UNIVERSITY OF TORONTO SCARBOROUGH

Lecture 9:
Experimental Design
Interfaces, Navigation & Devices - Part 1 & 2

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Administrivia

- Project:
  - P3 – Peer Evaluations (Due: Friday, July 15)
  - P4 - 15% (Usability Evaluation, Data Analysis, Final Report, 10 min Presentation)
    - Presentation Schedule – coming soon (Aug 4, 5, 9, 10)
    - Report Due – Aug 10
- Assignment 3: Due: July 15
- Tutorial next two weeks – P4 Usability Testing
- Any Questions?

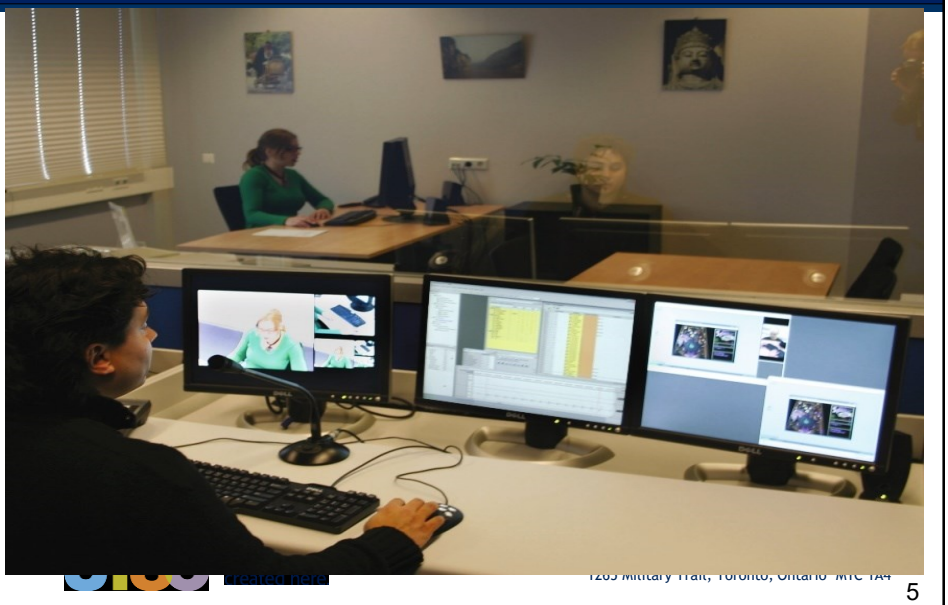
Final Exam

Monday, August 22, 2022
9:00 – 11:00 AM (EST)
In-Person
MW 170

Experimental Design

- Usability Testing
- Experiments
- Field Studies

Recall



Usability Testing

- Involves recording performance of typical users doing typical tasks.
- Controlled settings.
- Users are observed and timed.
- Data is recorded on video & key presses are logged.
- The data is used to calculate performance times, and to identify & explain errors.
- User satisfaction is evaluated using questionnaires & interviews.
- Field observations may be used to provide contextual understanding.

Testing Conditions

- Usability lab or other controlled space.
- Emphasis on:
  - selecting representative users;
  - developing representative tasks.
- 5-10 users typically selected.
- Tasks usually around 30 minutes
- Test conditions are the same for every participant.
- Informed consent form explains procedures and deals with ethical issues.

Types of Data

- Time to complete a task.
- Time to complete a task after a specified time away from the product.
- Number and type of errors per task.
- Number of errors per unit of time.
- Number of times online help and manuals accessed.
- Number of users making an error.
- Number of users successfully completing a task.
- Number of clicks

Usability Testing: The iPad

- 7 participants with 3+ months experience with iPhones
- Signed an informed consent form explaining:
  - what the participant would be asked to do;
  - the length of time needed for the study;
  - the compensation that would be offered for participating;
  - participants' right to withdraw from the study at any time;
  - a promise that the person's identity would not be disclosed; and
  - an agreement that the data collected would be confidential and would be available to only the evaluators
- Then they were asked to explore the iPad
- Next they were asked to perform randomly assigned specified tasks

Examples of the Tasks

App or website	Task
iBook	Download a free copy of *Alice's Adventures in Wonderland* and read through the first few pages.
Craigslist	Find some free mulch for your garden.
eBay	You want to buy a new iPad on eBay. Find one that you could buy from a reputable seller.
Time Magazine	Browse through the magazine and find the best pictures of the week.
Epicurious	You want to make an apple pie for tonight. Find a recipe and see what you need to buy in order to prepare it.
Kayak	You are planning a trip to Death Valley in May this year. Find a hotel located in the park or close to the park.

Table 14.1 Examples of some of the tests used in the iPad evaluation (adapted from Budiu and Nielsen, 2010).

Source: Copyright Nielsen Norman Group, from report available at http://www.nngroup.com/reports/.

Example of the equipment

Figure 14.6 The setup used in the Chicago usability testing sessions

Source: Copyright Nielsen Norman Group, from report available at http://www.nngroup.com/reports/.

Problems & Actions

- Problems detected:
  - Accessing the Web was difficult
  - Lack of affordance and feedback
  - Getting lost
  - Knowing where to tap
- Actions by evaluators:
  - Reported to developers
  - Made available to public on nngroup.com
- Accessibility for all users important

Discussion Questions

1. Was the selection of participants for the iPad study appropriate?

2. What might have been the problems with asking participants to think out aloud as they complete the task.

Experiments

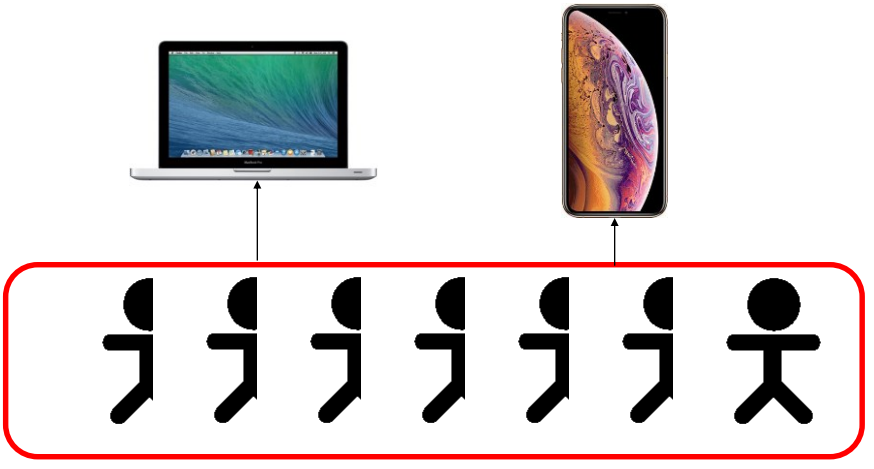
- Test hypothesis
- Predict the relationship between two or more variables.
- Independent variable is manipulated by the researcher.
- Dependent variable influenced by the independent variable.
- Typical experimental designs have one or two independent variables.
- Validated statistically & replicable.

