Tangible Interfaces

LCC 4730 / 6318 / 8803
Experimental Media
Spring 2007

Readings

Ishii, H., Ullmer, B. (1997). "Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms" in ***Proceedings of CHI '97***, ACM Press.

Ullmer, B., Ishii, H. (2000). "Emerging Frameworks for Tangible User Interfaces" in ***IBM Systems Journal***, Vol. 39, Nos. 3&4, 2000.

Research Motivation

GUI vs. **TUI**
Graphical User Interface — Tangible User Interface

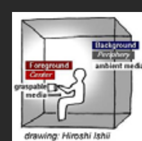
Graphical User Interfaces are not always an appropriate means of accessing digital information

Tangible User Interfaces enable computationally mediated interactions in physical locales and social contexts where traditional computer use may be difficult

E.g. meeting spaces, living spaces, and commercial, industrial or domestic contexts

Collaborative browsing of a shared media content database. Users navigate a map surface with physical pawns that represent handles to a particular person's media collection.

Some Definitions



[Ishii & Ullmer, 1997]

Giving physical form to digital information by seamlessly coupling the dual worlds of bits and atoms

Use physical spaces, surfaces, and objects as both *controls* and *representations* of digital information

Enable Co-located collaborative user interactions with digital information

Two main categories:

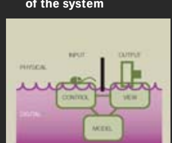
Tangible interfaces: Foreground interactions with graspable objects and augmented surfaces

Ambient Displays: Background information displays using ambient media

Tangible Interaction Model

Key Characteristics [Ullmer, Ishii 2000]

1. **Physical representations are computationally coupled to underlying digital information**
2. **Physical representations embody mechanisms for interactive control**
3. **Physical representations are perceptually coupled to actively mediated digital representations**
4. **The Physical state of the interface artifacts partially embodies the digital state of the system**

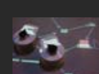


GUI interaction model
Model-View-Controller

TUI interaction model
Model-Control-Representation (physical / digital)

Taxonomy & Applications

Ullmer and Ishii [2000] provide the following categorization of TUI approaches:



1. Spatial Systems
Spatial configuration of objects in a reference frame is computationally interpreted and augmented.

E.g. Interactive tables
Urban Planning – I/O bulb [Underkoffler 1999]
Business Modeling – Sensetable [Patten 2001]
Multimedia Visualization – TViews [Mazalek 2002]

2. Constructive Systems
Modular electronically instrumented artifacts are used for constructing computationally interpreted physical structures.

E.g. Blocks assembly
Fluid mechanics – GDP (Geometry defining processors) [Anagnostou 1989]
Programming – AlgoBlock [Suzuki 1993]
Digital Storytelling – Triangles [Gorbet 1998]

3. Relational Systems
Logical relationships between tokens are mapped onto more abstract computational interpretations.

E.g. Tokens & constraints
Media manipulation – mediaBlocks [Ullmer 1998]
Databases – Tangible Query Interfaces [Ullmer 2002]

Sensing Technologies

Some approaches for interactive surfaces and object tracking for TUI systems:

1. Object tracking using tag sensing

Active or passive tags are embedded within the interaction objects, and an antenna reader is placed underneath the interaction surface. RFID tags and LC tags – low cost, can track multiple objects at once, can be difficult to scale the interaction surface size.

2. Object tracking using computer vision

Color/pattern recognition of labeled objects on a horizontal surface. The video camera can look at the objects from behind or in front. Requires clear line of sight from camera to objects. Obstruction (from hands, etc.) can pose problems.

3. Object tracking using acoustics

Fixed receivers on surface, active sonar pingers in objects. Modulation of signals can allow several objects to be tracked at once.

4. Bare hand tracking

Can be done with computer vision, capacitive sensing on a conductive surface, light curtains (IR LED arrays), or acoustic tap-tracking. The first three techniques are good for continuous movement of multiple hands, the latter handles only discrete taps.

5. Electrical contacts

Electrical contacts can be used in cases where objects are snapped together or placed at fixed locations.

