VRIJE UNIVERSITEIT BRUSSEL

Next Generation User Interfaces

Tangible, Embedded and Embodied Interaction

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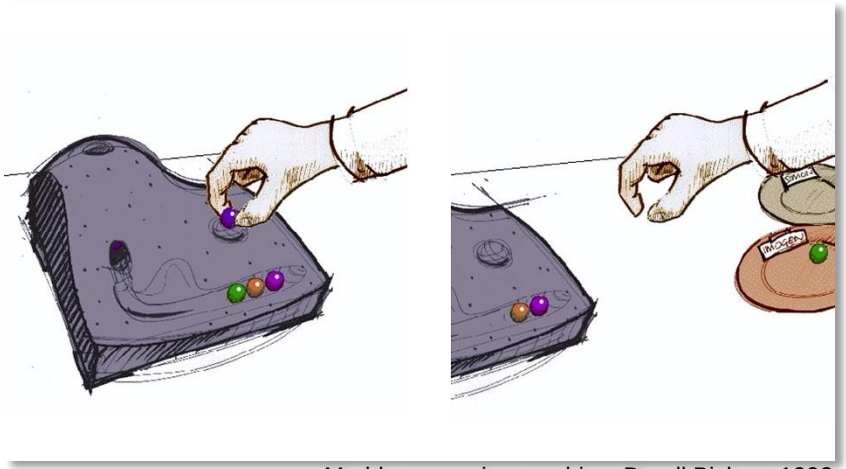
Marble Answering Machine Revisited

- Marble answering machine
  - incoming messages repre-sented by physical marbles
- Differences
  - familiar physical objects show the number of messages
  - *aesthetically pleasing* and *enjoyable to use*
  - *one step actions* to perform a task
  - simple but elegant design with less functionality
  - anyone can listen to any of the messages
- Might not be robust enough to be used in public space
  - *important to take into account where a product is going to be used*



Marble answering machine, Durell Bishop, 1992

Graspable User Interfaces (1995)

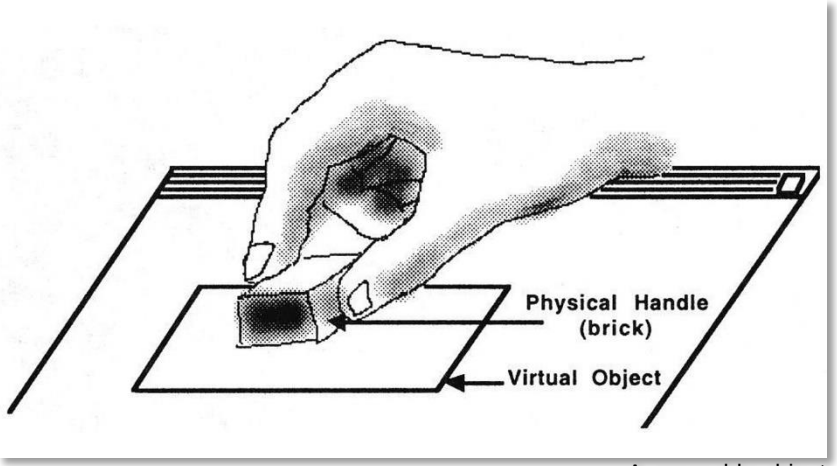
- Direct control of electronic or virtual objects through *physical handles* (bricks)
- A brick is a new user interface that is *tightly coupled* to a *virtual object*

GraspDraw on ActiveDesk

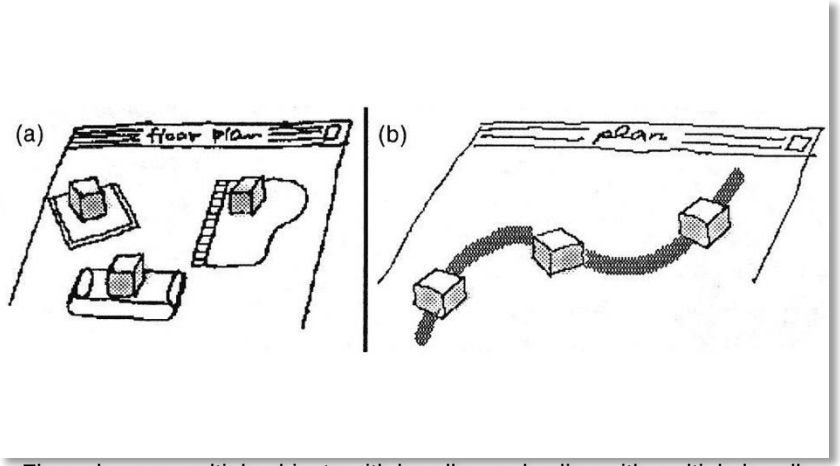
- Bricks are used on top of a large horizontal display surface known as the *ActiveDesk*
  - GraspDraw is one particular application

George W. Fitzmaurice, Hiroshi Ishii and William Buxton, *Bricks: Laying the Foundations for Graspable User Interfaces*, Proceedings of CHI 1995, ACM Conference on Human Factors in Computing Systems, Denver, USA, May 1995

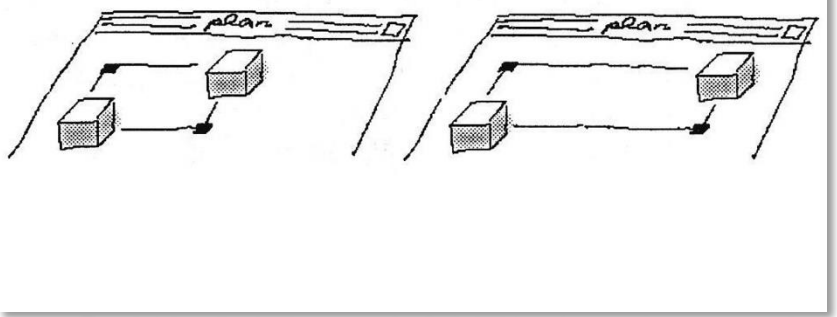
Graspable User Interfaces (1995) …



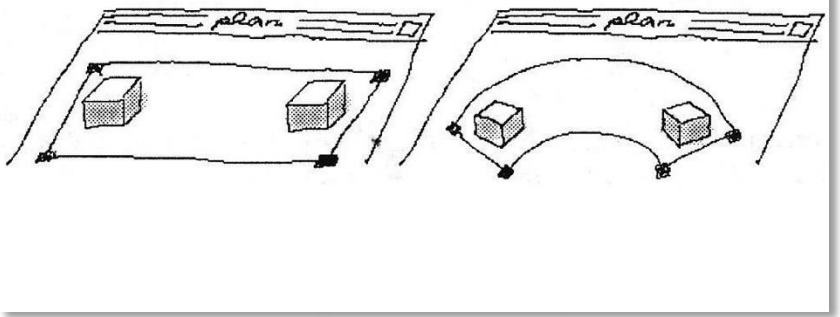
A graspable object



Floor planner: multiple objects with handles and spline with multiple handles



Two bricks attached to a single digital object (one acting as an anchor)