Experimental Designs

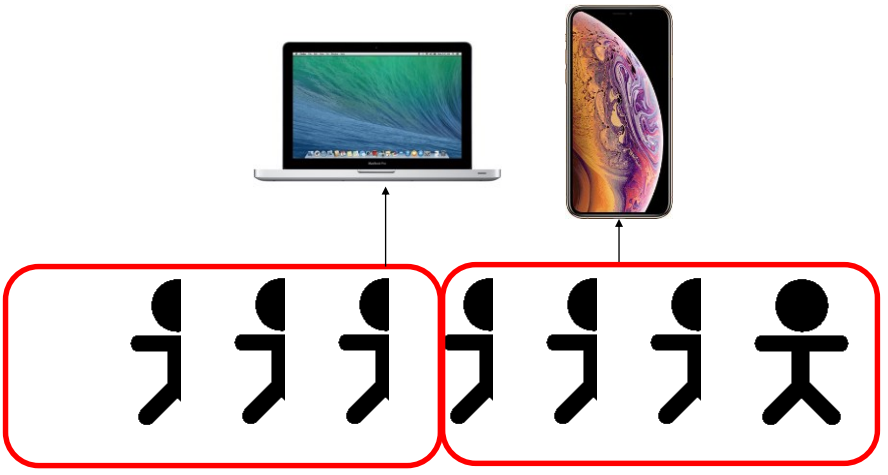
Different participants (Between-Subject Design)- single group of participants is allocated randomly to the experimental conditions.

Same participants (Within-Subject Design) - all participants appear in both conditions.

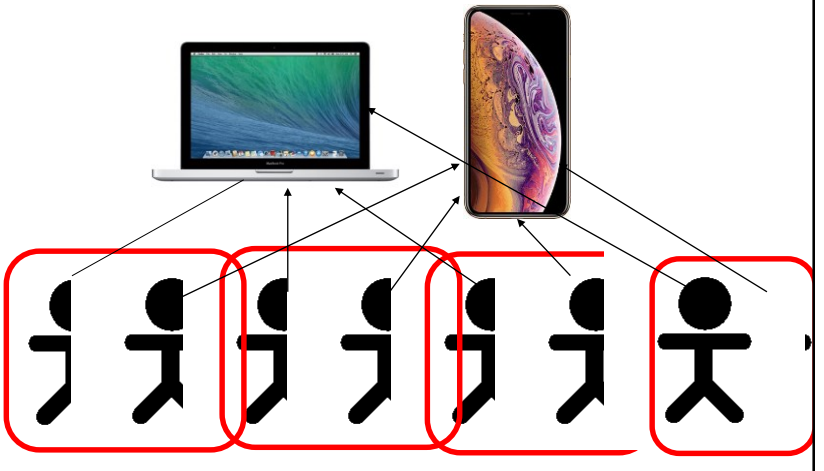
Matched participants (Pair-Wise Design) - participants are matched in pairs, e.g., based on expertise, gender, etc.



Within-Subject Experiment



Between-Subject Experiment



Matched Pair Wise Experiment

Different, Same, Matched - Design

Design	Advantages	Disadvantages
Different (Between-Subject)	No order effects	Many subjects & individual differences a problem
Same (Within-Subject)	Few individuals, no individual differences	Counter-balancing needed because of ordering effects
Matched (Pair-Wise)	Same as different participants but individual differences reduced	Cannot be sure of perfect matching on all differences

Usability Testing vs. Experiments

Usability testing

- Improve products
- Few participants
- Results inform design
- Usually not completely replicable
- Conditions controlled as much as possible
- Procedure planned
- Results reported to developers

Experiments for research

- Discover knowledge
- Many participants
- Results validated statistically
- Must be replicable
- Strongly controlled conditions
- Experimental design
- Scientific report to scientific community

Field Studies

- Field studies are done in natural settings.
- "In the wild" is a term for prototypes being used freely in natural settings.
- Aim to understand what users do naturally and how technology impacts them.
- Field studies are used in product design to:
  - identify opportunities for new technology;
  - determine design requirements;
  - decide how best to introduce new technology;
  - evaluate technology in use.

An in the wild study: UbiFit Garden

Figure 14.8 UbiFit Garden's glanceable display: (a) at the beginning of the week (small butterflies indicate recent goal attainments; the absence of flowers means no activity this week); (b) a garden with workout variety; (c) the display on a mobile phone (the large butterfly indicates this week's goal was met)

Source: From Consolvo, S., McDonald, D.W., Toscos, T. *et al* (2008) "Activity sensing in the wild: a field trial of UbiFit garden". In: *Proceedings of CHI 2008*, ACM Press, New York, p. 1799.

Key points

Usability testing takes place in controlled usability labs or temporary labs, focuses on performance measures, eg. how long and how many errors are made when completing a set of predefined tasks. Indirect observation (video and keystroke logging), user satisfaction questionnaires and interviews are also collected.

Affordable, remote testing systems are more portable than usability labs. Many also contain mobile eye-tracking and other devices.

Experiments test a hypothesis by manipulating certain variables while keeping others constant.

The experimenter controls independent variable(s) in order to measure dependent variable(s).

Field studies are evaluation studies that are carried out in natural settings to discover how people interact with technology in the real world.

Field studies that involve the deployment of prototypes or technologies in natural settings may also be referred to as ‘in the wild’.

Next …

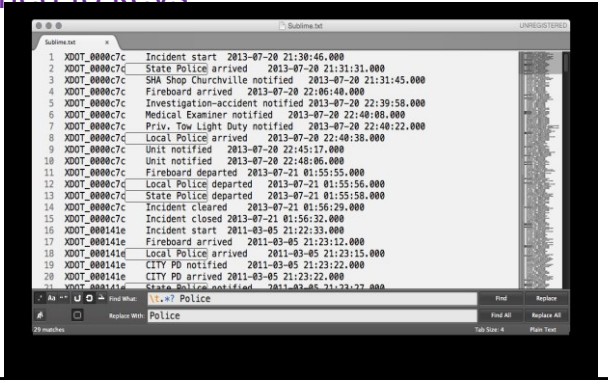
Interfaces (ID: Ch. 6)

- Design and research issues for different interfaces

1. Command-based	9. Pen
2. WIMP & GUI	10. Touch
3. Multimedia	11. Air Based Gesture
4. Information Visualization & Dashboards	12. Multi-modal
5. Web	13. Shareable
6. Consumer Electronics & Appliances	14. Virtual Reality
7. Mobile	15. Augmented Reality
8. Speech	16. Wearables
	17. Robots and Drones

1. Command-based

- Commands such as abbreviations (e.g. ls) typed in at the prompt to which the system responds (e.g. listing current files)
- Some are hard wired at keyboard, others can be assigned to keys



1. Command-based (cont'd)

- **What are some of the advantages?**
  - Efficient, precise, and fast
- **What are some of the disadvantages?**
  - Large overhead to learning set of commands

Example

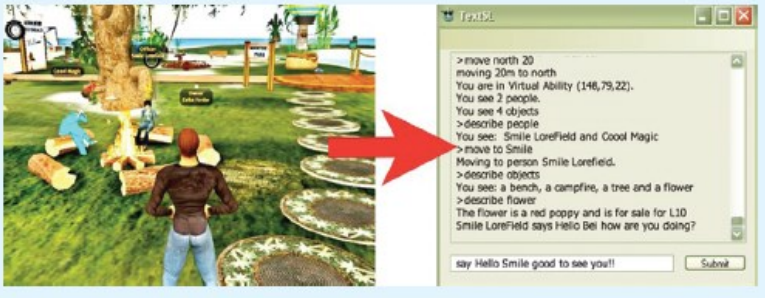


Figure 6.1 Second Life command-based interface for visually impaired users

Source: Reproduced with permission from http://www.eelke.com/images/textsl.jpg.

https://youtu.be/0Ba_w7u44MM

What could be some of the research and design issues?

