# Introduction to Tangible User Interfaces

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# From Graphic User Interfaces … to Graspable User Interfaces

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“**Graphic User Interfaces** represent information (bits) in the form of pixels on bit-mapped displays. These graphical representations are manipulated with generic remote controllers (such as mice and keyboards).

By **decoupling representation (pixels) from control (input devices)** this way, GUIs are malleable enough to graphically emulate a variety of media. However, when interacting with the GUI world, we cannot take advantage of our evolved dexterity or utilize our skills in manipulating physical objects (such as building blocks or clay models).”

Ishii, H. (2008). The tangible user interface and its evolution. Communications of the ACM, 51(6), 32-36.

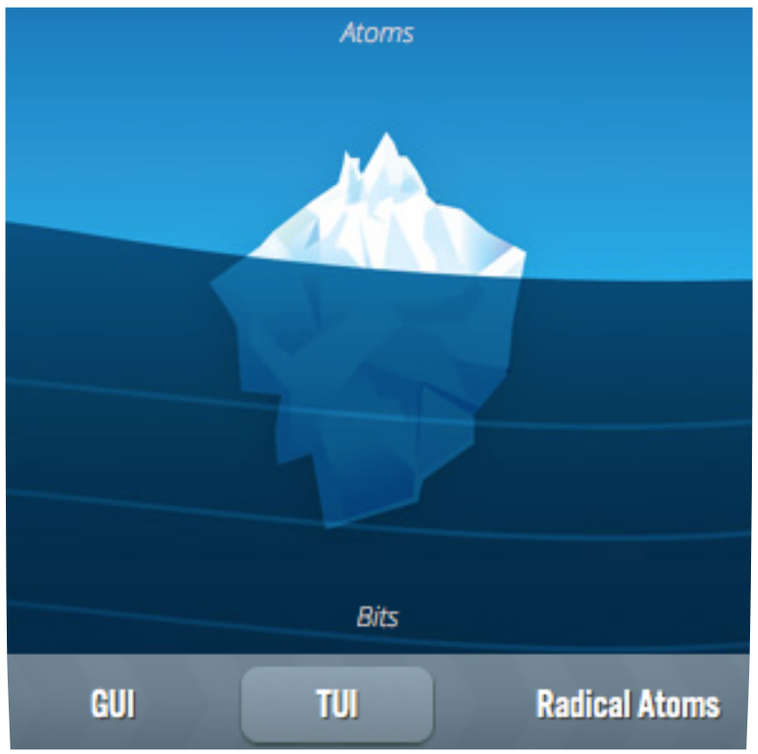
# Tangible Interaction intro

- Tangible Interaction (TI) is an area of study that seeks to explore a Human-Computer Interaction (HCI) paradigm less bounded to the screen.

- The focus is shifted from displays to "tangible" objects

# Tangible Interaction


You can see the information but you cannot interact directly with it




Part of the information is exposed to the physical world and you can interact directly with it

# TI Ideas & Principles

1. "to rejoin the richness of the physical world in HCI"
2. bridging the digital and the real world
3. physicality as a mean that could provide a richer and simpler interaction

# TI Information features

1. *static digital media* such as images and 3D
2. *dynamic digital media* such as live videos and dynamic touch
3. *digital attributes* such as color and other material properties
4. *computational operations and applications*
5. *simple data structures* such as lists or trees of media objects;
6. *complex data structures* such as combinations of data, operations, and attributes;
7. *and remote people, places, and things* (including other electronic devices)

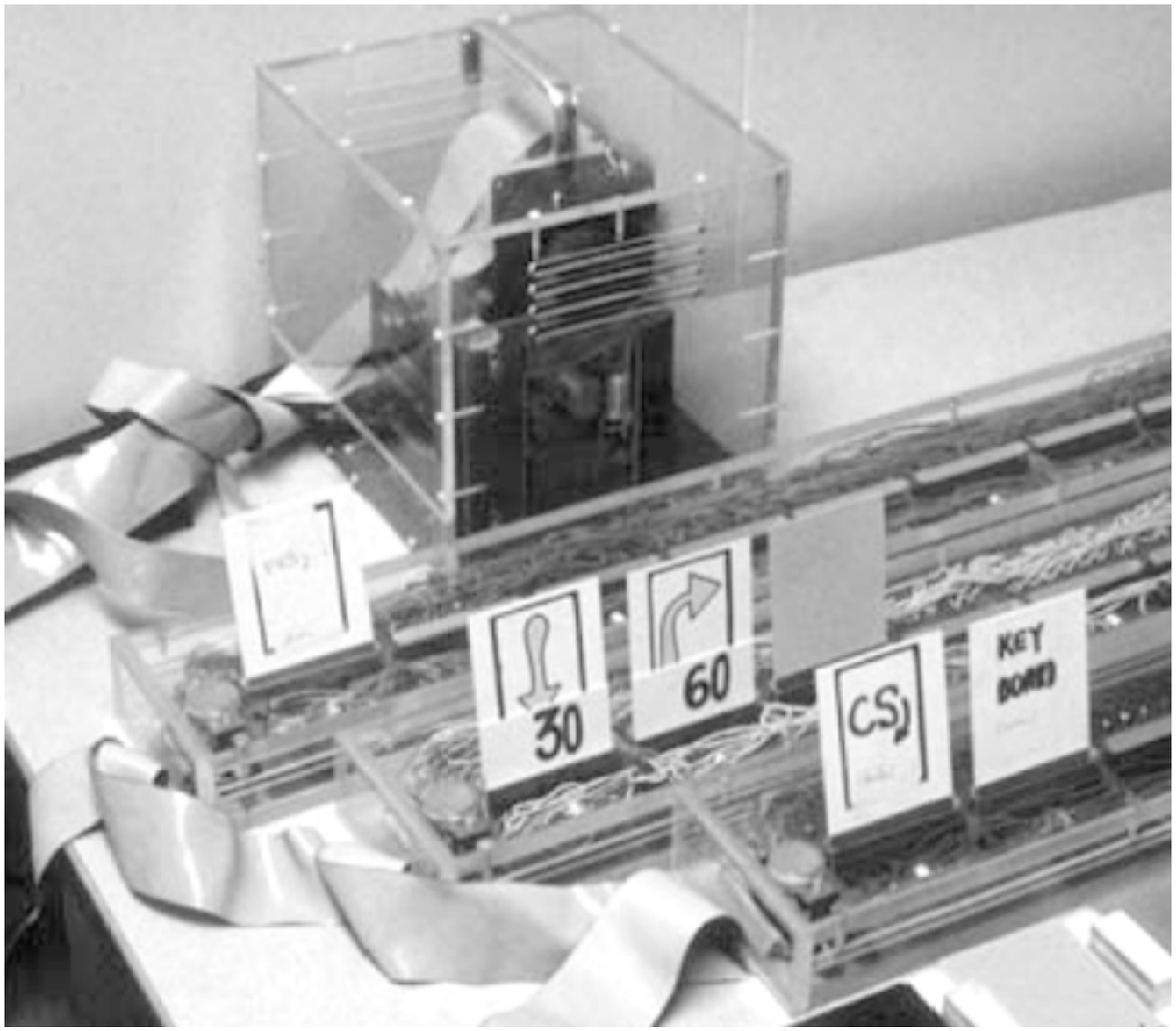
B. Ullmer and H. Ishii, “Emerging frameworks for tangible user interfaces,” in Human-Computer Interaction in the New Millenium, (J. M. Carroll, ed.), pp. 579–601, Addison-Wesley, 2001.

