

MAS 834: Tangible Interfaces

Media Arts and Sciences Graduate Seminar, Fall 2001

Prereq.: Permission of instructor

G (Fall)

3-3-6 H-LEVEL Grad Credit

When: **Friday, 2:00 PM - 5:00 PM**
September 14 - December 7, 2001

Where: **E15-054**

Instructor:	Hiroshi Ishii	ishii@media.mit.edu	One Cambridge Center 5F Tel. 3-7514
TAs:	James Patten	<jpatten@media.mit.edu>	
	Angela Chang	<anjchang@media.mit.edu>	
Guest speakers:	Rob Jacob	<rjacob@media.mit.edu>	Associate Prof, Tufts Univ.
	Rich Fletcher	<fletcher@media.mit.edu>	MAS Ph. D. candidate
	Brygg Ullmer	<ullmer@media.mit.edu>	MAS Ph. D. candidate
Secretary:	Lisa Lieberson	<lisasue@media.mit.edu>	One Cambridge Center 5F, Tel. 3-9836

Course description

People have developed sophisticated skills for perceiving and manipulating their physical environments. However, most of these skills are not engaged by the traditional Graphical User Interface (GUI) that has become the central approach in Human-Computer Interaction (HCI) design. The GUI represents information mainly as abstract pixels on flat rectangle screens, allowing people to manipulate them only indirectly with a remote controller such as a mouse and keyboard.

The Tangible User Interface (TUI) is an attempt to give physical form to digital information, making bits directly manipulable and perceptible by people. The goal of TUI research and design is to build the next generation of interfaces that go beyond the current and dominant GUI paradigm.

This course will explore the design space of TUIs, a new form of HCI which focuses on the physical embodiment of computational media. Tangible Interfaces will make bits accessible through augmented physical surfaces (e.g. walls, desktops, ceilings, windows), graspable objects (e.g. building blocks, models, instruments) and ambient media (e.g. light, sound, airflow, water-flow, kinetic sculpture) within physical environments.

This is a project course with enrollment limited to keep a design studio atmosphere. We will explore different ways of broadening the bandwidth of interaction between people and digital information through Tangible Interfaces that help people learn, design, and communicate using

the full range of human senses and skills. We will pursue the interfaces that are not only practical, but also aesthetically pleasing and engaging.

For example, we explore the interfaces that allow users to “grasp & manipulate” information by coupling digital information and computation with physical objects on augmented surfaces, so that multiple users can have direct access to the shared information space that supports collaboration, and enable users to be aware of information at the periphery of human senses using ambient display media such as light, sound, airflow, water movement, and kinetic sculpture in an augmented space, so that users can take advantage of peripheral awareness while focusing on foreground task.

The goal of this course is to design new instances of Tangible Interfaces that take advantage of physical affordance of objects and spaces to achieve a legibility and seamlessness of interaction not achievable with traditional GUI.

The instructor will provide:

Background – HCI, GUI, Ubiquitous Computing, and Augmented Reality
Framework and theory of TUIs,
Design examples and successful applications of TUIs, and
Enabling technologies for TUIs.

Students will design/develop experimental Tangible Interfaces, applications, underlying technologies, and/or theories using concept sketches, posters, physical mockups, and working prototypes. Studio discussion of ideas using tangible materials such as posters and physical mockups are encouraged to refine the design collaboratively. Over the course of the semester, each student is required to complete one warm-up exercise, two design projects, and one final presentation.

Grading is based on the following factors:

participation in class discussion: 30% (at least 80% of class attendance required.)
presentation of warm-up exercise: 10%
presentation of the completed first project: 20%
final presentation of the completed second project: 30%
final project report in CHI short paper format: 10%

Final project reports must be submitted to the instructor in CHI short paper format available at <http://www.acm.org/sigchi/chipubform/> by the final class on December 7. Submission of final project reports to CHI 2002 Short Talks and Interactive Posters (2-page paper, deadline: 12/7/01) is encouraged. <http://www.acm.org/sigchi/chi2002/short-talks.html> Alternative venue for submission would be DIS 2002 (deadline: 12/7/01). <http://www.acm.org/sigchi/dis2002/>

Mailing list:

- ti01@media.mit.edu all the admitted students to MAS.834 Fall 2001
 - ti01-staff@media.mit.edu instructors + TAs + secretary
- URL: <http://tangible.media.mit.edu:555/courses/ti01/> online syllabus