- Form, name types and structure are key research questions
- Consistency is most important design principle
  - e.g. always use first letter of command
- Command interfaces popular for web scripting

2. WIMP and GUI

- Xerox Star first WIMP -> rise to GUIs
- Windows
  - could be scrolled, stretched, overlapped, opened, closed, and moved around the screen using the mouse
- Icons
  - represented applications, objects, commands, and tools that were opened when clicked on
- Menus
  - offering lists of options that could be scrolled through and selected
- Pointing device
  - a mouse controlling the cursor as a point of entry to the windows, menus, and icons on the screen

GUIs

- Same basic building blocks as WIMPs but more varied
  - Color, 3D, sound, animation,
  - Many types of menus, icons, windows
- New graphical elements, e.g.
  - toolbars, docks, rollovers
- Challenge now is to design GUIs that are best suited for tablet, smartphone and smartwatch interfaces

Windows

- Windows were invented to overcome physical constraints of a computer display
  - enable more information to be viewed and tasks to be performed
- Scroll bars within windows also enable more information to be viewed
- Multiple windows can make it difficult to find desired one
  - listing, iconising, shrinking are techniques that help

An example

Figure 6.2 The boxy look of the first generation of GUIs. The window presents several check boxes, notes boxes, and options as square buttons

Source: Mullet, Kevin; Sano, Darrell, *Designing Visual Interfaces: Communication Oriented Techniques*, 1st, © 1995. Reproduced by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.

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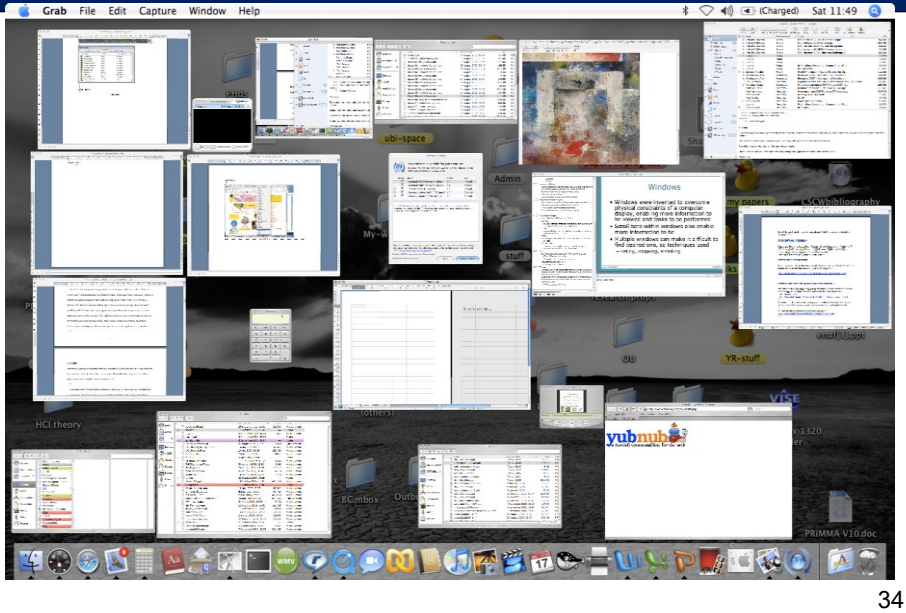
Apple Shrinking Windows



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Safari Panoramic Windows View

Figure 6.3 A window management technique provided in Safari: pressing the 4×3 icon in the top left corner of the bookmarks bar displays the 12 top sites visited, by shrinking them and placing them side by side. This enables the user to see them all at a glance and be able to rapidly switch between them

What are some of the research and design issues?

- Window management
  - enables users to move fluidly between different windows (and monitors)
- How to switch attention between windows without getting distracted
- Design principles of spacing, grouping, and simplicity should be used

Menus

- A number of menu interface styles
  - flat lists, drop-down, pop-up, contextual, and expanding ones, e.g., scrolling and cascading
- Flat menus
  - good at displaying a small number of options at the same time and where the size of the display is small, e.g. iPods
  - but have to nest the lists of options within each other, requiring several steps to get to the list with the desired option
  - moving through previous screens can be tedious

Expanding Menus

- Enables more options to be shown on a single screen than is possible with a single flat menu
- More flexible navigation, allowing for selection of options to be done in the same window
- Most popular are cascading ones
  - primary, secondary and even tertiary menus
  - downside is that they require precise mouse control
  - can result in overshooting or selecting wrong options

Cascading Menus

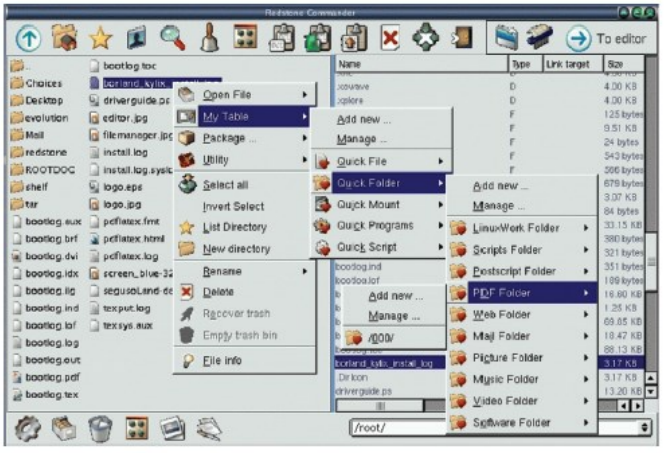


Figure 6.7 A cascading menu

Contextual Menus

- Provide access to often-used commands that make sense in the context of a current task
- Appear when the user presses the Control key while clicking on an interface element
  - e.g., clicking on a photo in a website together with holding down the Control key results in options ‘open it in a new window,’ ‘save it,’ or ‘copy it’
- Helps overcome some of the navigation problems associated with cascading menus

Scrolling Menu

Figure 6.4 A scrolling menu

Source: Screenshot of Camino browser, ©The Camino Project.

Is this method any better?

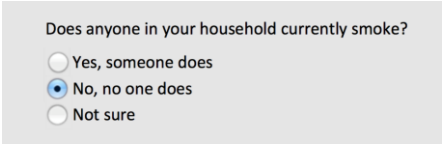
F	G	H	I	J
Fiji	Gabon	Haiti	Iceland	Jamaica
Finland	Germany	Holland	India	Japan
France	Gibraltar	Honduras	Indonesia	Jordan
French Guyana	Greece	Hong Kong	Iran	
French Polynesia	Greenland	Hungary	Ireland	
	Guadeloupe		Israel	
	Guam		Italy	
	Guatemala		Ivory Coast	

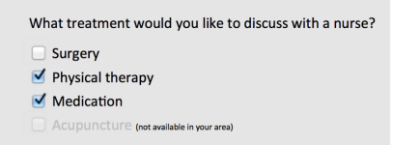
Figure 6.5 An excerpt of the listing of countries in alphabetical order from interflora.co.uk

Source: www.interflora.co.uk. Reproduced with permission.

Navigation by Selection

Radio Buttons and Checkboxes





What are some of the research and design issues?

