# Next Generation User Interfaces
## *Interactive Tabletops and Surfaces*

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# Tabletops



- The term tabletop was introduced in 2001

- Tabletop interfaces are suitable for a number of specific activities
  - multi-user (group) collaborative work
  - shared horizontal workspace
  - interaction with the table as well as objects placed on the table (affordances of the table)
    - relies on a user's mental model of traditional tables

- Tabletops support new forms of
  - hand and gesture interaction
  - tangible interaction
  - interactive visualisations

# Tabletops …

- **Typical tabletop applications**
  - viewing photos or videos
  - brainstorming
  - advanced visualisation and data analysis
  - what about productivity tasks?
    - word processing
    - email
    - ...

- **Current tabletop solutions seem to be used for dedicated tasks but *not as all-purpose computing devices***
  - missing keyboard input, precise pointing and standard applications
  - what about combining multi-touch with keyboard and mouse input?

# Tabletops …

- Ergonomic issues
  - neck muscle strain or back problems when using a horizontal tabletop as primary input device
  - what about tabletops with an adjustable angle?
  - visibility and reachability of elements when working in larger groups

# Tabletop Research Domains

- Computer Supported Cooperative Work (CSCW)
  - computer-mediated group collaboration and social interactions

- Human Computer Interaction (HCI)
  - beyond the desktop metaphor
  - individual user actions and performance

- Ubiquitous Computing (UbiComp)
  - beyond traditional desktop computer displays

- Tangible User Interfaces (TEI)
  - interaction with physical objects on a tabletop
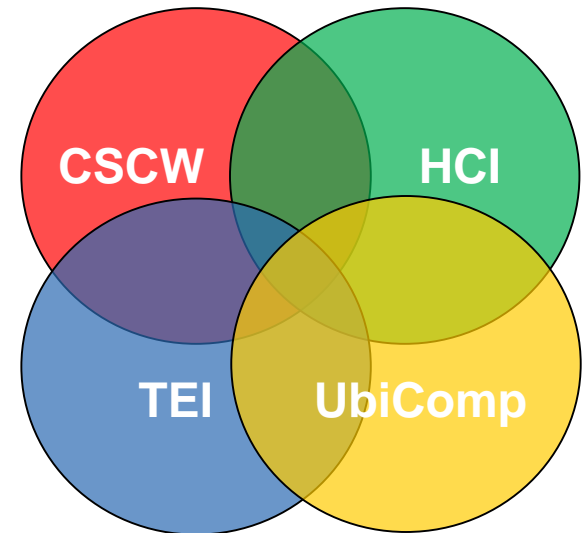
# Multi-User Tabletop Interfaces

- One of the core features of a tabletop interface is that there is enough room for multiple people to sit or stand around the table

- Users *share the interface*

- Studies have shown that users adopt *territories* on a tabletop for better coordination
  - *personal territories*
    - reserved for personal use (generally in front of the user)
  - *group territories*
    - space to perform main task activities (reachable by all users)
  - *storage territories*
    - used to store task resources and non-task items (in the periphery)
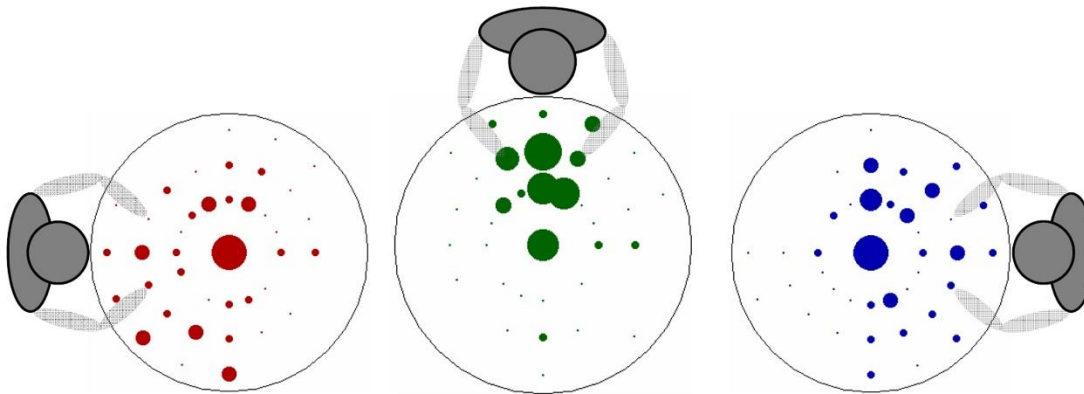
# Multi-User Tabletop Interfaces …
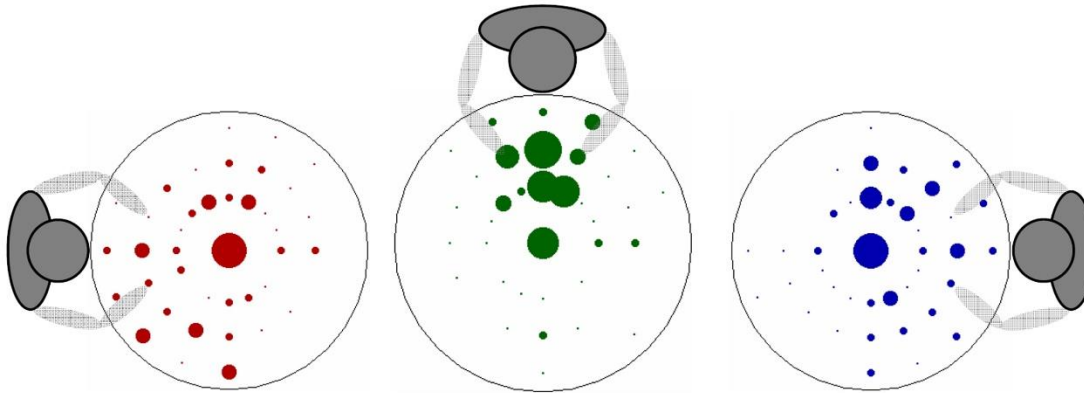


Scott et al., 2004

- **Some multi-user tabletop interfaces guidelines**
  - provide visibility and transparency of actions
    - users should see that actions are going on and which actions are performed
    - personal territory on laptop vs. personal territory on shared tabletop
  - provide appropriate table space
    - users should not run out of space when not participating in the group activity

# Multi-User Tabletop Interfaces …



Scott et al., 2004

- Some multi-user tabletop interfaces guidelines …
  - provide functionality in the appropriate locality
    - e.g. reading/writing support in personal territory
  - support casual grouping of items and tools in the workspace
    - e.g. group/organise resources in piles as reminder

# Enabling Technologies

- Basic components of a tabletop system
  - touch sensor technology
    - size that can be covered
    - real-time and multi-touch tracking
    - integration with display
    - planar or support for curved surfaces?
  - display
    - projectors
    - LCD displays
    - OLED displays
  - software
    - potentially events from multiple users and multiple fingers to be tracked
    - beyond traditional WIMP interfaces
    - rotation of display areas

# Resistive Touch Panels

- **Typically two clear layers coated with transparent conductive substances**
  - insulating layer between the two conductive sheets