Tentative Course Schedule

- (9/7*) No class
- 9/14 Course Overview and TUI Introduction by Ishii, Assignment 0 (warming-up exercise)
- 9/21* Context of TUI (part 1 and 2) by Prof. Rob Jacob
- 9/28 Poster presentation of assignment 0, Context of TUI (part 2) by Ishii,
Assignment-1 (first project)
- 10/5* Framework of TUI (Ullmer)
- 10/12 First project proposal due (assignment-1) – poster presentation
- 10/19 Tangible Interfaces Design Cases (part 1) by Ishii, Psychology of TUI (Patten)
- 10/26 Presentation of completed first project (assignment-1), Assignment-2 (second project)
- 11/2 Tangible Interfaces Design Cases (part 2) by Ishii
- 11/9* Enabling Technologies (Fletcher and Patten)
- 11/16 Second project proposal due (assignment-2) – poster presentation
- (11/23) no class - *Thanksgiving Vacation*
- 11/30 Tangible Interfaces Design Cases (part 3)
Context of TUI (part 3: future) by Ishii
- 12/7 Final presentation of completed second project (assignment-2)
CHI 2001 Short Talks and Interactive Posters submission deadline

Menu

- 1) **Course Preview:** Course schedule and sampler of the past projects
- 2) **Course Overview** (Ishii)
 - Overview of the course, projects, presentations, and possible submission to CHI/DIS conferences.
 - Perspective of Tangible Interfaces
 - Self introductions of students
- 3) **Context of Tangible Interfaces**
 - 3-A) **History of HCI** (Jacob),
 - Interaction styles: From Command Languages to Virtual Environments
 - Basic HCI concepts and terminology, Interaction Tasks, Techniques, and Devices; direct and indirect interaction, User interface software concepts
 - 3-B) **Emerging new paradigms**
 - Augmented Reality, Mixed Reality, Ubiquitous Computing, Tangible Bits
 - 3-C) **Future of Tangible Interface**
 - Integration with Industrial Design, Architectural Design, and Media Arts
- 4) **Framework for Tangible Interface Design** (Ullmer)
- 5) **Enabling Technologies for Tangible Interfaces** (Fletcher, Patten)
- 6) **Tangible Interfaces Design Cases**
 - 6-A) **Classic:** LiveWire (Natalie Jeremijenko),
Marble Answering Machine (Durrell Bishop), Anthony Dunne/ Fiona Raby
(Fields and Thresholds), Bricks - Graspable UI (Fitzmaurice)
 - 6-B) **TMG:** I/O Bulb and Urp, sensetable - platform for spatial TUI,
Triangles, bottles, InTouch, curlybot, PingPongPlus, and HandSCAPE (Jay Lee)

6-C) **Others:** Xerox PARC, U. of Colorado, Interval, CMU, etc.

6-D) **Media Arts** - Toshio Iwai, Naimark, Gansec, Meiwadenki, etc.

Assignments

0) Warming Up Exercise

Assignment-0: 1 page poster with sketches and text

- Analyze your interactions with everyday physical objects,
- Analyze the meaning of the objects and physicality, and
- Imagine: if these objects are connected to digital world, how it could help you to access to and manipulate the information or to communicate / collaborate with other people?
- Make a **poster** with design sketches (and text), and present in a class (5 minutes).

1) Project 1 (Assignment-1)

1-1) Assignment-1: first project proposal of “Tangible Interfaces” which utilizes graspable objects and your hands to manipulate digital information.

- Make a **plan** of your project to explore a form of Tangible Interfaces using graspable physical objects,
- Write a project proposal with sketches, and start mockup making.
- Make a **poster** with design sketches and text, and make a **physical mockup** for class presentation and discussion.
- Find a **partner** (2 students / group minimum) if possible and necessary.

1-2) First project proposal due

Presentations of first project proposals and design critique (all students)

- Bring a **poster** which summarizes your first project ideas with sketches. Poster does not need to be pretty but has to communicate your ideas well. We will put all the posters on the wall of a class room so that everyone can easily access to the ideas and review. Bring a **physical mockup** of your ideas to put on a table.
- Each group of students will give 5-10 minute presentation and discussion using this poster and physical mockup
- Find a **partner** (2 students / group minimum) to realize the idea you choose.

1-3) Discussion of the first project in progress

- Bring **revised posters** and/or **mockups**.
- We continue informal design discussion.