# Tangible Interaction

As an encompassing perspective it emphasizes **tangibility and materiality, physical embodiment of data, bodily interaction, and the embedding of systems in real spaces and contexts**. This embeddedness is why tangible interaction is always situated in physical and social contexts.

E. Hornecker and J. Buur, “Getting a grip on tangible interaction: A framework on physical space and social interaction,” in Proceedings of CHI06, pp. 437–446, NY: ACM, 2006.

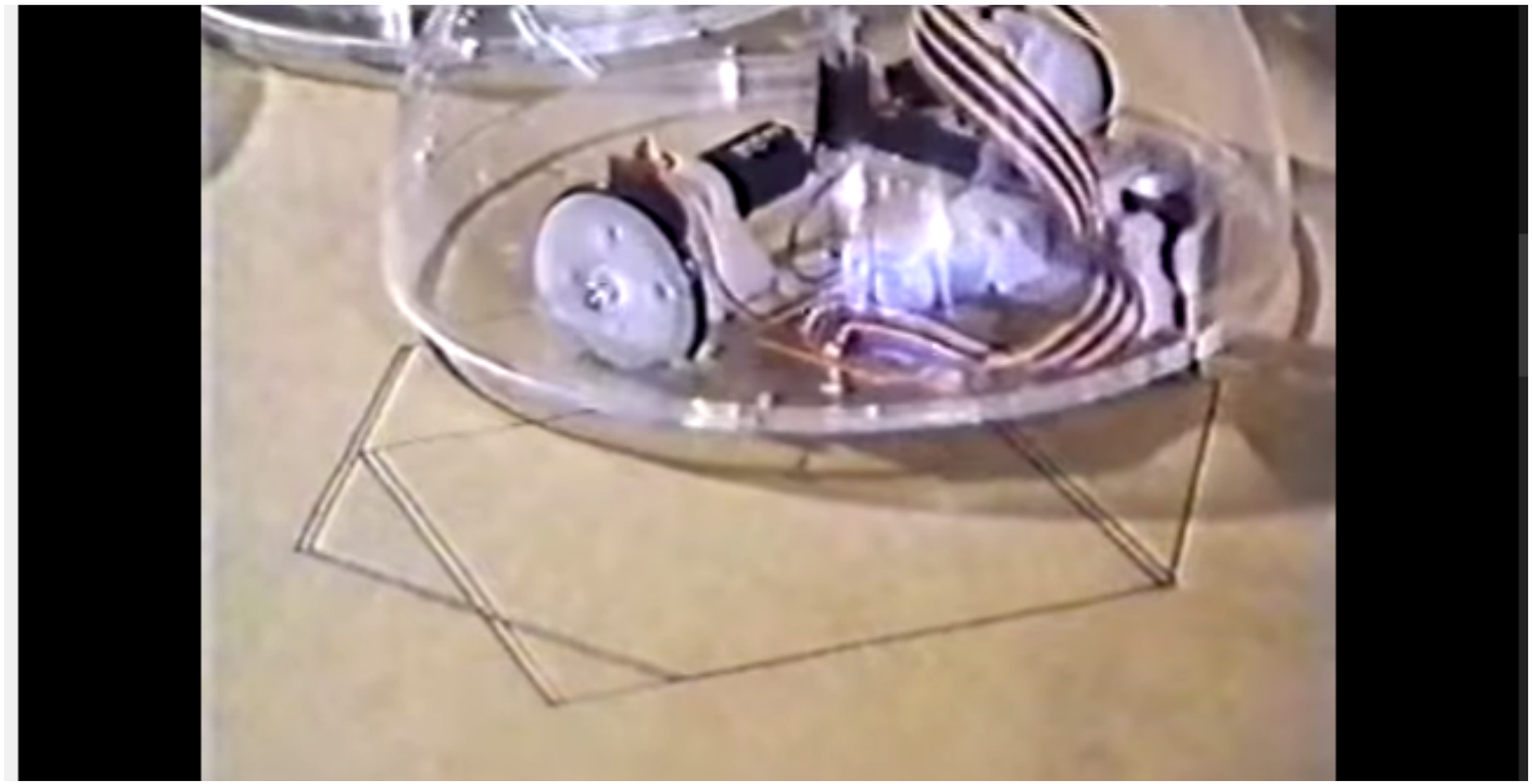
# TUI precursor: Radia Perlman Slot Machine




Morgado, L., Cruz, M., & Kahn, K. (2006). Radia Perlman-A pioneer of young children computer programming.