- **Controller alternates between the layers**
  - driving electric current on one and measuring the current on the other
    - detection of horizontal and vertical position
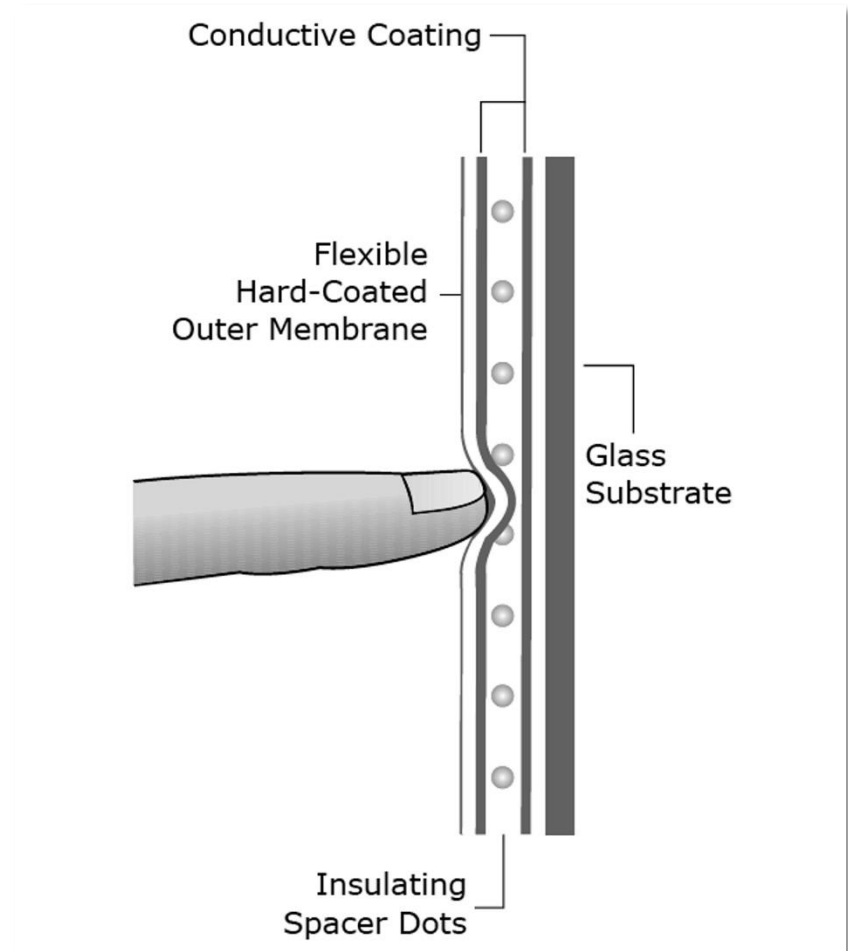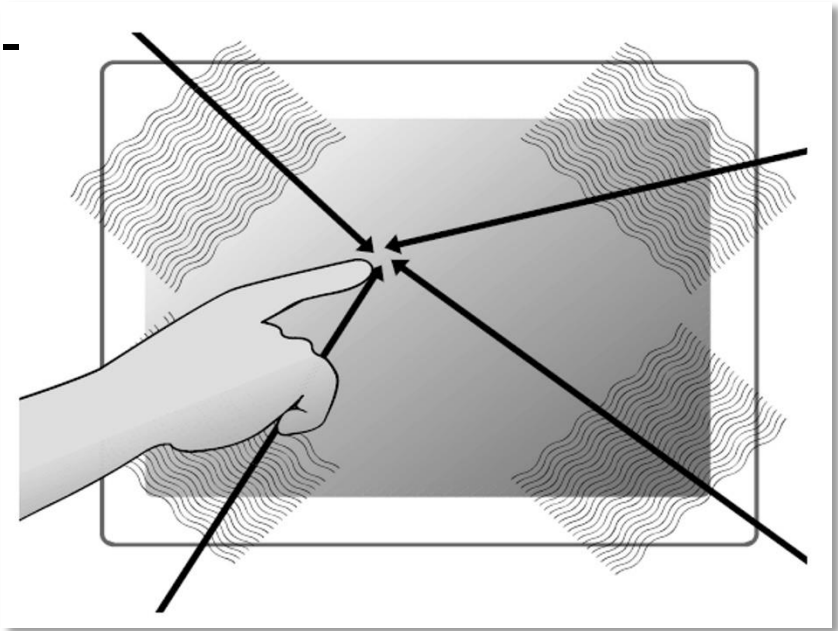


Schöning et al., 2008

# Resistive Touch Panels …

- Low-cost manufacturing
- Low power consumption compared to other approaches
- Input requires pressure on the outer layer
  - can also be used with a stylus or when wearing gloves
- Reduced display quality due to the additional layers
- Typically used for mobile phones, PDAs, digital cameras, …

# Surface Capacitive Touch Panels

- Uniform transparent conductive coating on glass panel

- Electrodes in each corner
  - uniform electric field across the conductive layer

- Touch with finger (or other conductive object) results in transport of charge



Schöning et al., 2008

- 👍 Better display quality than resistive panels

- 👍 High positional accuracy

- 👎 Difficult to detect multi-touch

# Projected Capacitive Touch Panels

- Sensor grid (electrodes) covered by front layer
- Enables *accurate detection of multi-touch*
- High positional accuracy
- Surface/projected capacitive solutions only work with finger/special stylus
- Not suited for large panels
  - slower transmission of electrical current
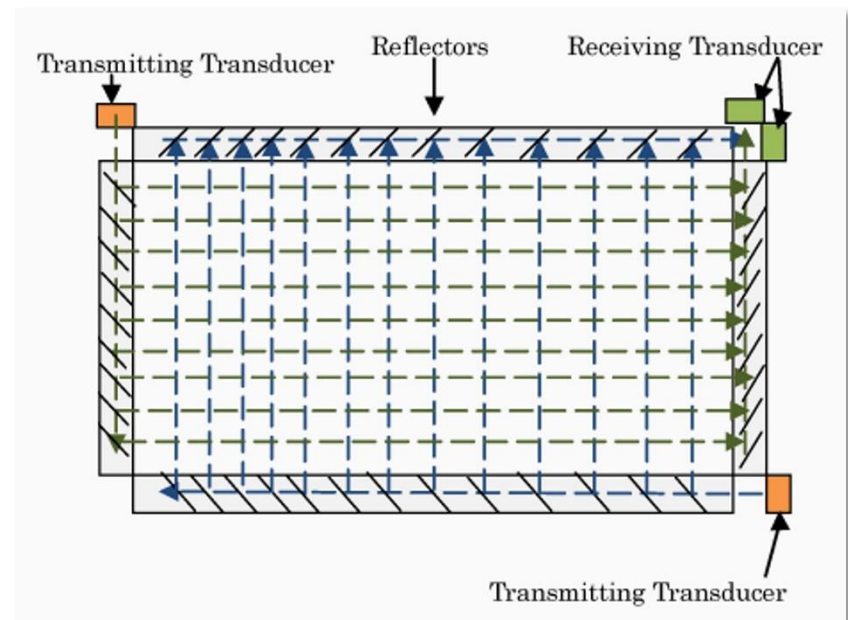- Typically used in more recent mobile phones, …



Touch Controller Chip

Back Glass Layer
Sensor Grid Layer
Front Glass Layer
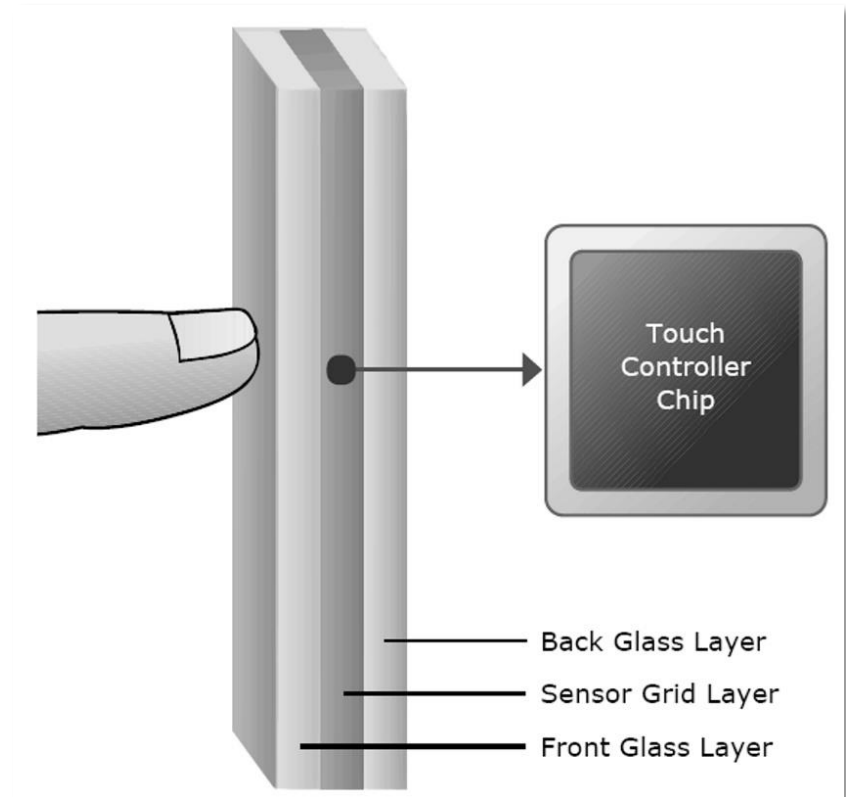
Schöning et al., 2008

# Surface Acoustic Wave (SAW)

- Glass panel with transmitting and receiving transducers as well as reflectors
  - ultrasonic waves



Transmitting Transducer    Reflectors    Receiving Transducer

Transmitting Transducer

[http://www.dmccoltd.com/english/museum/touchscreens/technologies/AcousticWave.asp]

- Soft material (e.g. finger) absorbs ultrasonic waves
  - detected by transducers

