Research investigation and exploration of TANGIBLE USER INTERFACES

Guided By: Keyur Sorathia, Asst. Prof

Apurva Gupta
10020509

Mehul Agarwal
10020525

Design Project 3

Scientific Discovery

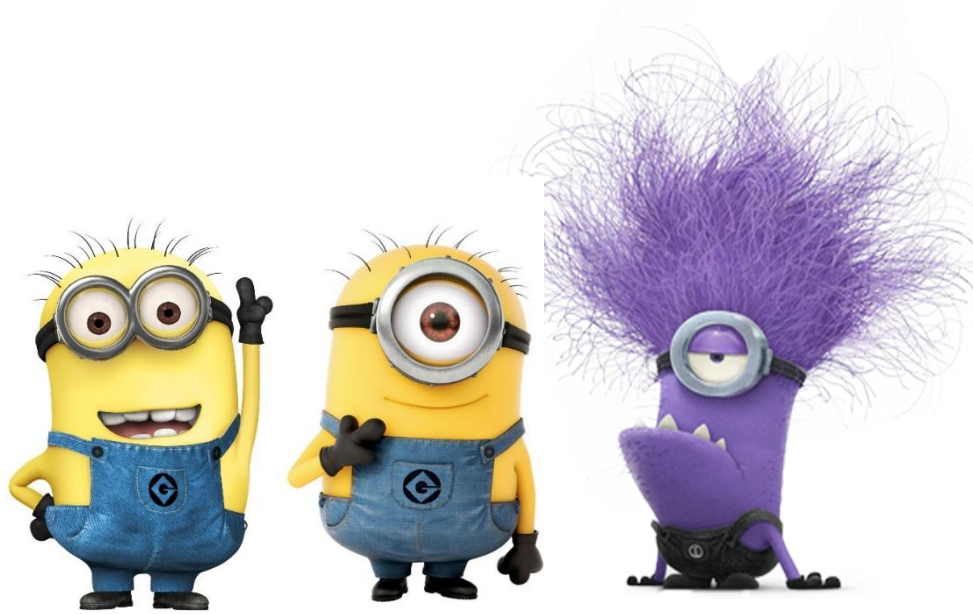
Phase 1 – Literature Survey

Adventure

Phase 2 – Analysis, Identification of research area & research question

Evil

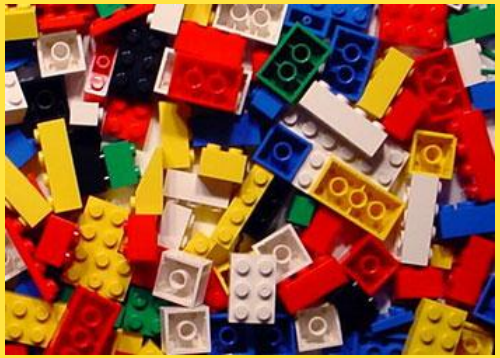
Phase 3 – Experimentation, Plan for next semester



Scientific Discovery

(Literature Research)

TANGIBLE

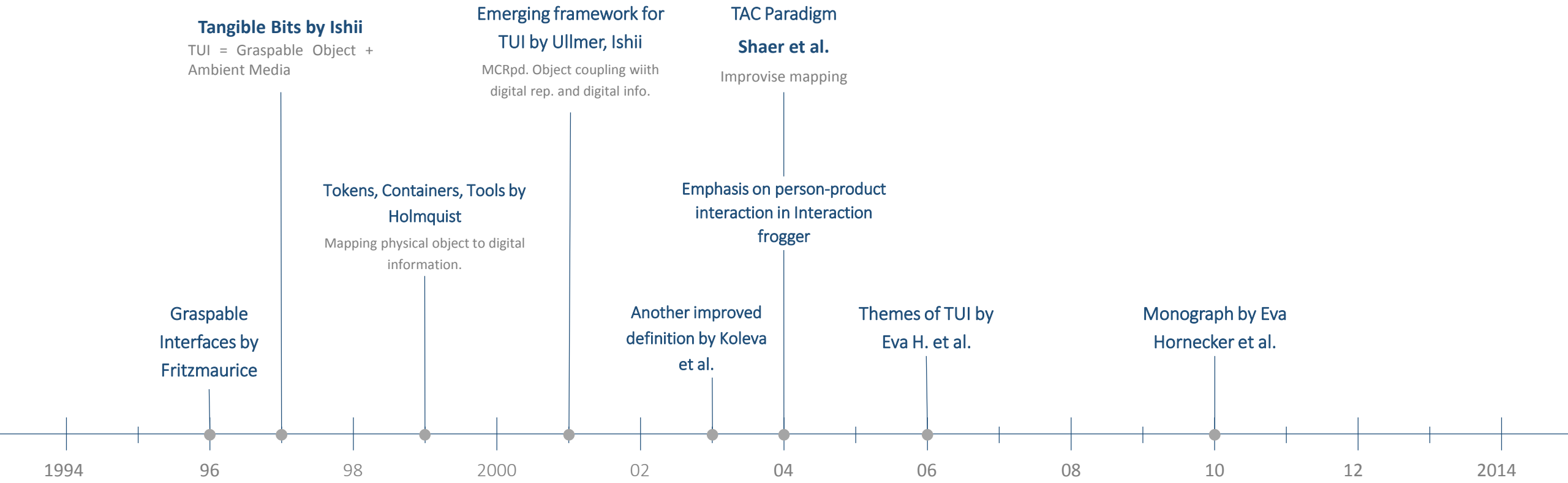


Anything and everything which we can touch and feel

"A **Tangible User Interface** gives physical form to digital information and computation, salvaging the bits from the bottom of the water, setting them afloat, and making them directly manipulable with human hands."
-by Hiroshi Ishii

The TUI timeline

past works in TUI



Classification Scheme

TUI Domain and context

Broader domain of which project is a part of and the specific context in which it is used.

Spatial, Relational or Constructive

Prototype (Evaluation and deployment)

Iconic or Symbolic and Metaphors

Method of Coupling

Static or Dynamic Binding

Input

Device and Interaction Language used for providing Input

Input Sensing Technology

Microcontroller, Camera Vision and RFID are 3 major technologies used for TUI projects.

Embodiment Axis

Embodiment Axis is relation between input and output device.

Feedback

Device, modality and type of feedback

Tangible Tools

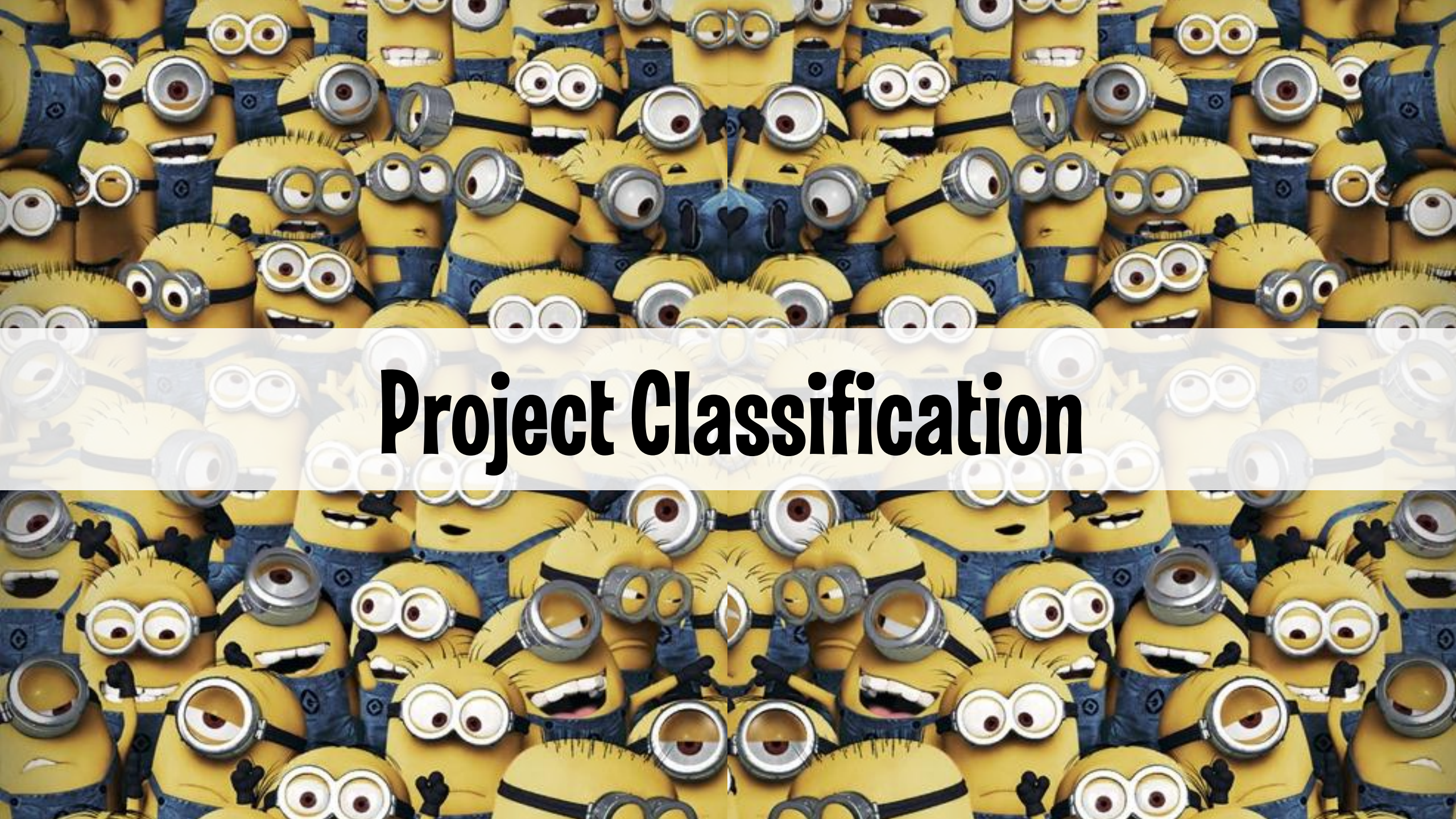
Tokens and Containers

TUI System

Direct-Manipulation, Behavioral Specifications or Communication Channels

Output

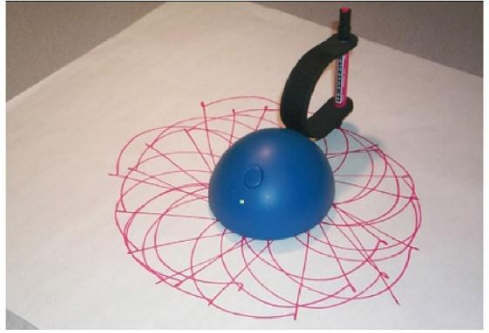
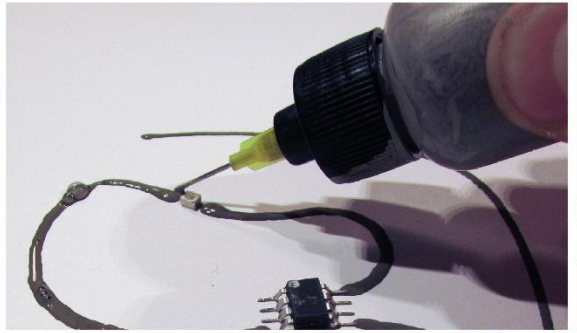
Device and modality used for providing output