# Seymour Papert Turtle

https://youtu.be/BTd3N5Oj2jk?list=PLlUr-fJyB7_jbEOS0sgQ9HutBN3LUJLa7

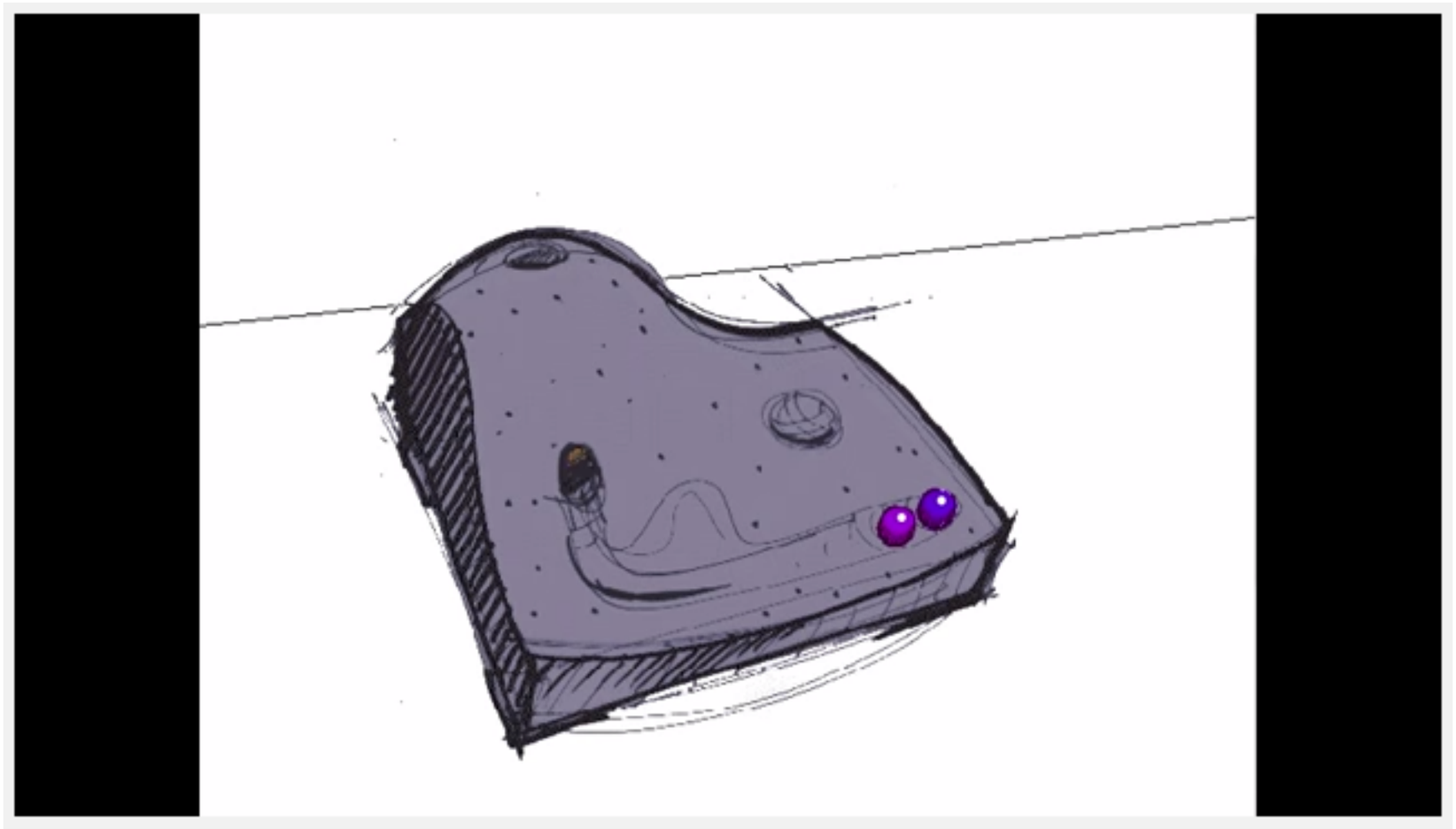



Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books, Inc..

Papert, S. (1993). The children's machine. TECHNOLOGY REVIEW-MANCHESTER NH-, 96, 28-28.

# TUI precursor: Bishop Marble Answer Machine

https://youtu.be/RgVbXV1krgU



Ishii, H., & Ullmer, B. (1997, March). Tangible bits: towards seamless interfaces between people, bits and atoms. In Proceedings of the ACM SIGCHI Conference on Human factors in computing systems (pp. 234-241). ACM.

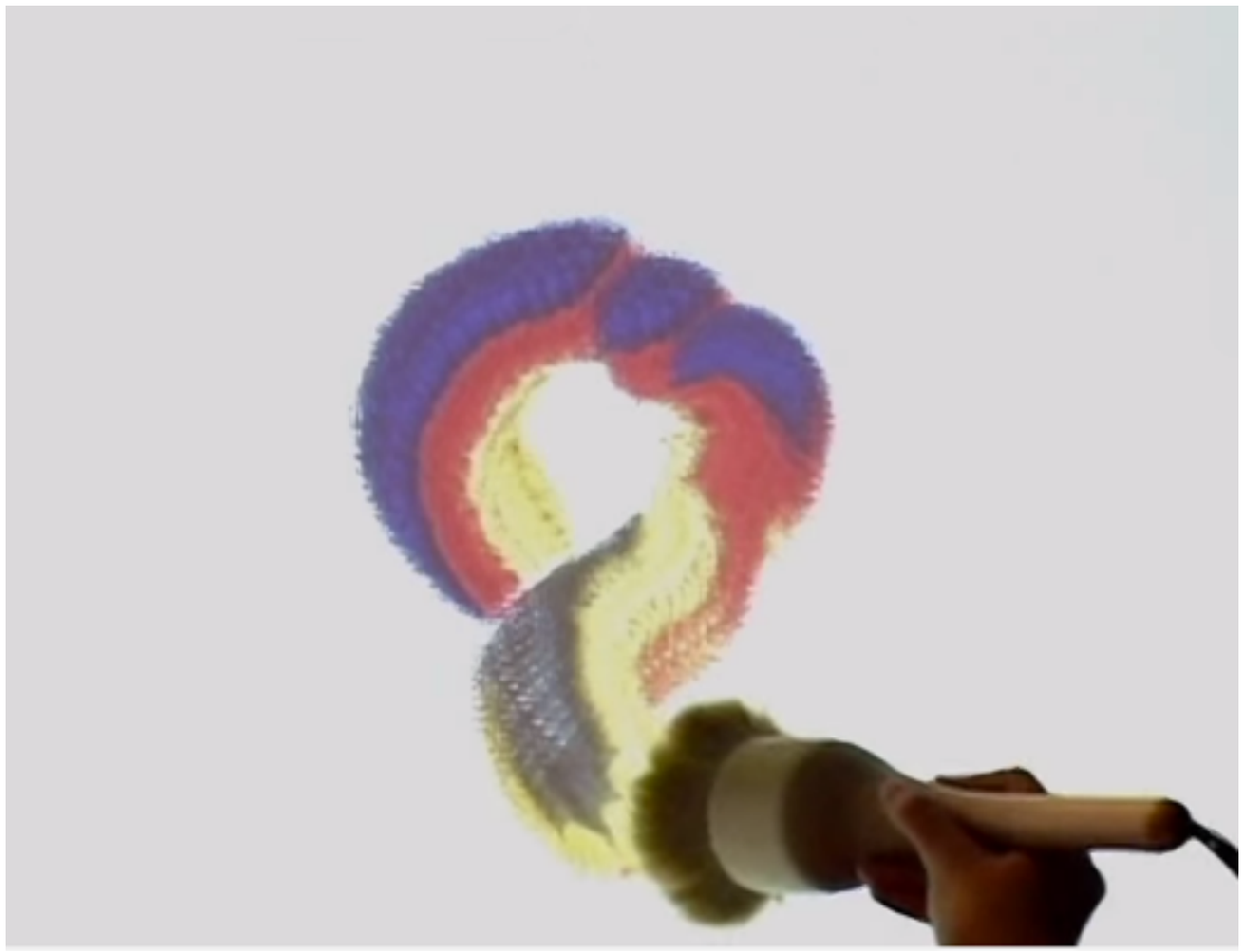
# TUIs main conceptual definition

"The key TUI idea remains: **give physical form to digital information**, letting serve as the representation and controls for its digital counterparts. TUIs **make digital information directly manipulatable with our hands and perceptible through our peripheral senses through its physical embodiment.**"

Ishii, H. (2008). The tangible user interface and its evolution. Communications of the ACM, 51(6), 32-36.

