The Design of Interactive Computational Media

Class 7: 25 Feb. 2003

Interaction Design

Hour 1:
Interaction Devices and Styles

Hour 2:
Interaction Techniques

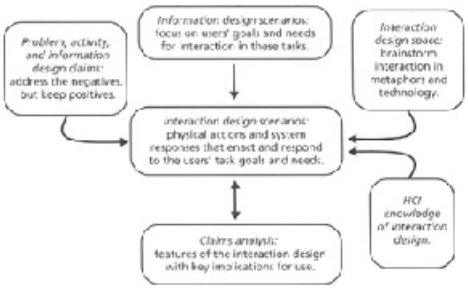
Interaction Devices and Styles

- Interaction design
- Norman's stages of action in HCI
- Interactive dialogues
- Graphical output technology
- Interactive input technology
- Interaction paradigms and styles
- Interaction techniques (to be continued in hour 2)

Interaction Design

- Interactive computational media are systems that allow users to carry out *activities* or *tasks*
- Functionality is determined in *activity design* phase
- Appearance is determined in *information design* phase
- *Interaction design* determines how users will carry out activities, i.e.
  - what steps they will take
  - what actions will comprise these steps, and
  - how these actions are realized with physical devices.

Interaction Design (Rosson & Carroll)



Norman's Stages of Action in HCI

The Gulf of Execution

- Setting goals
  - Examples of goals: entering text in a word processor, changing a cell in a spreadsheet, sketching in a paint program
  - Must keep interaction styles in mind
- Developing action plans
  - Affordances: Recall earlier discussion
  - Chunking to deal with complexity
  - Designing for errors: Will revisit this later in term
- Executing the plans
  - Input devices, interaction techniques, and pragmatics
  - Achieving articulatory directness in interactive dialogues
  - Optimizing performance

Interactive Dialogues

- Content and context of the dialogue
- Partners in the dialogue: person and machine
- Output and input media

Content and Context of the Dialogue

- Content, subject matter of the dialogue
  - The domain of discourse
  - The person's task (Need for task analysis)
  - Linear, "real time," as in command and control, versus non-linear, exploratory, as in problem solving, CAD
- Context
  - Constraints on the system and dialogue (hardware to be used, development time and cost, marketing requirements such as cost of system, etc.)
  - Requirements on the task (speed, accuracy, urgency, etc.)

Partners in Dialogue: Person and Machine

- One partner in the dialogue — the person
  - Expertise (based on intelligence & training, e.g., novice, expert)
  - Frequency of use (regular or casual)
  - Motivation (committed or alienated)
  - Style (active or passive)
  - Involvement (ultimate user or intermediary)
- Other partner in the dialogue — the machine
  - Response latency
  - Computational bandwidth
  - Response time

Output and Input Media

- Output media, technologies, and devices
  - Visual: B&W or colour, resolution, update bandwidth, etc.
  - Auditory: Speech, non-speech audio, etc.
- Input media, technologies, devices and actions
  - Touch, speech, eye movement, etc.
  - Typing, pointing, drawing, etc.

Interactive Dialogues: Design Criteria & Issues

- Design criteria
  - Consistency
  - System must be *articulate*
  - System must facilitate *articulate expression*
- Issues
  - Who's in control? User or system? Or *mixed initiative*?
  - "Artificial languages," and their lexical, syntactic, pragmatic, and semantic structure
  - The role of *metaphor*

Interactive Device Hardware

- Graphical output technology
- Interactive input technology

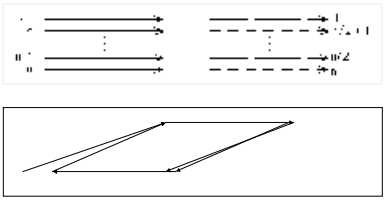
Different faces of computing

Graphical output technology

- Goal: Generation of picture (image) on display surface
  - Surfaces are (almost always) two-dimensional
  - Pictures may be two-dimensional, or representations of three-dimensional objects or scenes mapped to 2D
- Three key issues
  - The medium
    - *Soft copy*: screen or
    - *Hard copy*: paper
  - Method of generating the image
    - *Refreshed*: dynamic, continuously regenerating
    - *Stored*: Static, must be erased or must start afresh
  - Method of tracing out the image
    - *Random scan*: "Connect the dots"
    - *Raster scan*: "Like a TV"