👍 Excellent display quality since no layer on top

👍 Can support dual-touch

👎 Wide frame area necessary for transducers

# Frustrated Total Internal Reflection (FTIR)

- Optical total internal reflection
  - inner material must have a higher refractive index than outer material
  - angle at the boundary has to be sufficiently small



[http://www.teksol.in/2015/11/how-screen-touch-works.html]

- Infrared light is injected and reflected if a finger touches the surface
  - computer vision algorithms used to compute the location
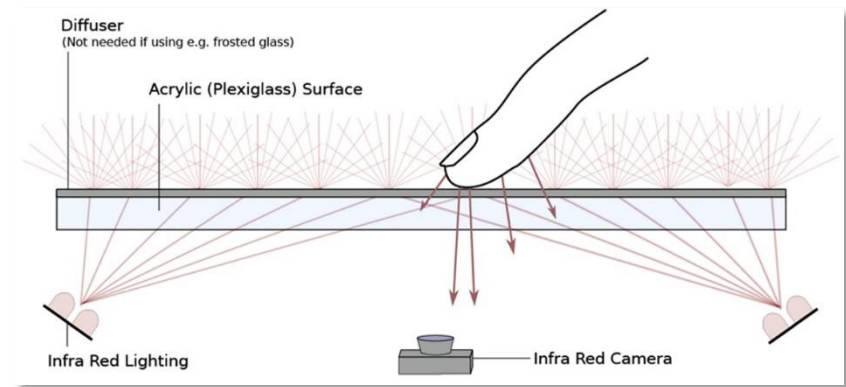- Back projection can be used in combination with FTIR
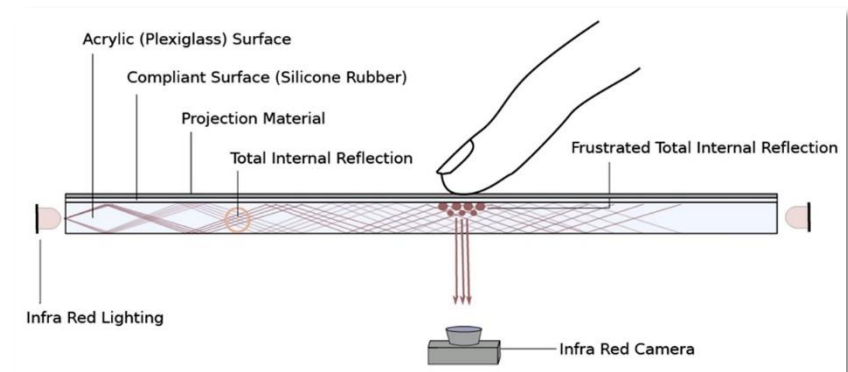
# Diffused Illumination (DI)

- Infrared light placed be-
  hind the projection surface

- Depending on the diffuser,
  DI might also detect fingers
  and objects above the
  surface



- Easier tracking of physical objects which might be
  identified by their shape or fiducial markers

# DigitalDesk

- DigitalDesk developed by Pierre Wellner at Xerox EuroPARC
  - camera-based tracking and projection
- *"Instead of making the workstation more like a desk, make the desk more like a workstation"*
- Many follow-up augmented desk projects
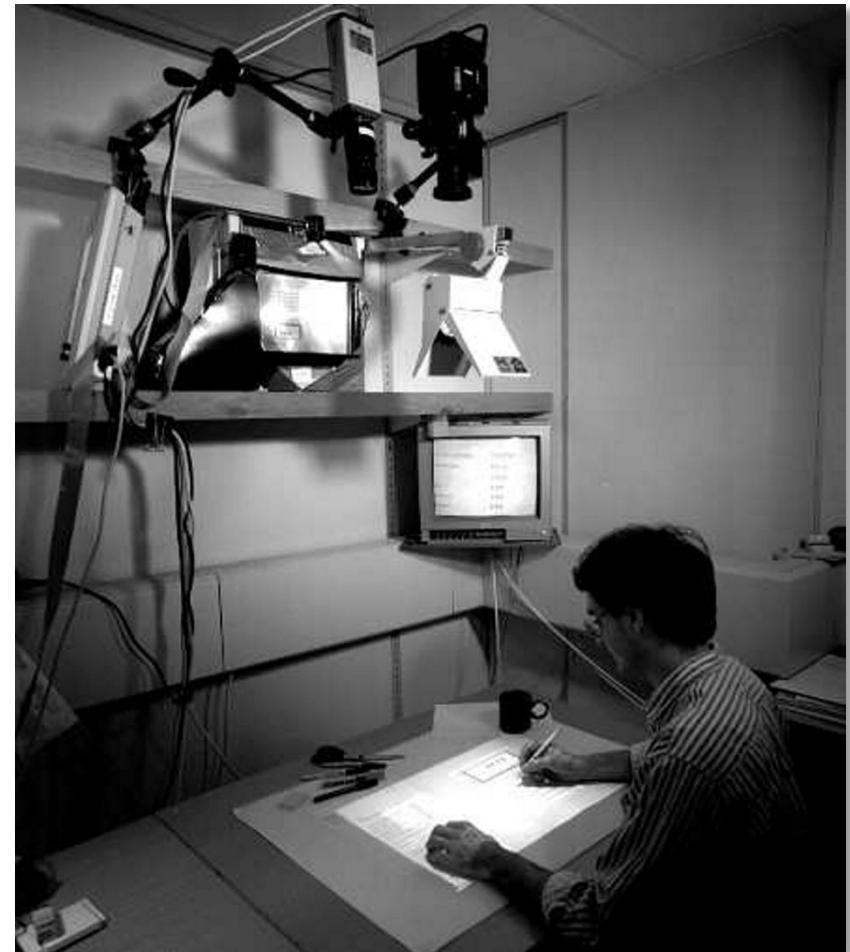


Wellner, DigitalDesk, 1991

# DiamondTouch Table

- Developed at Mitsubishi Electric Research Labora-tories (MERL) in 2001

- Front-projected interactive display

- Can detect *who is touching* the surface
  - capacitive coupling between the touch surface and receivers located in the chair of each user
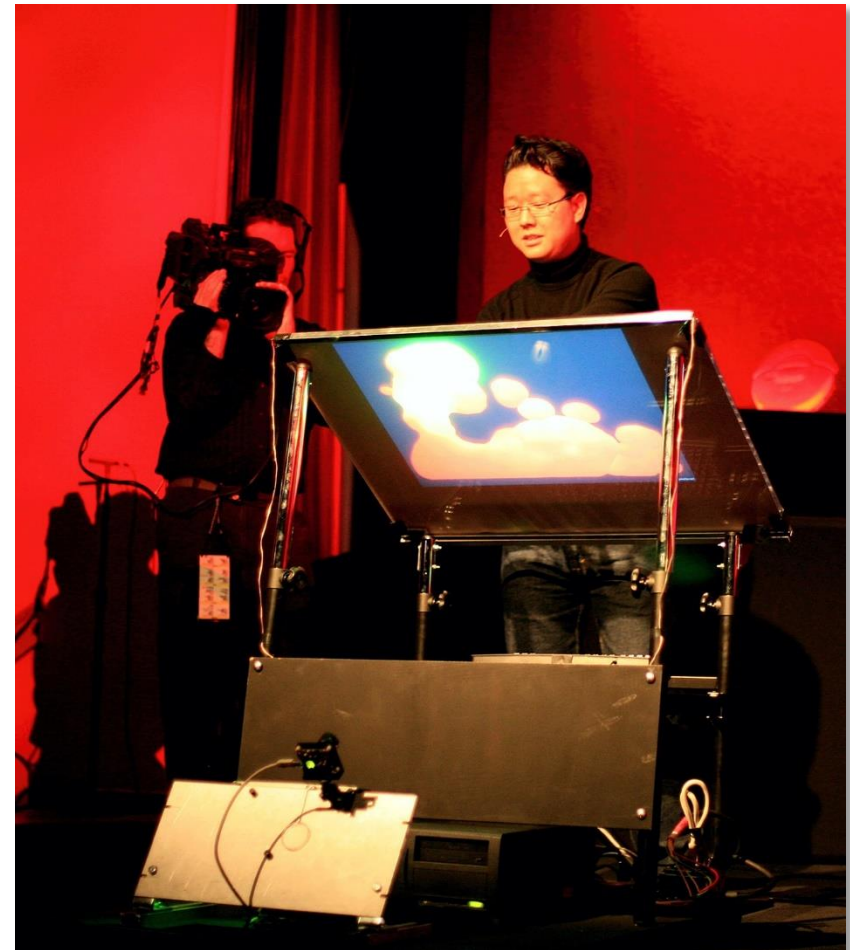


