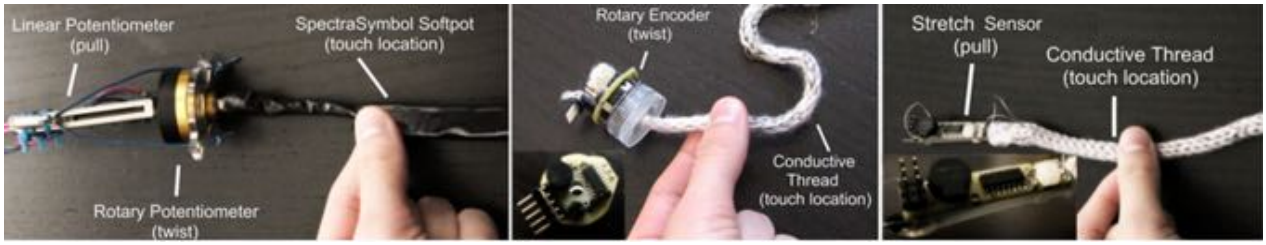
The Flat Finger: Exploring Area Touches on Smartwatches

Ian Oakley, Carina Lindahl, Khanh Le, DoYoung Lee, MD Rasel Islam
https://www.youtube.com/watch?v=G52fvjBycpo

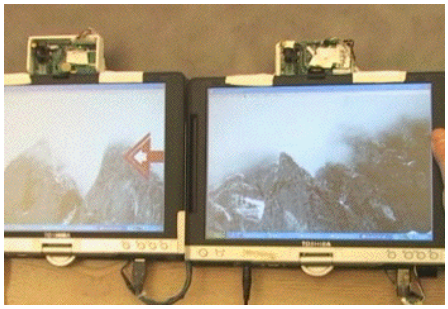
WatchIt [Perrault et al. 13]

- pointing/sliding gestures on the wristband
- shortcuts & continuous control
- eyes-free

Gestures... elsewhere



CordInput
(Schwarz et al 10)



Synchronous gestures
(Hinckley)

Stane
Murray-Smith et al. 08

Gestures on the body

Skinput [Harrison et al. 10]

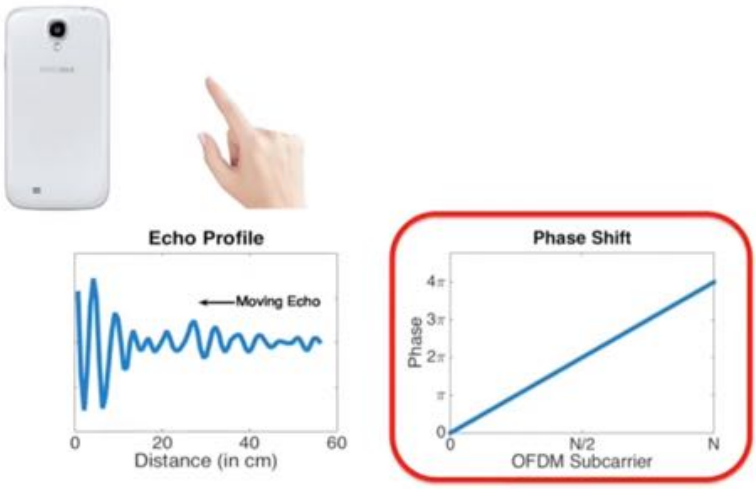
Skintrack [Zhang et al. 16]

iSkin [Weigel et al. 15]

Body-centric Design Space [Wagner et al. 13]

FingerIO: Using Active Sonar for Fine-Grained Finger Tracking

Rajalakshmi Nandakumar, Vikram Iyer, Desney Tan, Shyamnath Gollakota
https://www.youtube.com/watch?v=PpVUCEZvNjI
http://fingerio.cs.washington.edu/



Feedback

Tactile displays on the body [Gupta et al. 16]

Auditory menus [Zhao et al. 07]
- eyes-free selection

More...

ExoSkin: On-Body Fabrication
[Gannon et al. 16]

- hybrid fabrication system for designing and printing digital artifacts directly on the body.

Cilllia 3D Printed Micro-Pillar Structures for Surface Texture, Actuation and Sensing
[Ouet al. 16]

Mobile Augmented Reality

Here service

iOS App Metro Paris

Toolkits: Layar, Wikitude, etc.