# I/O Brush

https://youtu.be/8Vc8G0Fmhc4



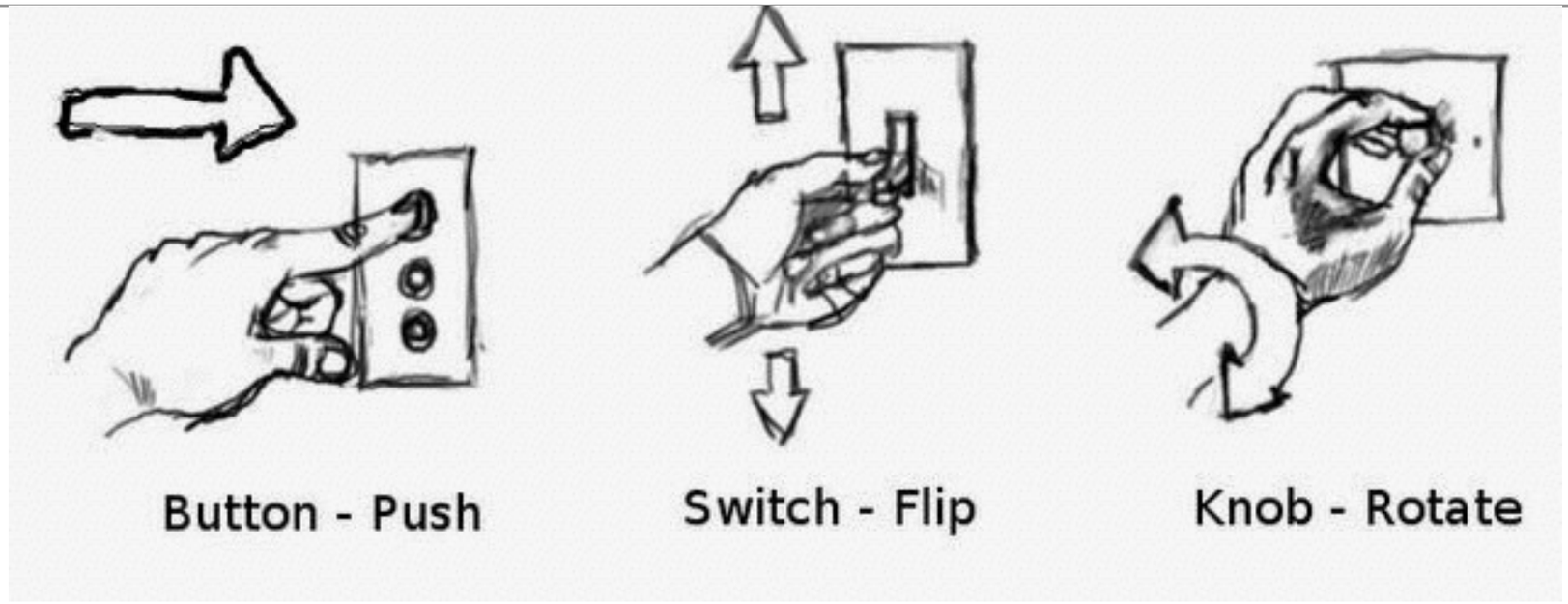
Ryokai, K., Marti, S., & Ishii, H. (2004, April). I/O brush: drawing with everyday objects as ink. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 303-310). ACM.

# TUIs as

"..an emerging post-WIMP (Windows Icon Menus Pointers) interface type that is concerned with **providing tangible representations to digital information and controls, allowing users to quite literally grasp data with their hands.**"

Shaer, O., & Hornecker, E. (2010). Tangible user interfaces: past, present, and future directions. Foundations and Trends in Human-Computer Interaction, 3(1–2), 1-137.

# Physical Affordances



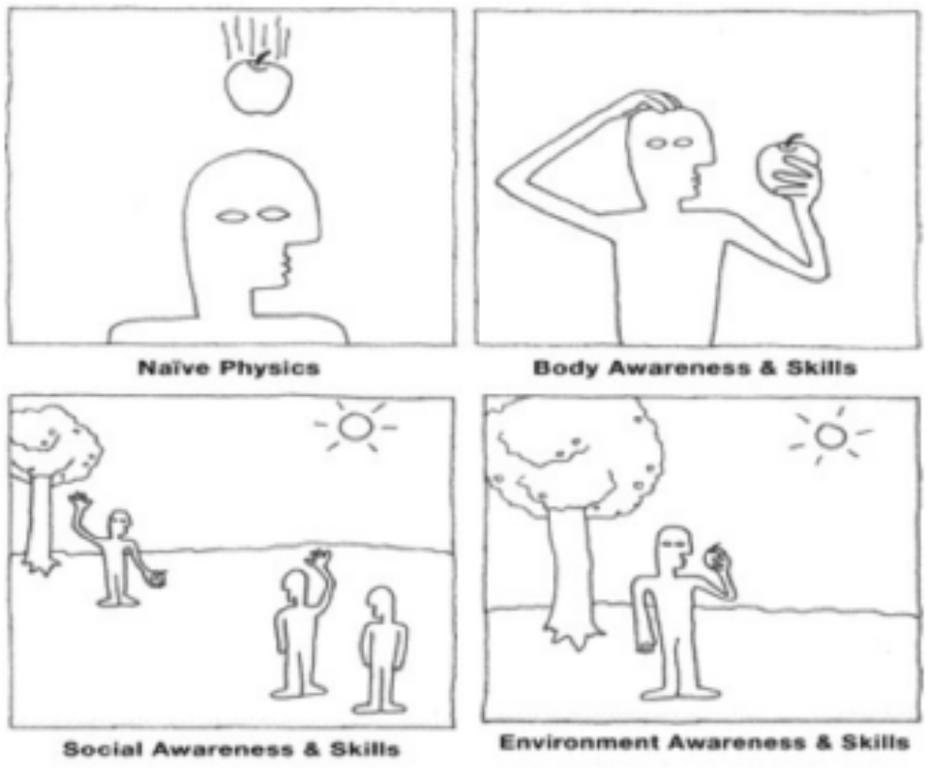

Perceptual psychologist J. J. Gibson (1977) coined the term and defined it as the actionable properties in the world

Donald Norman (1999) distinguished between *intentional* and *perceived affordances.*

Norman, D. A. (1999). Affordance, conventions, and design. interactions, 6(3), 38-43.

# Jacob Reality-Based interaction themes

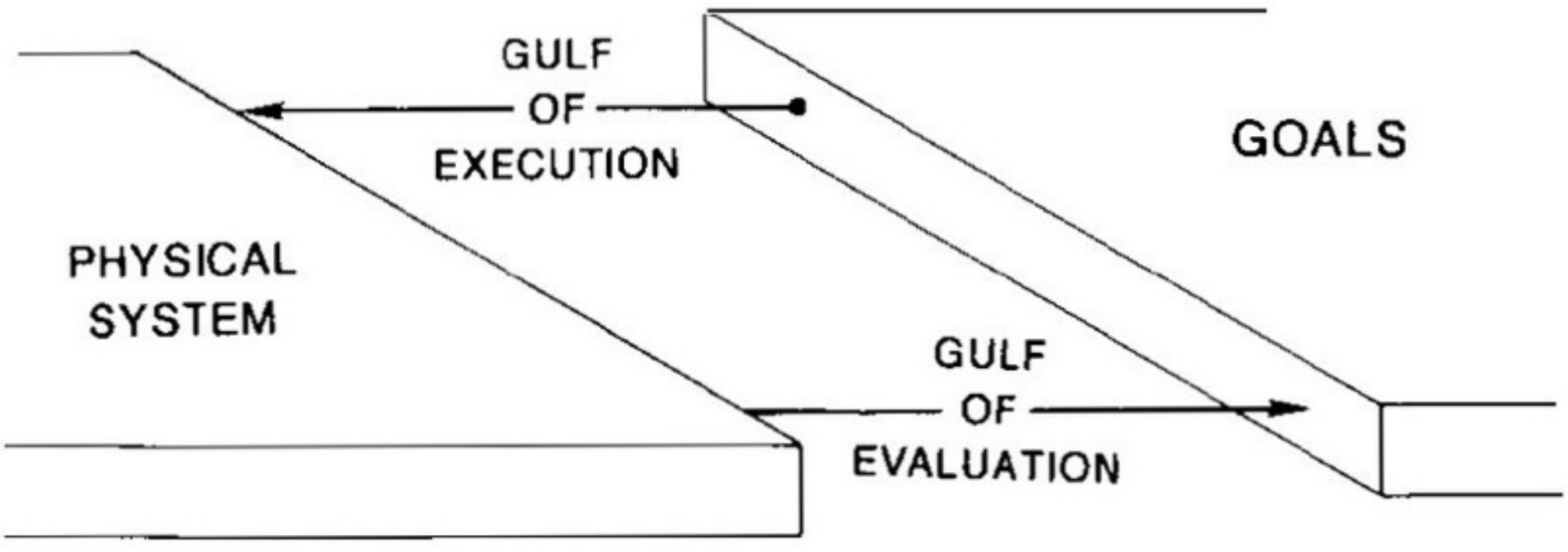
- ***Naıve Physics***: the common sense knowledge people have about the physical world.
- ***Body Awareness and Skills***: the awareness people have of their own physical bodies and their skills of controlling and coordinating their bodies.
- ***Environment Awareness and Skills***: the sense of surroundings people have for their environment and their skills of manipulating and navigating their environment.
- ***Social Awareness and Skills***: the awareness people have that other people share their environment, their skills of interacting with each other verbally or non verbally, and their ability to work together to accomplish a common goal.