[http://www.guillaumeriviere.name/collection/tabletop.html]
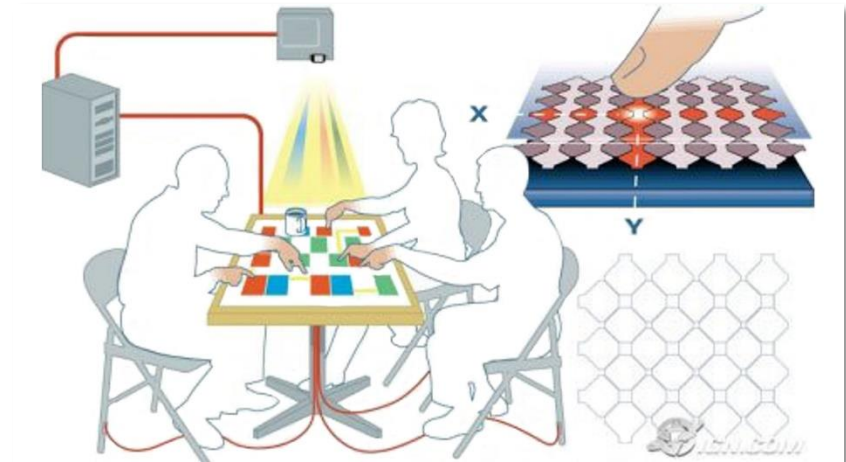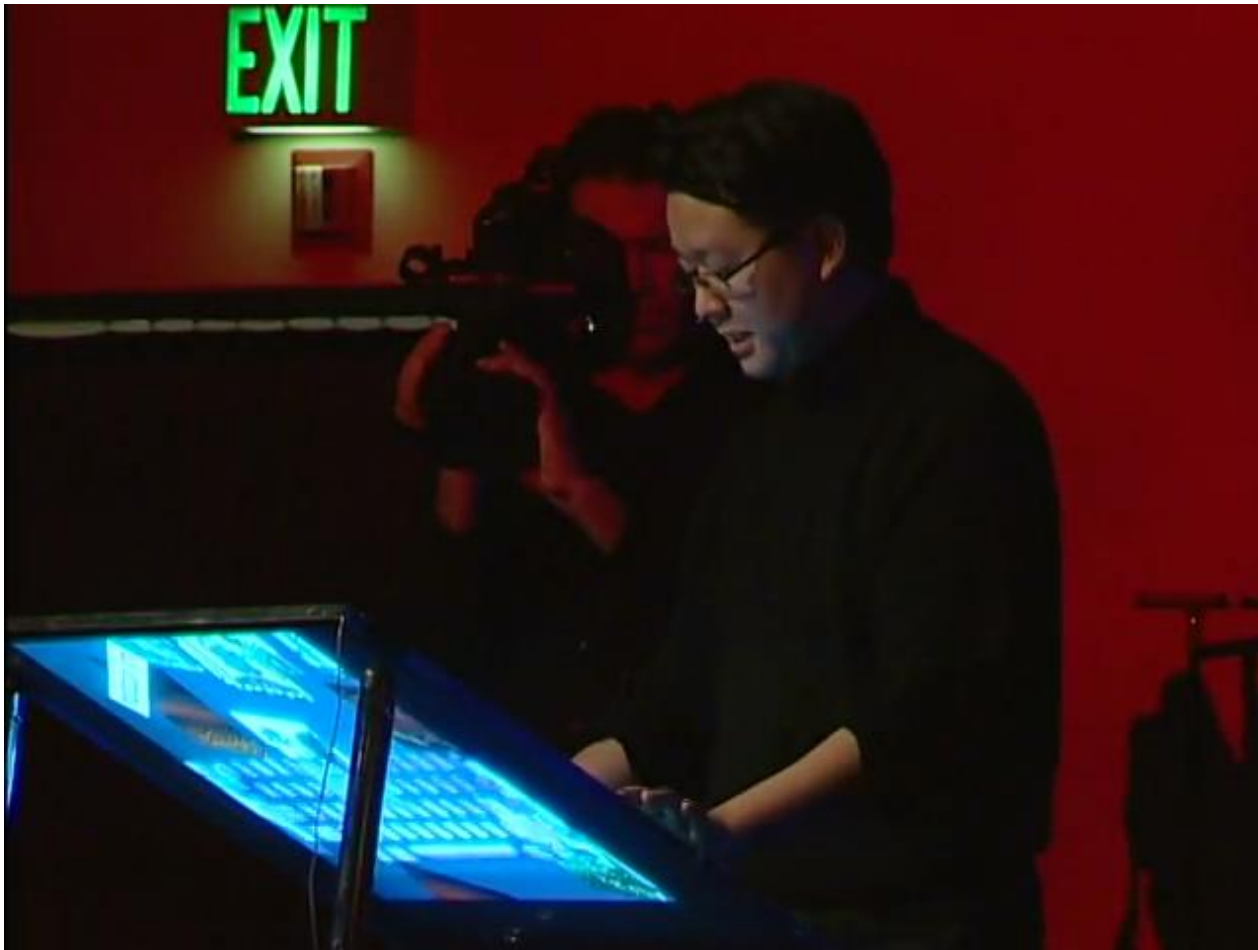
# Video: DiamondTouch Table

# Jeff Han's Multi-Touch Table

- Uses refined version of Frustrated Total Internal Reflection (FTIR)
- Simple and cheap implementation of a multi-touch surface presented in 2006
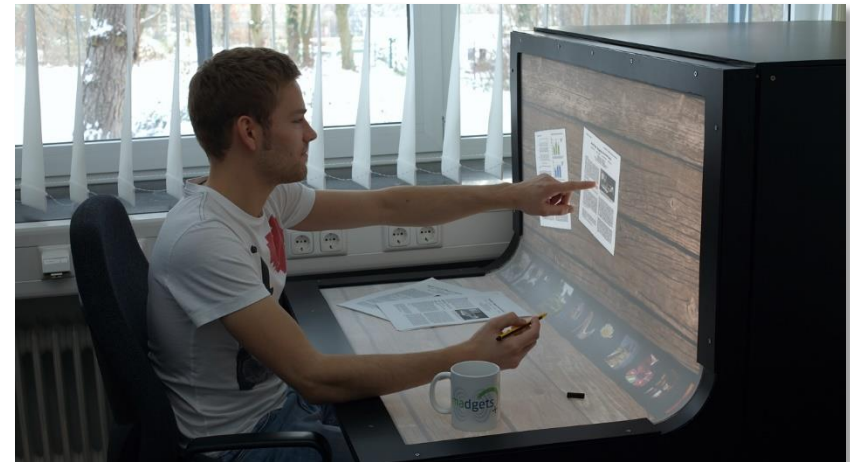
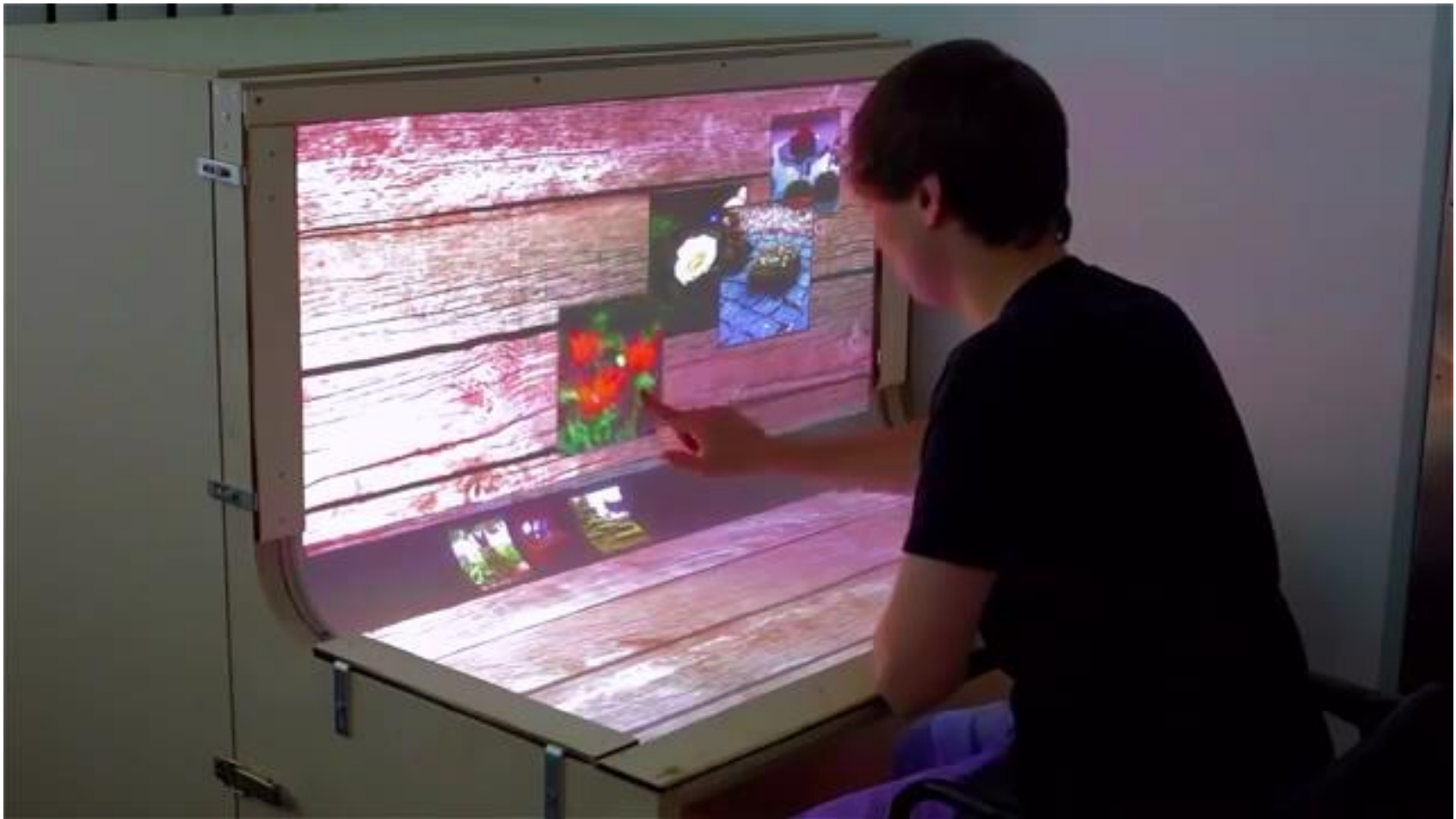# Video: Jeff Han's Multi-Touch Table