- What are best names/labels/phrases to use?
- Placement in list is critical
  - Quit and save need to be far apart
- Choice of menu to use determined by application and type of system
  - flat menus are best for displaying a small number of options at one time
  - expanding menus are good for showing a large number of options

Icon Design

- Icons are assumed to be easier to learn and remember than commands
- Can be designed to be compact and variably positioned on a screen
- Now pervasive in every interface
  - e.g. represent desktop objects, tools (e.g. paintbrush), applications (e.g. web browser), and operations (e.g. cut, paste, next, accept, change)

Icons

- Since the Xerox Star days icons have changed in their look and feel:
  - black and white -> color, shadowing, photorealistic images, 3D rendering, and animation
- Many designed to be very detailed and animated making them both visually attractive and informative
- GUIs now highly inviting, emotionally appealing, and feel alive

Icon Forms

- The mapping between the representation and underlying referent can be:
  - similar (e.g., a picture of a file to represent the object file)
  - analogical (e.g., a picture of a pair of scissors to represent 'cut)
  - arbitrary (e.g., the use of an X to represent 'delete')
- Most effective icons are similar ones
- Many operations are actions making it more difficult to represent them
  - use a combination of objects and symbols that capture the salient part of an action

Early Icons

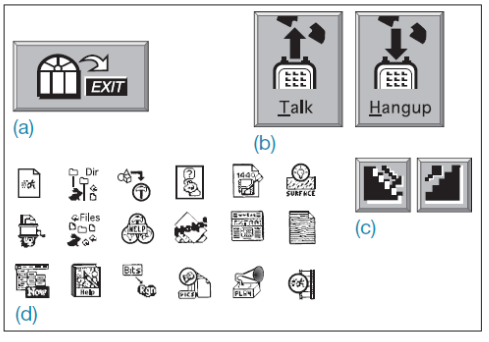


Figure 6.9 Poor icon set from the early 1990s. What do you think they mean and why are they so bad?

Source: K. Mullet and D. Sano: "Designing Visual Interfaces" Pearson 1995, reproduced with permission of Pearson Education.

Newer Icons

What are some of the research and design issues?

- There is a wealth of resources now so do not have to draw or invent new icons from scratch
  - guidelines, style guides, icon builders, libraries
- Text labels can be used alongside icons to help identification for small icon sets
- For large icon sets (e.g. photo editing or word processing) use rollovers

3. Multimedia

- Combines different media within a single interface with various forms of interactivity
  - graphics, text, video, sound, and animations
- Users click on links in an image or text
  -> another part of the program
  -> an animation or a video clip is played
  -> can return to where they were or move on to another place

Bioblast Multimedia Learning Env.

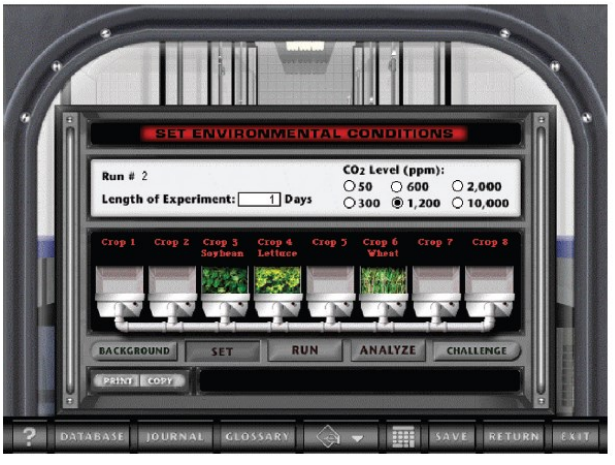


Figure 6.14 Screen dump from the multimedia environment BioBLAST
Source: Screenshot from BioBlast, ©Wheeling Jesuit University.

Pros and Cons

- Facilitates rapid access to multiple representations of information
- Can provide better ways of presenting information than can any media alone
- Can enable easier learning, better understanding, more engagement, and more pleasure
- Can encourage users to explore different parts of a game or story
- Tendency to play video clips and animations, while skimming through accompanying text or diagrams

Research and Design Issues?

- How to design multimedia to help users explore, keep track of, and integrate the multiple representations
  - provide hands-on interactivities and simulations that the user has to complete to solve a task
  - Use 'dynalinking,' where information depicted in one window explicitly changes in relation to what happens in another (Scaife and Rogers, 1996).
- Several guidelines that recommend how to combine multiple media for different kinds of task

4. Information Visualization & Dashboards

- Computer-generated interactive graphics of complex data
- Amplify human cognition, enabling users to see patterns, trends, and anomalies in the visualization (Card *et al,* 1999)
- Aim is to enhance discovery, decision-making, and explanation of phenomena
- Techniques include:
  - 3D interactive maps that can be zoomed in and out of and which present data via webs, trees, clusters, scatterplot diagrams, and interconnected nodes

More on this in "Lec 11" – Information search and visualization.

Dashboards

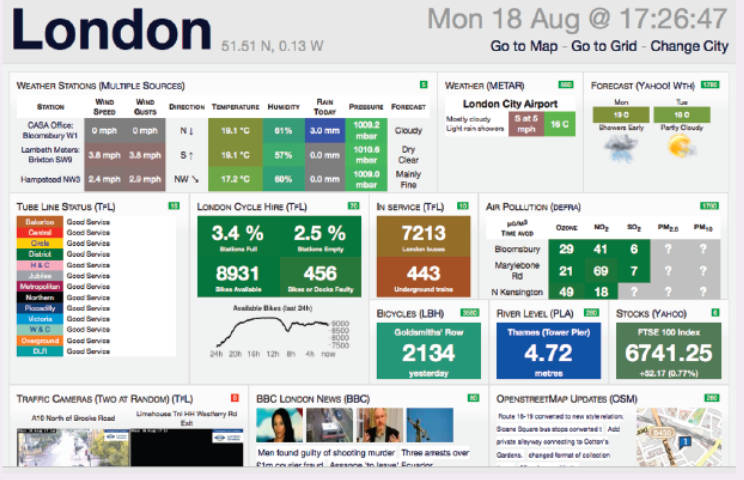
- Show screenshots of data updated over periods of time - to be read at a glance
- Usually not interactive - slices of data that depict current state of a system or process
- Need to provide digestible and legible information for users
  - design its spatial layout so intuitive to read when first looking at it
  - should also direct a user's attention to anomalies or unexpected deviations

Which Dashboard is best?

(a)

Figure 6.18 Screenshots from two dashboards: (a) British Airways frequent flier club that shows how much a member has flown since joining them, and (b) London City that provides various information feeds. Which is the easier to read and most informative?

Which Dashboard is best?



(b)

Research and Design Issues?

- Whether to use animation and/or interactivity
- What form of coding to use, e.g. color or text labels
- Whether to use a 2D or 3D representational format
- What forms of navigation, e.g. zooming or panning,
- What kinds and how much additional information to provide, e.g. rollovers or tables of text
- What navigational metaphor to use

5. Web

- Early websites were largely text-based, providing hyperlinks
- Concern was with how best to structure information to enable users to navigate and access it easily and quickly
- Nowadays, more emphasis on making pages distinctive, striking, and pleasurable
- Need to think of how to design information for multi-platforms - keyboard or touch?
  - e.g. smartphones, tablets, PCs

Usability versus attractive?

- Vanilla or multi-flavor design?
  - Ease of finding something versus aesthetic and enjoyable experience
- Web designers are:
  - “thinking great literature”
- Users read the web like a:
  - “billboard going by at 60 miles an hour” (Krug, 2000)
- Need to determine how to brand a web page to catch and keep ‘eyeballs’

In your face-ads

- Web advertising is often intrusive and pervasive
- Flashing, aggressive, persistent, annoying
- Often need to be ‘actioned’ to get rid of

Research and Design Issues?