R. J. K. Jacob, A. Girouard, L. M. Hirshfield, M. S. Horn, O. Shaer, E. T. Solovey, and J. Zigelbaum, “Reality-based interaction: A framework for post- WIMP interfaces,” in Proceedings of CHI 2008, pp. 201–210, NY: ACM, 2008.

# Norman’s gulfs

“They refer to the mismatch between internal goals and the expectation and the availability of information specifying the state of the world (or an artifact) and how we may change it.”




D. Norman, The Psychology of Everyday Things. New York: Basic Books, 1988.

https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/gulf-of-evaluation-and-gulf-of-execution

# TI design methods

- storyboarding
- sketches and lo-fi prototypes
- 3D models and medium-fi prototypes
- functional prototypes and hi-fi prototypes (Arduino and Makey Makey)

D. Norman, The Psychology of Everyday Things. New York: Basic Books, 1988.

https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/gulf-of-evaluation-and-gulf-of-execution

# Tangible computing common features

- *no single locus of control or interaction*. Instead of just one input device, there is a coordinated interplay of different devices and objects;

- *no enforced sequentiality (order of actions) and no modal interaction*; and

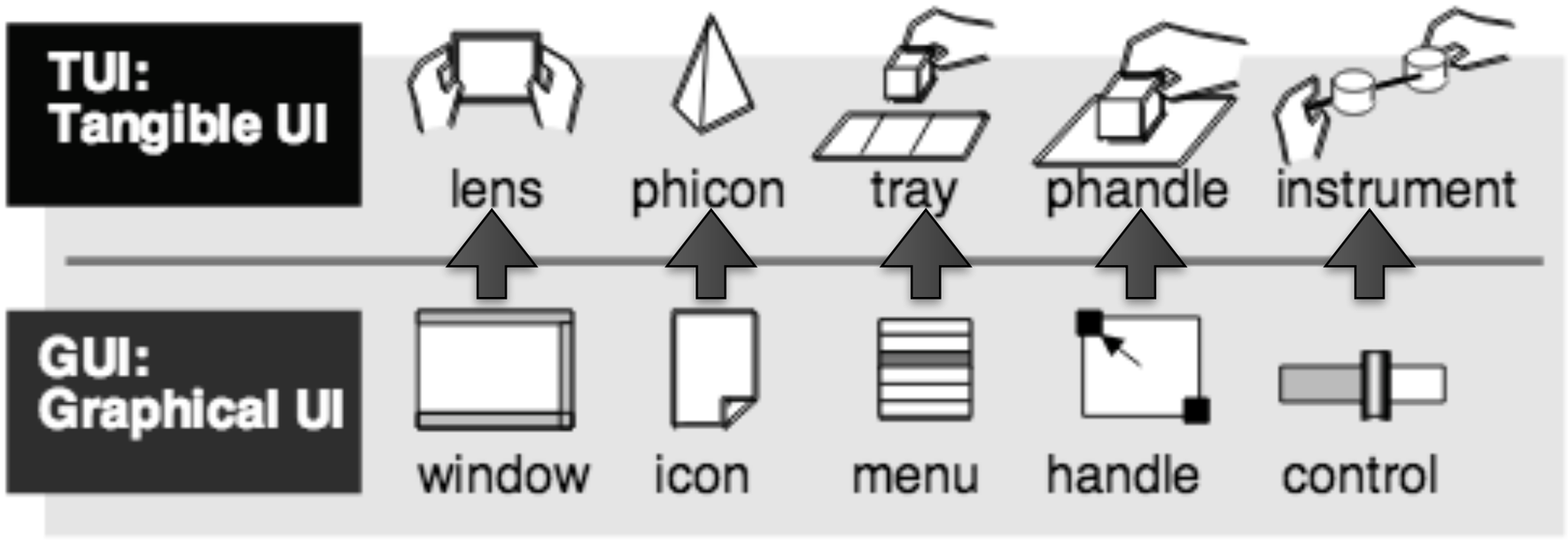
- the design of interface objects makes *intentional use of affordances* which guide the user in how to interact.

P. Dourish, Where the Action Is. The Foundations of Embodied Interaction. MIT Press, 2001.

# metaDESK: from icons to phicons

- The desktop metaphor is derived from the real world, Ishii and Ullmer tried to give back physicality

- Transform the software/graphical elements into tangible objects


Ullmer, Brygg, and Hiroshi Ishii. 1997. “The metaDESK: Models and Prototypes for Tangible User Interfaces.” In Proceedings of the 10th Annual ACM Symposium on User Interface Software and Technology, 223–32. ACM.

# Graspable & Tangible

- Graspable is a subset of tangible interaction
- Graspable Interfaces are using physical object to control “functions”
- Graspable exploit physicality (gestures, grasping behaviors, spatial reasoning)
- Tangible exploit physicality
- Seamless integration of input and output
- Tangible interfaces can be at the same time input and output devices (on the same physical object)

Fitzmaurice, G. W. (1996). Graspable user interfaces (Doctoral dissertation, University of Toronto).

