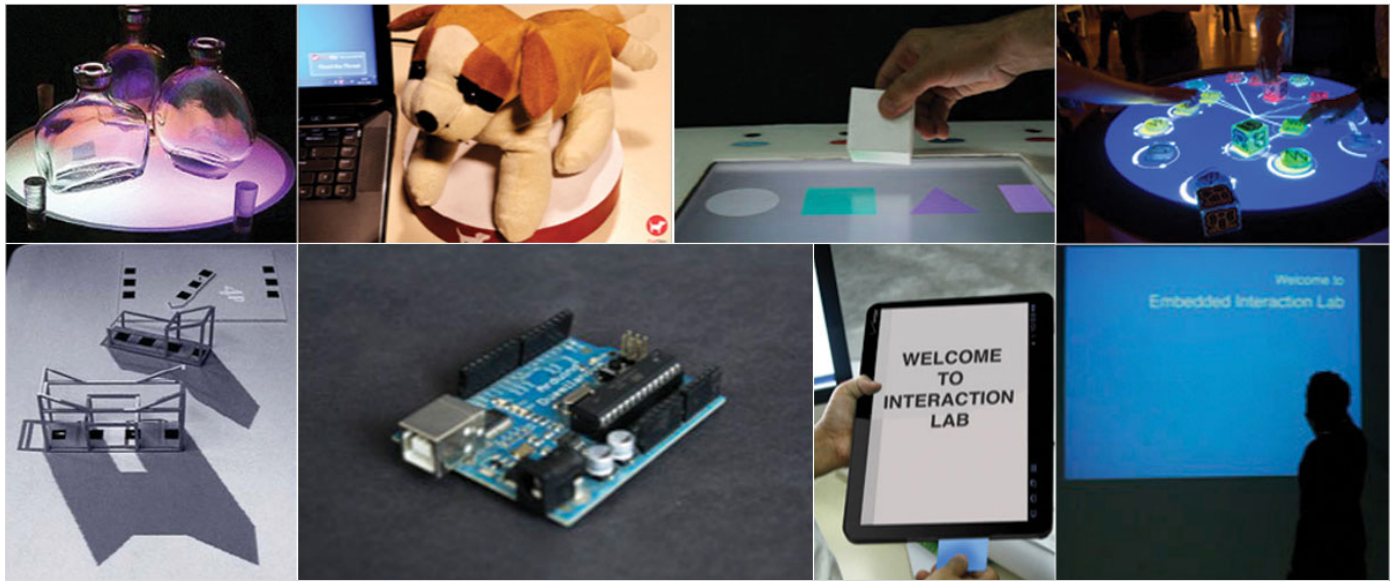
Design Course

Tangible User Interface (TUI) - I

Digital Data and Information

by
Prof. Keyur Sorathia
DoD, IIT Guwahati



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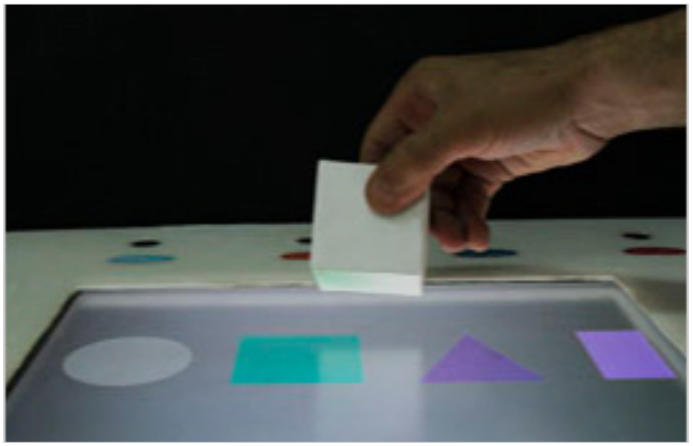
Introduction

We live in a real world, surrounded by real people & objects and interact with them in a real space; however most of our digital data and information is restricted to a set of metaphors such as keyboard, mouse and screen. We have relied majorly on screen based text and graphics to interact with computer, specifically digital data or information for more than 3 decades. Consider it wall mounted screen, hand held device, head mounted displays etc.