Generating the image

- Non-interlaced raster scan display (left), interlaced raster scan display (right), random scan display (bottom)



Graphical Output Technology

SCREEN	*Refreshed*	*Storage*
Random scan	Vector displays	Direct view storage tube
Raster scan	Digital video display	Liquid crystal displays Electroluminescent displays Plasma panels

PAPER	*Refreshed*	*Storage*
Random scan		Pen plotter
Raster scan		Laser printer Ink jet printer Dot matrix printer

Interactive Input Technology

- Goal: Control of and input to a program
  - Control: Start, stop, carry out specific actions, ...
  - Input: Data, parameters, drawings, sketches, gestures, ...
- Key issues
  - The medium
    - *Devices* held by the user (e.g., mouse, pen)
    - User *actions*: touch, speech, body movements
    - Representation of device on screen — cursor (tracking symbol)
  - Relationship of medium to display
    - *Direct,* on the display (e.g., touch-sensitive panel)
    - *Indirect,* separate from the display (e.g., touch tablet)
  - Type of data: *discrete* versus *continuous*
  - What is sensed: movement (e.g., mouse), position (e.g., pen on tablet), force (e.g., joystick)
  - *Dimensionality* (degrees of freedom): mouse (2), pen (2-5)
  - Device *pragmatics*: size, weight, shape, feel, etc

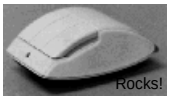
Interactive Input Technology Examples

	Discrete	*Continuous*
0 Dimensions	Push button Toggle switch Function keys	NNNNNNNNNN
1 Dimensions	Keyboard	Thumbwheel Slider
2 Dimensions	Touch panel	Touch tablet Joystick Trackball Mouse Data tablet + pen
3 Dimensions		Tablet + pen sensing position & pressure

The First Mouse

- 1968
- Douglas Engelbart
- Stanford Research Institute
- Separate rollers for x & y axes

33 years later



Interaction Paradigms and Styles

- Simple command languages
- Query languages, conversational languages
- Natural language input
- Menus
- Forms
- Icons
- Windows
- Direct manipulation
- Gestural interaction
- 3D interaction
- Audio I/O, including voice and non-speech audio
  (later in term)

Simple Command Languages

- User-initiated
  - Harder for beginner, more efficient for expert
  - Demands good retention by casual, infrequent users
- User must remember command *sequences*
- User must remember operators and arguments
  - The issues of *syntax* (operator before arguments or vice versa)
  - Operator after arguments: command termination is implicit even after variable number of arguments
  - Screen prompts can help
- Example: UNIX
  - ls -l *.doc
  - vacation start

Command Names

- Hard to choose “best, most natural” command name
  - Example: grep
- Designers have difficulty choosing “best” name
  - P(2 individuals generating same name) = 0.07-0.18 (Furnas)
  - Delete, remove, expunge, wipe out, take away, ...
- A possible solution: rich *aliases* in command names
- Design of a *congruent set* of command names
  - Up and down, right and left, add and subtract, ...
- Use of mnemonics (abbreviations)
  - Truncation, vowel deletion, etc.
  - Start with full name before introducing abbreviations
- Spelling a problem
  - But spelling checkers and correctors feasible

Command Language Syntax

- Applies to non-verbal as well as verbal dialogues
- Light buttons: {command argument}*
  - e.g., CIRCLE <pos1>; SQUARE <pos2>; TRIANGLE <pos3>
- Paint buckets: {set_mode {arguments}*}*
  - e.g., CIRCLE <pos1> <pos2> ; SQUARE <pos3> <pos4>
- *VIDEO — Selection-Positioning (Buxton, UofT, 1981)*

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

Query and Conversational Languages

- Query languages
  - Special-purpose language
  - Used for retrieving information from database
  - *Procedural* vs. *non-procedural* language
  - Data models (hierarchical, network, relational)
  - *Query by example*
- Conversational languages
  - Task language, *extensible* and fully programmable
  - LOGO, APL, 4th generation languages and environments