1-4) Presentations of completed first projects and design critique (all students)

- Bring a **poster** summarizing the results of your project.
- Bring working **prototypes / mockups**.
- Each group will give 5 – 10 minute presentation using the poaster / prototypes / mockups.
- All the students and instructors join design critiques.

2) Project 2 (Assignment-2)

2-1) Assignment-2: second project proposal (extended Tangible Interfaces) based on the reflection of your first project, explore one of the following three directions.

- Extension to architectural space: extend the scale of interface to a large room/building/public space and design the physical interface which utilizes objects, space, and peripheral sensory information (ambient media).
- Extension to the human body: extend the physical interface closer to the skin to take advantage of tactility of physical interface. Design your wearable/tangible interfaces.
- Extension of your first project toward practical applications with clear focus on tasks.
- Continue to work on the first project to come up with new design to solve the problems identified in the design review.
- Develop theoretical framework or principles which guides design of tangible interfaces.
- Develop underlying sensing/actuation technologies for tangible interfaces.
- Find a partner (2 students / group maximum), and
- Write a project proposal, draw sketches, and start mockup / prototype making. Make a poster for class discussion.

2-2) Second project proposal due.

Presentations of second project proposals and design critique (all students)

- Bring a poster which summarizes your project ideas. We will put all the posters on the wall for collaborative design critique.
- Bring a physical mockup or prototypes,
- Each group of students will give 5 – 10 minute presentation using this poster and physical mockup / prototype.
- Discuss on the possible submission of your final project report to CHI Short Talks and Interactive Posters or DIS 2002 (both deadlines: December 7, 2000).

2-3) Discussion of 2nd project in progress

- Bring revised posters and/or mockups.
- We will have informal design discussion

2-4) Presentations of completed 2nd projects and design critique (all students)

- Formal 10 minute CHI style talk including live demo (or video),
- 2 – 3 pages paper summarizing project due (in CHI paper format)

CHI, DIS and SIGGRAPH Calendar

12/7/00	CHI 2002 Short Talks and Interactive Posters submission deadline http://www.acm.org/sigchi/chi2002/short-talks.html
12/7/01	DIS 2002 submission deadline http://www.acm.org/sigchi/dis2002/

1/9/02	SIGGRAPH 2002 Full Papers submission deadline http://www.siggraph.org/s2002/cfp/papers/index.html
1/30/02	SIGGRAPH 2001 Emerging Technologies submission deadline http://www.siggraph.org/s2002/cfp/etech/index.html
3/13/02	SIGGRAPH 2001 Sketches and Applications submission deadline http://www.siggraph.org/s2002/cfp/sketches/index.html
4/20-25/02	CHI 2002, Minneapolis, USA http://www.acm.org/sigchi/chi2001/
6/25-28/02	DIS 2002, London, UK http://www.acm.org/sigchi/dis2002/
7/21-16/02	SIGGRAPH 2002, San Antonio, USA http://www.siggraph.org/s2002/conference/index.html

Suggested Reading List

Ackerman, D. (1990) A Natural History of the Senses, Random House, Inc.

Arias, E., Eden, H. and Fischer, G. (1997). Enhancing Communication, Facilitating Shared Understanding, and Creating Better Artifacts by Integrating Physical and Computational Media for Design. in Proceedings of Designing Interactive Systems: Processes, Practices, Methods, and Techniques, Amsterdam, August 1997, ACM, 1-12.

Buxton, W. (1995). Integrating the Periphery and Context: A New Model of Telematics. in Proceedings of Graphics Interface '95, 239-246.

Buxton, W. (1997) To appear in (Eds.). Hillsdale, N. J. E. (1997). Living in Augmented Reality: Ubiquitous Media and Reactive Environments. In Video Mediated Communication, pp. 363-384, S. W. Finn ed. Lawrence Erlbaum Associates.

Cooperstock, J., et al., "Evolution of a Reactive Environment," Proceedings of CHI '95, ACM, May 1995, pp. 170-177.

Crampton Smith, G. (1995). The Hand That Rocks the Cradle. I.D., May/June 1995, , 60-65.

Csikszentmihaly, M. and Rochberg-Halton, E. (1981) The Meaning of Things : Domestic Symbols and the Self (, Cambridge University Press.

Dunne, A. & Raby, F., Fields and Thresholds, November 1994,
<http://www.mediamatic.nl/Doors/Doors2/DunRab/DunRab-Doors2-E.html>

Feiner, S., MacIntyre, B., and Seligmann, D. Knowledge-based augmented reality. Communications of the ACM, 36(7), July 1993, 52-62.