Project Classification

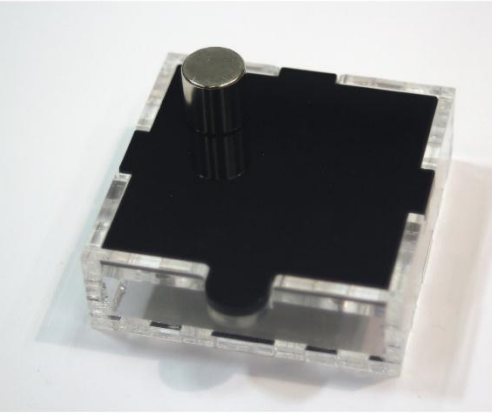


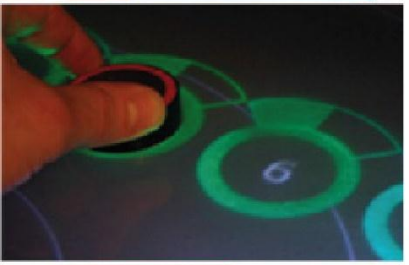
Text Only
Speech Only
TextSpeech

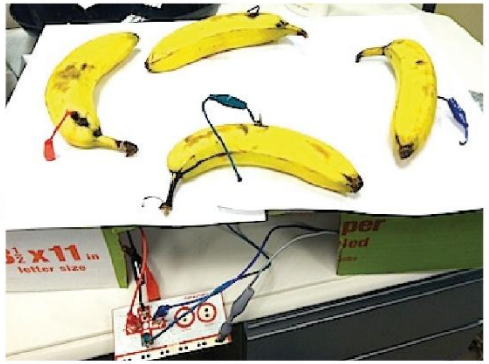
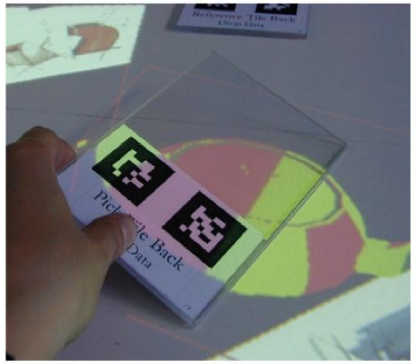
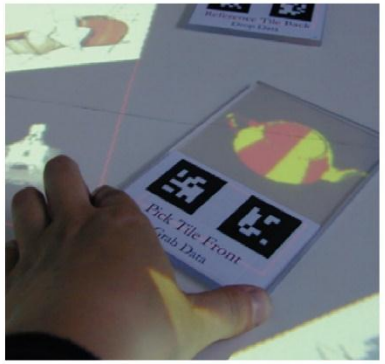



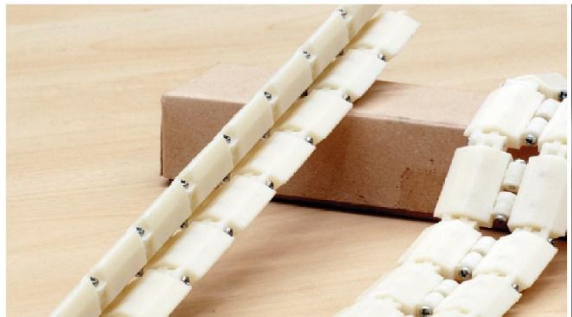


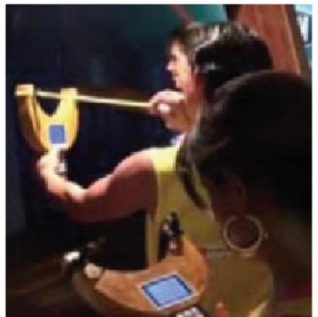








8½ x 11 in
letter size

Pick Tile Back
Grab Data

Pick Tile Front
Grab Data



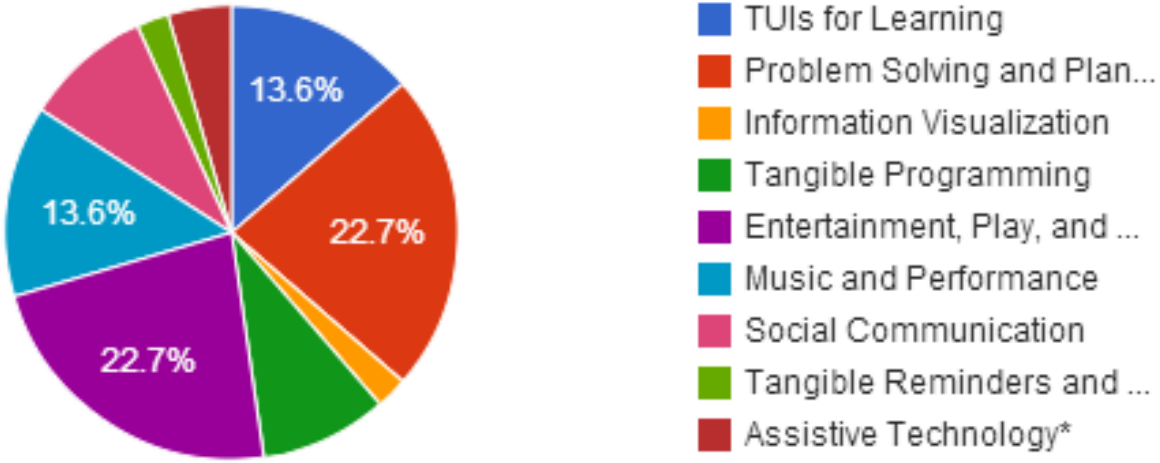



Adventure

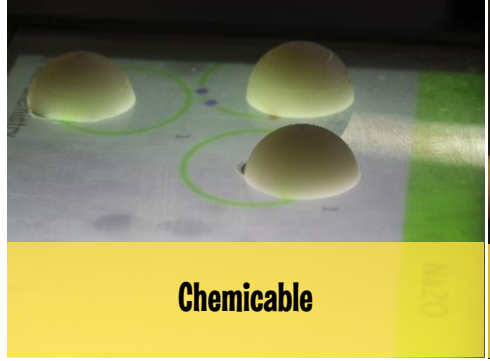
(Critical Analysis)

Analysis

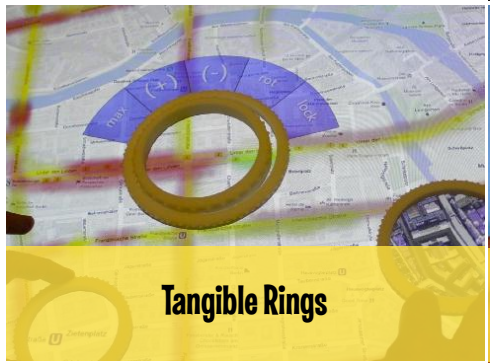
Application Domain



TUIs have been mostly used in field of Entertainment, Play and Edutainment and Problem Solving and Planning