Google Goggles

AR glasses

Google Glass

www.immersion.fr

Thad Starner

Head-Mounted displays

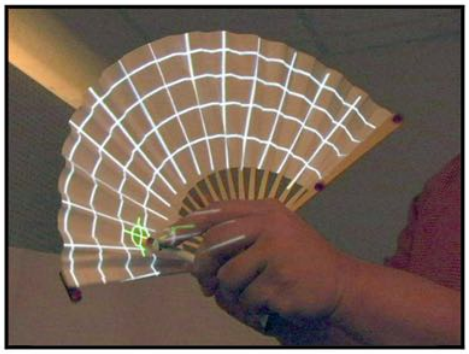
Eyeglasses

Contact lenses

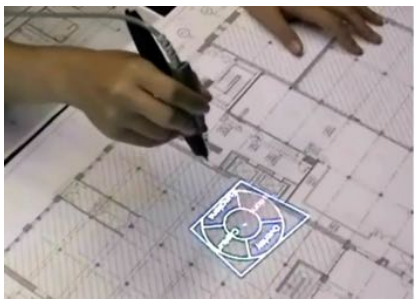
Virtual Retinal display

Picoprojectors

SixthSense [Mistry, Maes 2009]



Foldable interactive displays
[Lee et al. 2008]



PenLight [Song et al. 2009]

Interacting with the environment

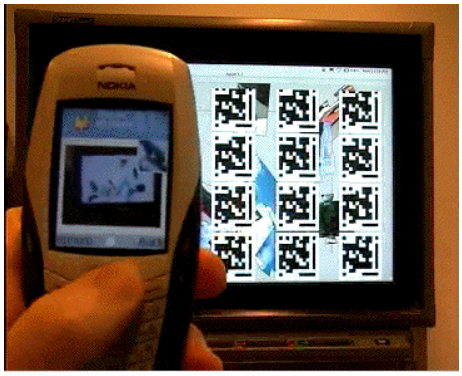
QR Codes or Visual Codes

Visual Code Widgets [Rohs 2004]

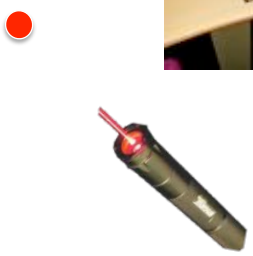
– camera phone as “see-through tool”

Sweep, Point and Shoot [Ballagas et al. 2005]

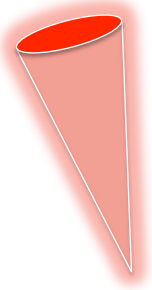
– the phone controls the screen



Pointing in the physical world [Delamare, Coutrix, Nigay 13]