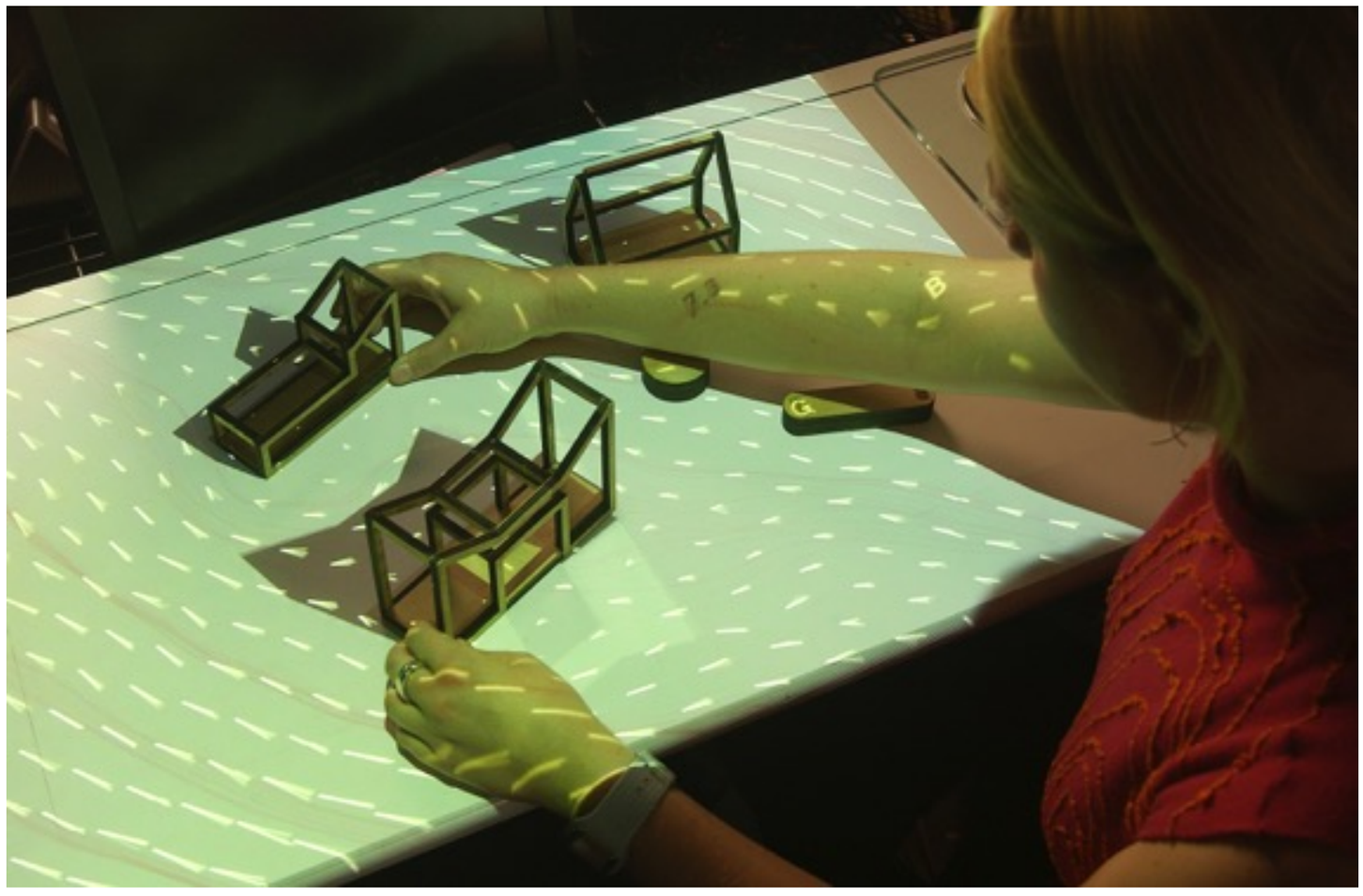
# Fitzmaurice 5 basic properties of Graspable User Interfaces

- space-multiplexing,
- concurrent access and manipulation (often involving two-handed interaction),
- use of strong-specific devices (instead of weak-general, that is generic and non-iconic),
- spatial awareness of the devices, and
- spatial reconfigurability.

G. W. Fitzmaurice, Graspable User Interfaces. Dissertation, Computer Science, University of Toronto, Canada, 1996

# Tangible and Direct Manipulation

Direct Manipulation: physical manipulation of tangible objects affect directly (without intermediates) their state



http://tangible.media.mit.edu/project/io-bulb-and-luminous-room/

# Dominant application areas

- learning,
- support of planning and problem solving,
- programming and simulation tools,
- support of information visualization and exploration,
- entertainment,
- play,
- performance and music,
- and also social communication.

# Tangibles and abstract thinking

- Learning complex structures and behaviors by building an interactive simulation
- Rate, Flow

Figure 1.
"Rectangle" Loop

Figure 2.
"Square" Loop

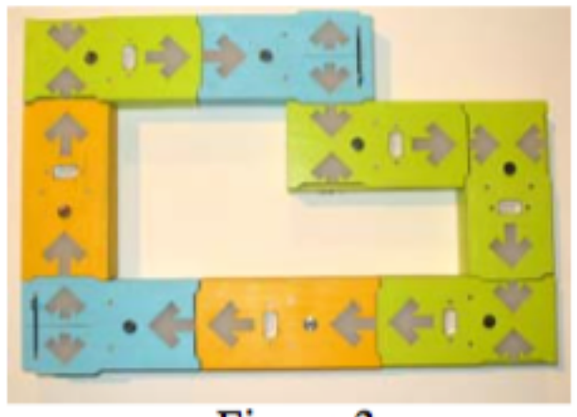


Figure 3.
"Non-Symmetric" Loop

Zuckerman, Oren, Tina Grotzer, and Kelly Leahy. 2006. "Flow Blocks as a Conceptual Bridge between Understanding the Structure and Behavior of a Complex Causal System." In Proceedings of the 7th International Conference on Learning Sciences, 880–86. International Society of the Learning Sciences.

# Sifteo Cubes

https://youtu.be/fEqq8JykQoQ

Merrill, D., Sun, E., & Kalanithi, J. (2012, May). Sifteo cubes. In CHI'12 Extended Abstracts on Human Factors in Computing Systems (pp. 1015-1018). ACM.