Chemicable


Dirty Tangible Interfaces


Tangible Rings

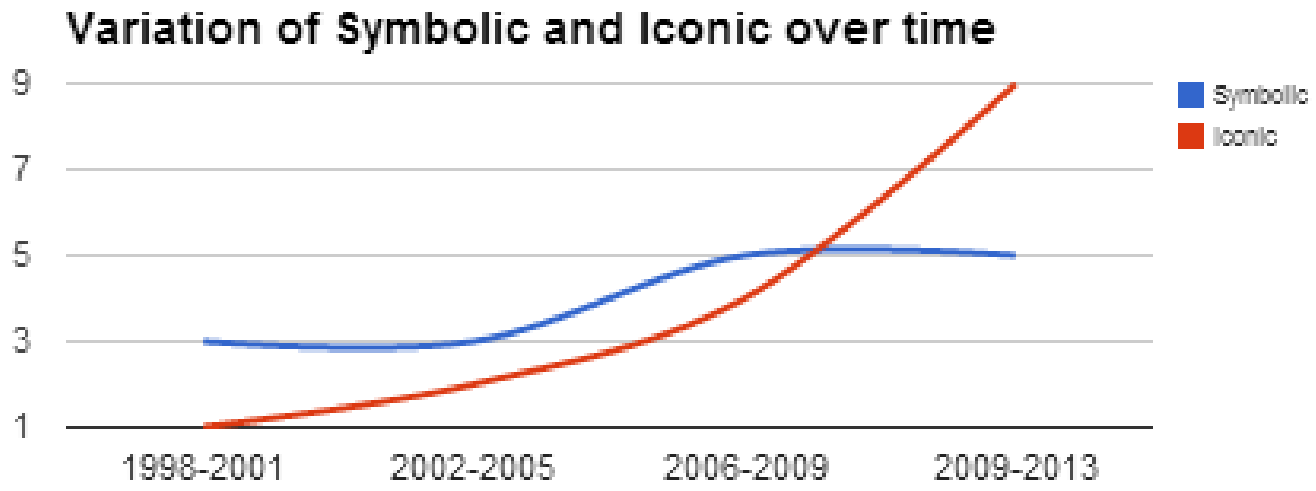
Tern


Slingshot

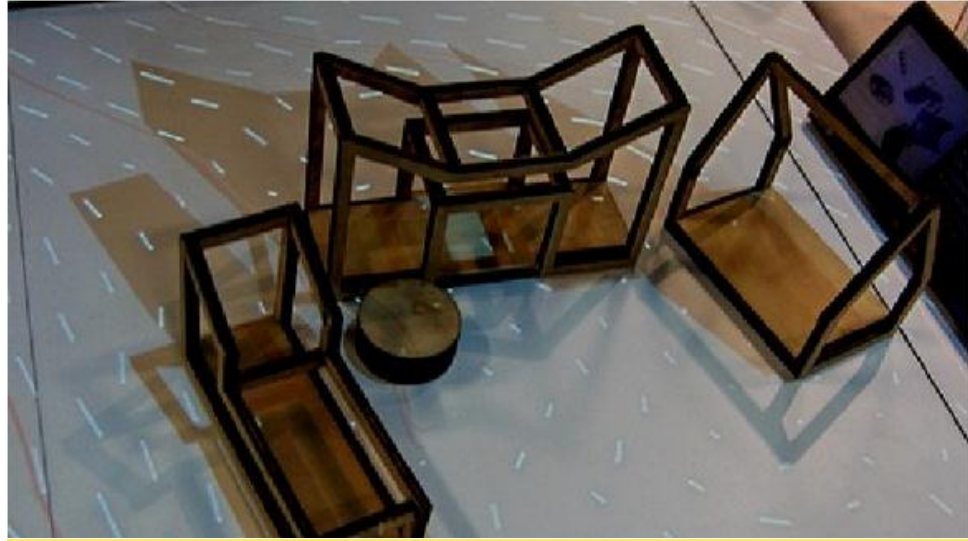

Music Mixing Interface


LumiTouch

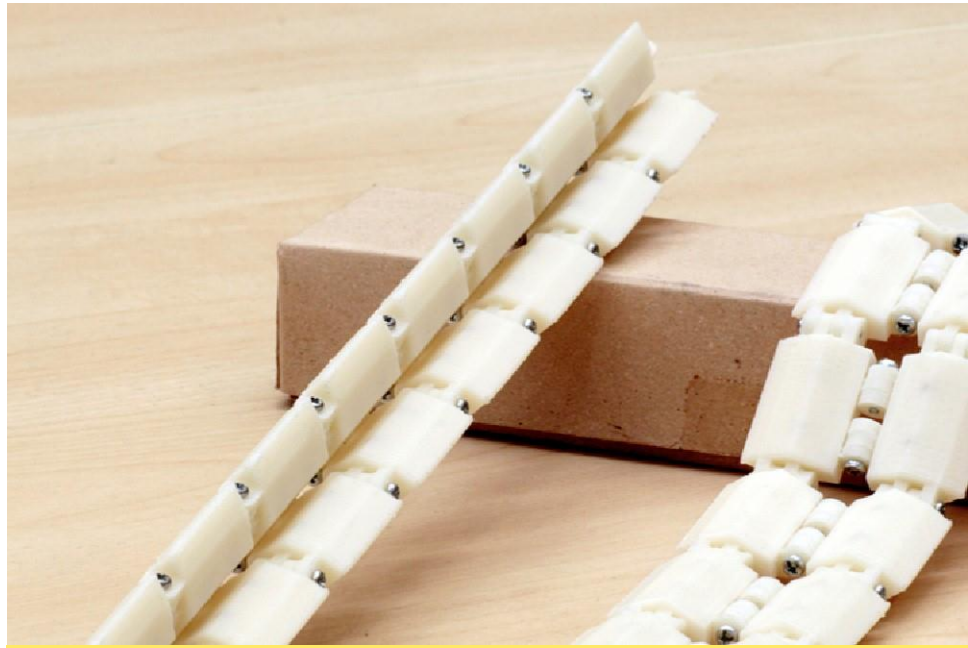

Tangible Tiles



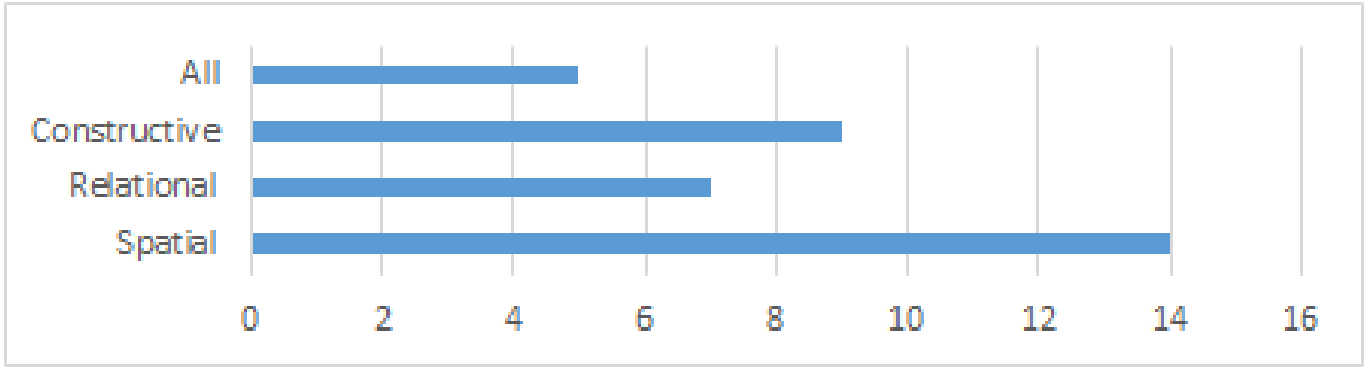
Iconic representation is increasing in projects and whereas use of Symbolic representation is more or less constant.



Urp (Iconic)



Ninja Tracks (Symbolic)

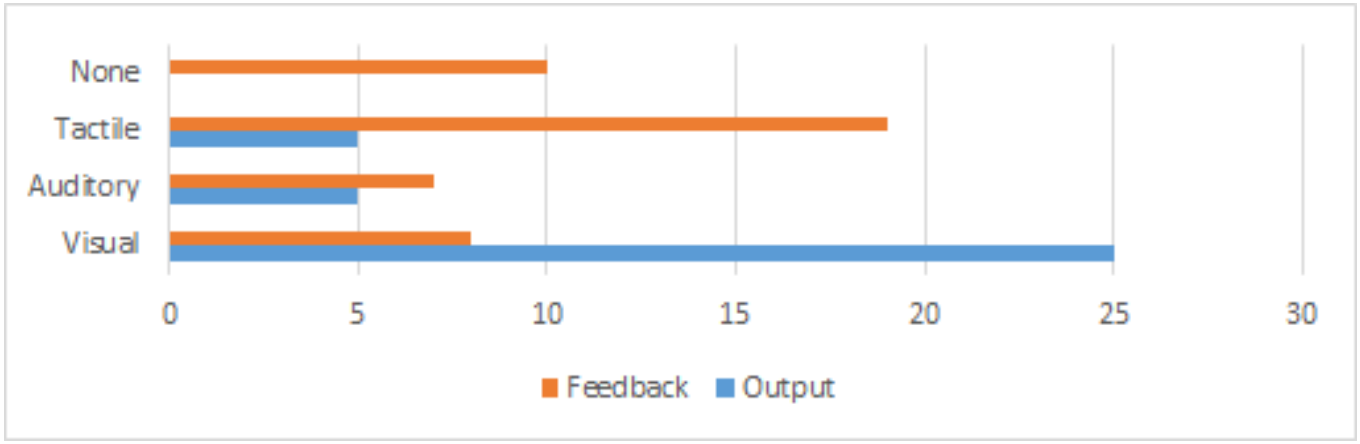


Spatial properties are explored in many projects. This can be also due to spatial advantage of TUIs over GUI. But there are very few projects that use all the three (Spatial, Relational and Cognitive) capabilities of TUIs.

Tangible Rings (Spatial)

Siftables (Relational)

Tangible Triangles (Constructive)

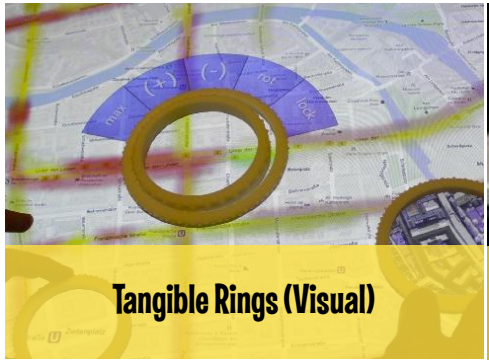


Visual is more preferred medium for Output whereas tactile is preferred more for feedback.

Almost 25% of projects read did not have any kind of feedback.

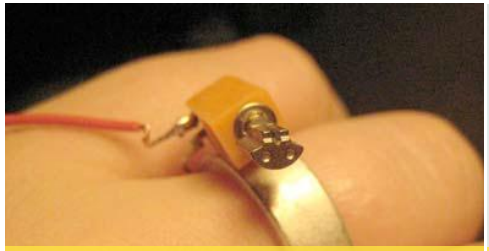
Smell and taste were not chosen as feedback or output modality in any of the papers read.

Slurp (Audio + Visual + Tactile)

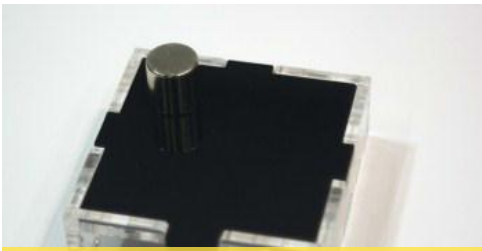


Tangible Rings (Visual)

Music Cubes (Audio)



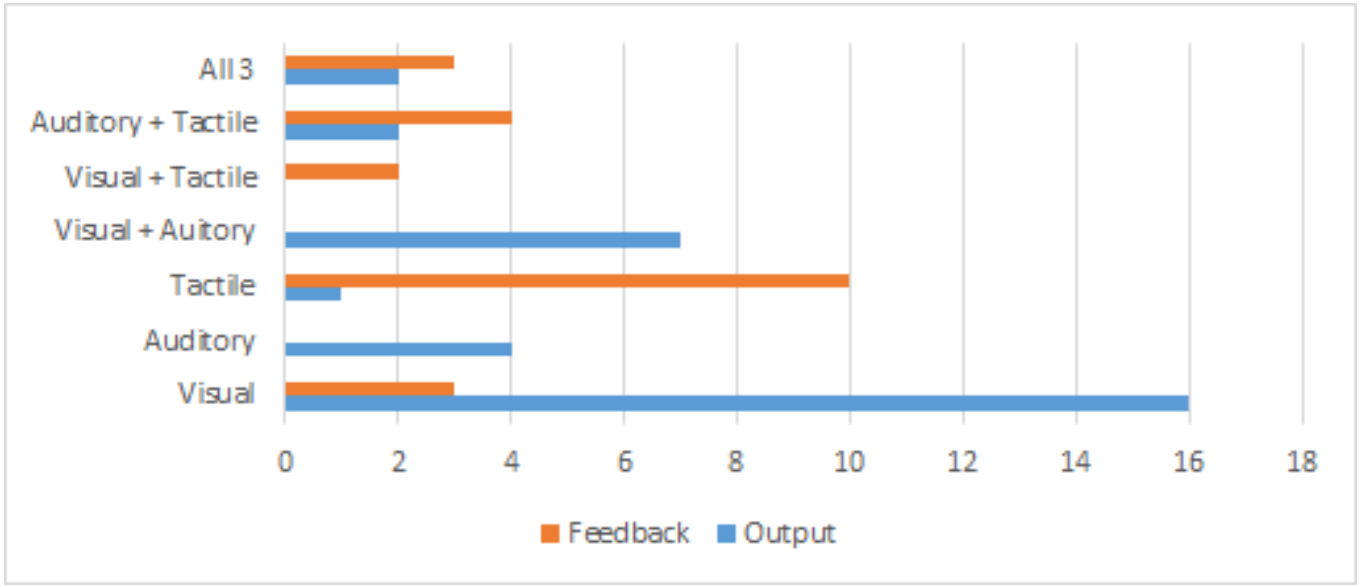
UnitedPulse (Tactile)



Haptic Cues (Audio + Tactile)

CurlyBot (Visual + Tactile)

Music Mixing (Visual + Audio)



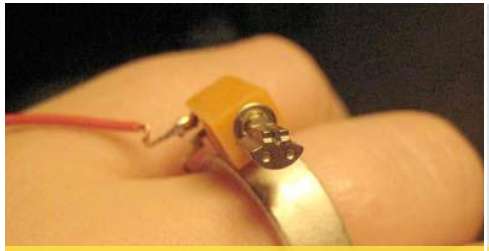
Output- Visual followed by equal preference of auditory and tactile. Feedback- Tactile, Visual and then auditory.