Fitzmaurice, G., "Situated Information Spaces and Spatially Aware Palmtop Computers," CACM, July 1993, Vol. 36, No. 7, pp. 38-49.

Fitzmaurice, G., Ishii, H., Buxton, W., "Bricks: Laying the Foundations for Graspable User Interfaces," Proceedings of Conference on Human Factors in Computing Systems (CHI '95), ACM, Denver, May 1995, pp. 442-449.

Ishii, H., Kobayashi, M. and Arita, K., "Iterative Design of Seamless Collaboration Media," Communications of the ACM (CACM), ACM, Vol. 37, No. 8, August 1994, pp. 83-97.

- Krueger, M., "Artificial Reality II," Addison Wesley, 1991
- Lubar, S. and Kingery, W. D. (ed.) (1995). History from Things : Essays on Material Culture. Smithsonian Institute Press.
- Mackenzie, C. L. and Iberall, T. (1994) The Grasping Hand , Advances in Psychology, 104, North-Holland, Elsevier Science B. V.
- McCullough, M. (1996) Abstracting Craft: The Practiced Digital Hand, The MIT Press, Cambridge, MA.
- Norman, D. A. "Things That Make Us Smart," Addison Wesley, 1993.
- Norman, D. A., "Psychology of Everyday Things," Basic Books, 1988
- Pedersen, E. and Sokoler, T. (1997). AROMA: Abstract Representation Of Presence Supporting Mutual Awareness. in Proceedings of Conference on Human Factors in Computing Systems (CHI '97), Atlanta, March 1997, , 51-58.
- Pentland, A. P. (1996). Smart Rooms. Scientific American. 274, 4 (1996), 54-62.
- Resnick, M. (1993). Behavior Construction Kits. Communications of the ACM. 36, 7 (1993), 64-71.
- Shneiderman, B. (1997). Designing the User Interface: Strategies for Effective Human-Computer Interaction, Third Edition, Addison-Wesley, Reading, Mass. (1997).
- Weiser, Mark, Does Ubiquitous Computing Need Interface Agents?
MIT Media Lab Symposium on Interface Agents, Cambridge, MA 1992.
- Weiser, M., "The Computer for the 21st Century," Scientific American, 1991, 265 (3), pp. 94-104.
- Weiser, M. and Brown, J.S., Designing Calm Technology, December 1995,
<http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm>
- Wellner, P. (1993). Interacting with Paper on the DigitalDesk. Communications of the ACM. 36, 7 (1993), 87-96.
- Wellner, P., Mackay, W. and Gold, R. (1993). Computer Augmented Environments: Back to the Real World. Communications of the ACM. 36, 7 (1993), 24-26.

TMG papers

- Patten, J., and Ishii, H., A Comparison of Spatial Organization Strategies in Graphical and Tangible User Interfaces, in Proceedings of Designing Augmented Reality Environments (DARE '00) , (Elsinore, Denmark, April 12-14, 2000), pp. 41-50
- Frei, P., Su, V., Mikhak, B., and Ishii, H., curlybot: Designing a New Class of Computational Toys, in Proceedings of Conference on Human Factors in Computing Systems (CHI '00) , (The Hague, The Netherlands, April 1-6, 2000), ACM Press, pp.129-136
- Lee, J., Su, V., Ren, S., and Ishii, H., HandSCAPE: A Vectorizing Tape Measure for On-Site Measuring Applications, in Proceedings of Conference on Human Factors in Computing Systems (CHI '00) , (The Hague, The Netherlands, April 1-6, 2000), ACM Press, pp.137-144
- Yarin, P., and Ishii, H., TouchCounters: Designing Interactive Electronic Labels for Physical Containers (video), in Extended Abstracts of Conference on Human Factors in Computing Systems (CHI '00), (The Hague, The Netherlands, April 1-6, 2000), ACM Press, pp.18-19

Underkoffler, J., Ullmer, B., and Ishii, H., Emancipated Pixels: Real-World Graphics In The Luminous Room , in Proceedings of SIGGRAPH '99 , (Los Angeles, California USA, August 8-13, 1999), ACM Press, pp. 385-392.

Ishii, H., Fletcher, R., Lee, J., Choo, S., Berzowska, J., Wisneski, C., Cano, C., Hernandez, A., and Bulthaupt, C., musicBottles, in Conference Abstracts and Applications of SIGGRAPH '99 , Emerging Technologies, (Los Angeles, California USA, August 8-13, 1999), ACM Press, pp. 174.