Moving and rotating both bricks at the same time

Graspable User Interfaces (1995) …

- Advantages of Graspable UI design
  - encourages two-handed interactions
  - shifts to more specialised context-sensitive input devices
  - allows for more parallel input specification
  - makes use of our skills for physical object manipulations
    - affordances of artefacts define how we use the interface
  - externalises traditionally internal computer representations
  - facilitates interactions by making interface elements more "direct and manipulable" by using physical artefacts
  - takes advantage of our spatial reasoning skills
  - affords multi-person collaborative use
  - …
- *Foundations of tangible interaction*

Affordances

- Term *affordance* introduced in 1977 by psychologist James J. Gibson in the '*The Theory of Affordances*'
  - originally defined as *all possible actions with an object* in an environment independent of an individual's ability to recognise these actions
- Don Norman refined the term affordances in the context of human-machine interaction
  - only those possible actions with an object that can be recognised by an individual
  - an affordance of an object tells us something (gives us a clue) about *how to use the object*
  - good interaction design will take affordances and the related discoverability into account

Video: The Norman Door

Definition of Tangible Interaction

- Tangible interaction is an *umbrella term* for
  - graspable user interfaces
  - tangible user interfaces
  - embodied interaction
- Tangible Interaction encompasses user interfaces and interaction approaches that emphasise
  - tangibility and materiality of the interface
  - physical embodiment of data
  - whole-body interaction
  - embedding of the interface and user interaction in real spaces and contexts
  - physical objects as representation and control for digital information

Tangible Bits (1997)

- Beyond GUIs ("painted bits")
  - *Tangible User Interfaces (TUIs)* augment the physical space by coupling digital information to everyday objects and environments
  - physical instantiation of GUI elements in TUI
- Key concepts
  - interactive surfaces
  - coupling of bits and atoms
  - ambient media (inspired by Life Wire)

Hiroshi Ishii

Brygg Ullmer

Hiroshi Ishii and Brygg Ullmer, *Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms*, Proceedings of CHI 1997, ACM Conference on Human Factors in Computing Systems, Atlanta, USA, March 1997

Life Wire (1995)

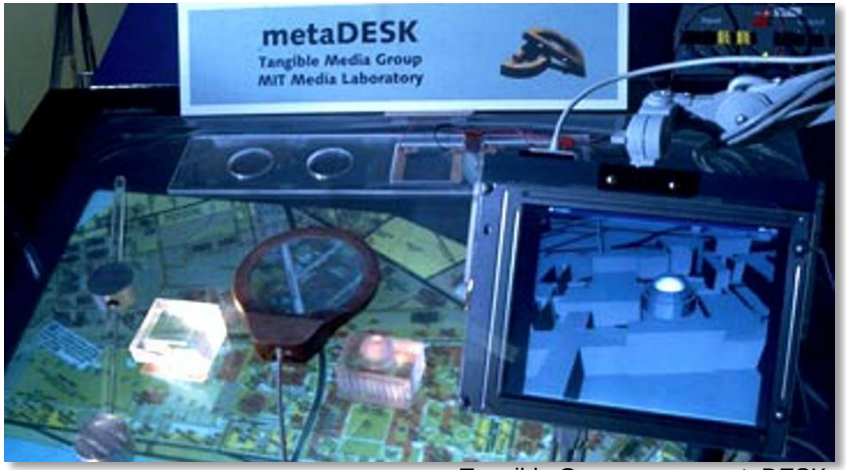
- Life Wire (dangling string) designed by Natalie Jeremijenko while she was an artist in residence at Xerox PARC
  - plastic cord attached to electric motor mounted on the ceiling
  - motor connected to the local Ethernet and each passing network packet triggers a switch of the motor
  - bits flowing through the network become tangible through motion, sound and touch

Life Wire, 1995

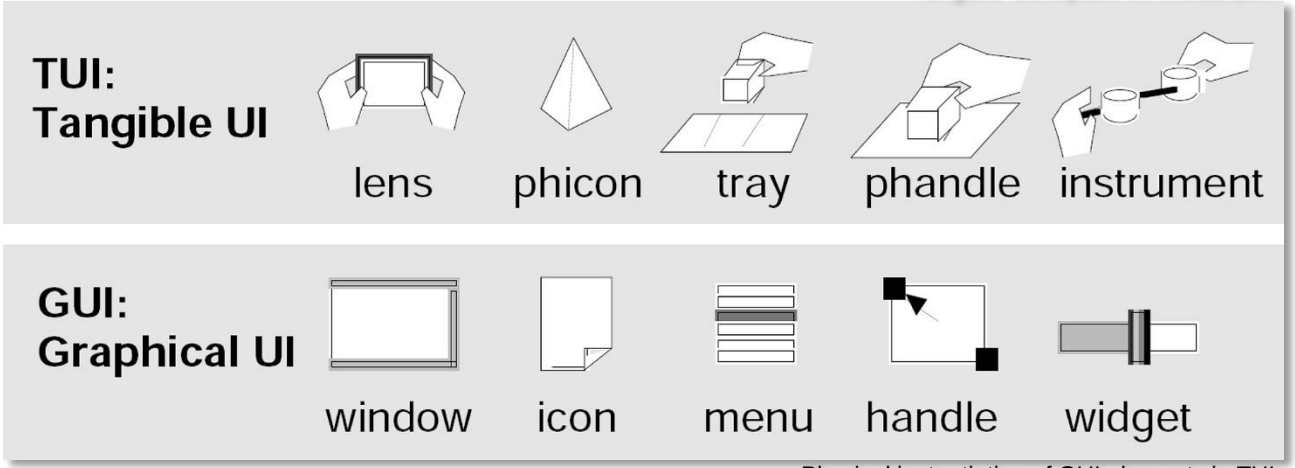
Natalie Jeremijenko

metaDESK

- Back-projected graphical surface with various tools
  - phicons
  - activeLENS and passiveLENS
  - instruments
- Tangible Geospace
  - application prototype