Combination of Visual + Auditory was preferred for Output while combination of Tactile + Auditory was preferred for feedback.

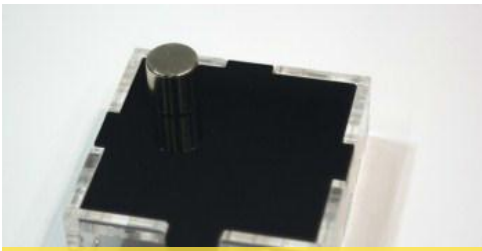
Slurp (Audio + Visual + Tactile)

Tangible Rings (Visual)

Music Cubes (Audio)



UnitedPulse (Tactile)



Haptic Cues (Audio + Tactile)

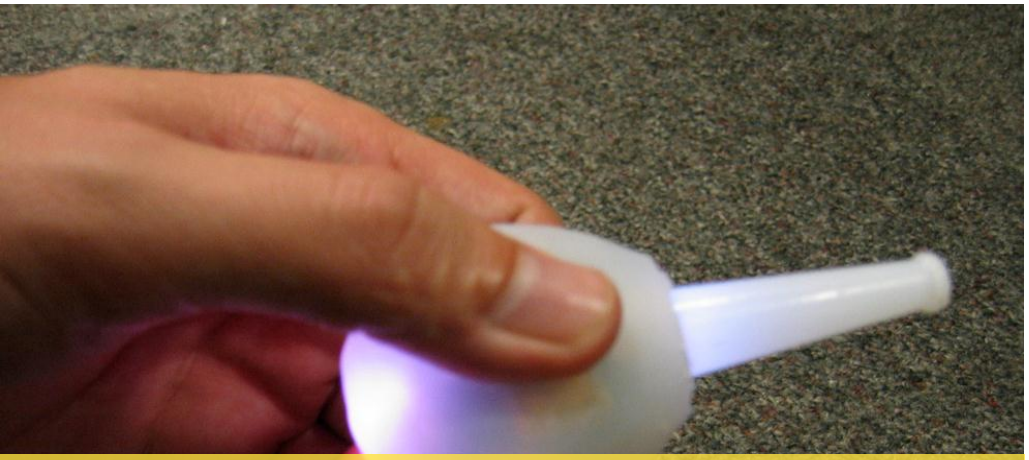
CurlyBot (Visual + Tactile)

Music Mixing (Visual + Audio)

Research Areas

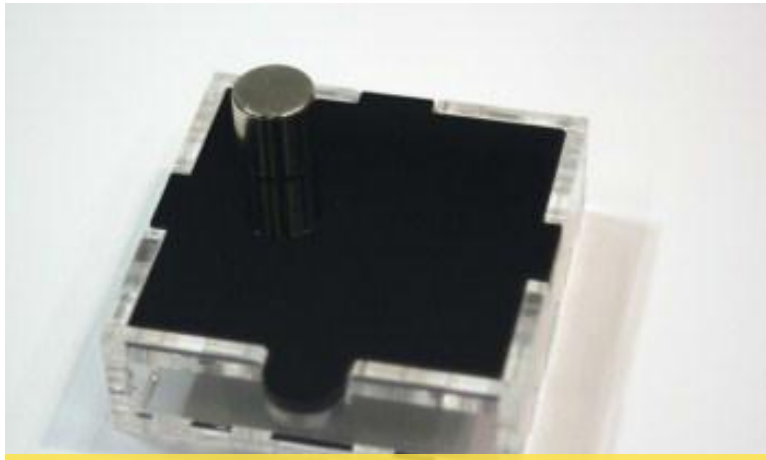
Feedback modalities in TUI system

- When/what kind of feedback is appropriate to use in a TUI?
- Its dependence on: Context, users, collaborative nature of the system/task, individual interaction, etc.



Slurp (Audio + Visual + Tactile)

Tangible Rings (Visual)

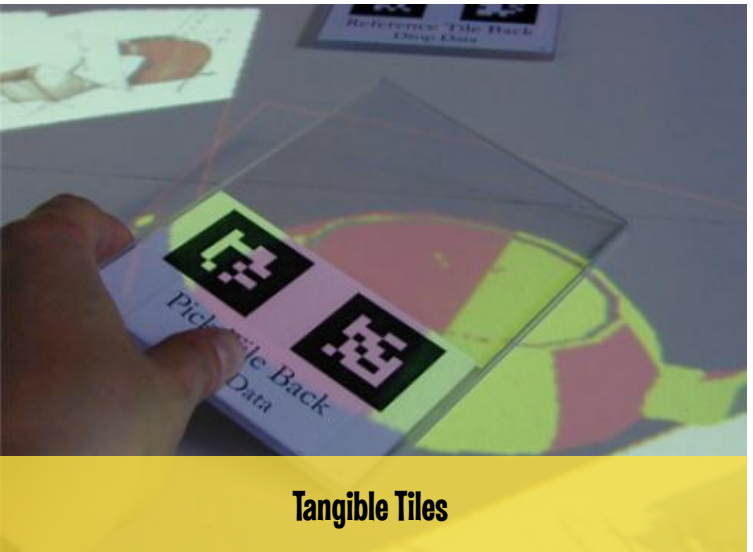


Haptic Cues (Audio + Tactile)

Relation between no. of task and TUI handle (tool)

- Multiple handles for one task
- One handle for multiple tasks (similar to mouse)
- One handle for one task i.e. Custom handles/Specialized handle

In case of multiple tangibles for one task, how does user defined actions affect the usability of the TUI system. *Does it make the system easy to use or does it result in a cognitive overload?*



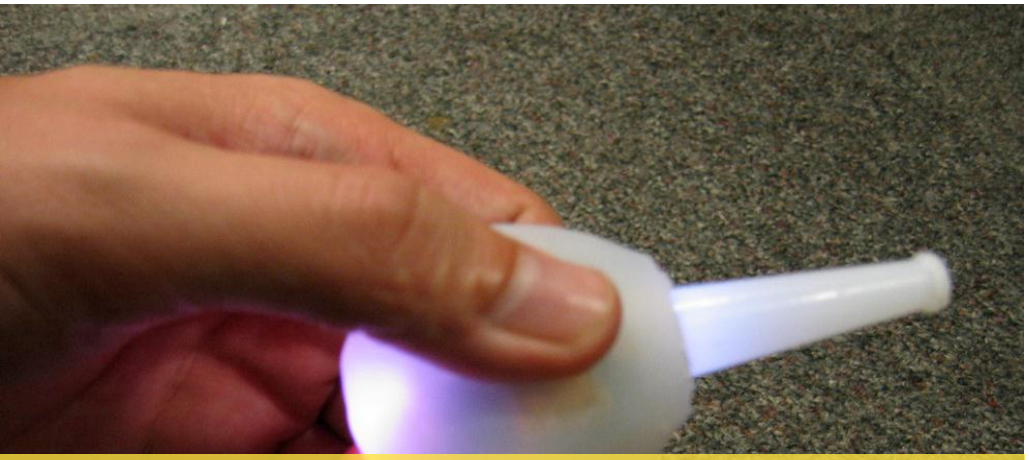
Tangible Tiles

Ninja Tracks

Urp

Impact and importance of gestures in Tangible Interfaces.

Combining theories of gestural interfaces and tangible interfaces and studying the impact and extent of gestures in tangible interfaces.



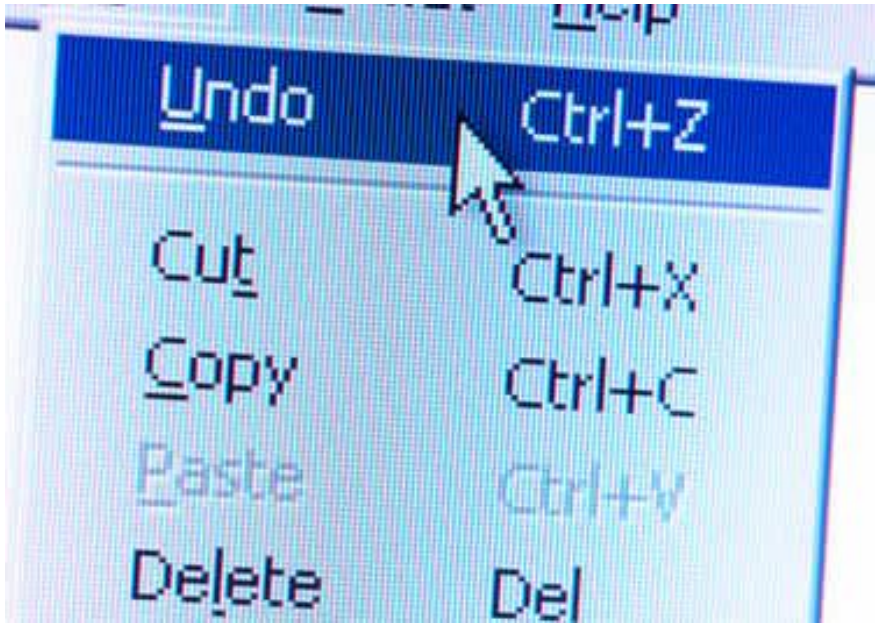
Slurp (Eyedropper Gesture)