# BendDesk

- Seamlessly combines a vertical and a horizontal multi-touch surface

- Uses 2 projectors and 3 cameras
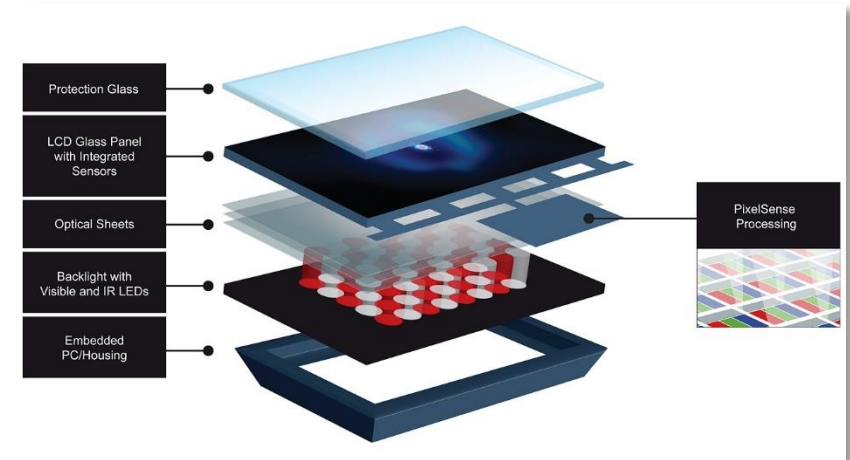  - FTIR-based tracking



Weiss et al., 2010

# Video: BendDesk

# Microsoft PixelSense (Samsung SUR40)

- **Samsung produces the hardware and Microsoft the software**

- **40 inch LED backlit LCD display (1920×1080)**
  - integrated PC and *PixelSense technology*

- **Backlight with IR LEDs**
  - reflected by fingers and other objects
    - multi-touch and real objects
  - pixels act as IR sensors





Protection Glass

LCD Glass Panel with Integrated Sensors

Optical Sheets

Backlight with Visible and IR LEDs

Embedded PC/Housing

PixelSense Processing

[http://www.embeddedinsights.com/channels/wp-content/uploads/2011/03/110329-surface.png]
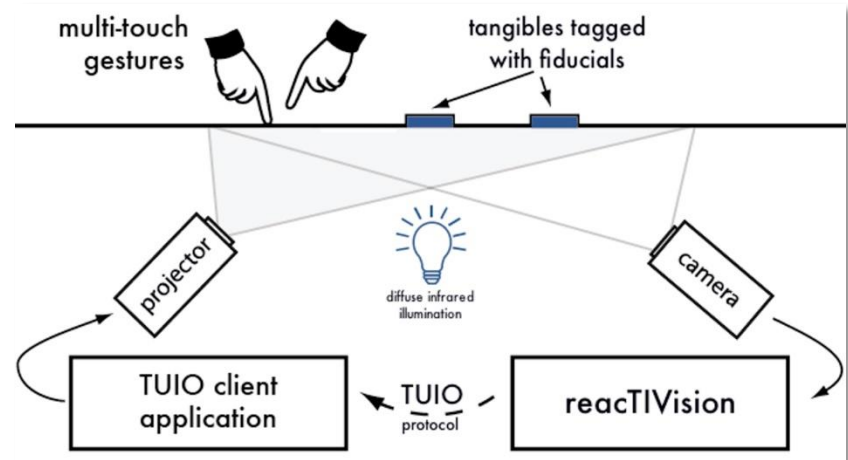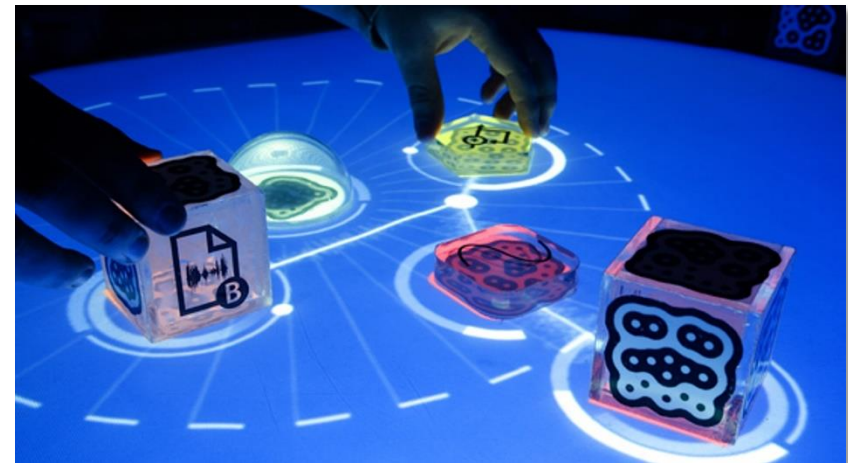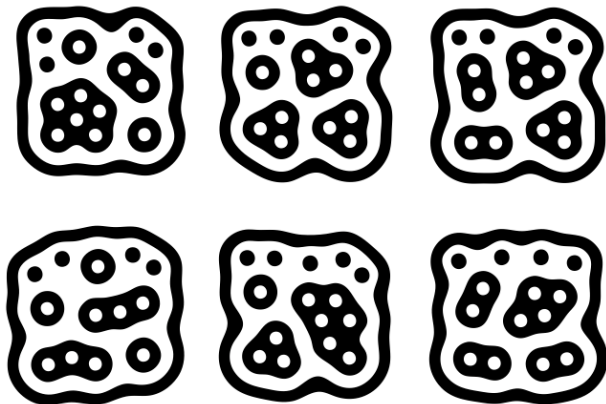
# Video: Microsoft PixelSense