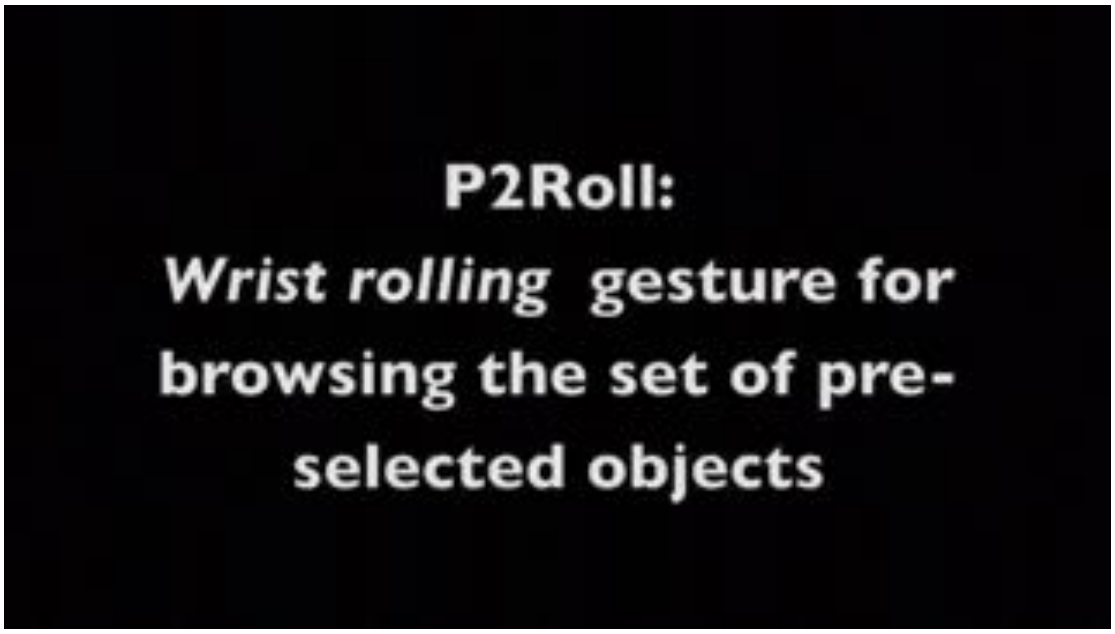
Alternative



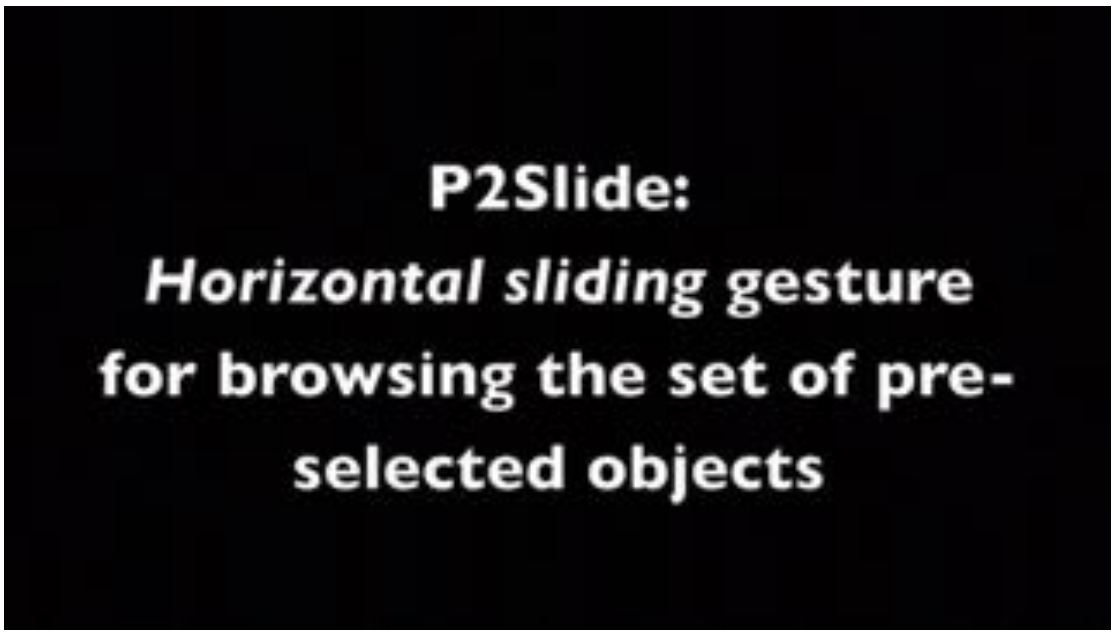
Ray-Casting is difficult to improve in the physical world

Volume-based pointing & disambiguation step

P2Roll [Delamare, Coutrix, Nigay 13]



P2Slide [Delamare, Coutrix, Nigay 13]

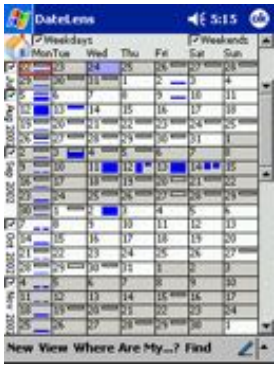


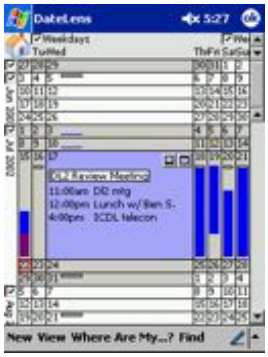
Visualisation

Halo [Baudisch 03]

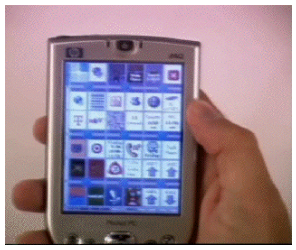
Personalized Compass [Miau et al. 16]

Visualization: zoomable interfaces





Fisheye View: DateLens [Berderson]



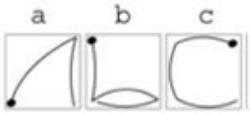
Semantic zooming : LaunchTile

Text entry

ShapeWriter [Zhai 08]
and iPhone keyboard

QuickWriting

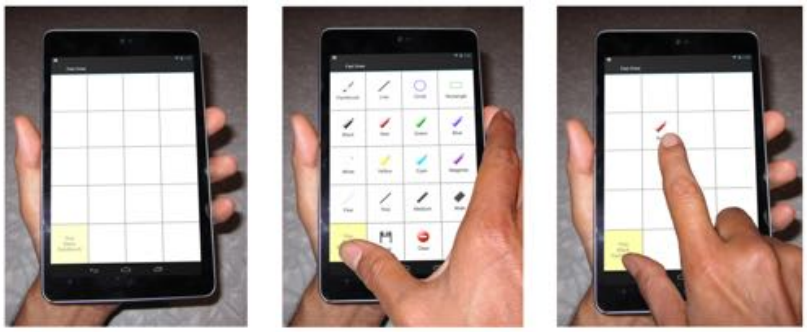
Grafiti (Palm OS)



EdgeWrite
[Wobbrock 06]

Spatial memory

FastTap [Gutwin et al. 2014]



Spatial memory

- Spatial Pointing Shortcuts
  - Inspired from method of Loci
  - Abstract links between commands and objects in the environment
- Components
  - Spatial memory
  - Object memory
  - Semantic memory (storytelling)