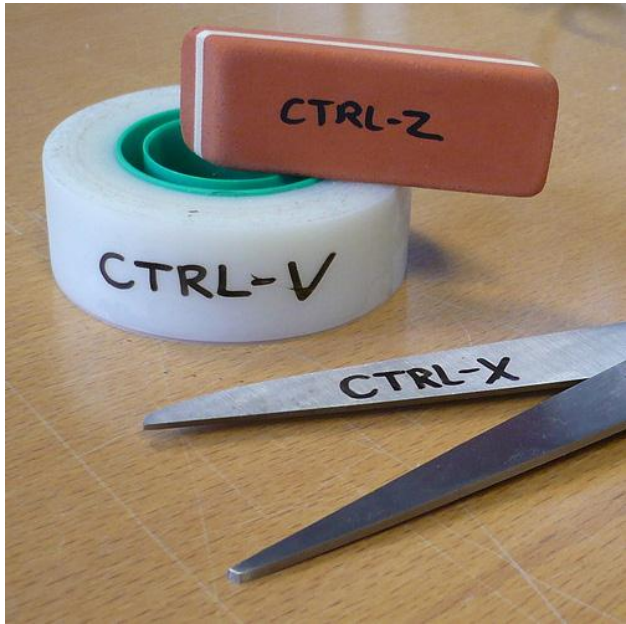
Tangible Rings (Lens Gesture)

Music Cubes (Shake Gesture)

GUI specific task (Copy-Paste or Undo) for Tangible Interfaces

Understand acceptance of critical (core GUI) tasks of GUIs (e.g. ctrl v) in TUIs and its affects on user's perception when interacting with the system.





Accessibility studies about population prefers tangible and if the usage is governed by: Gender, Age, Urban/ rural, Healthy/ disabled or Acceptance of the defined actions/gestures for the system. ***Does the system needs modification to cater to different people?***

Relation between affordances and knowledge of the user.

- How does this knowledge change/depend on context, geographical location, social structure and interactions of the user?
- How does the acceptance of the TUI change if an object is introduced in the system of which the user does not know about?
- How does acceptance of such a system depend on the context/location/social structure of the user.

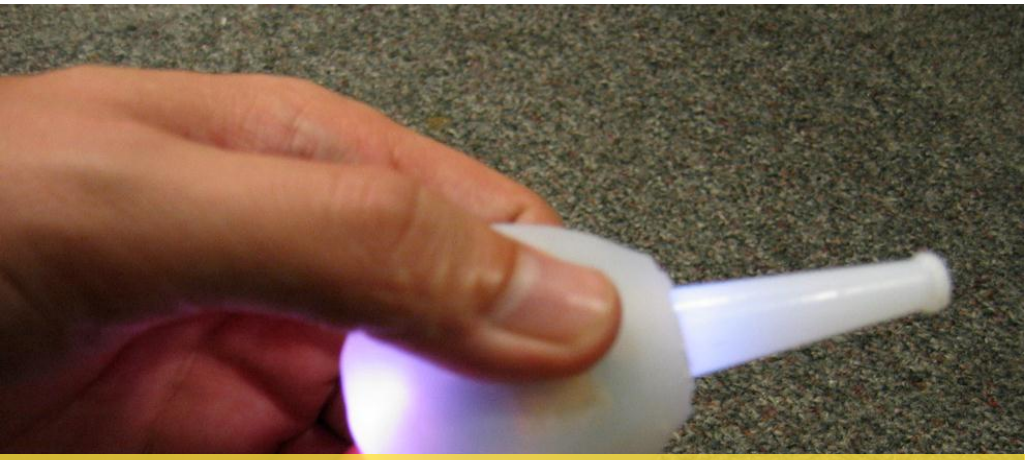
How the TUI system differ for novice user or experienced user?
Can the same system perform easy to complex tasks or do we need to make modifications based on the level of experience of the user.

Comparing TUI and GUI on following parameters:
Computational, Work load, Task Complexity, Ergonomics, Entry threshold for the system, Contexts, Technological literacy of the user (as defined by innovation adoption curve) For above mentioned
Is TUI better than GUI, or a hybrid solution makes a better option?

Input and output of a system could be co-located and coincident or spaced differently in time and space. Study could be undertaken to understand ***how does concurrence of input/output space affects users perception, experience etc.***

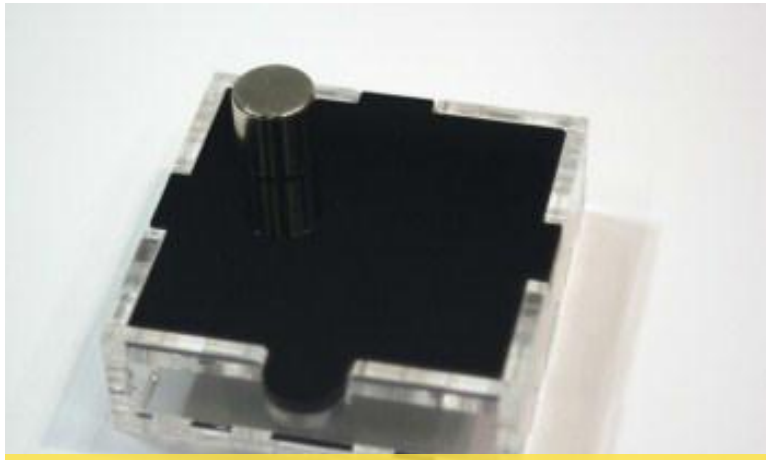
Feedback modalities in TUI system

- When/what kind of feedback is appropriate to use in a TUI?
- Its dependence on: Context, users, collaborative nature of the system/task, individual interaction, etc.



Slurp (Audio + Visual + Tactile)

Tangible Rings (Visual)



Haptic Cues (Audio + Tactile)

Feedback and Output Modalities

Visual is more preferred medium for Output whereas tactile is preferred more for feedback.

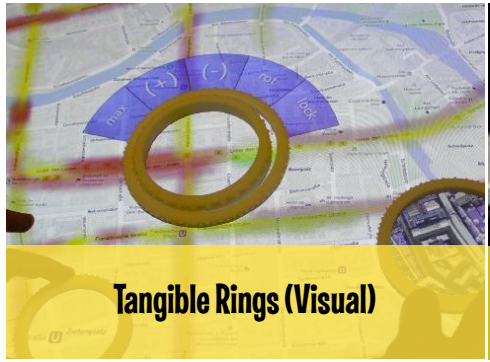
Almost 25% of projects read did not have any kind of feedback.

Smell and taste were not chosen as feedback or output modality in any of the papers read.

Output- Visual followed by equal preference of auditory and tactile. Feedback- Tactile, Visual and then auditory.

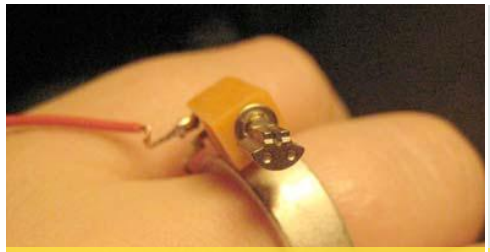
Combination of Visual + Auditory was preferred for Output while combination of Tactile + Auditory was preferred for feedback.

Slurp (Audio + Visual + Tactile)

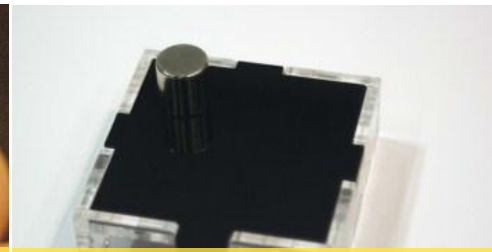


Tangible Rings (Visual)

Music Cubes (Audio)



UnitedPulse (Tactile)



Haptic Cues (Audio + Tactile)

CurlyBot (Visual + Tactile)

Music Mixing (Visual + Audio)

Statement From Research Papers

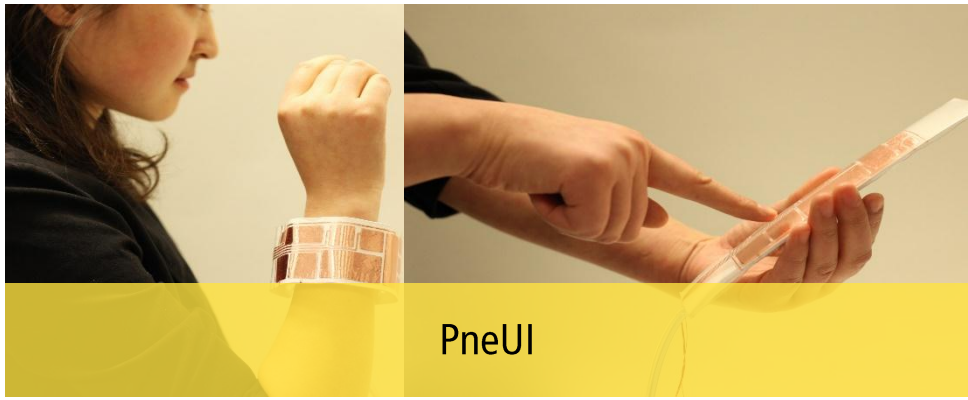
- Previous personal experience played a key factor in their reaction to interruption modalities.
- As the context changes, so should the feedback modality.
- Feedback did not affect overall performance or error rates but gave participants assurance in their interactions.
- The feedback is a natural consequence of the action and it matters how it is conveyed.
- Psychophysical data indicate that interaction between modalities is the rule as opposed to the exception in brain function.
- The modality that carries a signal which is more discontinuous (and hence more salient) becomes the influential or modulating modality.
- The strong effect of visual signals on the other modalities, consistent with the commonsense notion that human is primarily a vision dominated animal.
- Modality appropriateness hypothesis: modality that is most appropriate or reliable with respect to a given task is the modality that dominates the perception in the context of that task. Vision has a higher spatial resolution, hence its dominance in spatial tasks, whereas audition has a higher temporal resolution, hence its dominance in temporal tasks.
- Users can switch between modalities and reach 100% recognition rates after 2 days of regular use.

Using Data obtained from analysis of projects and Points from the theoretical papers

Effectiveness of materiality as feedback modality over tactile, audio, etc.

Inherent Feedback v/s Augmented Feedback- How does user performance change?

Importance of Feedback for first time user v/s experienced user?