TUI Research

Interactive Tables

Application Domains

Across different physical contexts…

Homes: personal/home management, entertainment
E.g. [Shen 2003] Personal Digital Historian on DiamondTouch

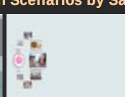
Work: meetings, collaborative design, strategy, planning, control
E.g. [Patten 2002] Supply Chain Visualization on Sensetable

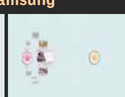
Schools: teaching tool, shared creative activities

Public places: kiosks, table games, online access, art projects

User Interaction Scenarios by Samsung


Sending and receiving messages


Building slideshows with images and music


Listening to common music playlists


Downloading images from digital camera

Digital Desk

[Wellner, EuroParc, 1991]

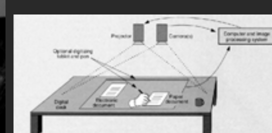
Allows user interactions with real paper on a physical desktop to be augmented with digital information

Top-projected video

Camera tracking from above to recognize action gestures

Digitizing pen and tablet for computer input

Microphone in table surface



Video Clip

Graspable Bricks

Bricks: a graspable user interface on the ActiveDesk for direct control of virtual objects, e.g. drawing

[Fitzmaurice 1995]

Video Clip

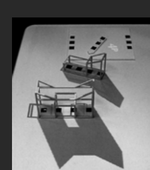
Application functionality:

- Wired objects
- Two-handed interactions

Technical implementation:

- Sensing: Ascension Flock of Birds 6D input devices
- Display: rear-projected computer screen

Urp: Urban Planning Workbench



Urp: a luminous-tangible workbench for urban planning and design [Underkoffler 1999]

Application functionality:

- Shadows and time of day
- Distance measurements
- Light reflections
- Wind simulation
- Site views and snapshots

Technical implementation:

- Sensing: color/pattern recognition using computer vision (poses problems with occlusion)
- Display: front projected graphics

Video Clip

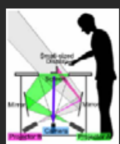
Tablescape Plus

Yasuaki Kakehi, Makato Iida, Takeshi Naemura

The University of Tokyo, 2006

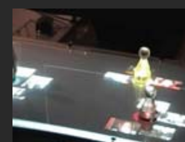
Tabletop interaction platform where digital imagery is displayed in the vertical plane (upstanding objects) as well as the horizontal (table surface).

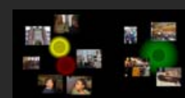
Objects are tracked using computer vision from below (reflective material attached to base)



Tangible Viewpoints

Storytelling engine for multi-viewpoint stories





Character-driven narratives
Physical pawns used as tangible embodiments of multiple character viewpoints in a story.

Audience interaction
Story segments appear as thumbnails around the pawns, fading in and out as viewers move forward through the story. Clips are displayed on external monitor.

Clip metadata
Annotations based on character viewpoint and place in narrative flow.

Computational engine
Spreading activation network coupled with rule-based story structure. Allows the system to adapt to viewer preferences while still providing a coherent overall narrative.

Character viewpoints
Breadth vs. depth and thread intersections.

Tangible Spatial Narratives

Creating narrative landscapes in a physical form

Spatial structured narratives
Audiences can collectively reflect upon and navigate complex spatially structured and multi-viewpoint stories.

Audience interaction
Visual landscapes displayed on the interaction surface provide a spatial framework on which the pawns are moved. Thumbnails indicate clip segments that can be selected and played. Clock tool used to adjust story time.

Clip metadata
Annotations based on location, character, and time.

Clip retrieval
Database queries based on character, location, time.

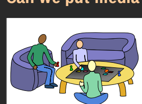
User Interactions

Kids sharing personal stories
Computer Clubhouse, Boston Museum of Science

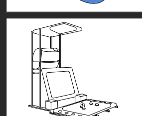
Artists browsing video collections
Haystack School of Mountain Crafts

Motivation

Can we put media tables in the home?



Vision
A sociable interface for the home environment



Reality
Limitations of existing sensing and display technologies

How to move forward from the current prototypes?

