Design of Multimodal Media Systems

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Updates for course notes at
www.icics.ubc.ca/hci/multimodal/
Endowment from IBM, Alias, Wavefront & Gov. of Canada

Research human interaction with rich media
   Technological tools, media, & environs
   Cognition, collaboration and communication tasks

Design of new art, media & technologies
   Fels’ Sound Sculpting, lamascrapes
   National Film Board, Banff New Media Institute, NewMIC
   Commercial projects, spin-off companies and non-profits

Co-evolution of culture, institution, and technology

MAGUS Interdisciplinary graduate specialization
What is the course about?

Interactive media & applications for emerging visual, auditory, & haptic displays

Essential background on multimodal perception

Integration in a design cycle
What will we talk about?

1. Information processing & design
2. Visual channels & systems
3. Information visualization applications
4. Integrating haptic & auditory modalities
5. Implementing multimodal interaction
Why a new approach?

• “Classic” HCI: User/Task/Tool Model
  Theoretical underpinnings
  Cogsci of conscious thought
  Learning, memory, problem solving
  Sequences of operations
  Task, Protocol & GOMS/keystroke analysis
  Command-line, menus, workplace systems

While interaction design can be traced back (at least) to Vannevar Bush 1945 Atlantic Monthly piece *As We May Think*, HC I as an organized discipline began in the late 70s. One SIGSOC, the ACM Social and Behavioral Computing SIG gave “People-oriented Systems: When and How?” the first ACM panel on HCI in 78, leading to the founding of SIGCHI in 82.

Cognitive Science followed a parallel path, Miller of “Magic number 7+2” fame has said that cognitive Science as a discipline began in 1956 at a conference in Cambridge MA. The Cognitive Science Society was founded about the same time as SIGCHI, in 79 in a hotel room at the Kansas City airport (see http://ruccs.rutgers.edu/faculty/cogscitalk/fashions.html) for more on this important meeting.

This was, of course, before the GUI, and the match between the Cogsci theories of mental processing and the limited perceptual support that technology could provide led to a concentration on cognitive HCI-- learning and memory, mental scripts and schemas etc.

For more information on HCI history, please refer to:
http://sigchi.org/bulletin/1996.1/
http://www-2.cs.cmu.edu/~amulet/papers/uithistory.tr.html
Classic HCI reaches its limits

4 usability labs test same software
(Molich)

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Poor agreement on individual problems

A number of studies by Rolf Molich have documented the poor reproducability of user studies of the same software in difference labs. It can be argues that HCI methodologies have failed to ‘scale up’ to dealing with the more complex applications of today. This course addresses some possible causes and solutions.
As computer interfaces become more immersive and ubiquitous, bottlenecks in performance shift from limitations in cognitive processing to perception, intersensory integration and embodied interaction.
Bill Buxton was kind enough to give me permission to use his slide from last year’s SIGGRAPH. It shows a plot of development effort (and I will suggest, HCI effort) versus growth for different sizes of displays. The mass of our efforts are in the region that applies to desktop systems, yet the opportunities are elsewhere. Bill suggested that the linear scale was in some ways misleading, since the interaction of small and large devices and displays would be an increasingly important aspect of their use.

We suggest that sound, haptics and other modalities of interaction are also growth areas that are not receiving the level of attention that they deserve.
The new computer graphics

Range of display sizes

Networked display & control devices

Increasingly multimodal interactive graphics

Need knowledge of multimodal perception & attention

Must integrate in design/build/test cycle
One casualty of the move to more complex interactive environments that “download” processing to perceptual systems may be the basic spiral model of software development. The larger design space of multimodal and immersive environments makes the design stage more difficult-- if designers themselves lack valid intuitions about the impact of their designs on users’ perceptual systems how can they design them effectively? Similarly, what constitutes a test of the perceptual interaction of a given design?
Limits of designers’ intuition

About thoughts, goals & plans?
- Accurate
About vision, hearing, attention & memory?
- Very inaccurate
Design-by-intuition fails
Lack of awareness of the limits of intuition is the

Metacognitive Gap

Fisher: Sensory Channels

Yet, our ability to intuitively understand the performance characteristics of our perceptual system is poor at best.
Moore’s law and human evolution

- Transistor density doubles every 24 months
- Disk density doubles every 12 months
- Brain volume doubles every $3 \times 10^7$ months

Fisher: Sensory Channels
Example of metacognitive gap

- **Intuition**: Single mental processor
- **Cognitive Science**: Modular processing systems operate in parallel.
  - Restricted flow of information and control
  - Processing characteristics are counterintuitive

The term “User illusion” originated at Xerox PARC to describe the illusion created for user i.e. the visual metaphor of the desktop GUI. We have an alternative User Illusion now-- the illusion that there is a unitary user at all

Modularity suggests the intuition of a single mind is itself illusory.
In addition, there is a great deal of evidence that suggests that much of the processing that takes place at the perceptual level is contained within a number of modular perceptual processes. These operate in parallel over the same information, often combining multiple sensory channels in ways that are neither accessible to consciousness nor able to communicate with the other systems processing the same stimuli.
The 2 gulfs of multimodal design

- **Gulf of design:** How to constrain the very large multimodal design space?
- **Gulf of assessment:** How to test user perception, intersensory integration and embodied interaction?