PneUI


Slingshot


Music Cubes


Reactable


Music Mixing (Advanced User)

Examples of Material Feedback

Checking if the rice is cooked

Toothpaste

Fresh Fruit

Coconut

Piggy Bank

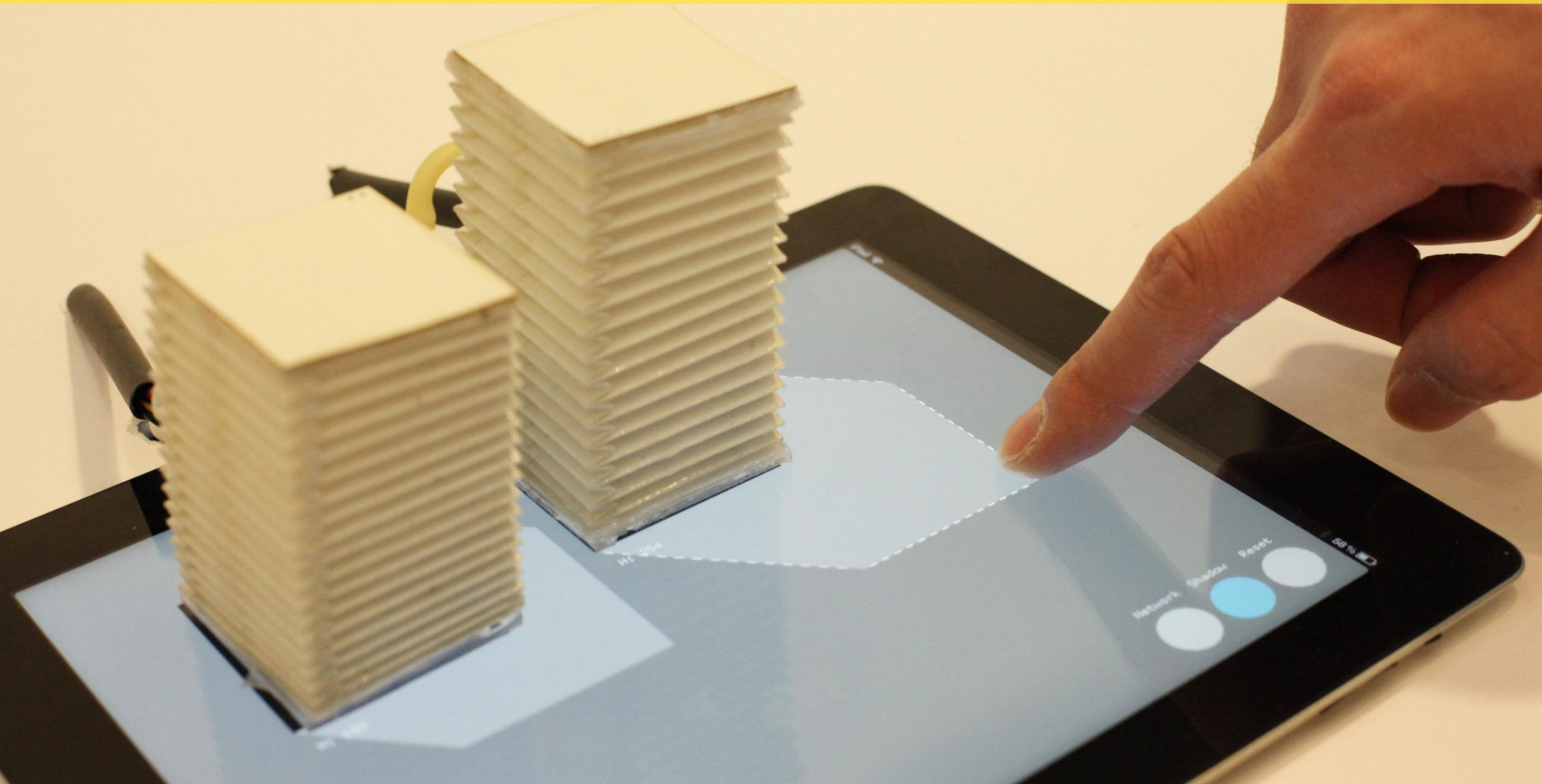
Batman's Cape

Current Research in Material modality

InForm

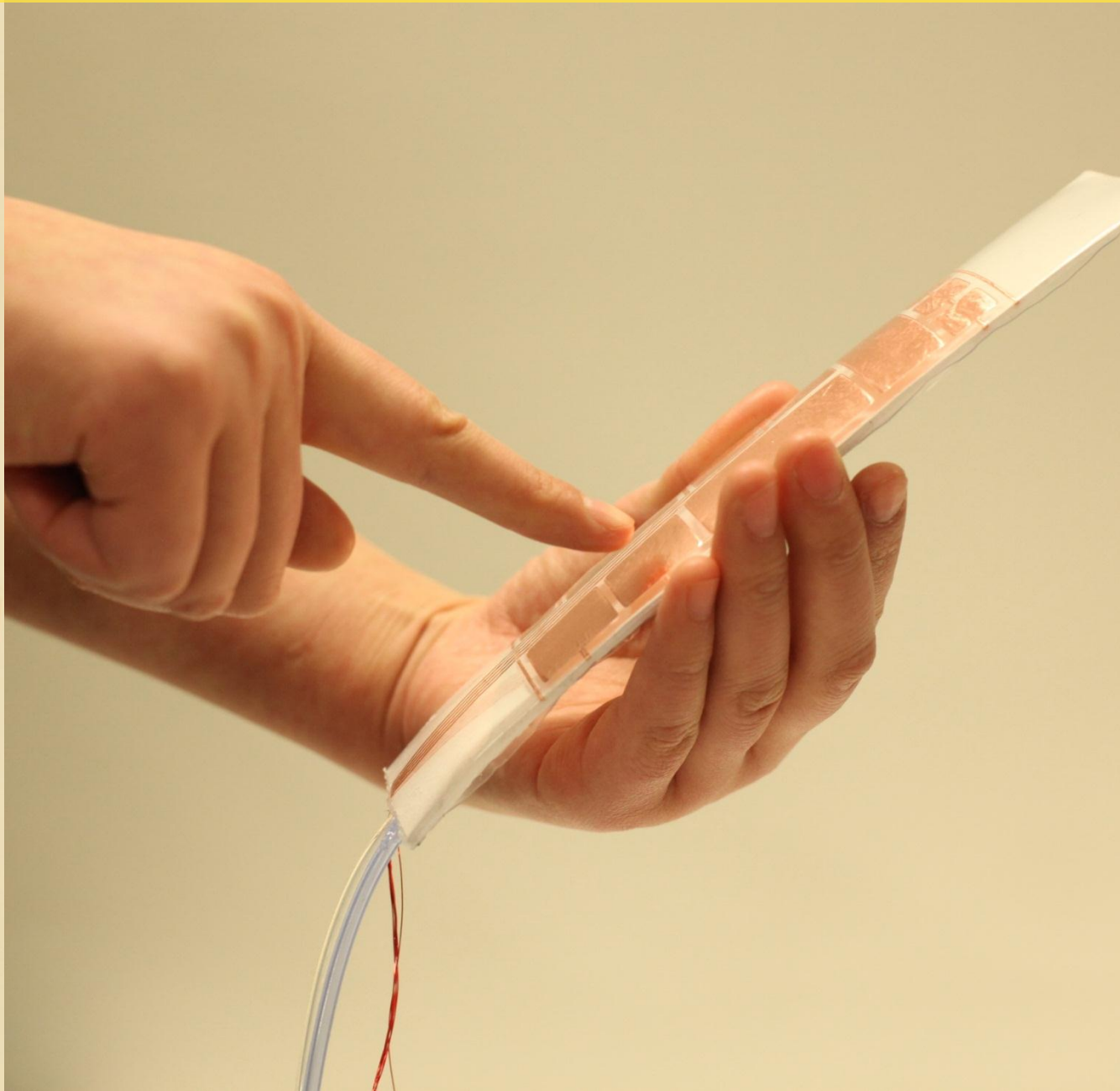
Invisible Helmet

PneUI



PneUI

PneUI



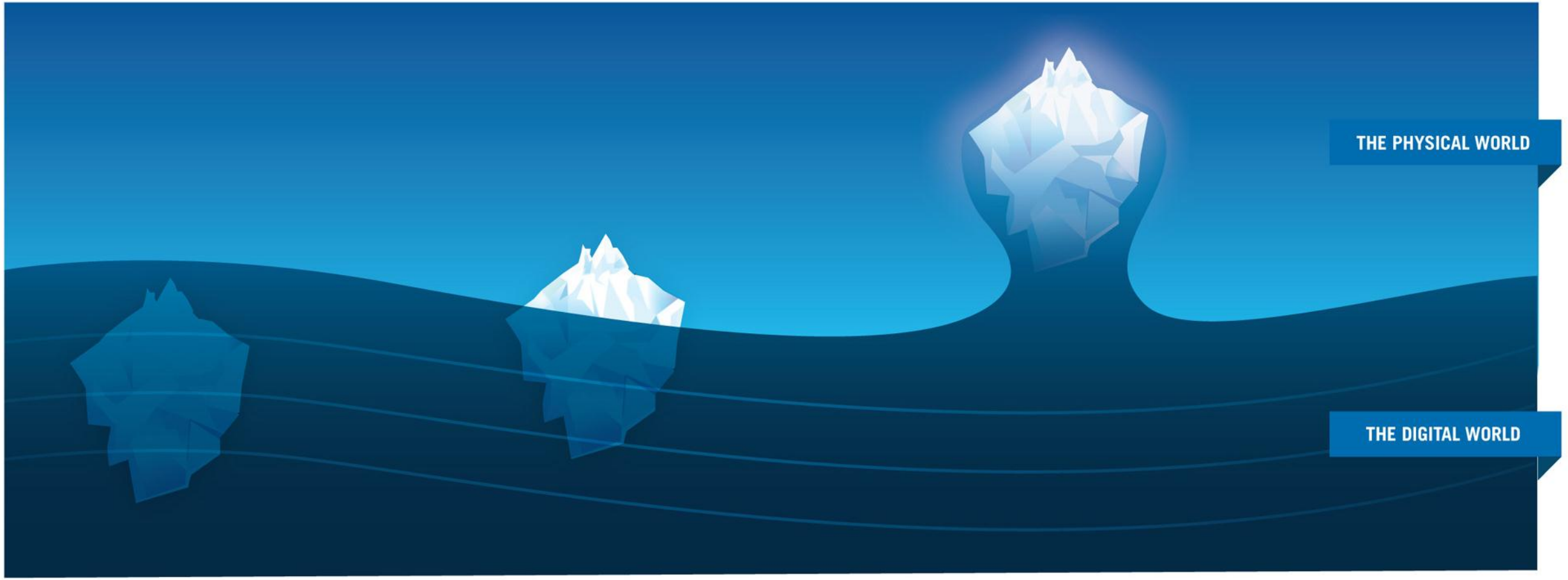
Jamming User Interface (Transparent Haptic Lens)