Ishii, H., Wisneski, C., Orbanes, J., Chun, B., and Paradiso, J., PingPongPlus: Design of an Athletic-Tangible Interface for Computer-Supported Cooperative Play, in Proceedings of Conference on Human Factors in Computing Systems (CHI '99), (Pittsburgh, Pennsylvania USA, May 15-20, 1999), ACM Press, pp. 394-401.

Yarin, P., and Ishii, H., TouchCounters: Designing Interactive Electronic Labels for Physical Containers, in Proceedings of Conference on Human Factors in Computing Systems (CHI '99), (Pittsburgh, Pennsylvania USA, May 15-20, 1999), ACM Press, pp. 362-369.

Underkoffler, J., and Ishii, H., Urp: A Luminous-Tangible Workbench for Urban Planning and Design, in Proceedings of Conference on Human Factors in Computing Systems (CHI '99), (Pittsburgh, Pennsylvania USA, May 15-20, 1999), ACM Press, pp. 386-393.

Brave, S., Ishii, H. and Dahley, A., Tangible Interfaces for Remote Collaboration and Communication , in Proceedings of CSCW '98, (Seattle, Washington USA, November 1998), ACM Press, pp. 169-178.

Ishii, H. "The Last Farewell": Traces of Physical Presence. interactions 5, 4 (July + August 1998), ACM, pp. 55-56.

Ullmer, B., Ishii, H. and Glas, D., mediaBlocks: Physical Containers, Transports, and Controls for Online Media, in Proceedings of SIGGRAPH '98, (Orlando, Florida USA, July 1998), ACM Press, pp. 379-386.

Gorbet, M., Orth, M. and Ishii, H., Triangles: Tangible Interface for Manipulation and Exploration of Digital Information Topography, in Proceedings of Conference on Human Factors in Computing Systems (CHI '98), (Los Angeles, April 1998), ACM Press, pp. 49-56.

Underkoffler, J. and Ishii, H., Illuminating Light: An Optical Design Tool with a Luminous-Tangible Interface, in Proceedings of Conference on Human Factors in Computing Systems (CHI '98), (Los Angeles, April 1998), ACM Press, pp. 542-549.

Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gorbet, M., Ullmer, B. and Yarin, P., ambientROOM: Integrating Ambient Media with Architectural Space (video), in Summary of Conference on Human Factors in Computing Systems (CHI '98), (Los Angeles, April 1998), ACM Press, pp. 173-174.

Wisneski, C., Orbanes, J. and Ishii, H., PingPongPlus: Augmentation and Transformation of Athletic Interpersonal Interaction (short paper), in Summary of Conference on Human Factors in Computing Systems (CHI '98), (Los Angeles, April 1998), ACM Press, pp. 327-328.

Dahley, A., Wisneski, C. and Ishii, H., Water Lamp and Pinwheels: Ambient Projection of Digital Information into Architectural Space (short paper), in Summary of Conference on Human Factors in Computing Systems (CHI '98), (Los Angeles, April 1998), ACM Press, pp. 269-270.

Wisneski, C., Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B. and Yarin, P., Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information,

in Proceedings of International Workshop on Cooperative Buildings (CoBuild '98), (Darmstadt, Germany, February 1998), Springer Press, pp. 22-32. 1997

Ullmer, B. and Ishii, H., The metaDESK: Models and Prototypes for Tangible User Interfaces, in Proceedings of Symposium on User Interface Software and Technology (UIST '97), (Banff, Alberta, Canada, October, 1997), ACM Press, pp. 223-232.

Gorbet, M. G. and Orth, M., Triangles: Design of a Physical/Digital Construction Kit, in Proceedings of Designing Interactive Systems (DIS '97), (Amsterdam, August 1997), ACM Press, pp. 125-128.

Ishii, H. and Ullmer, B., Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms, in Proceedings of Conference on Human Factors in Computing Systems (CHI '97), (Atlanta, March 1997), ACM Press, pp. 234-241.

Brave, S. and Dahley, A., inTouch: A Medium for Haptic Interpersonal Communication (short paper), in Extended Abstracts of Conference on Human Factors in Computing Systems (CHI '97), (Atlanta, March 1997), ACM Press, pp. 363-364.

Small, D. and Ishii, H., Design of Spatially Aware Graspable Displays, in Extended Abstracts of Conference on Human Factors in Computing Systems (CHI '97), (Atlanta, March 1997), ACM Press, pp. 367-368.