Interfaces are not designed to immerse into spaces and objects, instead it forces people to interact with screen-based metaphors. We as human beings have a great ability to perform gestures, speech, remember interactions with natural objects; however computers do not use these mediums. They ask users to sit on a chair, play with keyboard, learn to use mouse, drop downs, software to know even a tiny set of information.

Here comes tangible user interfaces (TUI), where digital information is presented through interacting with physical metaphor. Physical objects play a central role as physical representations and control of digital information (augmenting physical and virtual realities). TUI thinks beyond desktop metaphor of mouse, keyboard, icon, drop-down, files, folders etc. and embeds information in real world.



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About

There is many ways one can define Tangible User Interface (TUI), although all of them convey almost the same message. Below are the few of them:

• "Giving physical form to digital information that fits to our social, cultural and physical context".

• "Computation that moves beyond the traditional confines of desktop & blends into our daily experiences of physical and digital world".

• "Augmentation of Physical & Virtual world".

• "Integrating information with Everyday Physical Objects".

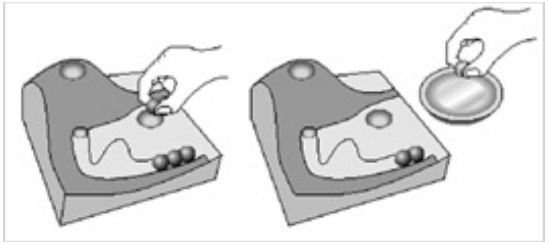
• "Mapping physical objects to digital data".

Physical environment input becomes an interface to interact with digital information as subtle changes in color, movement, smell, form, sound, light, audio, video etc.

• Hiroshi Ishii and Brett Ulmer says,
"Tangible user interface = user interfaces that augment the real physical world by coupling digital information to everyday physical objects and environment."

Few examples are mentioned below for appropriate understanding of above statements.

1. Marble Answering Machine:
The physical marbles represent incoming messages. The number of marbles that have moved into the pin-ball like chute indicates the number of messages. When a marble is dropped into a slot in the machine, the recorded message is played. Dropping the same marble into another slot on the phone dials the caller who left the message.



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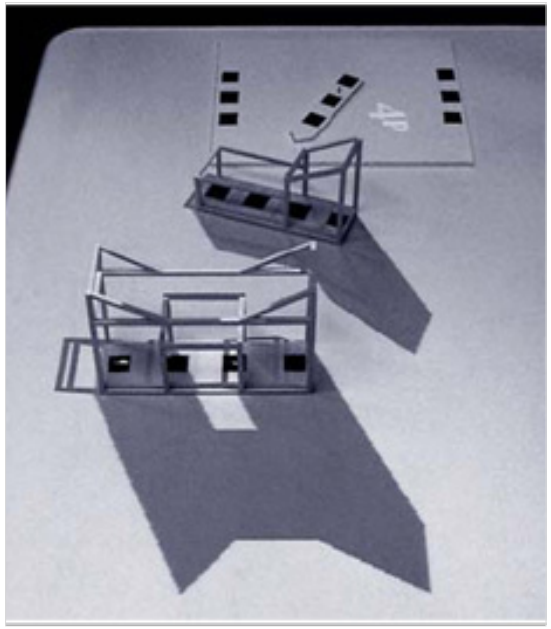
2. Urban Planning Workbench (Urp):
Urban planning workbench uses scaled physical models of architectural buildings to configure and control an underlying urban simulation of shadow, light reflection, wind flow, etc, based on the positions and orientations of physical models of buildings, on the table surface.



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3. Music Bottles:
Music bottles project is a designed table and various sets of three corked bottles that "contain" the sounds of three instruments or tracks of various musical genres. When a bottle is placed onto the stage area of the table and the cork is removed, the corresponding instrument becomes audible.

Tangible interaction is an interdisciplinary area. It includes a span of several disciplines such as HCI, interaction design, product/industrial design, ubiquitous computing, electronics and computer science.