- Need to consider how best to design, present, and structure information and system behavior
- But also content and **navigation** are central
- Veen's (2001) design principles

  (1) Where am I?

  (2) Where can I go?

  (3) What's here?

6. Consumer Electronics and Appliances

- Everyday devices in home, public place, or car
  - e.g. washing machines, remotes, photocopiers, printers and navigation systems)
- And personal devices
  - e.g. MP3 player, digital clock and digital camera
- Used for short periods
  - e.g. putting the washing on, watching a program, buying a ticket, changing the time, taking a snapshot
- Need to be usable with minimal, if any, learning

A Toaster

Figure 6.19 A typical toaster with basic physical controls

Smart Refrigerator

http://www.forbes.com/sites/michaelkanellos/2016/01/13/hold-the-laughter-why-the-smart-fridge-is-a-great-idea/#784c11dc56f5

Research and Design Issues

- Need to design as transient interfaces with short interactions
- Simple interfaces
- Consider trade-off between soft and hard controls
  - e.g. buttons or keys, dials or scrolling

7. Mobile

- Handheld devices intended to be used while on the move
- Have become pervasive, increasingly used in all aspects of everyday and working life
- Apps running on mobiles have greatly expanded, e.g.
  - used in restaurants to take orders
  - car rentals to check in car returns
  - supermarkets for checking stock
  - in the streets for multi-user gaming
  - in education to support life-long learning

Mobile Challenges

- Smaller screens, small number of physical keys and restricted number of controls
- Innovative physical designs including:
  - roller wheels, rocker dials, up/down 'lips' on the face of phones, 2-way and 4-way directional keypads, softkeys, silk-screened buttons
- Usability and preference varies
  - depends on the dexterity and commitment of the user
- Smartphones overcome mobile physical constraints through using multi-touch displays

Small Screen Displays - Challenges

- Small devices have very focused functionalities and few selectable areas.
- Discoverability is often an issue

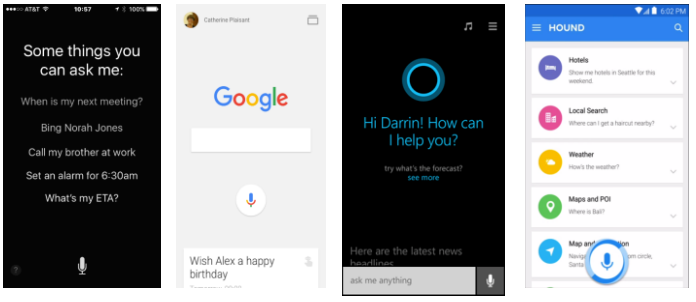
Research and Design Issues?

- Mobile interfaces can be tricky and cumbersome to use for those with poor manual dexterity or ‘fat’ fingers
- Key concern is hit area
  - area on the phone display that the user touches to make something happen, such as a key, an icon, a button or an app
  - space needs to be big enough for fat fingers to accurately press
  - if too small the user may accidentally press the wrong key

8. Speech

- Where a person talks with a system that has a spoken language application, e.g. timetable, travel planner
- Used most for inquiring about very specific information, e.g. flight times or to perform a transaction, e.g. buy a ticket
- Also used by people with disabilities
  - e.g. speech recognition word processors, page scanners, web readers, home control systems

Designing spoken interaction



- Mobile devices assistants (from left to right: Siri, GoogleNow, Cortana and Hound) all have similar microphone buttons, but different ways of presenting suggestions

Research & Design Issues?

- How to design systems that can keep conversation on track
  - help people navigate efficiently through a menu system
  - enable them to easily recover from errors
  - guide those who are vague or ambiguous in their requests for information or services
- Type of voice actor (e.g. male, female, neutral, or dialect)
  - do people prefer to listen to and are more patient with a female or male voice, a northern or southern accent?

Break (10 min)

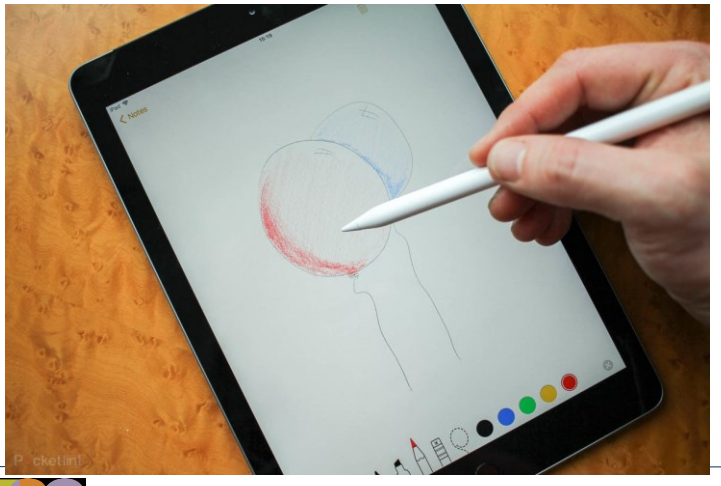
The plan for today is …

Interfaces (ID: Ch. 6)

- Design and research issues for different interfaces

1. Command-based	**9. Pen**
2. WIMP & GUI	**10. Touch**
3. Multimedia	**11. Air Based Gesture**
4. Information Visualization & Dashboards	**12. Multi-modal**
5. Web	**13. Shareable**
6. Consumer Electronics & Appliances	**14. Virtual Reality**
7. Mobile	**15. Augmented Reality**
8. Speech	**16. Wearables**
	17. Robots and Drones

9. Pen



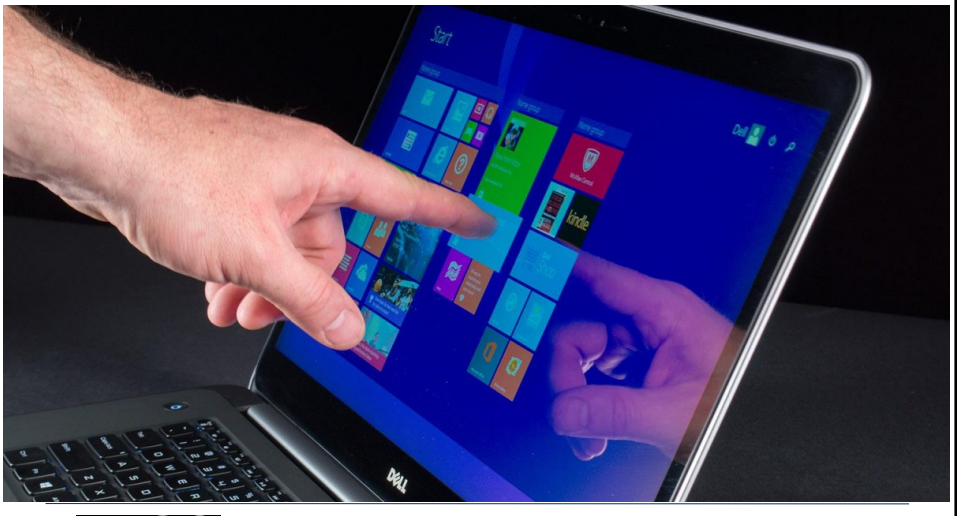
9. Pen

- Enable people to write, draw, select, and move objects at an interface using lightpens or styluses
  - capitalize on the well-honed drawing skills developed from childhood
- Digital pens, e.g. Anoto, use a combination of ordinary ink pen with digital camera that digitally records everything written with the pen on special paper