Radical Atoms

GUI PAINTED BITS

TUI TANGIBLE BITS

RADICAL ATOMS

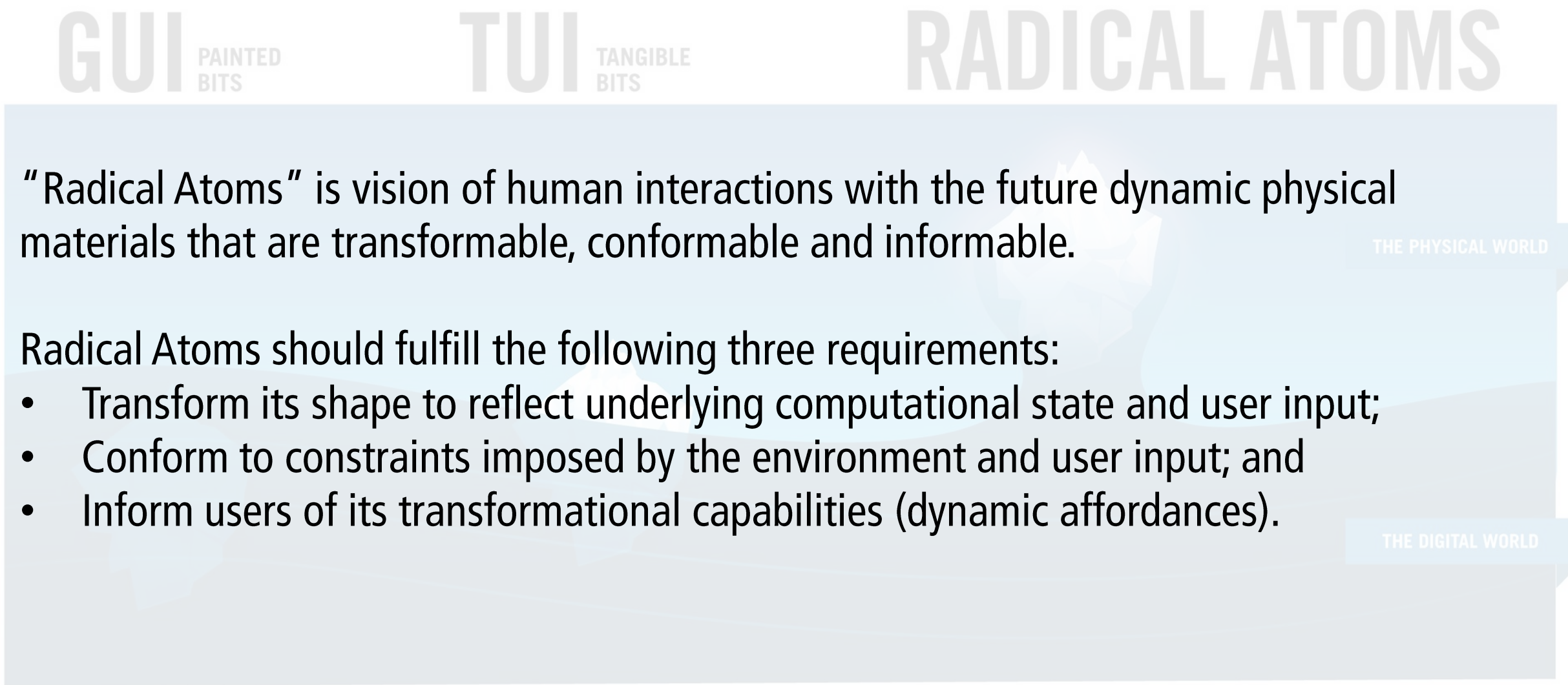


A Graphical User Interfaces only let users see digital information through a screen, as if looking through a surface of the water. We interact with the forms below through remote controls such as a mouse, a keyboard or a touch screen.

A Tangible User Interface is like an iceberg: there is a portion of the digital that emerges beyond the surface of the water - into the physical realm - that acts as physical manifestations of computation, allowing us to directly interact with the 'tip of the iceberg.'

Radical Atoms is our vision for the future of interaction with hypothetical dynamic materials, in which all digital information has physical manifestation so that we can interact directly with it - as if the iceberg had risen from the depths to reveal its sunken mass.

Radical Atoms



"Radical Atoms" is vision of human interactions with the future dynamic physical materials that are transformable, conformable and informable.

Radical Atoms should fulfill the following three requirements:

- Transform its shape to reflect underlying computational state and user input;
- Conform to constraints imposed by the environment and user input; and
- Inform users of its transformational capabilities (dynamic affordances).

A Graphical User Interfaces only let users see digital information through a screen, as if looking through a surface of the water. We interact with the forms below through remote controls such as a mouse, a keyboard or a touch screen.

A Tangible User Interface is like an iceberg: there is a portion of the digital that emerges beyond the surface of the water - into the physical realm - that acts as physical manifestations of computation, allowing us to directly interact with the 'tip of the iceberg.'

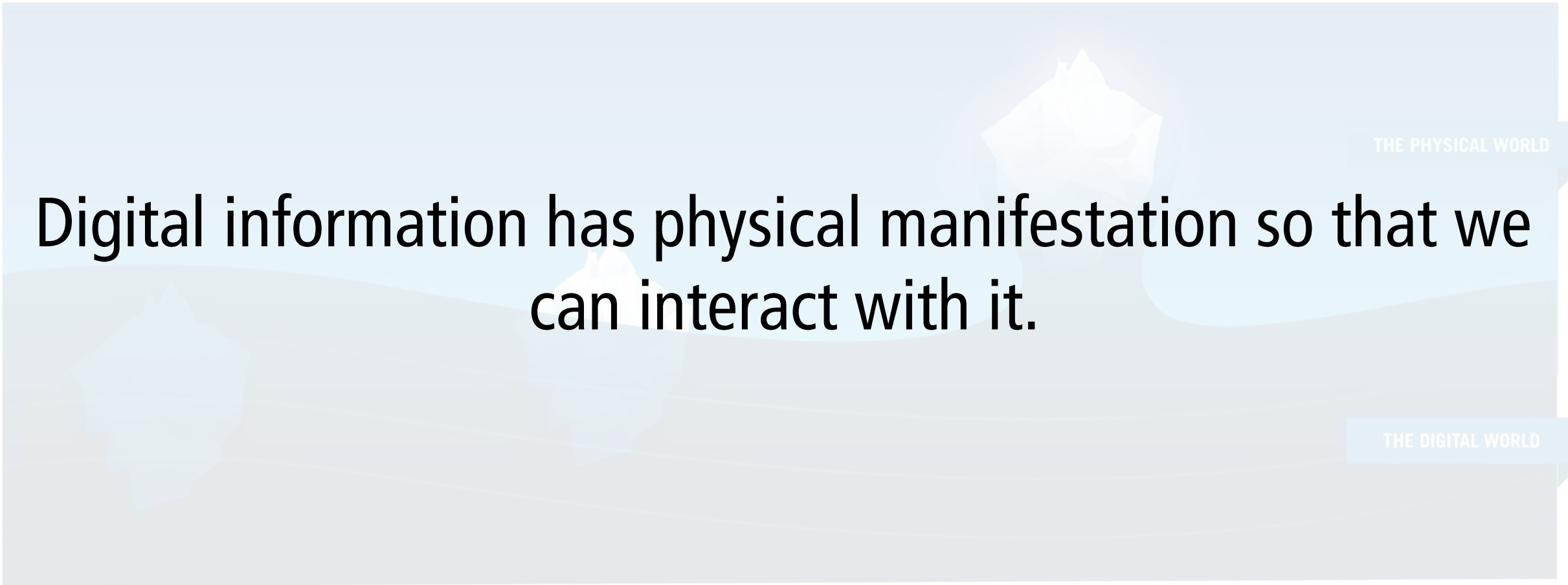
Radical Atoms is our vision for the future of interaction with hypothetical dynamic materials, in which all digital information has physical manifestation so that we can interact directly with it - as if the iceberg had risen from the depths to reveal its sunken mass.

Radical Atoms

GUI PAINTED BITS

TUI TANGIBLE BITS

RADICAL ATOMS



Digital information has physical manifestation so that we can interact with it.

A Graphical User Interfaces only let users see digital information through a screen, as if looking through a surface of the water. We interact with the forms below through remote controls such as a mouse, a keyboard or a touch screen.

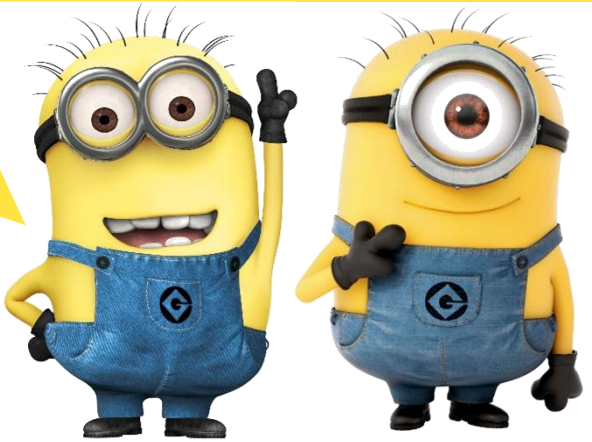
A Tangible User Interface is like an iceberg: there is a portion of the digital that emerges beyond the surface of the water - into the physical realm - that acts as physical manifestations of computation, allowing us to directly interact with the 'tip of the iceberg.'