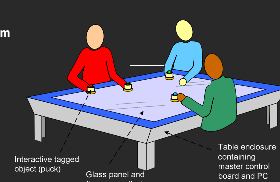
Sensing – larger scalable surfaces, track more objects, portability
Display – provide embedded display, avoid external infrastructure

TViews Table

Sociable media interaction platform for the home environment

Table designed for scalability
- Different table/display sizes
- Large number of objects
- Many applications on one table
- Connect many tables together

Objects designed for portability
- Any object on any table
- Customize objects with external I/O devices



Industry Perspective

Hardware Vendor
E.g. Samsung
TViews table for the home

Software Vendor
Application packages including software + set of objects

TViews Example Applications

Photo browsing interactions

Shared interactions, automatic spatial organization, power of digital content

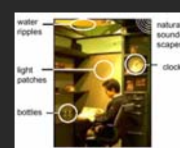
TUI Research

Ambient Displays

ambientROOM

[Ishii, 1997]

- An augmented architectural space that uses ambient media to convey information at the periphery of human perception
  - Light, shadow, sound, airflow, water movement
  - Physical handles such as bottles and a clock to control ambient display of bits
- Enabling seamless transitions between background awareness and foreground activity



Video Clip

Ambient Devices

TUI Research

Information Visualization & Browsing

Tangible Query Interfaces

[Ullmer, 2002]

[Video Clip]

Physical tokens placed within constraints can be used to query relational databases.

- Token rotation maps to parameter selection
- Token adjacencies maps to Boolean AND/OR operations
- Token ordering maps to result sorting
- Individual racks map to parenthetical groupings

Example domains:

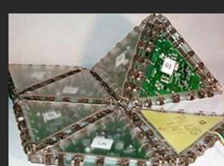
- Media databases, network management, and bioinformatics

TUI Research

Physical/Digital Construction Kits

Triangles

[Gorbet, 1998]



[Video Clip]

Physical/digital construction kit based on identical, flat, plastic triangles that connect together physically and digitally with magnetic conducting connectors

- Connections can trigger specific digital events
- Allow 2D and 3D formations

Example application spaces:

- Storytelling, education, rapid prototyping

Topobo

[Raffle, 2004]

[Video Clip (narrated)]

[Video Clip (music)]

3D constructive assembly kit with kinetic memory that serves as a learning tool for dynamic structures

- Combination of passive (static) and active (motorized) components
- Quickly assemble dynamic biomorphic forms
- Animate those forms by pushing, pulling, and twisting them
- Observe the system repeatedly play back those motions

TUI Research

Arts and Entertainment

PingPongPlus

[Wisneski, 1998]

[Video Clip]

Digitally enhanced ping pong that is played with ordinary paddles and balls on a reactive table.

- Input: Acoustic sensing used to track ball hits on table
- Output: Projection of moving patterns and images on the table, acoustic feedback

genieBottles

[Mazalek, 2001]

A story of entrapment and attempted escape told by three genies who live in glass bottles

Bottles used as containers and controls for digital audio information

I/O Brush

[Ryokai, 2004]

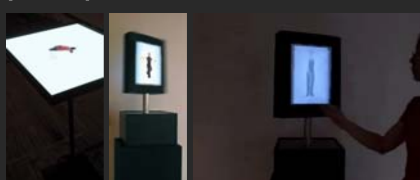
Drawing tool that uses the physical world as a color palette. Allows users to draw with colors, textures and movements from their physical surroundings.

Paintbrush with embedded video camera, lights and touch sensors

Video Clip

Spinning Dancers and Tilting Table

[Lee, 2004]



Physical interactions with the digital video screen; tangible interactions serve as a direct link to the media content

Morphovision

Toshio Iwai, 2006

Illusory distortion of a physical object (miniature house) using a high-speed rotating table and a synchronized scanning beam of light.

[video]

TUI Research

Arts and Entertainment

(Especially relevant to the Garden Theme)

Orgone Reef

Philip Beesley, University of Manitoba, 2003

Installation piece and a technical exercise in construction and fabrication, speculates on what the skin of a building could be like in the future.

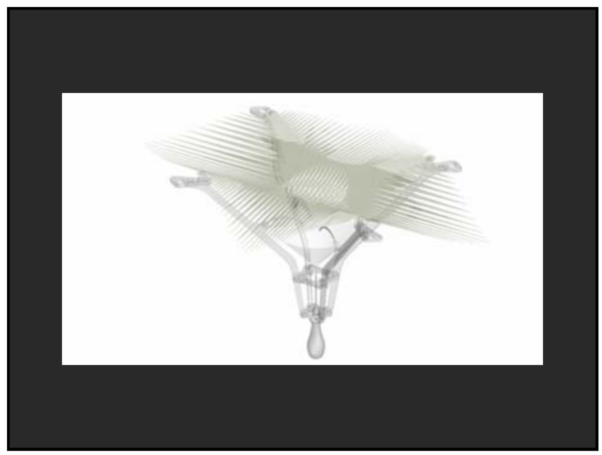
An interlinking matrix manufactured by a lasercutter. Probes the possibilities of combining artificial and natural processes to form a hybrid ecology.