Tangible Geospace on metaDESK



Physical instantiation of GUI elements in TUI

Video: metaDESK

ambientROOM

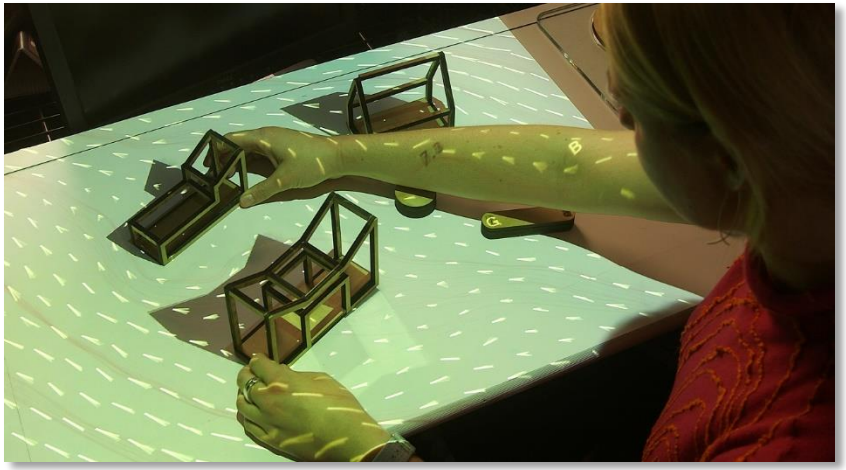
- Complements the cogni tively-foreground inter-actions of the metaDESK with *ambient media*
  - ambient light or shadows
  - sound
  - airflow

ambientROOM

- Communicate information at the periphery of human perception
  - investigate how the parallel background processing can be used to convey information via ambient media
  - enable seamless transition between primary foreground task and background processing

Urp

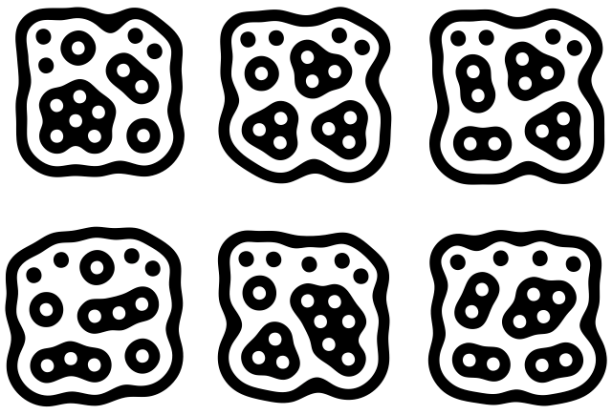
- System supporting urban planning
- Integration of physical model with an interactive simulation
  - tangible models of buildings throw a digital shadow on the interactive surface
  - simulated wind shown as projected arrows on the table
- Various physical tools available to
  - measure distance between two points or wind speed
  - change material of building (e.g. glass walls) or daytime