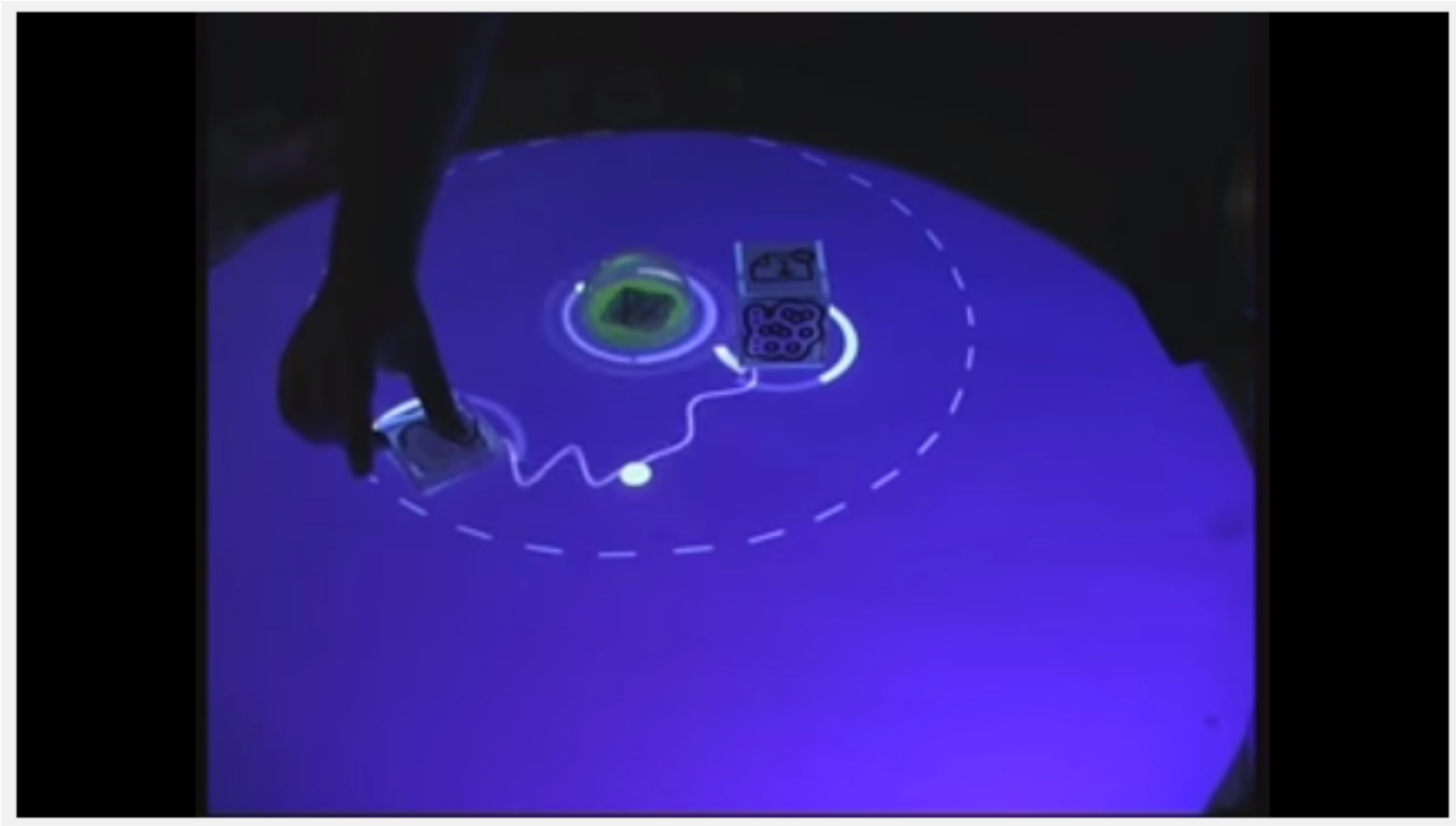
# Osmo

https://www.youtube.com/watch?v=CbwIJMz9PAQ

https://www.playosmo.com

# Reactable

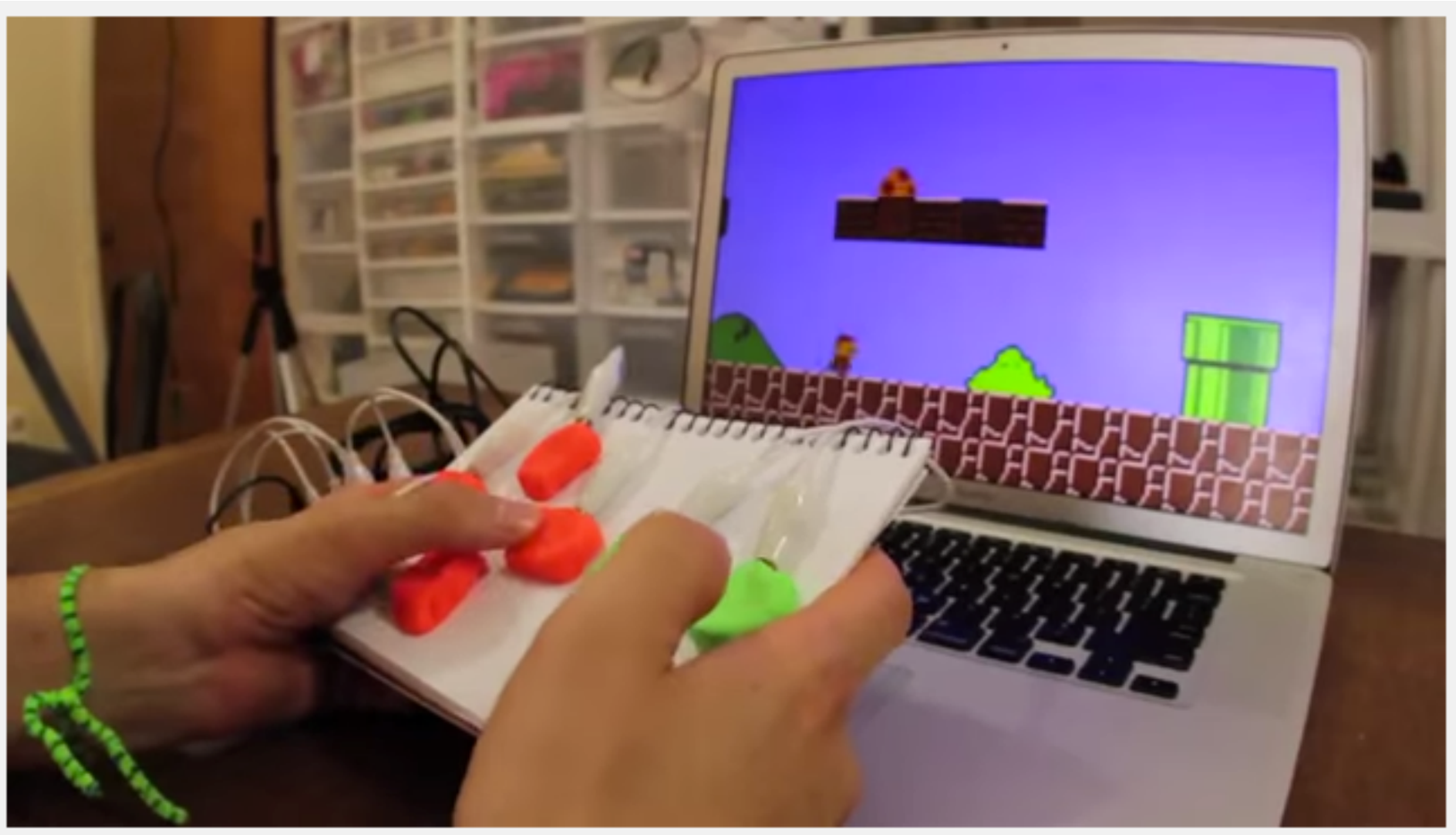
https://youtu.be/0h-RhyopUmc



Jordà, S., Geiger, G., Alonso, M., & Kaltenbrunner, M. (2007, February). The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In Proceedings of the 1st international conference on Tangible and embedded interaction (pp. 139-146). ACM.

# Makey Makey

https://youtu.be/rfQqh7iCcOU



Collective, B. S. M., & Shaw, D. (2012, February). Makey Makey: improvising tangible and nature-based user interfaces. In Proceedings of the sixth international conference on tangible, embedded and embodied interaction (pp. 367-370). ACM.

# Evaluation methods

- *Comparative studies*: quantitative empirical lab studies, heuristic evaluations, and qualitative observation studies, often based on video analysis and sometimes conducted in the field

- *Ethnographic observation and video analysis*

- Disadvantages of *trial studies* are that users might rate the system high because of its novelty, and that effects of long-term adaption and learning cannot be investigated

Shaer, O., & Hornecker, E. (2010). Tangible user interfaces: past, present, and future directions. Foundations and Trends in Human-Computer Interaction, 3(1–2), 1-137.