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Evolution

The traditional screen based interfaces and disciplines like virtual reality, which embedded people into virtual world and were seen as estranging people from the real world. Additionally, with technology becoming cheaper, smaller, smarter and coming quickly to the market, it was possible to embed information into our surrounding objects, spaces, environment, fabrics etc. This motivated the development of the discipline called Tangible User Interface.

The notion of Tangible User Interface constituted an alternative vision for computer interfaces that brings computing back into the real world, which was originally conceived in the mid 90's. (Wellner, Mackay, Gold 1993; Ishii, Ullmer 1997).Tangible user interface was envisioned as an alternative to graphical user interface. It was proposed to represent digital content through tangible objects, which could then be manipulated via physical interaction with tangibles. The idea was to grasp data with hand and to unify representation and control. The thought behind it was to use physical devices to interact with digital content.

In 1996, Fitzmaurice's PhD thesis had explored the use of graspable bricks as a more direct input mechanism for the interaction with graphical representations. It also suggested the use of multiple graspable objects instead of the generic input device such as mouse, keyboard etc. An early example of TUI was marble answering machine by Durrel Bishop in early 1990s, where marbles were used to represent message left on answering machine. Placing those marbles plays the message recorded in it.

Similarly, MIT's Tangible Media Group developed a project called Urp (Urban Planning Workbench), where they created a map that was manipulated with placing iconic representation of central buildings on it and moving these apart. The Urp and the more advanced Augmented Urban Planning Workbench allowed digital simulations of air flow, shadows, reflections, and other data based on the positions and orientations of physical models of buildings, on the table surface.

Later, researchers and scientists around the world developed interesting projects such as Topbo, Jive, Reactable, Microsoft Surface, Siftablesand many more. Today almost every appliance contains electronic & digital components and becoming smart & intelligent, which has formed new challenges and opportunities to bring back various design disciplines together. TUI not only includes the interface, but aspects such as form factor, physical properties of the object, materials, technology etc. forced computer scientists, interaction designers and industrial designers to focus on designing complex behaviour that is digitally controlled.

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Major Considerations

Major Considerations include:
4.1 Tangible Input
4.2 Output
4.3 Input-Output Technology

4.1 Tangible Input:
Tangible input presents the input modalities used to interact with information.
• "What kind of medium is used for input? What kind of interface we use to interact with information?"

There are wide range of possibilities to decide the input modalities depending on the content and context. For example, placing a product introduction card on the surface must provide information about the product or placing a cube on the table surface.
E.g. Wall, table, document, 3D objects.

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4.2 Output:
Output represents the output possibilities used to provide information/ required data to users.
• "What kind of a medium is used for output? How the information is been showcased?"

There are several possibilities to decide the output medium to showcase information to users. The output may range from a desktop screen to wall-projected surface to audio output and mechanical movement of 3D objects.

4.3 Input-Output Technology:
Input-Output technology represents the importance of technology understanding and usage in tangible user interface.
• What is the technology behind the input-output interactions?
• "What kind of possible input technologies are available today?"

Understanding of technology plays a vital role in defining interaction modalities. Designer needs to be aware of latest possible technologies, their functionality & possible usage is designing application.

E.g. Use of QR code in advertising. Due to technological advancement, the technological components have become smaller, cheaper & smarter to use. Also, development of tools such as arduino, RFID phidgets etc. and software such as reactivision, processing, vvvv etc. have made hardware prototyping much easier.

Technologies such as different kinds of sensors, camera, barcode, image processing, 2D pointing, audio capture, speech recognition, actuators etc. can be used for TUIs.
(Image: arduino, processing, fiducial).

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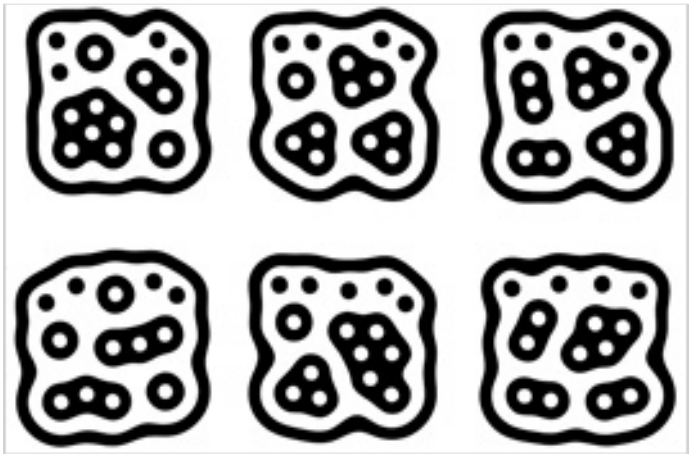