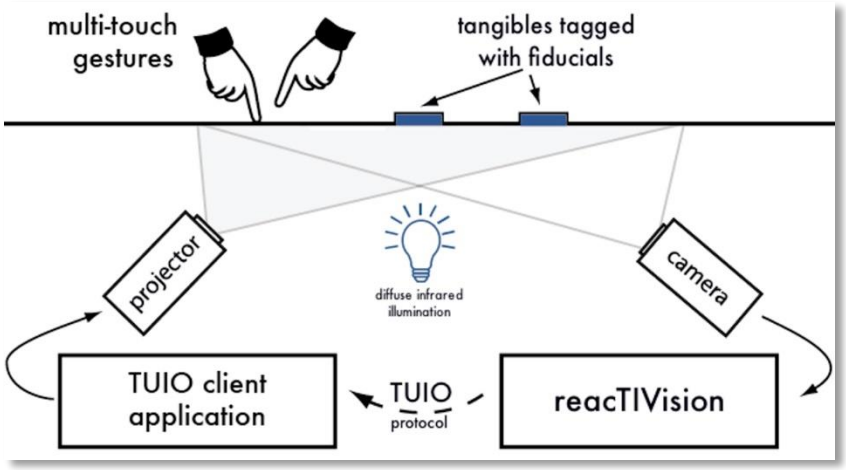


Urp system

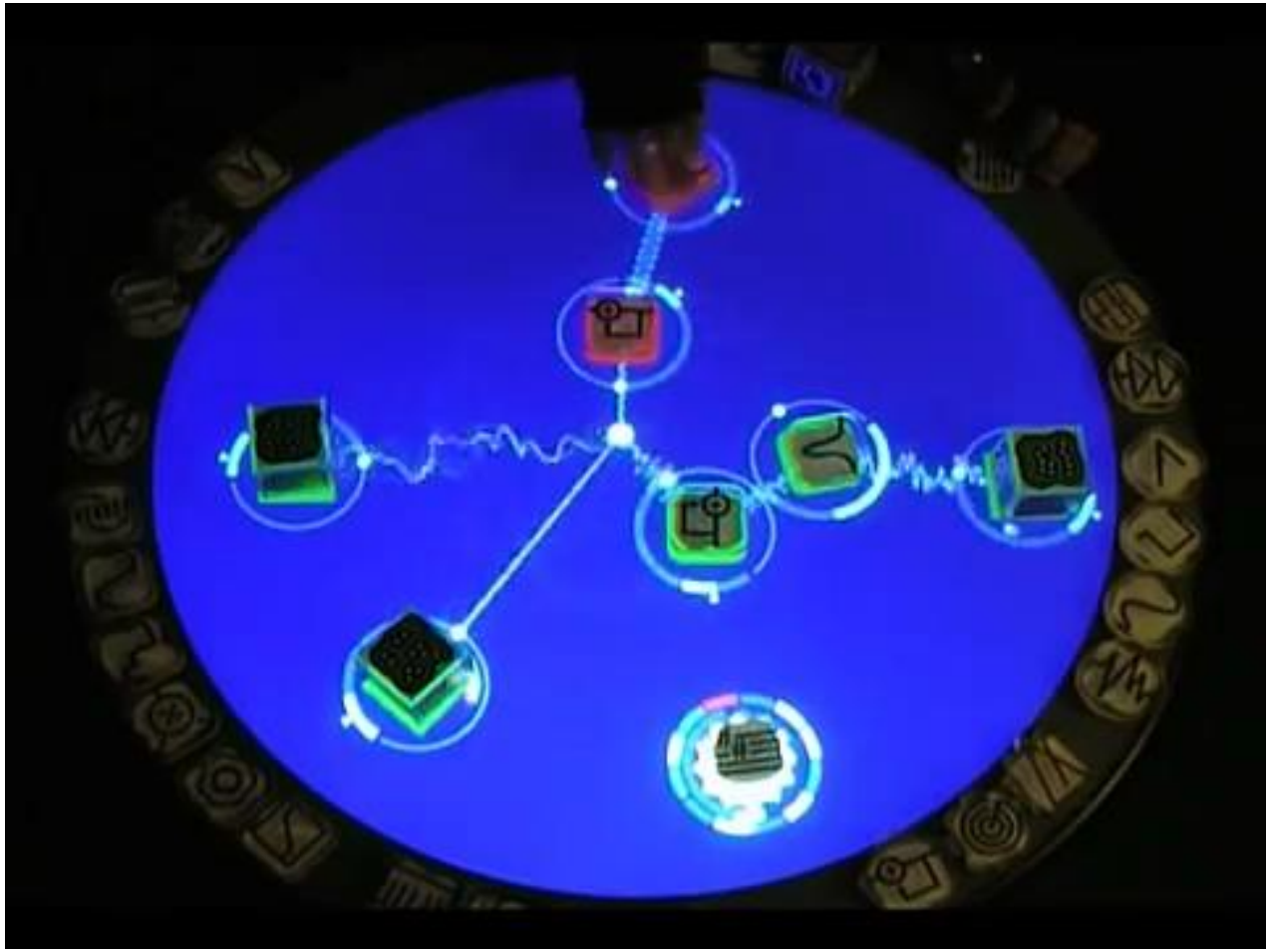
ReacTIVision and Reactable

- Open source toolkit for tangible multi-touch surfaces
- *Fiducial markers* and multi-touch finger tracking





Video: Reactable

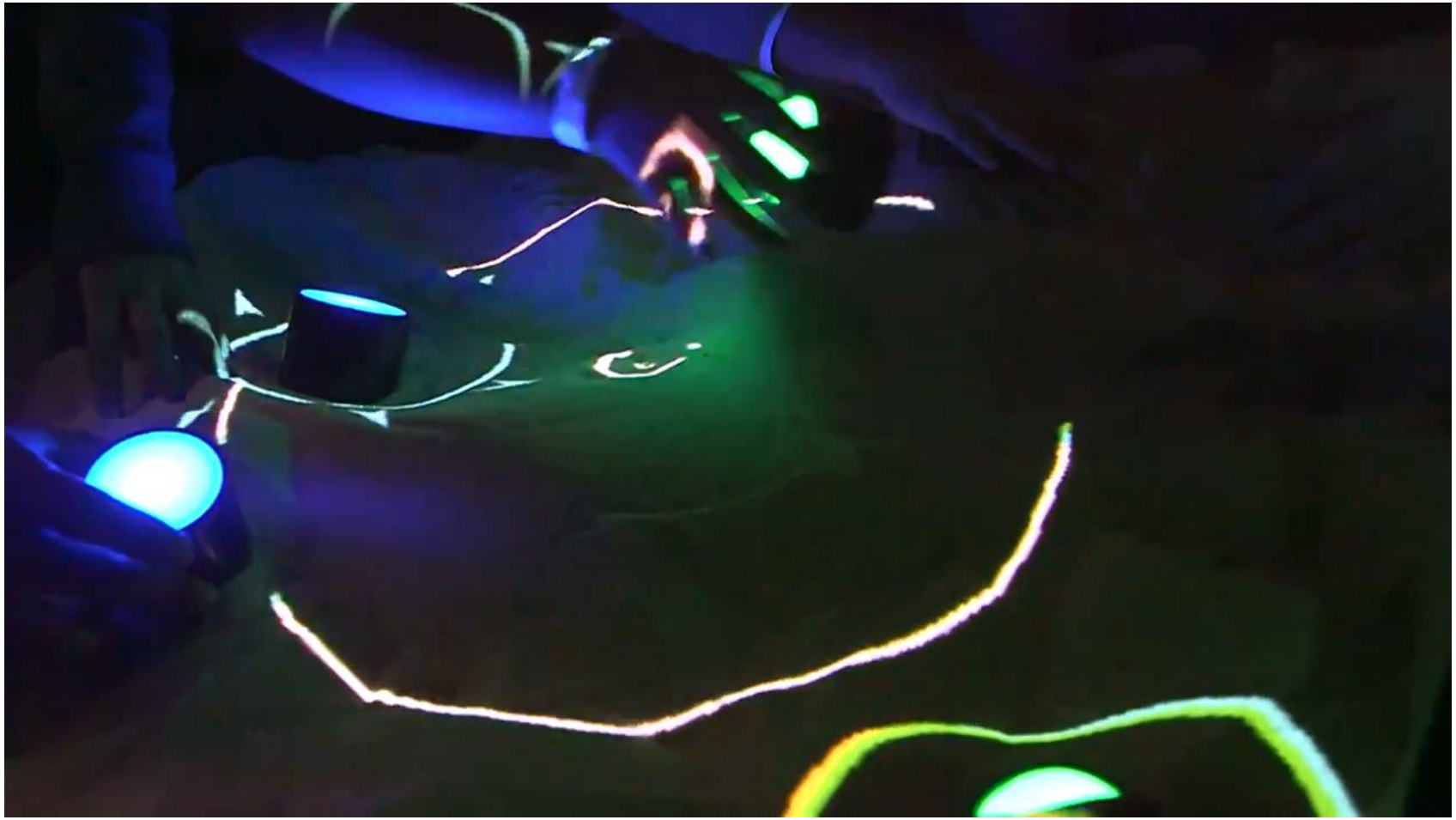


The Sand Noise Music Device

- Interactive art installation offering an intuitive and tactile method for controlling and interacting with a generative electronic music system
  - virtual objects move in the sand and obey the laws of gravity (e.g. speed up when flowing downhill)
  - users can move the physical objects as well as change the topography of the sand landscape