# Tangible Interaction with children

- How tangible interaction affect a playful experience
- There are differences
- Pro & Cons

Dynamics during game are different but most of the children preferred the augmented version

Hinske, Steve, Matthias Lampe, Nicola Yuill, Sara Price, and Marc Langheinrich. 2009. “Kingdom of the Knights: Evaluation of a Seamlessly Augmented Toy Environment for Playful Learning.” In Proceedings of the 8th International Conference on Interaction Design and Children, 202–5. ACM.

# Strenghts and Limitations

***Strenghts:***

- collaboration
- situatedness
- tangible thinking
- gesture
- support epistemic actions and thinking props
- tangible representations
- Multiple input objects (space multiplexing) and directness of interaction
- Affordances

***Weaknesses:***

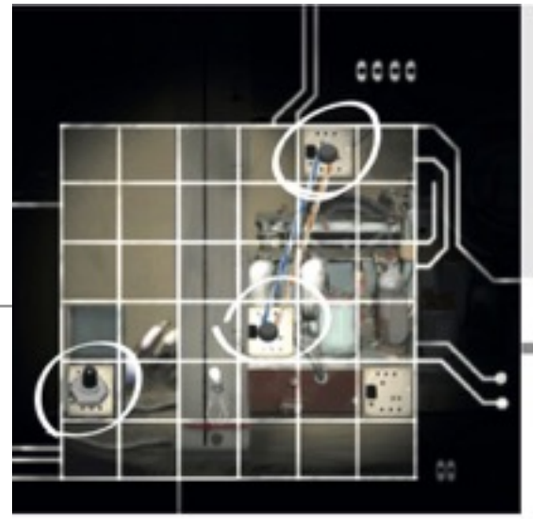
- scalability
- physical clutter
- versatility and malleability
- user fatigue

Shaer, O., & Hornecker, E. (2010). Tangible user interfaces: past, present, and future directions. Foundations and Trends in Human-Computer Interaction, 3(1–2), 1-137.

# OHR

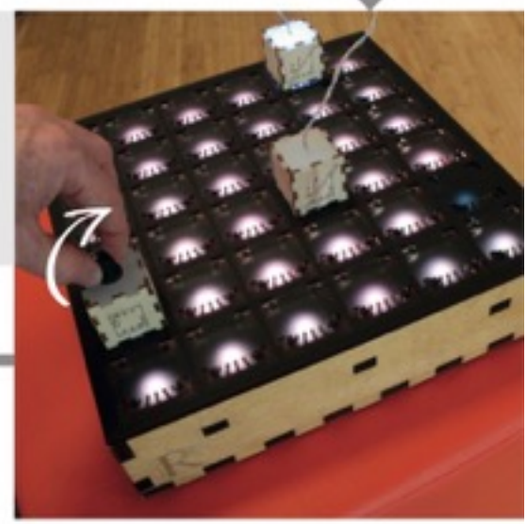
- Digital gameboard
- Tangible blocks
- Visual feedbacks
- New method of interaction with video games

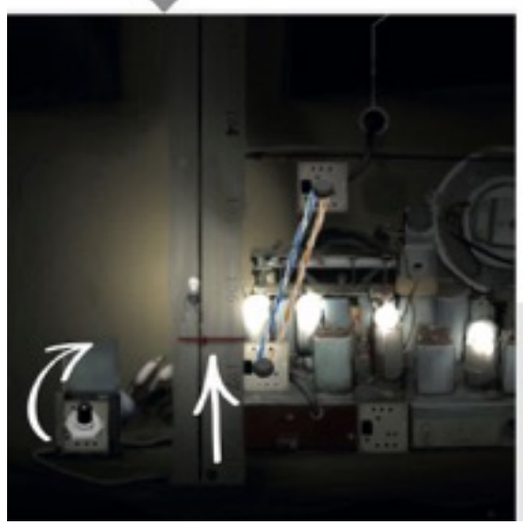
https://www.youtube.com/watch?v=0Gh0tuTHAXk



The matrix have been evoked. The Radiant Blocks have been placed on the Radiant² in legitimate cells. Their digital representations appears in game.

The matrix have been disevoked. The player interacts with the active Radiant Block (in this case turning a potentiometer) changing its value.

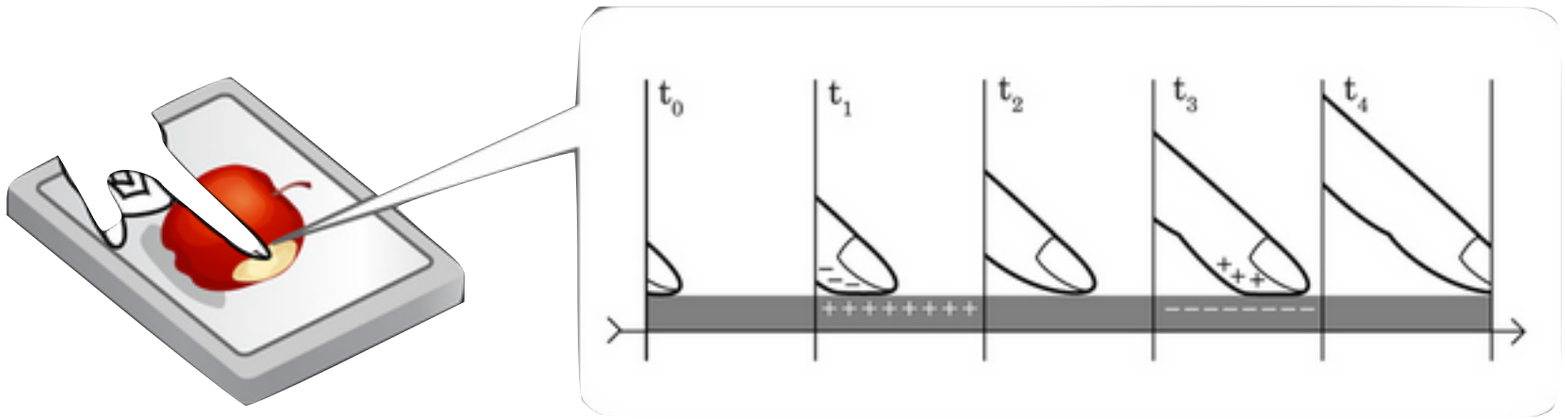




As a result the digital representation of the Radiant Block reproduces its behaviour, affecting the in-game world.

# Further thinking: Tesla Touch technologies

- Simulate tactile feedbacks on touch screens
- Using complex technology we are able to modify the friction of the screen
- Design the UX exploiting tactile sensations




https://www.youtube.com/watch?v=3I3MDNZk-3I

# Suggested readings

- Shaer, O., & Hornecker, E. (2010). Tangible user interfaces: past, present, and future directions. Foundations and Trends in Human-Computer Interaction, 3(1–2), 1-137.
- C. O'Malley and D. Stanton Fraser, "Literature review in learning with tangible technologies," NESTA futurelab report 12, Bristol, 2004.
- http://tangible.media.mit.edu/