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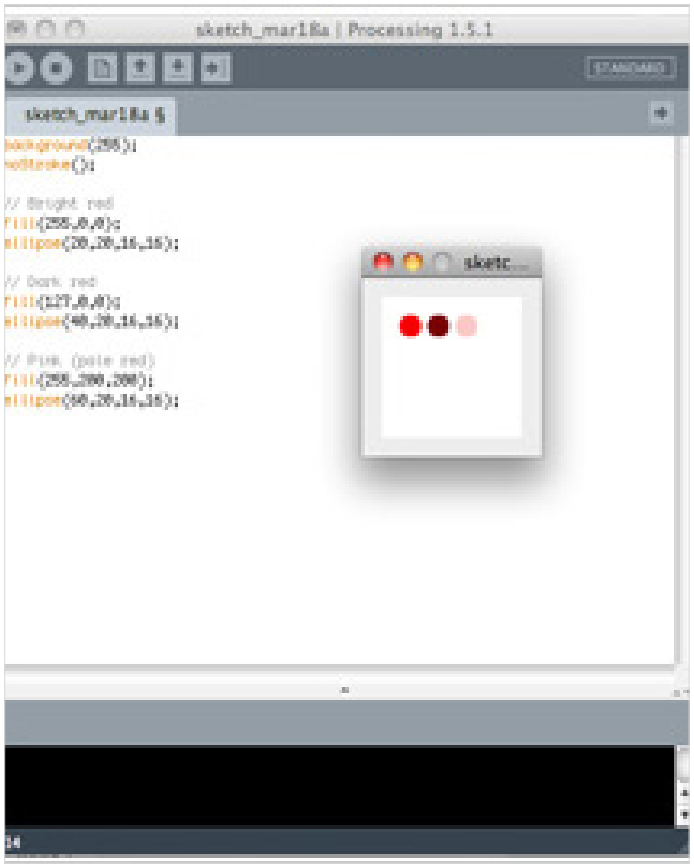

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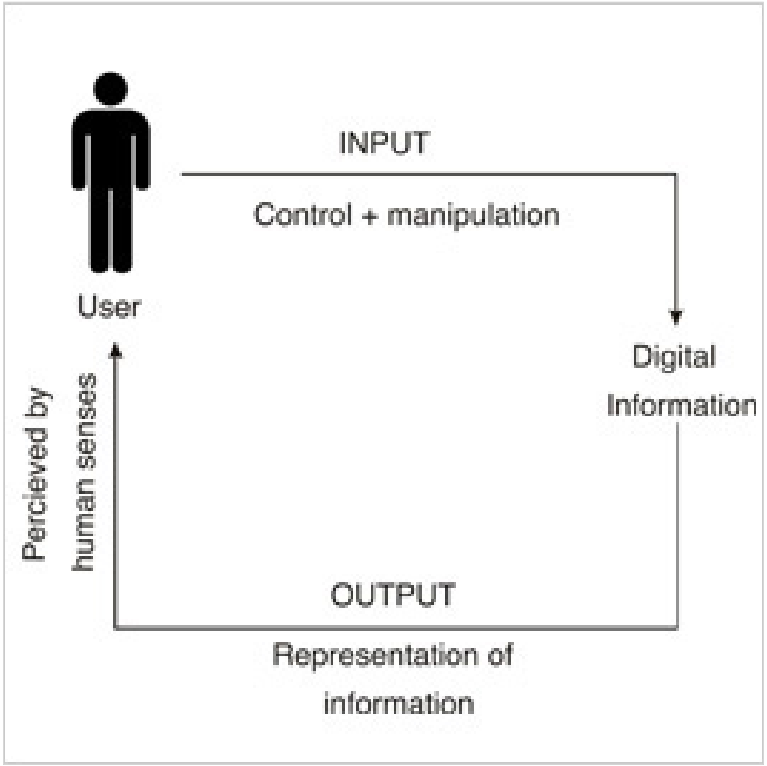
Basic Model