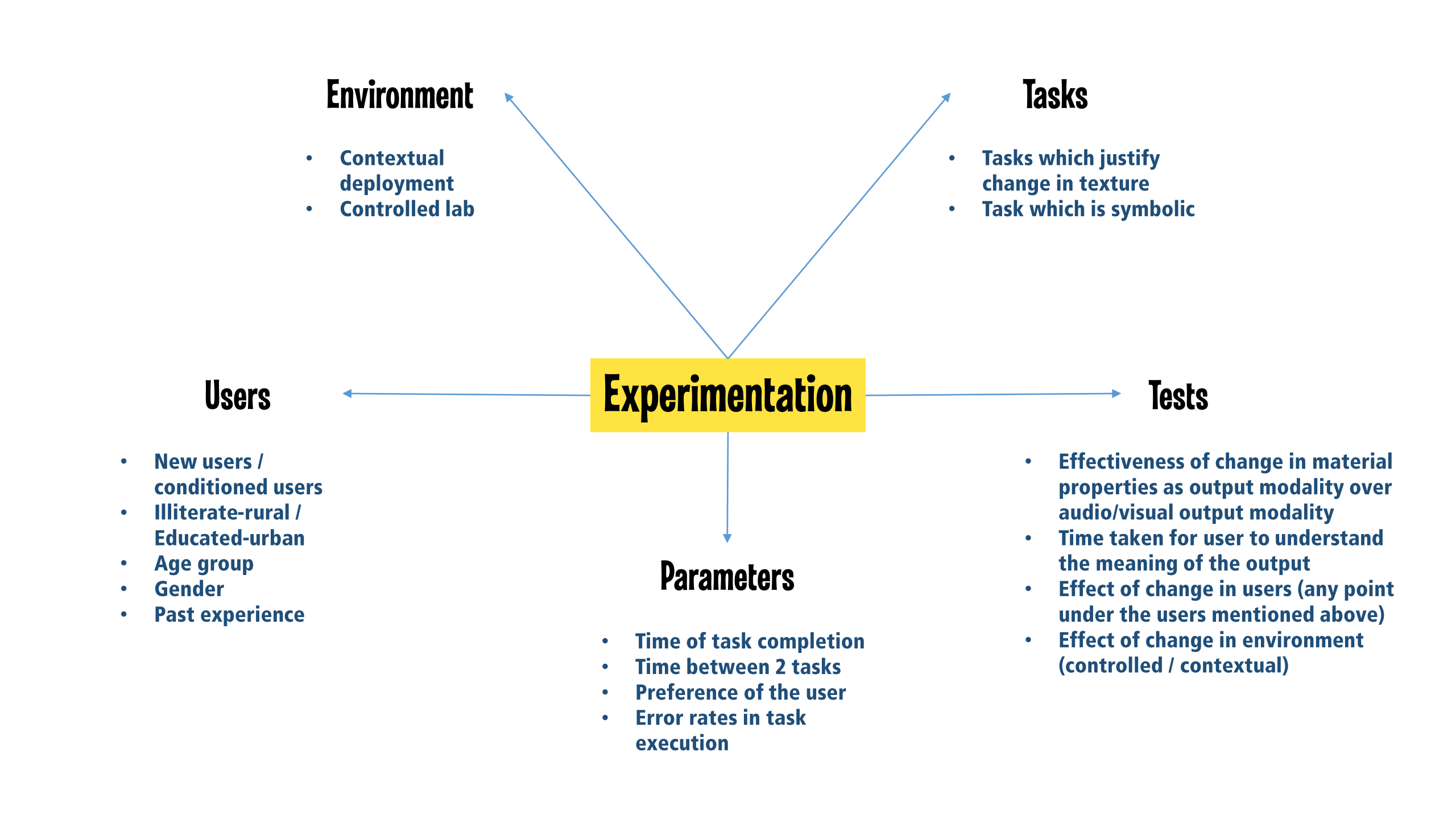
Radical Atoms is our vision for the future of interaction with hypothetical dynamic materials, in which all digital information has physical manifestation so that we can interact directly with it - as if the iceberg had risen from the depths to reveal its sunken mass.

Evil

(Experimentation)

Hypothesis and Experimentation



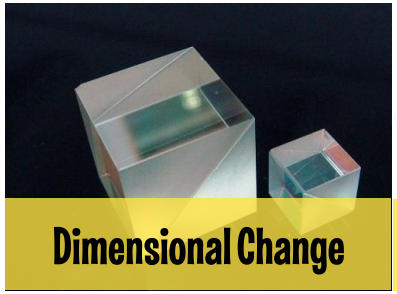

Environment
Contextual deployment
Controlled lab
Tasks
Tasks which justify change in texture
Task which is symbolic
Experimentation
Users
New users / conditioned users
Illiterate-rural / Educated-urban
Age group
Gender
Past experience
Tests
Effectiveness of change in material properties as output modality over audio/visual output modality
Time taken for user to understand the meaning of the output
Effect of change in users (any point under the users mentioned above)
Effect of change in environment (controlled / contextual)
Parameters
Time of task completion
Time between 2 tasks
Preference of the user
Error rates in task execution

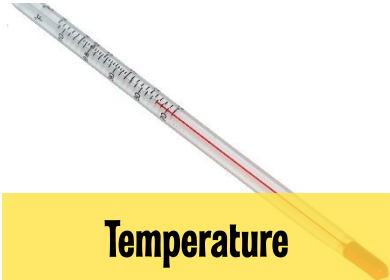
Material Properties

Color
Rigidity (If the object is stiff or soft)
Sound of object (wood and steel differ in sound)
Texture
Shape

- Dimensional (changing length/breadth/height)
- Organic (cube ---> amoeba-like shape)

Smell of the object
Weight
State (Liquid/solid/gas)
Temperature





Aim of the Experiment:

1. Investigation of (feedback) influence on overall performance on
    - Task completion time
    - Error Rates
    - Satisfaction
2. Understanding how well the user understands the task
    - Task completion time
3. User preference of feedback modalities

Mode of the Experiment: 5 point Likert Scale

Ho: Feedback has no influence on overall performance with respect to task completion. [1]

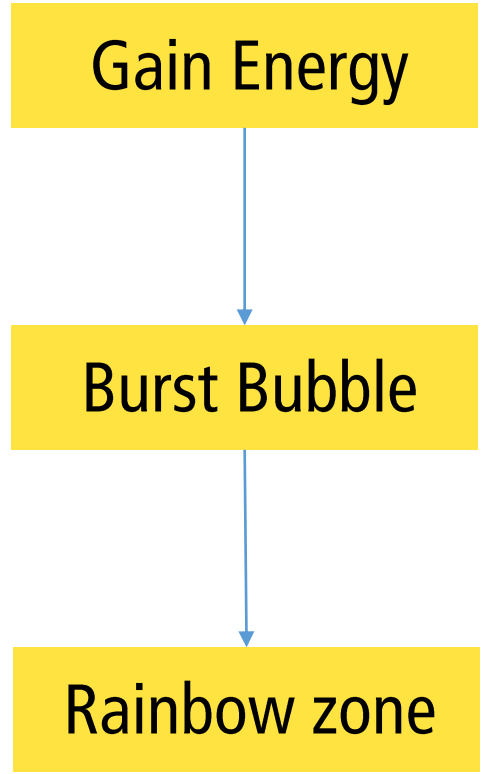
H1: Feedback represented through visual modality has better performance rates than feedback through physical manifestation . [2]

H2: Feedback represented through visual feedback will have a higher user preference than physical manifestation. [2]

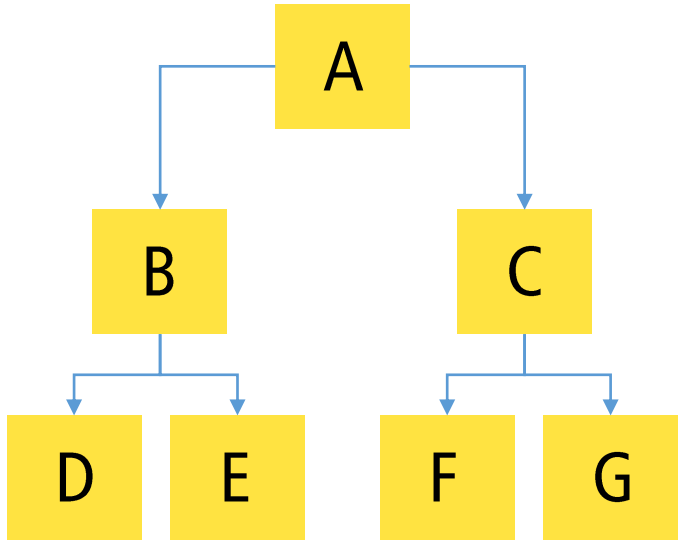
1. Hausen, D., Wagner, C., Boring, S., & Butz, A. (2013, April). Comparing modalities and feedback for peripheral interaction. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 1263-1268). ACM.
2. Shimojo, S., & Shams, L. (2001). Sensory modalities are not separate modalities: plasticity and interactions. *Current opinion in neurobiology*, *11*(4), 505-509.

Feedback Serial task

- Hypothesis Visual feedback modality is more effective than feedback through physical manifestation
- Users: 19-22 yrs old.
- Controlled Experiment (in Lab)
- There are two scenarios one in which feedback is audio/visual and other in which the feedback is physical manifestation.
- Task
  - Initially participant is asked to fill demographic questionnaire.
  - Participant is engaged in a series of task whereby he gets feedback after every sub-task.
  - Participants will play game in which different tasks have to be performed in sequence- Gain Energy (Shape change)
    bubble burst (Texture change)
    rainbow zone (color feedback)
  - Moderator will give the trial of the experiment.
- After both tasks users are asked to fill in questionnaire with Likert scale.



Hierarchal task navigation.



- Hypothesis: Feedback has no effect in performance with respect to task completion time.
- Users: 19-22 yrs old.
- Controlled Experiment (in Lab)
- There are two scenarios one in which feedback is audio and other in which the feedback is physical manifestation.
- Task
  - Initially participant is asked to fill demographic questionnaire.
  - Participants have to navigate to appropriate album of an artist.
    - First: Physical Changes according to genres of song.
    - Second: Feedback will be demonstrated through visual representation.
  - Moderator 1 will give the trial of the experiment.
- After both the tasks users are asked to fill in Likert scale.

Timeline

January: Development of Experiment
February: Experimentation
March-April: Analysis and Paper Publication

Log on to:

medium.com/interaction-modalities

to watch the whole show

References

Ishii, Hiroshi, and Ullmer, Brygg. "Tangible bits: towards seamless interfaces between people, bits and atoms." *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*. ACM, 1997.

Ullmer, Brygg, and Ishii, Hiroshi. "Emerging frameworks for tangible user interfaces." *IBM systems journal* 39.3.4 (2000): 915-931.

Ishii, Hiroshi. "The tangible user interface and its evolution." *Communications of the ACM* 51.6 (2008): 32-36.

Edge, Darren. "Tangible user interfaces for peripheral interaction." *University of Cambridge, Computer Laboratory, Technical Report* UCAM-CL-TR-733 (2008).

Mazalek, Ali, and Elise Van Den Hoven. "Framing tangible interaction frameworks." *AI EDAM (Artificial Intelligence for Engineering Design, Analysis and Manufacturing)* 23.3 (2009): 225.

Shaer, Orit, and Eva Hornecker. "Tangible user interfaces: past, present, and future directions." *Foundations and Trends in Human-Computer Interaction* 3.1–2 (2010): 1-137.

Hornecker, Eva. "Beyond affordance: tangibles' hybrid nature." *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction*. ACM, 2012.