# ReacTIVision

- Open source toolkit for tangible multi-touch surfaces

- *Fiducial markers* and multi-touch finger tracking







Kaltenbrunner and Bencina, 2007

# Video: Reactable
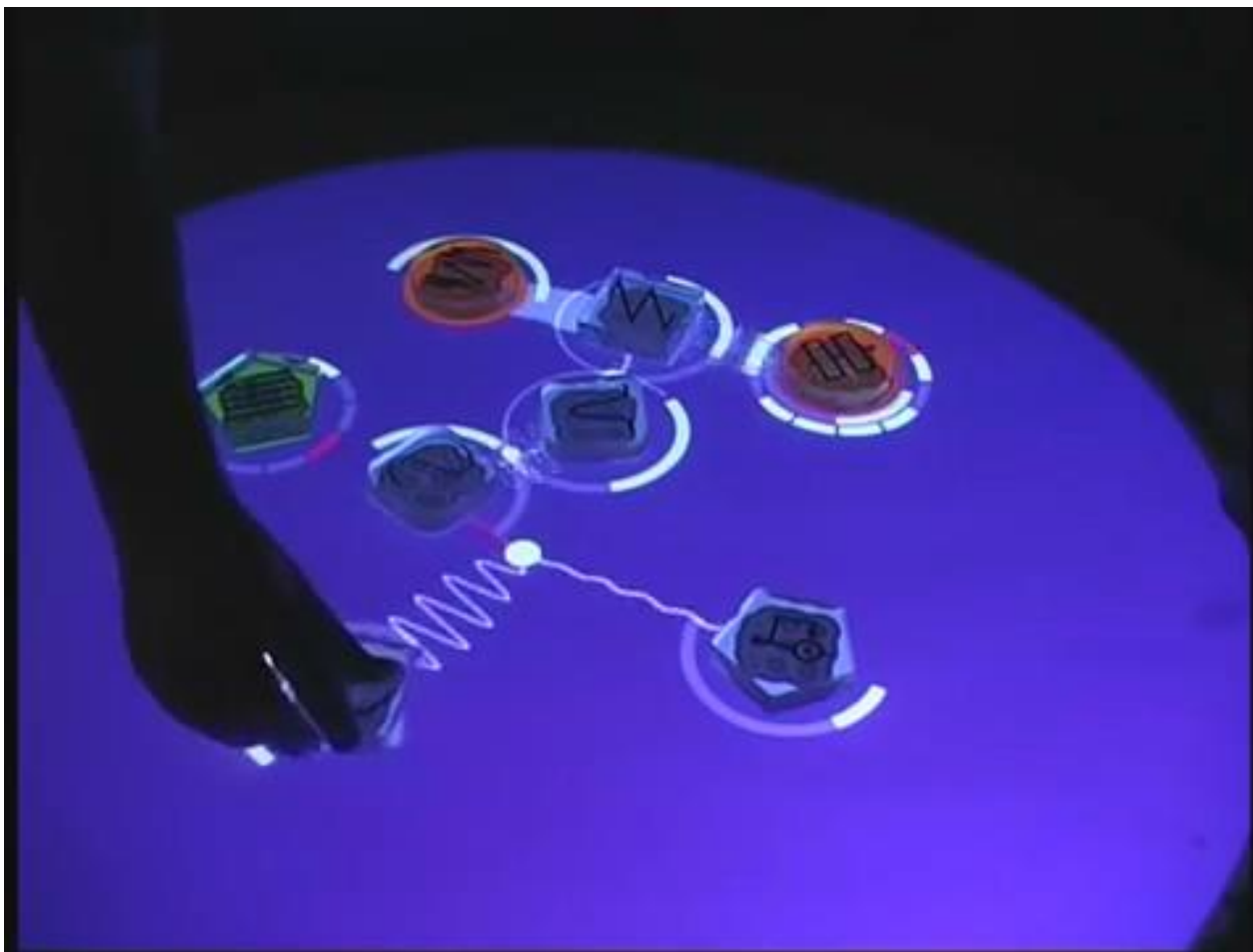
# iTable Interactive Tabletop

- Interactive tabletop based on digital pen a paper technology
  - developed by the GlobIS group at ETH Zurich
  - table surface covered with Anoto pattern
    - e.g. pattern printed on paper and covered with glass
  - top projection
  - high precision pen tracking
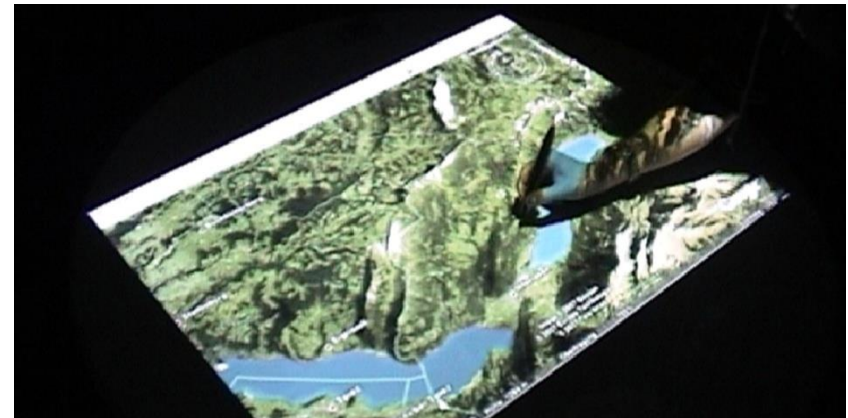

**Pen-Based Google Earth Browser**


**Pen-Based Drawing Tool**

# Video: iTable Interactive Tabletop

# Pen and Touch Interaction on Tabletops

- Pen and touch interaction for authoring and editing documents on tabletops
  - simultaneous use of two modalities
  - alternative to on-screen widgets (for experts)
  - non-dominant hand postures define the pen mode
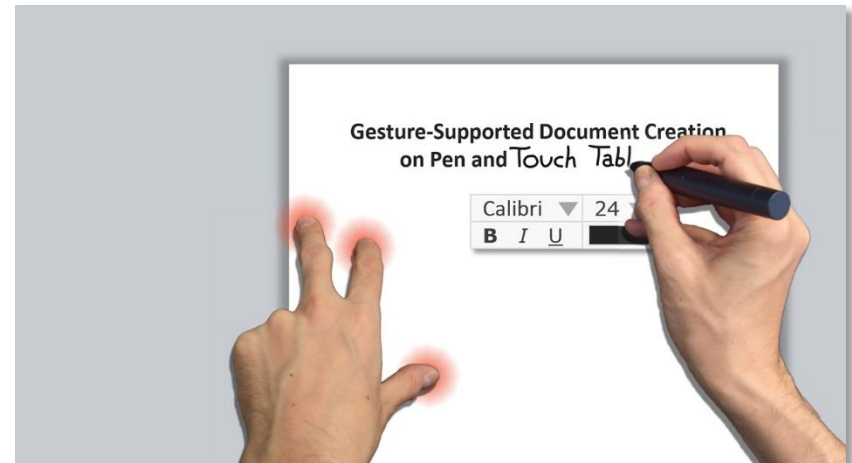


Matulic and Norrie, 2013

# we-inspire Room

- Ideation technology
  - based on Anoto's digital pen and paper technology
- Large collaborative interactive wall surface
- Various applications
  - sketch, write, brainstorm and capture





projectors + wall surface + pens + paper

+ palettes + PC + apps
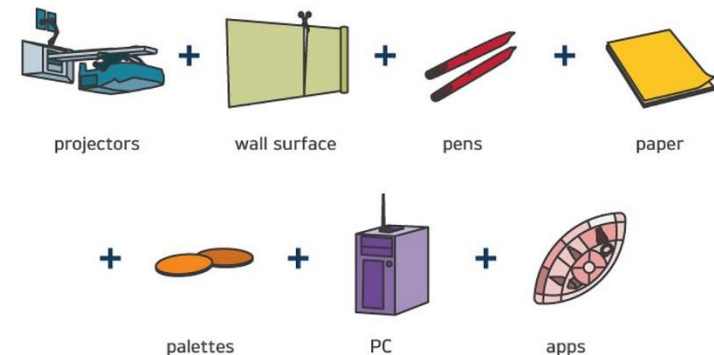
# Video: we-inspire Room

# HP Sprout

- **Immersive computing platform by HP**

- **All-in-one PC**
  - capacitive tactile touchpad with top projection
  - 3D scanning cameras
  - creative work without mouse and keyboard …
  - *"blended reality"*