Dealing with the perceptual and attentive bottlenecks is a challenge:
Institutionally, in that most of the people who understand human perception and attention are in different academic departments and faculties and are rarely found in the private sector.
Culturally, in that the language and goals of perceptual researchers are different than designers
Administratively, in the university, since perceptual researchers are hired, promoted, and tenured on the basis of publications of findings about human characteristics and not support for successful interfaces.
Procedurally, in that there is no current software engineering/design model that is user-centred at the level of perception/attentional bottlenecks.
Multimodal development cycle

Design for key sensory & motor systems

Walkthrough or experiment

Implement prototype

Assess specific aspects of interaction

Literature
Foraging:
HCI & graphics
Psychology
Kinesiology
Sociology
Architecture...

One casualty of the move to more complex interactive environments that “download” processing to perceptual systems may be the basic spiral model of software development. The larger design space of multimodal and immersive environments makes the design stage more difficult— if designers themselves lack valid intuitions about the impact of their designs on users’ perceptual systems how can they design them effectively? Similarly, what constitutes a test of the perceptual interaction of a given design?
Bridging the 2 Gulfs

- **Gulf of design:** Provide a “tool chest” of MM perception/action phenomena for designers
- **Gulf of assessment:** Research methods can be adapted for user testing of MM perception/action

**Goal is informed craft**

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**Administratively,** in the university, since perceptual researchers are hired, promoted, and tenured on the basis of publications of findings about global models of human characteristics and not support for successful interaction with a specific user population or customized for a single user.

**Procedurally,** in that there is no current software engineering/design model that is user-centred at the level of perception/attentional bottlenecks.
Design of Interactive Multimodal Media Systems Schedule

• 1:45 Welcome and course overview: (Fisher)
  – Perspectives on design

• 2:00 Attentional & nonattentional processes in vision (Rensink)
  – “At-a-glance” displays, Change blindness, Attentional processes
  – Constraints on dynamic visual displays, nonconscious perception

• 2:50 Application to information visualization part 1 (Munzner)
  – Visual encoding
  – Space and dimensionality

• 3:15 BREAK
Design of Interactive Multimodal Media Systems Schedule

- **3:30 Application to information visualization II (Munzner)**
  - Glyphs and abstraction
  - Aggregation
- **3:55 Intersensory interactions: (Fisher)**
  - Information integration, dynamics of multimodal processing
  - Multimodal events and sensory fusion: Vision, hearing, haptics
- **4:40 Application to virtual environments & exotic interfaces (Fels)**
  - Communicating human experience: information, emotion, environment
  - Displays
  - Biopotentials
  - Virtual environments
  - Intimacy and embodiment
  - Automatic behaviour
  - Sources of aesthetics
  - Design examples
Our inability to intuitively understand perceptual phenomena can be traced to the structure of thought, otherwise known as the Cognitive Architecture of processing. This structure makes clear the limitations in the flow of information from low-level perceptual processes to cognition and to action. In particular the inability of conscious thought to influence perceptual operations is known as “cognitive impenetrability”. It is also the case that much of the processes that take place in the perceptual stage are hidden from conscious thought.
Key Points for HCI Practice

The Metacognitive Gap: The need for a grounded Cognitive Science approach
Reflective design practice methods
  Integrating CogSci with interaction design
  Iterative design cycle
Examples of extended HCI
  Cognitive architecture: Multimodal displays and how they are understood
  Situated cognition: embodied interaction with complex displays

The critical point to understand here is something that I have been calling the “metacognitive gap”. While our intuitions can help us to explain other’s behaviour, and introspection can help us to understand our own beliefs, goals and intentions, there is no corresponding mechanism to naturally understand our perceptual and attentive processes. These require a research approach.
More of the Molich data. Here looking at problems found by multiple different HCI groups examining the same software. It shows that there is very poor agreement on individual problems.
Intended audience for this course

People involved in the design of interactive media and applications for emerging computer graphics display technologies
People looking for the essential background on multimodal perception
People interested in how to integrate these constraints into the design process
Course Design

- Dr. Sidney Fels, Associate Professor, Dept. of Electrical & Computer Engineering, UBC Ph.D. and M.Sc., Computer Science, University of Toronto; B.A.Sc., Electrical Engineering, University of Waterloo.
- Dr. Brian Fisher, Associate Director, UBC Media and Graphics Interdisciplinary Centre (MAGIC), Ph.D. Experimental Psychology, Univ. of California at Santa Cruz, B.A. Biology Hiram College.
- *Dr. Karon Maclean, Assistant Professor, UBC Department of Computer Science, Ph.D. and M.Sc., Mechanical Engineering, Massachusetts Institute of Technology; B.Sc., Biological Sciences & Mechanical Engineering, Stanford University
- Dr. Tamara Munzner, Assistant Professor, UBC Department of Computer Science; Ph.D and B.S. Computer Science, Stanford University