This section provides understanding of model of user interface, model of graphical user interface and model of tangible user interface. These models have been inspired from models proposed by Professor Hiroshi Ishii. These are:

5.1 Model of User Interface
5.2 Model of Graphical User Interface
5.3 Model of Tangible User Interface

5.1 Model of User Interface:
Model of user interface proposes two main aspect; control and representation. User provides an input with actions, controls to manipulate the information; based on performed actions digital information is been represented and perceived by human senses (E.g. Visual, audio, haptic etc.)



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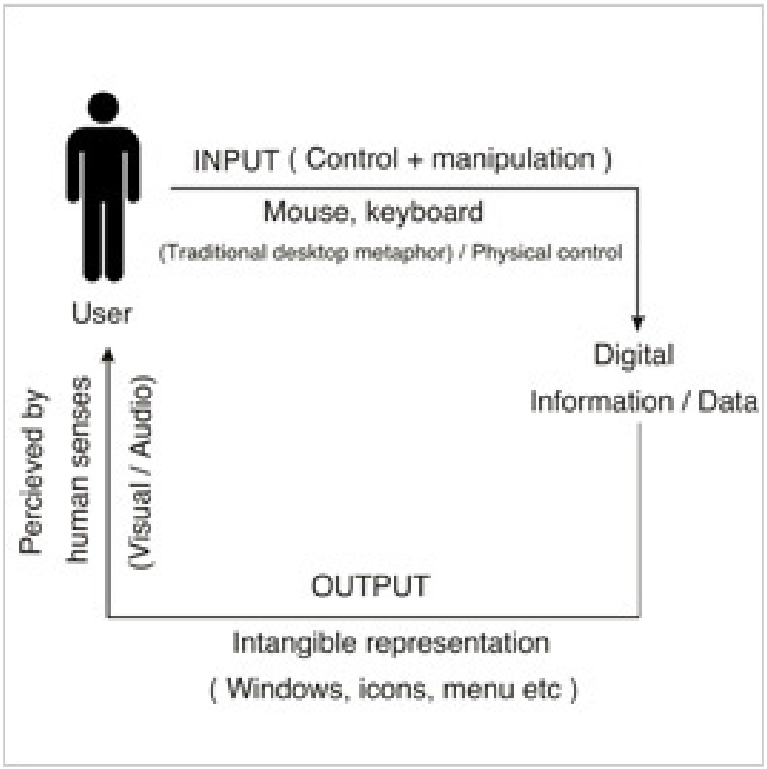
5.2 Model of Graphical User Interface:

Typically, in graphical user interface, physical controls (mostly mouse, keyboard, touch etc.) are used to interact and manipulate with digital information, while information is represented through intangible elements such as icons, menu, drop down etc. The information representation is perceived by human senses (E.g. Visual and Audio).



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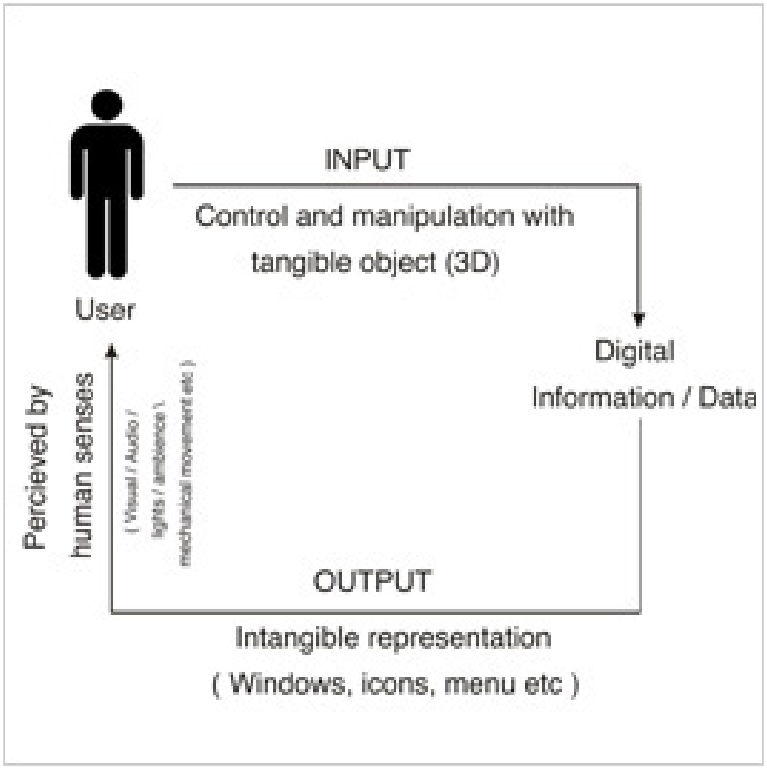
5.3 Model of Tangible User Interface:

Digital information is represented through intangible and/or tangible elements; whereas actions are manipulated using graspable objects (e.g. cube, theme based metaphor such as use of bottles in "music bottle" etc.) Immediate tactile feedback is sensed by user when object is grasped and manipulated. Grasped objects can have additional computational feedback to enhance the responsiveness. Digital information is represented through the appropriate use of tangible and/or intangible elements.
E.g. Visual, audio, lights, ambience, mechanical movements etc.



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Types

There are mainly two types of TUI:
6.1 Passive TUIs
6.2 Active TUIs

6.1 Passive TUIs:
Digital information is represented in tangible and/or intangible form; however participation of the user with the product is relatively less. User may not directly interact with the product, but indirectly control and manipulate the product state.

Pupspy presents passive tangible user interface. A metaphor of dog is used to represent pupspy that protects your computer from virus attacks. Once the virus in the computer is detected, pupspy starts barking signifying the threat. If virus from the system is removed, pupspy wages his tail & ears start moving.

Here, users are not directly interacting with pupspy. However, there is an indirect interaction with the product through computers.

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6.2 Active TUIs:
Users are actively involved in interacting with digital information. The participation of the user is very high & response from the system is immediate.

Reactable represents active tangible user interface. The reactable is a multi-user electro-acoustic music instrument with a tabletop tangible user interface, which is developed at the MTG in Barcelona. Blocks of different shapes are placed on the table top, moving them vertically, horizontally or rotating them creates music or sound effects.

In reactable, users are directly interacting with information (in this case music/sound effects) and based on users' actions and manipulation, the contents are changing.

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Key Question

Mapping of Physical Objects to Digital Computation:
It is important to understand and choose the appropriate mapping of physical objects with the possible feedback.

Mapping of objects include:

• Choice of the input object:
- Why a particular object is chosen as input modality?
- Is the relationship appropriate between chosen object, its actions & provided output?
(e.g. using a metaphor of cricket bat & performing gestures of hitting a ball should result in a game of cricket, not football)

• Placement of the input object:
- Is the object used for input (control & manipulation) placed properly that user understands the next steps of interaction?

There are two ways to choose mapping of the object:
1. Abstract object:
The chosen input object may not have any kind of relationship with provided output; however, there may be a possibility of performed actions associated with provided output. Reactable project uses abstract objects (cube, triangle, hexagon etc.) to represent music.

2. Specific object:
The chosen object have a very clear relationship with the provided output, so that user is able to make direct relationship between input and output. Here, the actions associated may have or not have any kind of relationship with provided output.

E.g. Urban workbench project uses specific building elements & clocks to represent shadow, wind etc. in a newly designed architectural space.

Actions and its Association with Objects:
actions associated with the objects must provide immediate feedback for further steps of interactions. Here, actions supported by the objects must be based on well-understood actions related to the object.

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E.g. if wine bottle is chosen as input, the opening of a bottle cork is a well-understood action
Appropriate coupling of tangible and intangible representation

Output of TUI can be represented both in tangible and intangible format. It is very essential to understand the balance and perceptual coupling of tangible representation to dynamic intangible representation. Tangible elements should be over shadowed or even should not be invisible.

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Reactable:
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Contact Details

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More details about his research can be found on https://www.keyursorathia.com/

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