The sand noise music device

Video: The Sand Noise Music Device

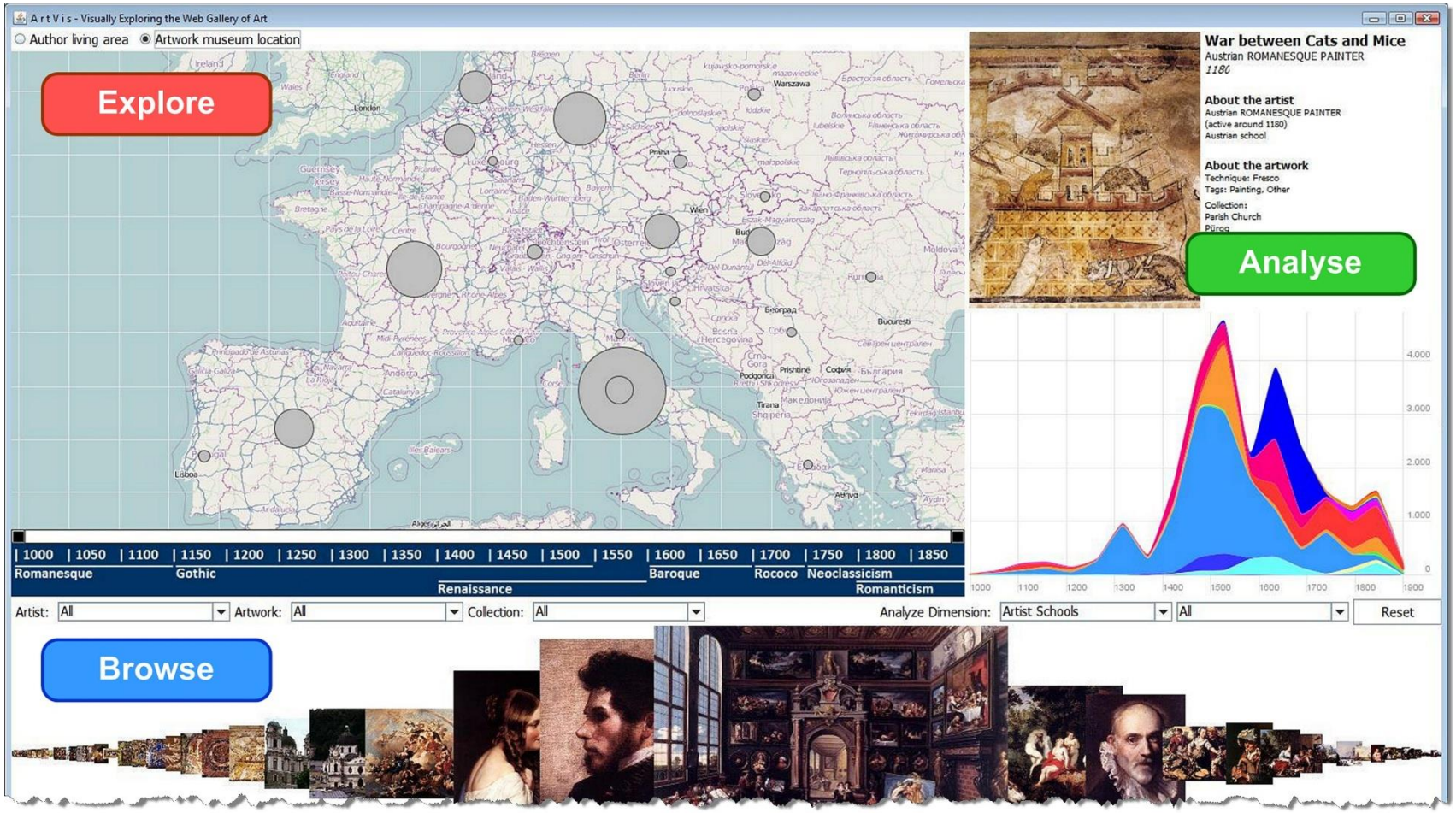


ArtVis

- Advanced visualisation techniques in combination with a TUI
  - explore Web Gallery of Art
  - faceted browsing
  - phidgets-based TUI
  - RFID-tagged physical objects
- Three main components to *explore*, *analyse* and *browse* the information
  - new insights about large collections of data

Bram Moerman

ArtVis ...



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ArtVis ...

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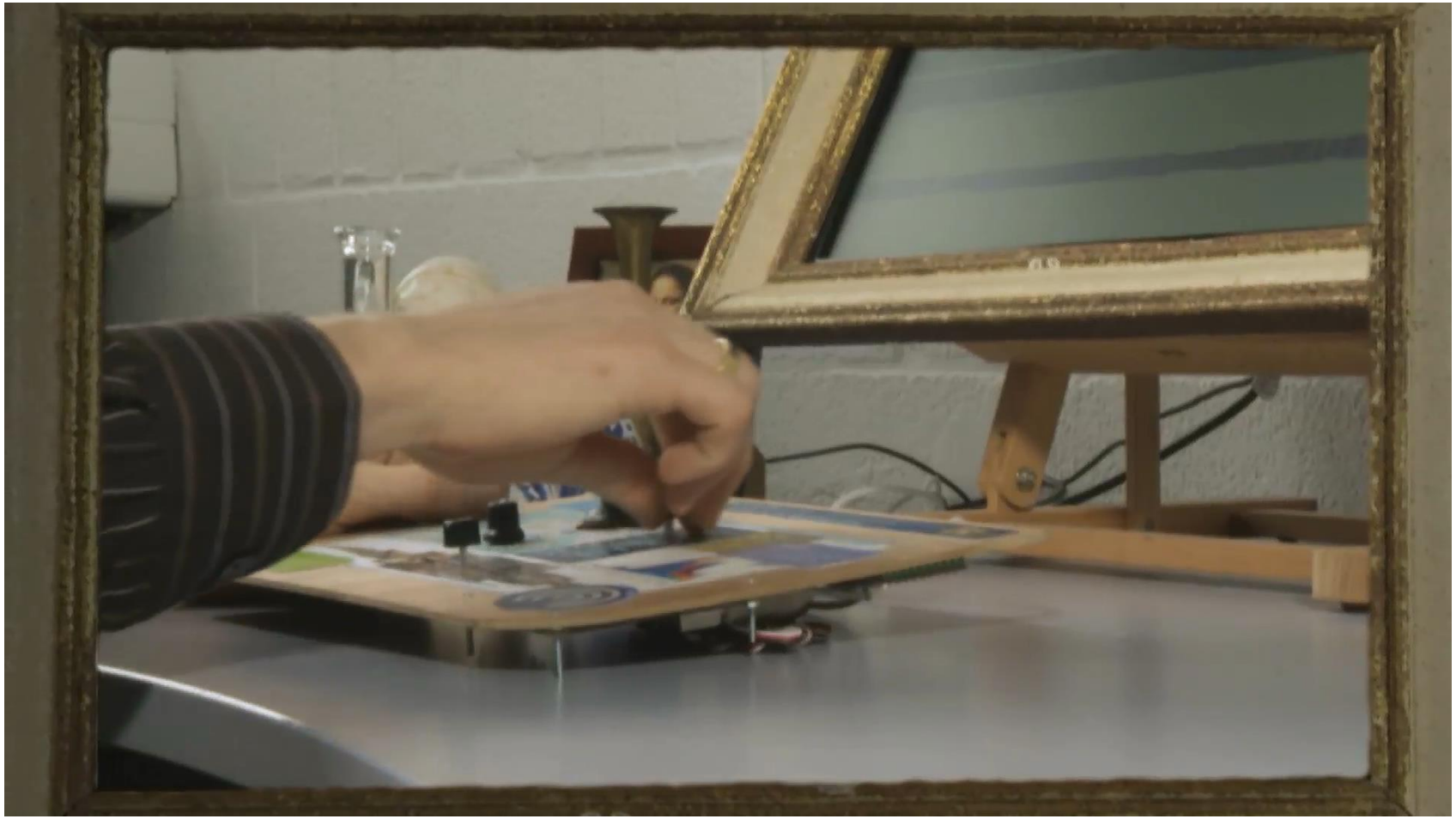
Video: ArtVis