Pros and Cons

- Allows users to quickly and easily annotate existing documents
- Can be difficult to see options on the screen because a user's hand can occlude part of it when writing
- Can have lag and feel clunky

10. Touch

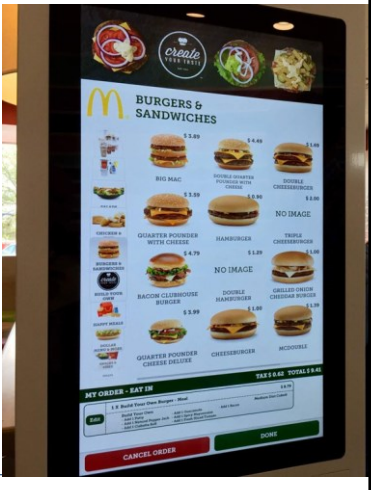


10. Touch

- Touch screens, such as walk-up kiosks, detect the presence and location of a person's touch on the display
- Multi-touch support a range of more dynamic finger tip actions, e.g. swiping, flicking, pinching, pushing and tapping
- Now used for many kinds of displays, such as Smartphones, iPods, tablets and tabletops

Research and design issues

- Core design concerns include whether size, orientation, and shape of touch displays effect collaboration
- Much faster to scroll through wheels, carousels and bars of thumbnail images or lists of options by finger flicking
- More cumbersome, error-prone and slower to type using a virtual keyboard on a touch display than using a physical keyboard



11. Air Based Gestures

- Uses camera recognition, sensor and computer vision techniques
  - can recognize people's body, arm and hand gestures in a room
  - systems include Kinect
- Movements are mapped onto a variety of gaming motions, such as swinging, bowling, hitting and punching
- Players represented on the screen as avatars doing same actions

11. Air Based Gestures

Gestures in the Operating Theatre

- A touchless system that recognizes gestures
- Surgeons can interact with and manipulate MRI or CT images
  - e.g. two-handed gestures for zooming and panning

Figure 6.25 Touchless gesturing in the operating theater
Source: Courtesy of Kenton O'Hara, Microsoft.

Research and design issues

- How does computer recognize and delineate user's gestures?
  - Deictic and hand waving
- Does holding a control device feel more intuitive than controller free gestures?
  - For gaming, exercising, dancing

12. Multi-Modal

- Meant to provide enriched and complex user experiences
  - multiplying how information is experienced and detected using different modalities, i.e. touch, sight, sound, speech
  - support more flexible, efficient, and expressive means of human–computer interaction
  - Most common is speech and vision

Research and design issues

- Need to recognize and analyse speech, gesture, and eye gaze
- What is gained from combining different input and outputs
- Is talking and gesturing, as humans do with other humans, a natural way of interacting with a computer?

13. Shareable

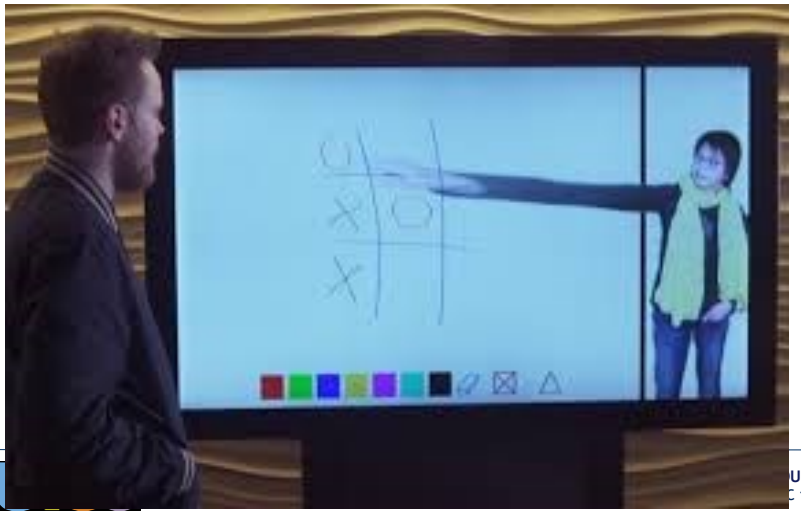
- Shareable interfaces are designed for more than one person to use
  - provide multiple inputs and sometimes allow simultaneous input by co-located groups
  - large wall displays where people use their own pens or gestures
  - interactive tabletops where small groups interact with information using their fingertips
  - e.g. DiamondTouch, Smart Table and Surface

A Smartboard

(a)

ImmerseBoard

ImmerseBoard allows two users to be co-located and work on the same shared screen



DiamondTouch Tabletop

(b)

igure 6.27 (a) A SmartBoard in use during a meeting and (b) Mitsubishi's interactive tabletop inter-ace, where collocated users can interact simultaneously with digital content using their fingertips

ource: (a) ©2006 SMART Technologies Inc. Used with permission. (b) Image courtesy of Mitsubishi Electric esearch Labs.

Another tabletop touch device

- Three users working concurrently on a large tabletop touch device.
  - They can use their hands and fingers to manipulate the objects on the device
  - Note the use of the different hand gestures

Advantages

- Provide a large interactional space that can support flexible group working
- Can be used by multiple users
  - Can point to and touch information being displayed
  - Simultaneously view the interactions and have same shared point of reference as others
- Can support more equitable participation compared with groups using single PC

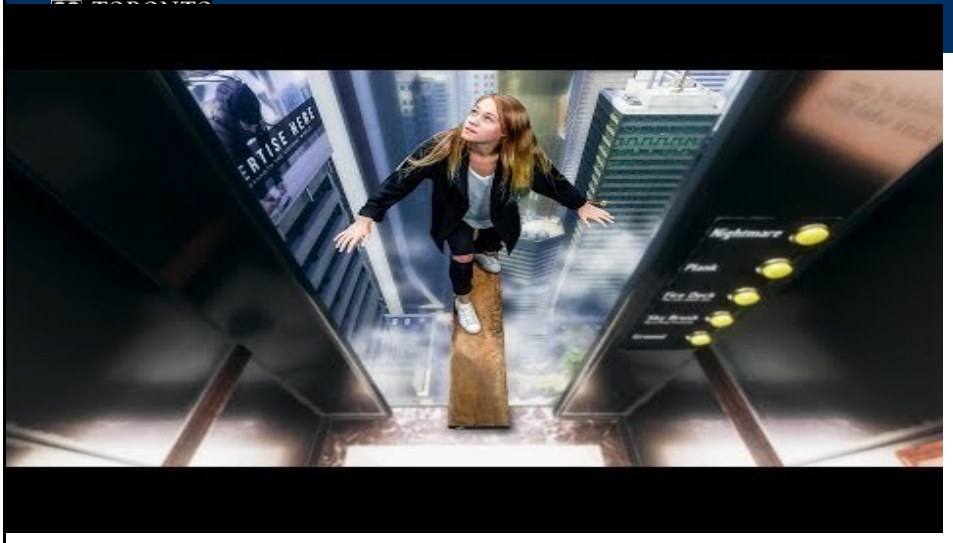
Research and design issues

- Core design concerns include whether size, orientation, and shape of the display have an effect on collaboration
- Horizontal surfaces compared with vertical ones support more turn-taking and collaborative working in co-located groups
- Providing larger-sized tabletops does not improve group working but encourages more division of labor

14. Virtual Reality

- Computer-generated graphical simulations providing:
  - "the illusion of participation in a synthetic environment rather than external observation of such an environment" (Gigante, 1993)
- Provide new kinds of experience, enabling users to interact with objects and navigate in 3D space
- Create highly engaging user experiences

Source: http://blogs.unimelb.edu.au/learning-environments-virtual-reality-research-and-development-lab/comment-page-1/



University of Toronto Student Delivers First Virtual Reality Biochemistry Lecture

Tweet Share G+ Save

Dec 11, 2017

Author: Heidi Singer

A University of Toronto graduate student is believed to be the first to use virtual reality in a biochemistry research lecture — allowing audience members to immerse themselves in 3D to better understand how the eye uses light to create vision.