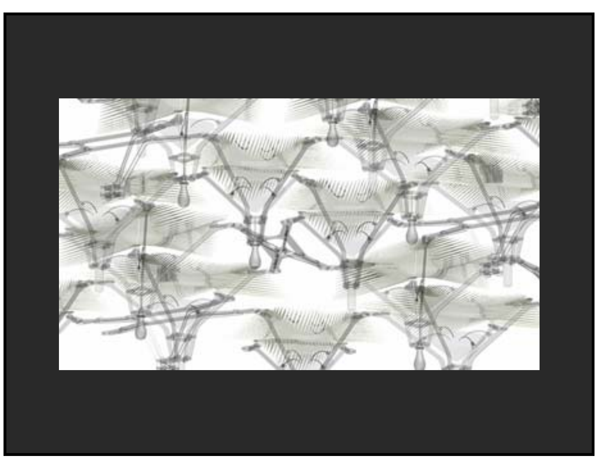
Video Clip - Second Skin

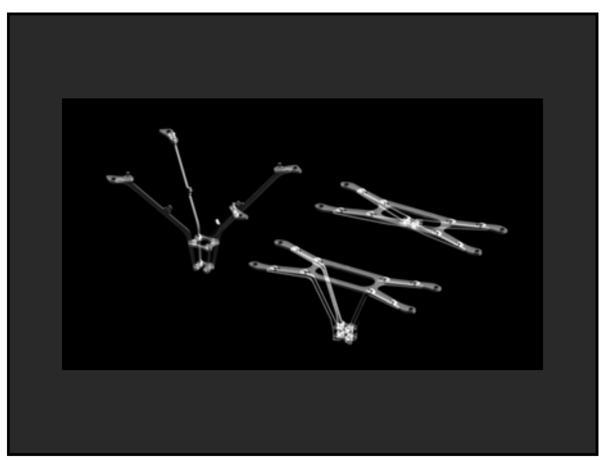
Video Clip - Patterned Sheets

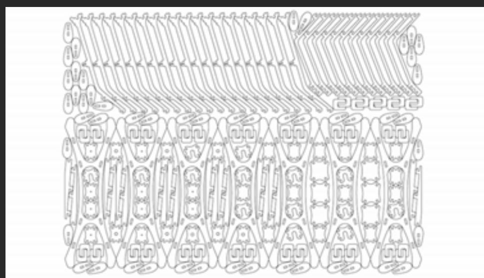
Video Clip - Carnivorous Energy

More Orgone Reef images...









Submerging Technologies

Paul Dietz, Jonathan Westhues, John Barnwell, William Yerazunis (MERL) & Jeff Han (NYU), 2006

Three interactive water displays demonstrate sensing techniques that exploit the electro-optical properties of water itself.

Tantalus Fountain: proximity of hands is detected by measuring the capacitance to ground of the water bell via an electrode placed in the nozzle

Aqua Harp: light travels inside the column of water. Light sensors in the receiving tank detect decrease in light when the stream is interrupted.

TouchPond: IR light travels through the water and when the surface is disturbed by a touch, the escaping light is detected by a camera underneath the pond. The piece also uses video projection from below.

Tantalus Fountain

Aqua Harp

TouchPond

White Noise / White Light

Meejin Yoon, Matthew Reynolds, 2004

Interactive sound and light installation created for the Athens 2004 Olympics.

Comprised of a 50' x 50' grid of fiber optics and speakers, the sound and light field responds to the movement of people as they walk through it by transmitting white light from LEDs and white noise from speakers below.

Motion is detected via a passive IR sensor, causing the LEDs to glow brighter and the white noise to grow louder. When motion stops, the light and sound fade.

WNWL - Video Clip 1

WNWL - Video Clip 2

Siggraph 2006

Emerging Technologies Video