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Sifteo Cubes (Siftables)

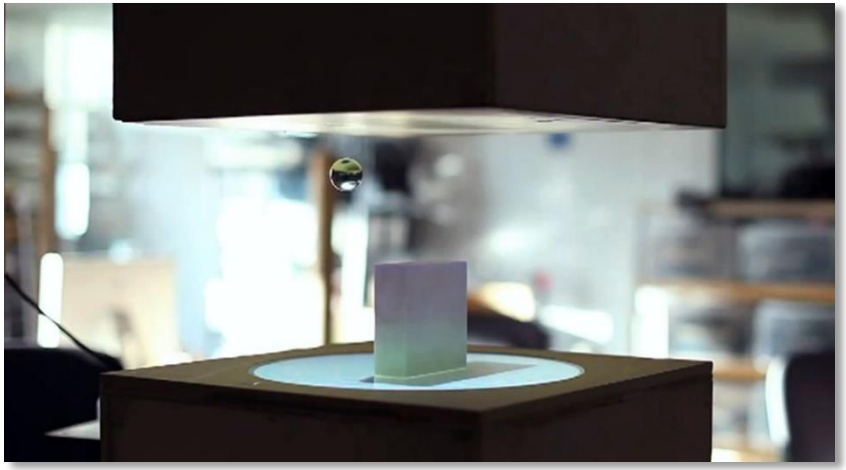
- Interactive gaming platform for
  - spatial reasoning
  - collaboration
  - pattern recognition
  - …
- Originated from Siftables
- Features
  - 1.5" block with 128x128 colour TFT LCD
  - 32 bit ARM CPU
  - 3-axis accelerometer
  - near-field object sensing technology (detect closeby Sifteo cubes)

Sifteo Cubes

Video: Siftables

ZeroN

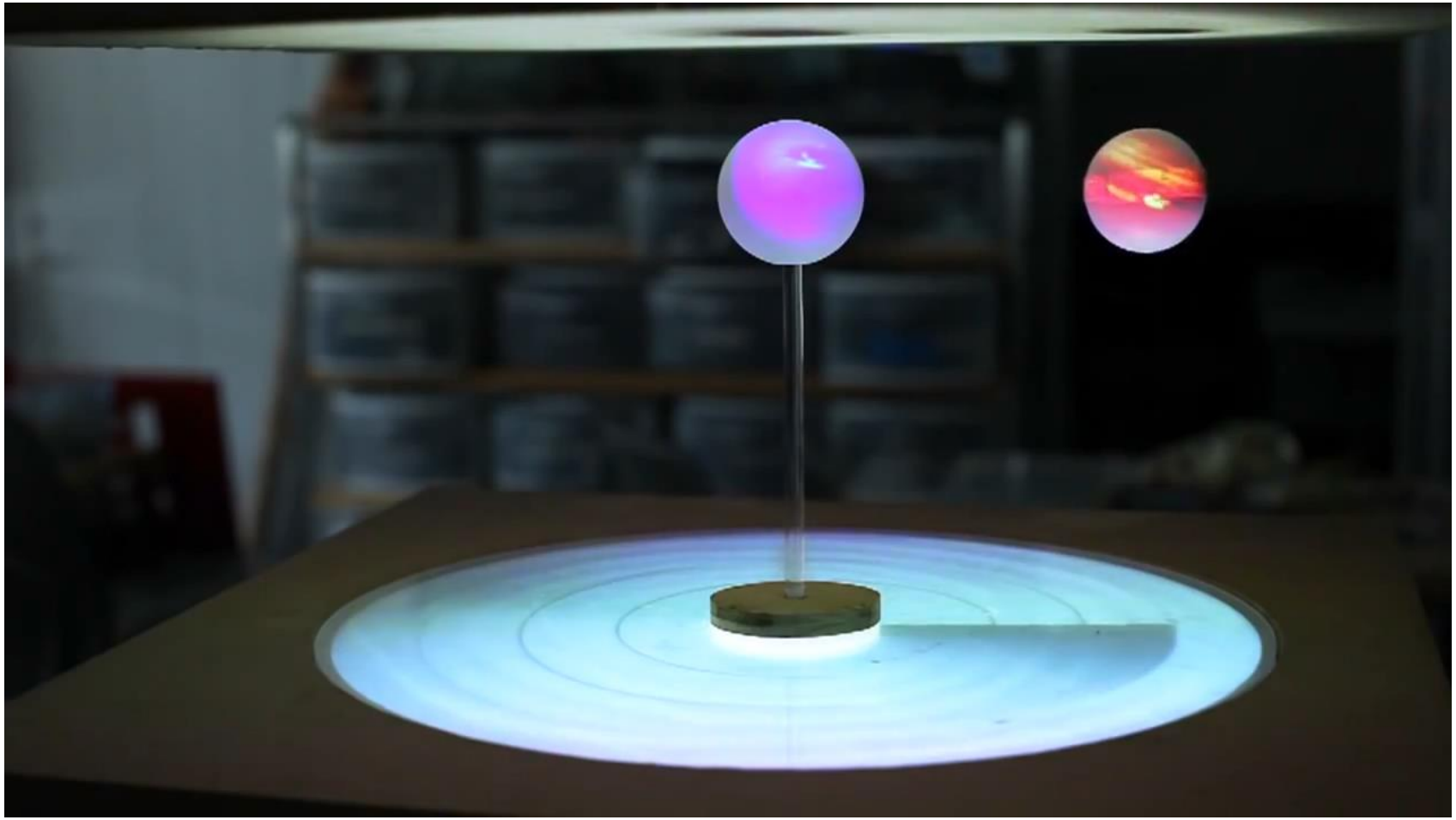
- Anti-gravity interaction element that can be levitated and moved freely by a computer in 3D space
  - explores how altering the fundamental rule of the physical world will transform interaction between humans and materials in the future