Pros and Cons

- Can have a higher level of fidelity with objects they represent compared to multimedia
- Induces a sense of presence where someone is totally engrossed by the experience
  - "a state of consciousness, the (psychological) sense of being in the virtual environment" (Slater and Wilbur, 1999)
- Provides different viewpoints: 1st and 3rd person
- Head-mounted displays are uncomfortable to wear, and can cause motion sickness and disorientation

Research and Design Issues?

- Much research on how to design safe and realistic VRs to facilitate training
  - e.g. flying simulators
  - help people overcome phobias (e.g. spiders, talking in public)
- Design issues
  - how best to navigate through them (e.g. first versus third person)
  - how to control interactions and movements (e.g. use of head and body movements)
  - how best to interact with information (e.g. use of keypads, pointing, joystick buttons);
  - level of realism to aim for to engender a sense of presence

iTurk: Turning Passive Haptics into Active Haptics by Making Users Reconfigure Props in Virtual Reality

Lung-Pan Cheng[1], Li Chang[12], Sebastian Marwecki[1], Patrick Baudisch[1]
[1]Hasso Plattner Institute, [2]ETH Zurich
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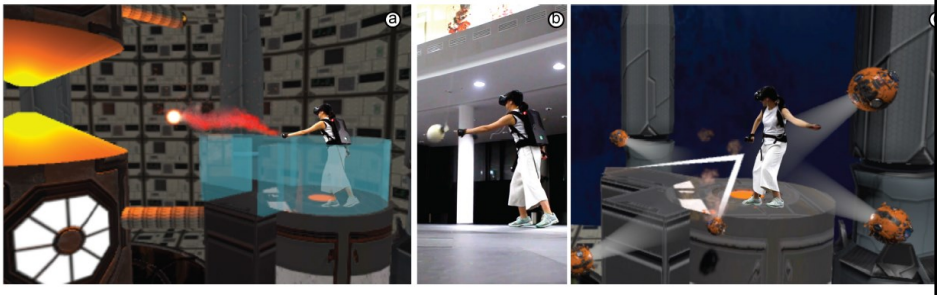

Figure 1: (a) As the user launches a plasma ball into the reactor, she feels the physical impact of hitting the prop. (b) The haptic feedback comes from a physical prop on a pendulum. The user's hit, however, also sets the pendulum in motion. (c) When the us later fends off a group of flying droids, the system renders each one of them using one period of the swinging pendulum. Every o of the user's hits is not only a haptic experience, but also provides the impulse for the next attack. As a result, the experience fee alive, even though the user is the only animate entity in it.

15. Augmented and Mixed Reality

- Augmented reality - virtual representations are superimposed on physical devices and objects
- Mixed reality - views of the real world are combined with views of a virtual environment
- Many applications including medicine, games, flying, and everyday exploring

Examples

- In medicine
  - virtual objects, e.g. X-rays and scans, are overlaid on part of a patient's body
  - aid the physician's understanding of what is being examined or operated
- In air traffic control
  - dynamic information about aircraft overlaid on a video screen showing the real planes, etc. landing, taking off, and taxiing
  - Helps identify planes difficult to make out

An Augmented Map

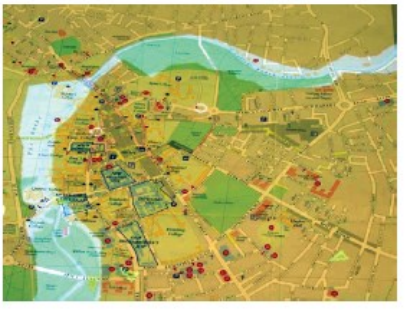

Figure 6.30 An augmented map showing the flooded areas at high water level overlaid on the paper map. The handheld device is used to interact with entities referenced on the map

Source: Reproduced with permission.

Top Gear James May in AR

- Appears as a 3D character to act as personal tour guide at Science Museum

Figure 6.31 James May appearing in 3D Augmented Reality

Source: http://www.wired.com/2012/04/top-gear-host-narrates-museum-exhibits-as-augmented-reality-avatar/. Roberto Baldwin/Wired/©Conde Nast

Augmented Reality Example

- Using augmented reality overlays, various points of interest can be shown on a mobile phone
- Icons represent the type of place (food, shopping, etc.) and distances from the current location
- Links are provided to user reviews

Augmented Reality Example

- Customers can use their personal mobile devices to pull up objects from the IKEA Catalog and see how the various items would look in their own house

Research and Design Issues?

- What kind of digital augmentation?
  - When and where in physical environment?
  - Needs to stand out but not distract from ongoing task
  - Need to be able to align with real world objects
- What kind of device?
  - Smartphone, head up display or other?

CatAR: A Novel Stereoscopic Augmented Reality Cataract Surgery Training System with Dexterous Instrument Tracking Technology

Yu-Hsuan Huang[1, 3, *], **Hao-Yu Chang**[2], **Wan-ling Yang**[1], **Yu-Kai Chiu**[2], **Tzu-Chieh Yu**[2], **Pei-Hsuan Tsai**[1], **Ming Ouhyoung**[1, 2, †]
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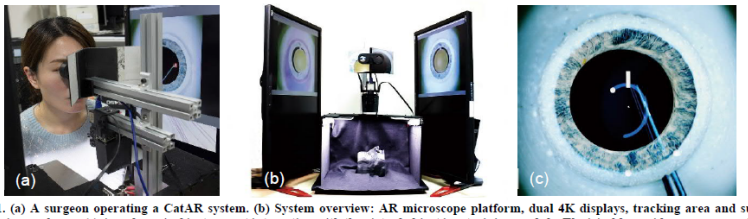

Figure 1. (a) A surgeon operating a CatAR system. (b) System overview: AR microscope platform, dual 4K displays, tracking area and surgical mannequin are shown. (c) A real surgical instrument interacting with the virtual object in a training module. The iris, blue guidance curve, and white rectangle are virtual objects overlaid on a real scene.