# Video: HP Sprout



featuring a 23 inch diagonal screen
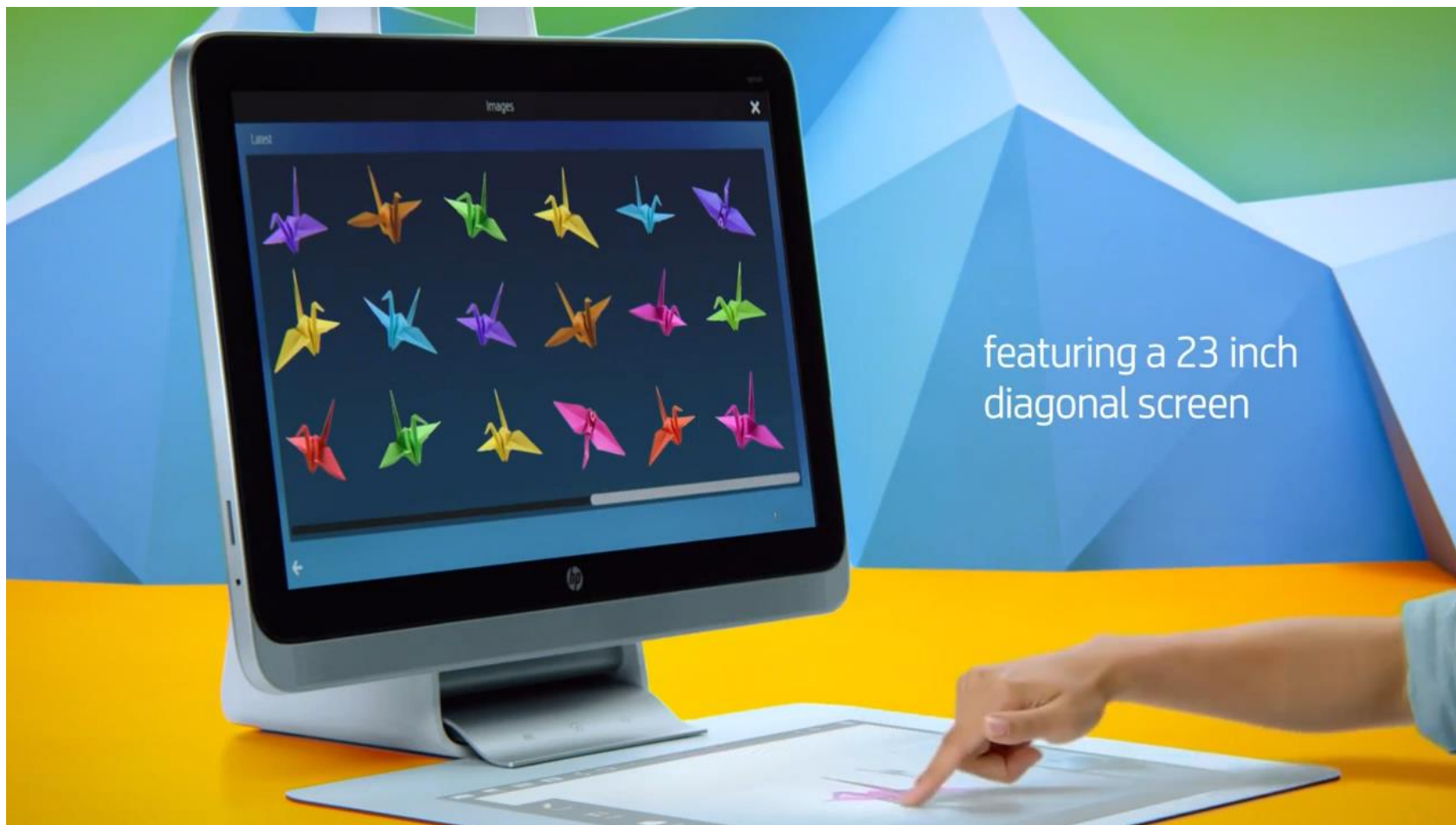
# Microsoft Surface Studio

- All-in-one PC
  - 28-inch 4.5K *PixelSense* display
  - screen can be tilted to flat position (hinge design)
- New tools for creative process
  - e.g. *Surface dial*
    - control for different applications when placed on the screen
    - haptic feedback (menu options)
- Release date early 2017

# Video: Microsoft Surface Studio
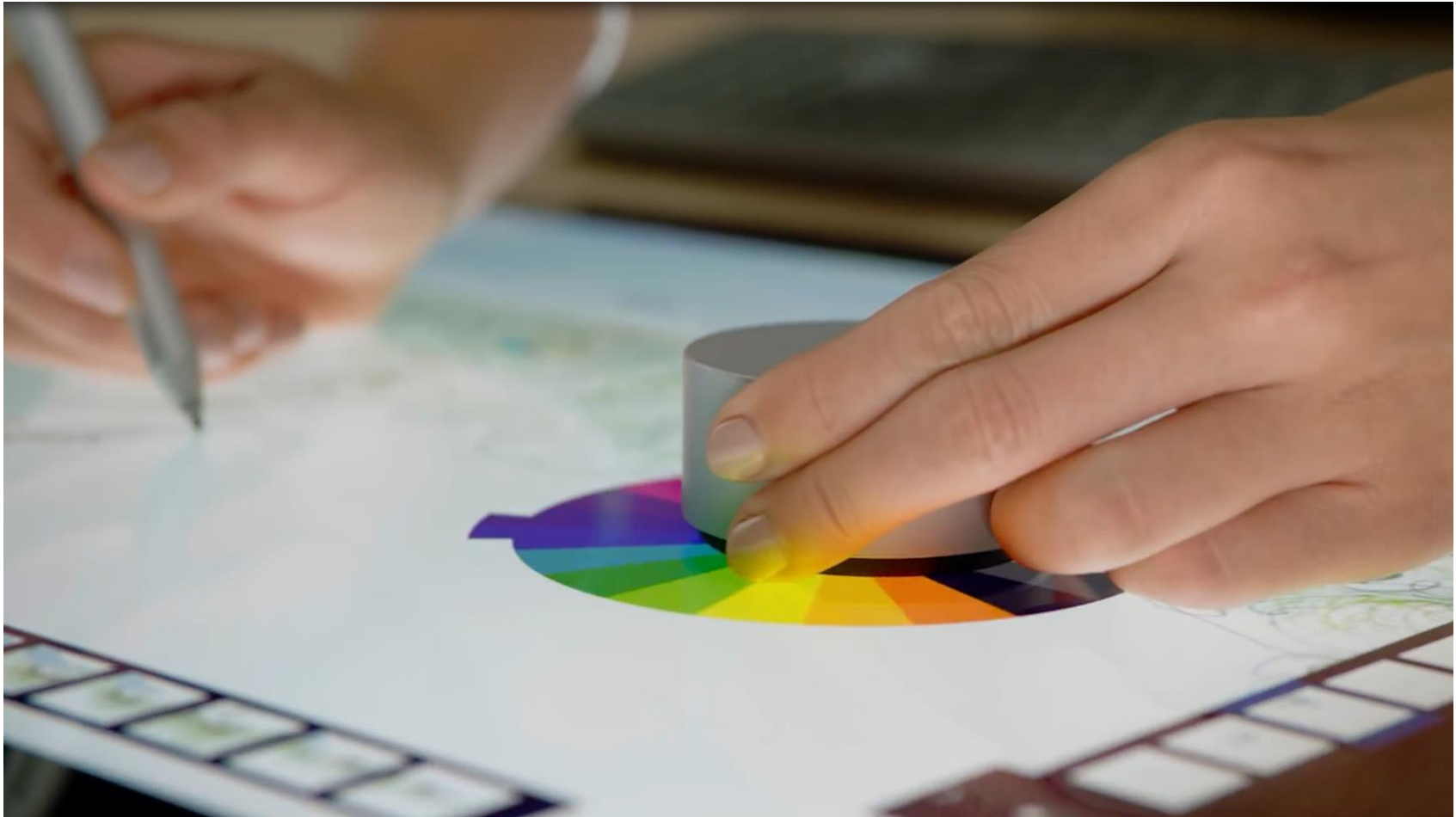
# OLED Technology

- Displays based on Organic Light Emitting Diodes (OLEDs)
  - flexible/thinner than LCDs
  - no background light
  - 1000 times faster tan LEDs
  - can be printed and produced at less costs
- Combination of OLED displays with thin multi-touch devices
  - ultimate tabletop system

# Windowless Plane

- Futuristic windowless plane design concept by Technicon Design

- Video stream from wing-mounted cameras

- Screen estate could also be used for
  - showing movies
  - video conferences
  - …