ZeroN

- Users can place or move the ZeroN in the mid-air 3D space in the same way they can place and interact with objects on surfaces

Video: ZeroN

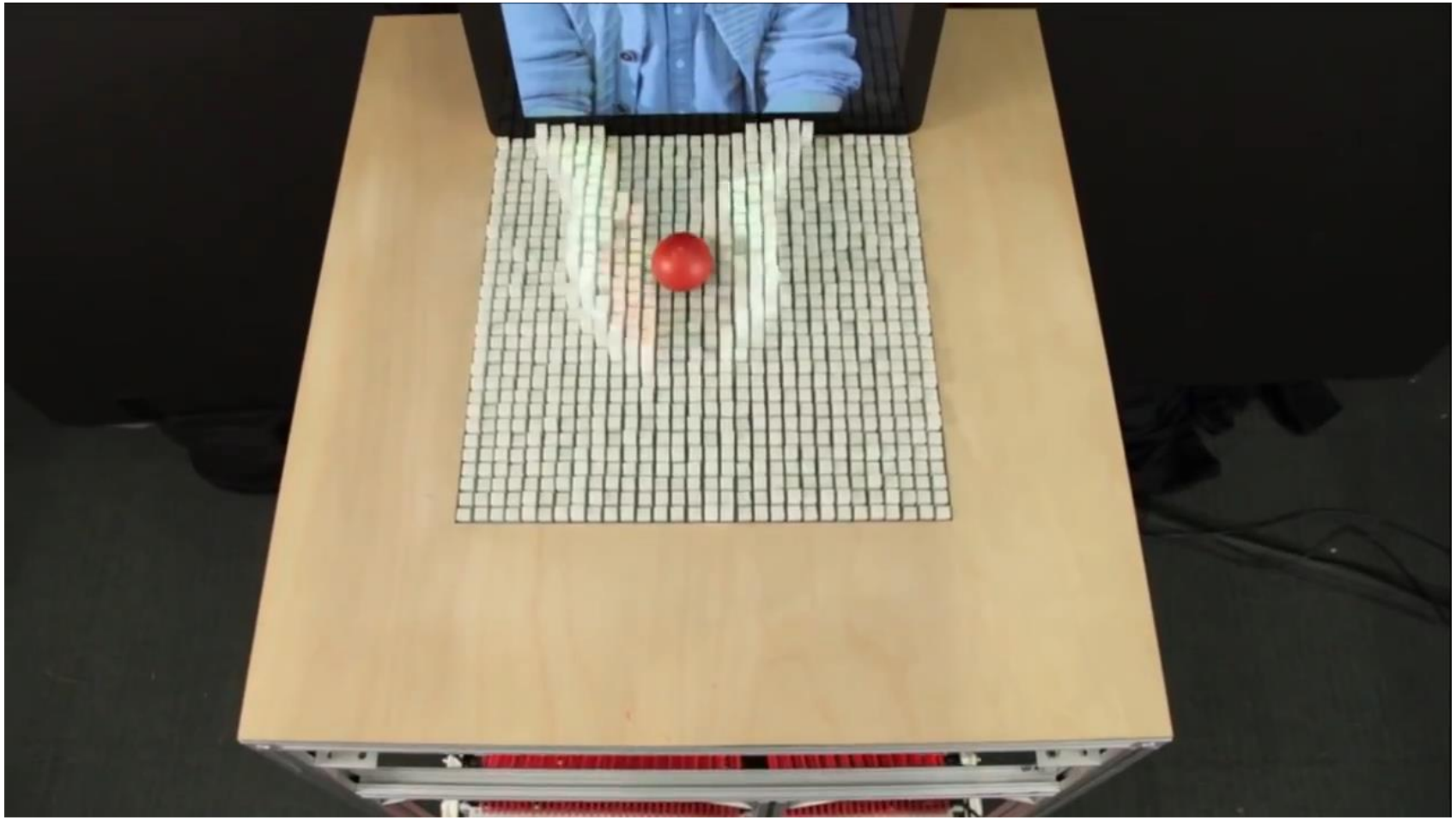


TRANSFORM

- Dynamic *shape display* that can physically render 3D content
  - tangible interaction with digital content
    - geospatial data
    - 3D modelling
    - …
  - TRANSFORM display can also interact with the physical world around it
  - remote users can be displayed physically
- Step towards MIT's vision of *Radical Atoms*

TRANSFORM, MIT

Video: TRANSFORM



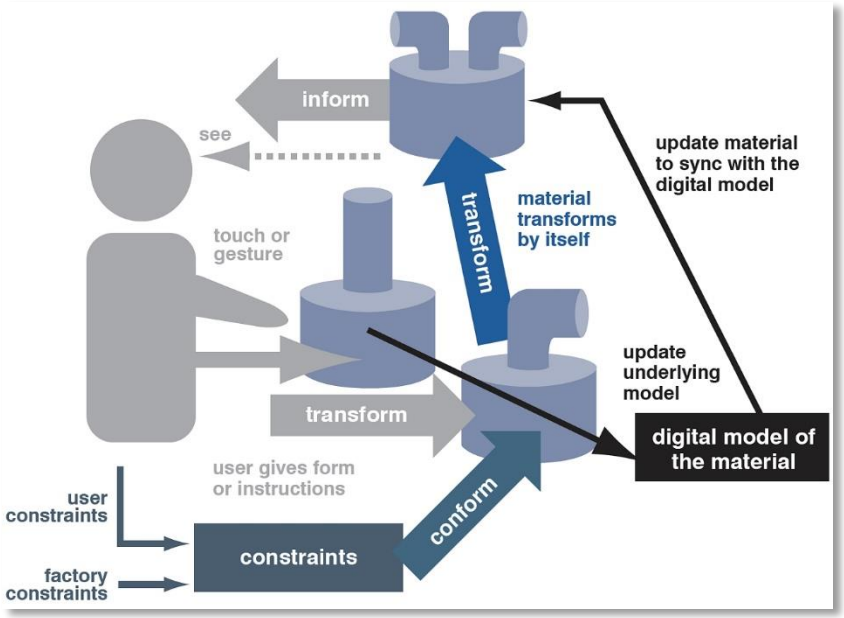
Radical Atoms (2012)