ABSTRACT
We propose CatAR, a novel stereoscopic augmented reality (AR) cataract surgery training system. It provides dexterous instrument tracking ability using a specially designed infrared optical system with 2 cameras and 1 reflective marker. The tracking accuracy on the instrument tip is 20 μm, much higher than previous simulators. Moreover, our system allows trainees to use and to see real surgical instruments while practicing. Five training modules with 31 parameters

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): Multimedia Information Systems - *Artificial, augmented, and virtual realities*

BACKGROUND AND RELATED WORK
Cataract is a clouding of the lens in the eye that occludes vision. According to a recent assessment by the World Health Organization [26], cataract is responsible for 51% of blindness, representing 20 million people worldwide, which

Remixed Reality: Manipulating Space and Time in Augmented Reality

David Lindlbauer[1,2], **Andrew D. Wilson**[1]

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Berlin, Germany

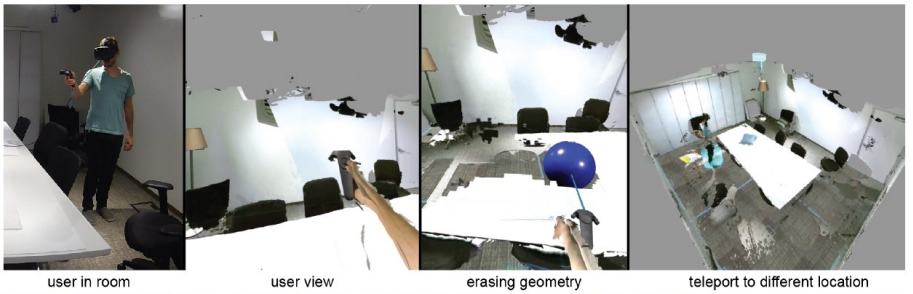

Figure 1. We present a novel take on mixed reality, called *Remixed Reality*. The user (*left*) wears a VR headset and sees a live reconstruction of the environment (*second left)* captured through multiple external depth cameras. This allows leveraging the benefits of virtual environments *(*e.g., easy modification of the environment by removing geometry, *second right*) and dynamic viewpoints while allowing users to see the actual physical world (e.g., teleportation, *right). All images in the paper were captured live with our working implementation of Remixed Reality.*

Virtual vs. Augmented Reality

- Virtual reality breaks the physical limitations of space and allow users to act as though they were somewhere else
- Augmented reality shows the real world with an overlay
- Situational awareness shows information about the real world that surrounds you by tracking your movements in a computer model

16. Wearables

- First developments were head- and eyewear-mounted cameras that enabled user to record what was seen and to access digital information
- Since, jewellery, head-mounted caps, smart fabrics, glasses, shoes, and jackets have all been used
  - provide the user with a means of interacting with digital information while on the move
- Applications include automatic diaries, tour guides, cycle indicators and fashion clothing

Google Glass

Figure 6.32 Google Glass

Source: https://www.google.co.uk/intl/en/glass/start/.
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Apple iWatch

- The Apple Watch on the left supports both fitness as well as personal information management applications, such as email, calendar, and electronic payment
- The Fitbit Surge smartwatch on the right is designed mainly for personal fitness applications, and contains a stopwatch, heart rate monitor, and GPS

Research and Design Issues?

- Comfort
  - needs to be light, small, not get in the way, fashionable, and preferably hidden in the clothing
- Hygiene
  - is it possible to wash or clean the clothing once worn?
- Ease of wear
  - how easy is it to remove the electronic gadgetry and replace it?
- Usability
  - how does the user control the devices that are embedded in the clothing?

17. Robots and Drones

17. Robots and Drones

- Four types of robot
  - remote robots used in hazardous settings
  - domestic robots helping around the house
  - pet robots as human companions
  - sociable robots that work collaboratively with humans, and communicate and socialize with them – as if they were our peers

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Advantages

- Pet robots are assumed to have therapeutic qualities, helping to reduce stress and loneliness

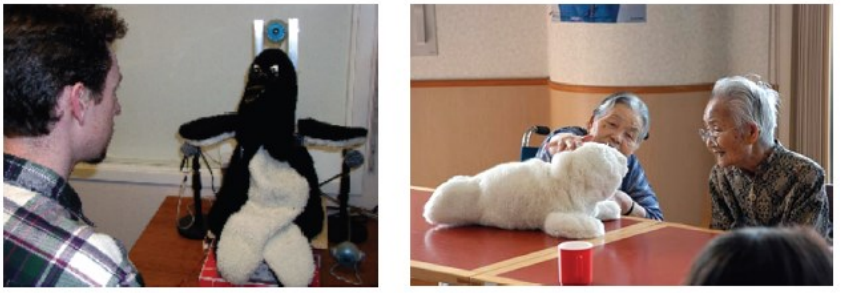


Figure 6.33 Left: Mel, the penguin robot, designed to host activities; right: Japan's Paro, an interactive seal, designed as a companion, primarily for the elderly and sick children

Source: (left) Image courtesy of Mitsubishi Electric Research Labs. (right) Courtesy of Parorobots.com.

Drones

- Unmanned aircraft that are controlled remotely and used in a number of contexts
  - e.g. entertainment, such as carrying drinks and food to people at festivals and parties;
  - agricultural applications, such as flying them over vineyards and fields to collect data that is useful to farmers
  - helping to track poachers in wildlife parks in Africa
- Can fly low and stream photos to a ground station, where images can be stitched together into maps
- Can be used to determine the health of a crop or when it is the best time to harvest the crop

Drone at a Vineyard

Figure 6.34 A drone being used to survey the state of a vineyard

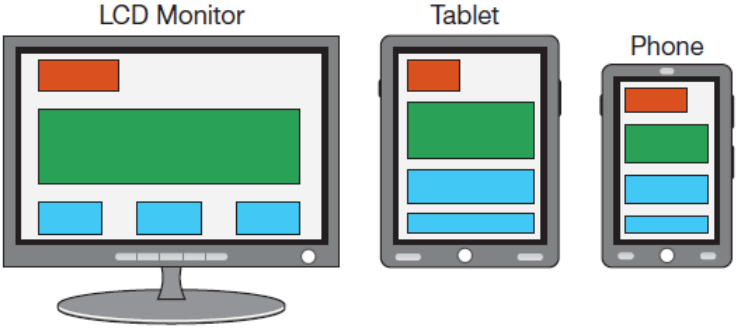
Source: Courtesy of Discover Sonoma County Wine
http://www.latimes.com/business/la-fi-drones-agriculture-20140913-story.html#page=1.

Drone at Weddings

Research and Design Issues

- How do humans react to physical robots designed to exhibit behaviors (e.g. making facial expressions) compared with virtual ones?
- Should robots be designed to be human-like or look like and behave like robots that serve a clearly defined purpose?
- Should the interaction be designed to enable people to interact with the robot as if it was another human being or more human-computer-like (e.g. pressing buttons to issue commands)?
- Is it acceptable to use unmanned drones to take a series of images or videos of fields, towns, and private property without permission or people knowing what is happening?

Which Interface?



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Which Interface?

- Is multimedia better than tangible interfaces for learning?
- Is speech as effective as a command-based interface?
- Is a multimodal interface more effective than a monomodal interface?
- Will wearable interfaces be better than mobile interfaces for helping people find information in foreign cities?
- Are virtual environments the ultimate interface for playing games?
- Will shareable interfaces be better at supporting communication and collaboration compared with using networked desktop PCs?

Which Interfaces?

- Will depend on task, users, context, cost, robustness, etc.
- Mobile platforms taking over from PCs
- Speech interfaces also being used much more for a variety of commercial services
- Appliance and vehicle interfaces becoming more important
- Shareable and tangible interfaces entering our homes, schools, public places, and workplaces

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Summary

- Many innovative interfaces have emerged post the WIMP/GUI era, including speech, wearable, mobile, and tangible!
- Raises many design and research questions to decide which to use
  - e.g. how best to represent information to the **user** so they can carry out ongoing activity or task
- New interfaces that are context-aware or monitor raise ethical issues concerned with what data is being collected and what it is used for

That's it for today!