- Plane needs less fuel

# Video: Windowless Plane



IN FLIGHT VIDEO CONFERENCING
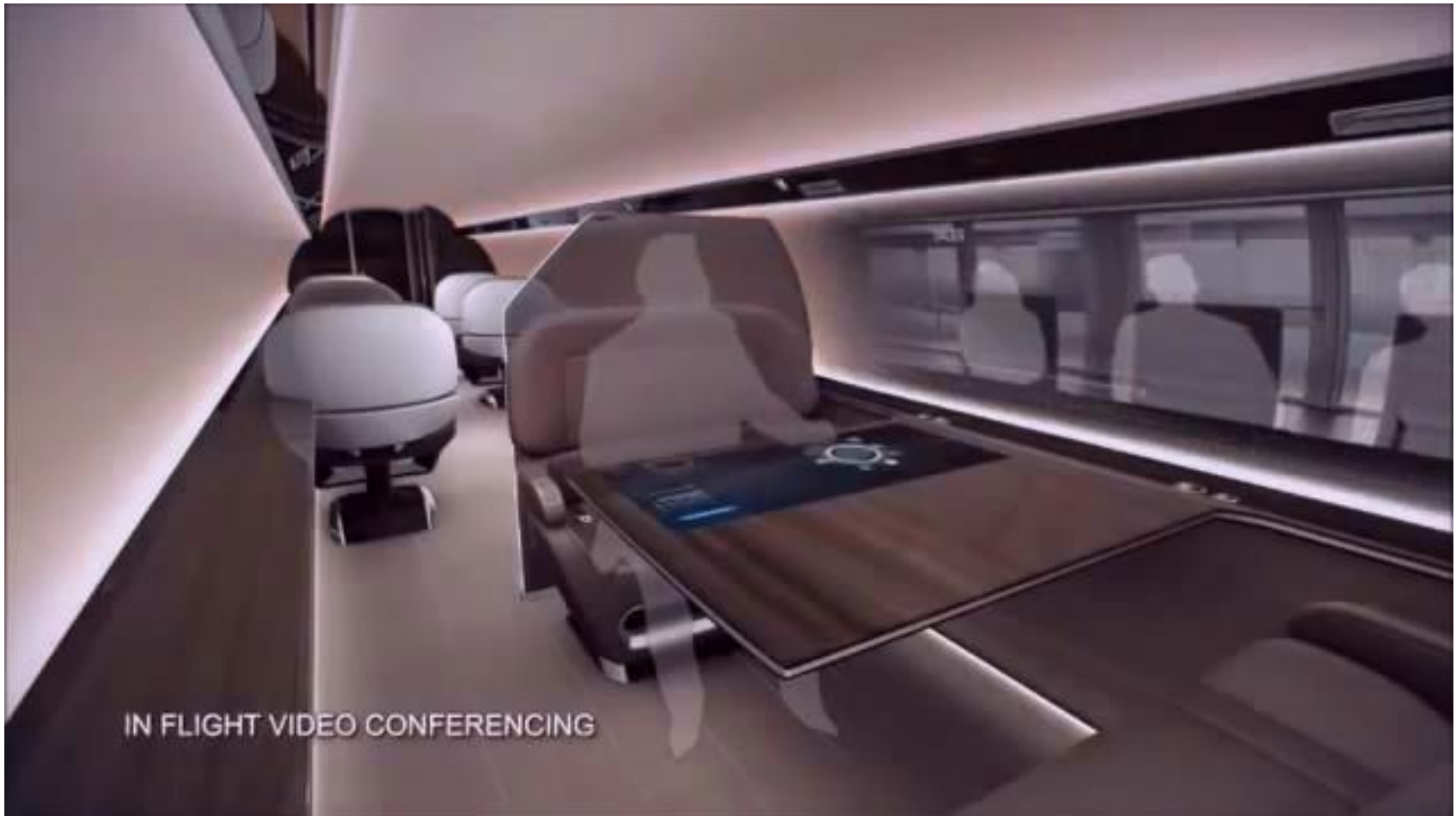
# AquaTop Display

- Interactive water surface that can for example be used in a bathroom
  - gesture-based interaction
  - Kinect in combination with top projection
- New possibilities to interact with a water surface
  - e.g. poking fingers from beneath the water



Takahashi et al., 2012

# Video: AquaTop Display

# Video: A Day Made of Glass

# Video: A Day Made of Glass 2

# References

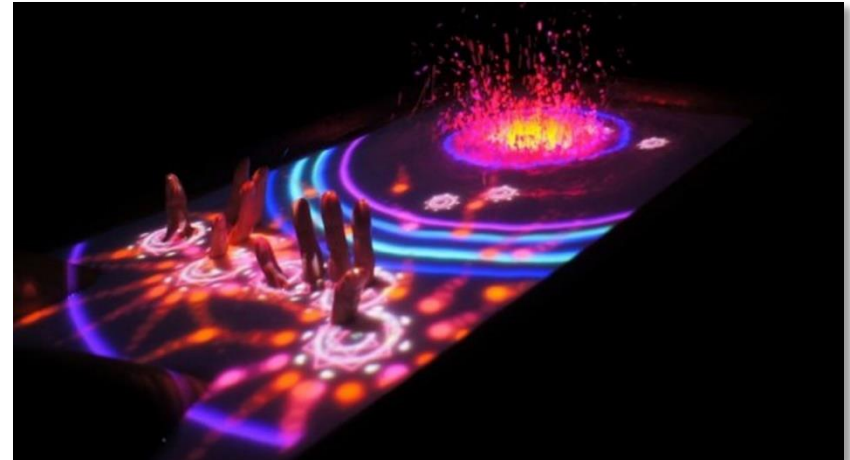- S.D. Scott, M. Sheelagh, T. Carpendale and K.M. Inkpen, *Territoriality in Collaborative Tabletop Workspaces*, Proceedings of CSCW 2004, International Conference on Computer Supported Cooperative Work, Chicago, USA, November 2004
  - http://dx.doi.org/10.1145/1031607.1031655

- J. Schöning et al., *Multi-Touch Surfaces: A Technical Guide*, Technical Report TUM-I0833, 2008
  - http://campar.in.tum.de/pub/schoening2008multitouch/schoening2008multitouch.pdf

- Jeff Han's Multi-Touch Table, 2006
  - http://www.ted.com/talks/jeff_han_demos_his_breakthrough_touchscreen

# References …

- P. Wellner, *The DigitalDesk Calculator: Tangible Manipulation on a Desk Top Display*, Proceedings of ACM UIST 1991, Symposium on User Interface Software and Technology, Hilton Head, USA, November 1991
  - http://dx.doi.org/10.1145/120782.120785

- M. Weiss, S. Voelker, C. Sutter and J. Borchers, *BendDesk: Dragging Across the Curve*, Proceedings of ITS 2010, International Conference on Interactive Tabletops and Surfaces, Saarbrücken, Germany, November 2010
  - http://dx.doi.org/10.1145/1936652.1936654

# References …

- M. Kaltenbrunner and R. Bencina, *ReacTIVision: A Computer-Vision Framework for Table-based Tangible Interaction*, Proceedings of TEI 2007, International Conference on Tangible and Embedded Interaction, Baton Rouge, USA, February 2007
  - http://dx.doi.org/10.1145/1226969.1226983

- F. Matulic and M.C. Norrie, *Pen and Touch Gestural Environment for Document Editing on Interactive Tabletops*, Proceedings of ITS 2013, International Conference on Interactive Tabletops and Surfaces, St Andrews, UK, October 2013
  - http://dx.doi.org/10.1145/2512349.2512802

# References

- Y. Takahashi, Y. Matoba and H. Koike, *Fluid Surface: Interactive Water Surface Display for Viewing Information in a Bathroom*, Proceedings of ITS 2012, International Conference on Interactive Tabletops and Surfaces, Cambridge, USA, November 2012
  - http://dx.doi.org/10.1145/2396636.2396687

- C. Müller-Tomfelde (Ed.), *Tabletops – Horizontal Inter-active Displays*, Springer 2010
  - http://dx.doi.org/10.1007/978-1-84996-113-4

- BendDesk
  - https://www.youtube.com/watch?v=5VNTPwVvLzE

# References …

- Microsoft PixelSense
  - https://www.youtube.com/watch?v=58dsqozft3k

- HP Sprout
  - https://www.youtube.com/watch?v=t7v_7keCQf0

- Microsoft Surface Studio
  - https://www.youtube.com/watch?v=BzMLA8YIgG0

- iTable Interactive Tabletop
  - https://www.youtube.com/watch?v=rc7I5h6XirY

- we-inspire Collaboration Technology
  - https://www.youtube.com/watch?v=eLfpMlyt4BA

- AquaTop Display
  - https://www.youtube.com/watch?v=fYJneaa2O8I

# References …

- Reactable
  - https://www.youtube.com/watch?v=0h-RhyopUmc

- A Day Made of Glass
  - https://www.youtube.com/watch?v=6Cf7IL_eZ38

- A Day Made of Glass 2
  - https://www.youtube.com/watch?v=jZkHpNnXLB0

- Technicon Design Windowless Plane
  - https://www.youtube.com/watch?v=lNo3Sj_ri78

# Next Lecture
*Gesture-based Interaction*