- Vision taking a leap *beyond Tangible Bits*
  - assuming a hypothetical generation of materials that can change their form and appearance dynamically
- Radical Atoms is
  - a computationally transformable and reconfigurable material that is *bidirectionally coupled* with an underlying digital model (bits)
  - the future material that can transform its shape, conform to constraints and inform the users of its affordances
  - a vision for the future of *human-material interaction*, in which all digital information has a physical manifestation so that we can interact directly with it
  - about a new *Material User Interface (MUI)*

Hiroshi Ishii, Dávid Lakatos, Leonardo Bonanni and Jean-Baptiste Labrune, *Radical Atoms: Beyond Tangible Bits, Toward Transformable Materials*, interactions 19(1), January 2012

Radical Atoms Concept

- *Transform*
  - interface can transform its shape to modify the model and reflect changes in the computational model
- *Conform*
  - interface has to conform to some physical laws and user constraints (e.g. for safety)
- *Inform*
  - user has to be informed about changing interface affordances

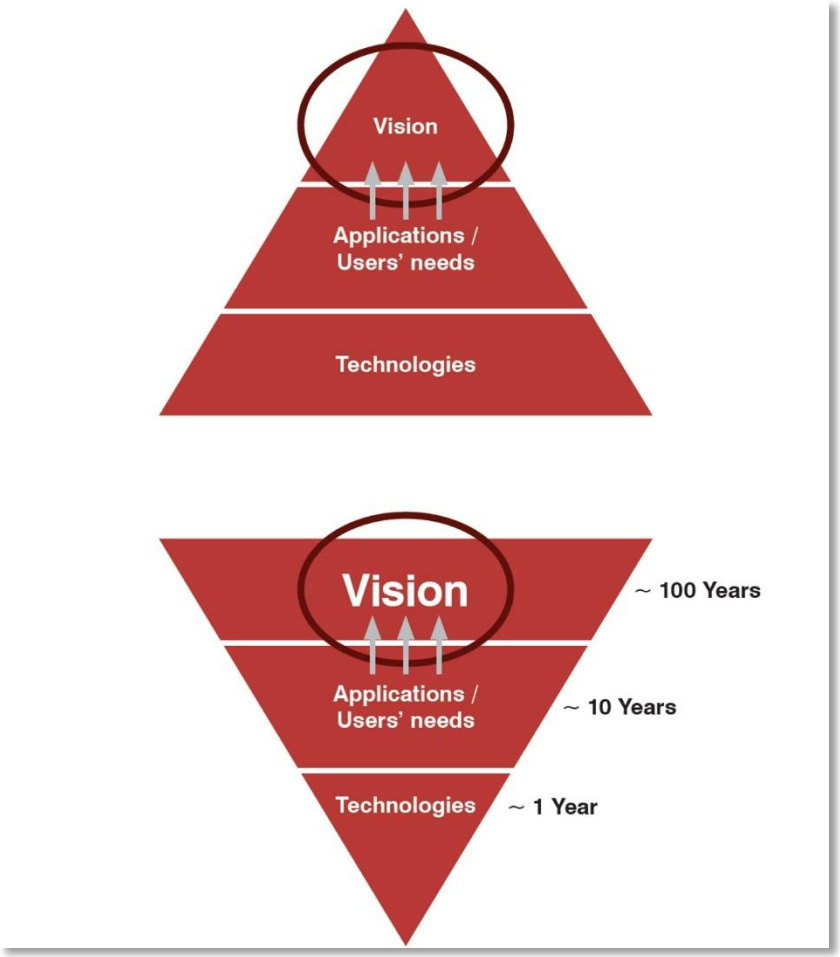


Interactions with Radical Atoms

- Direct touch and gestural interaction
  - gestures coupled with direct touch create an interaction appropriate for Radical Atoms since users are able to rapidly reform dynamic materials at all scales
- Context-aware transformation
  - context-aware transformations of the hand tool/interface
    - e.g. screwdriver adapting to the type of screw it is operating on
- Shape-memory clay: *Perfect Red*
  - Perfect Red is a fictional material that can be sculpted like and responds according to rules inspired by CAD operations
    - e.g. if we split a piece in two even halves, then the operations performed on one part are mirrored on the other part

Vision-Driven Design Research

- Quantum leaps in HCI rarely result from studies on user needs but from the passion and dreams of visionaries
  - e.g. Douglas Engelbart
- *Vision-driven research*
  - strong vision can last beyond our lifespan
  - have to wait for enabling technologies but *exploration of interaction design can already start!*



Homework

- Read the following paper that is available on PointCarré (papers/Ishii 2012)
  - H. Ishii, D. Lakatos, L. Bonanni and J.-B. Labrune, *Radical Atoms: Beyond Tangible Bits, Toward Transformable Materials*, interactions, 19(1), January 2012

References

- G.W. Fitzmaurice, H. Ishii and W. Buxton, *Bricks: Laying the Foundations for Graspable User Interfaces*, Proceedings of CHI 1995, ACM Conference on Human Factors in Computing Systems, Denver, USA, May 1995
  - http://dx.doi.org/10.1145/223904.223964
- J.J. Gibson, *The Ecological Approach to Visual Perception, Chapter 8: The Theory of Affordances*, 1979, ISBN-13: 978-1848725782
  - http://cs.brown.edu/courses/cs137/readings/Gibson-AFF.pdf

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- Eva Hornecker, Tangible Interaction
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- Durrell Bishop's Marble Answering Machine
  - https://www.youtube.com/watch?v=RgVbXV1krgU
- The Norman Door
  - https://www.youtube.com/watch?v=yY96hTb8WgI
- metaDESK
  - https://www.youtube.com/watch?v=FsHHYK_UXkw
- ambientROOM
  - http://vimeo.com/48815734

References …

- Reactable
  - https://www.youtube.com/watch?v=Mgy1S8qymx0&gl=BE
- The Sand Noise Music Device
  - https://www.youtube.com/watch?v=VJgD-lEUPpo
- Siftables
  - http://www.ted.com/talks/david_merrill_demos_siftables_the_smart_blocks
- TRANSFORM
  - https://www.youtube.com/watch?v=lCARHatJQJA
- ZeroN
  - https://www.youtube.com/watch?v=-i2kJMJz7Wg

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