Natural Language Input

- Some DBMS query languages are “English like”
  - Work for limited range of discourse, subset of English
- *Habitability* in restricted natural language: “The ability of users to stay within the limits of a computer language while expressing themselves productively”
- What about full natural language?
  - Unlikely in foreseeable future
  - But good progress in last decade
- Problems
  - Verbose: many keystrokes, particularly hard on poor typists
  - Ambiguity, anaphora, ellipsis, etc.
- Could employ voice input, but this is not necessary

Natural Language Input

- *VIDEO: Embodiment in Conversational Interfaces (J. Cassell, et al., MIT Media Lab, CHI 1999 Videos)*
- Recognition, plus timing, turn-taking, interruptions, …

Menu Dialogues

- Computer-initiated *display of alternatives*
  - Text
  - Voice, e.g., “Would you like to speak to... 1. Linda... 2. Susie... 3. Pierre... or 4. The operator”
- Response variables
  - Typing number or keyword, or hitting function key?
  - Single keystroke, or ENTER required?
  - Single token responses only, or arguments too?
- Menu display and organization
  - Menu items displayed as words or pictographs (icons)?
  - Menu pages simple, pull-down, pop-up, scrolled, paged, tree structured, adaptive?

Menu Dialogues

- Depth (d) versus breadth (b) tradeoff: $n = b^d$
  - Very deep: b=2 d=6
  - Intermediate: b=4 d=3
  - Shallower: b=8 d=2
  - One-level: b=64 d=1
  - Generally, breadth better than depth
- Importance of menu organization
  - Logical, alphabetic, frequency of use, recency of use
  - Adaptive versus adaptable menus

Form Filling Dialogues

- Computer-initiated *display of requirements*
- Design variations
  - How is cursor positioned? (Automatically, or by user?)
  - How is help provided without obliterating form?
  - One form at a time, or multiple forms in parallel?
  - Navigation through forms
- Voice forms, as in Olympic Message System, e.g., “Please provide your name..... now your ID#.....”

Menus and forms

- Menus and forms often used in tandem, as in Olympic Message System, information for telephone numbers (home or business? what city? …)
- ***VIDEO — OLYMPIC MESSAGING SYSTEM (J. Gould et al, IBM, CHI 1985 Videos)*

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

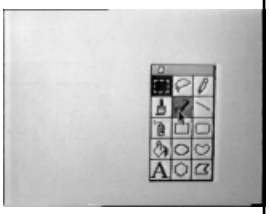
Questions and Discussion

Break

Interaction Techniques

- Icons
- Windows
- GUIs
- Direct manipulation
- Gestural interaction
- 3D interaction
- Audio I/O (later this term)
- Multimodal interaction

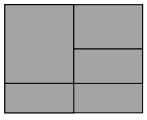
Icons

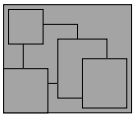


- Pros
  - "Universality!?", not dependent upon one natural language
  - Compactness
  - Multi-dimensionality
- Cons
  - Not all concepts representable clearly
  - Hard to handle large # of similar objects (e.g., file 1, file 2, ...)
  - Need to learn a "new language"
- *VIDEO — Animated Icons (Baecker, Small, and Mander, Apple, CHI'89)*

Windows

- Rectangular areas
  - Multiple, concurrent, interleaved tasks
  - Individual contexts
- Tiled (left, below) & overlapping (right, below) windows





Graphical User Interfaces (GUIs)

- Components of GUIs
  - Windows (one of them active)
  - Menus
  - Icons
  - Controls and control panels
  - Query and message boxes
  - Mouse/keyboard interface
  - Direct manipulation
- Common GUIs
  - Microsoft Windows
  - Apple Macintosh OS Interface

Direct Manipulation

- Shneiderman definition
  - Continuous representation of the object of interest
  - Manipulation through physical actions
  - Rapid, incremental, reversible operations
  - Layered or spiral approach to learning
- Examples
  - WYSIWYG text editors (like Xerox Star. Microsoft Word)
  - Spreadsheets
  - Graphics, musical score editors

Tablet Dialogues with Mouse and Pen

- Tracking symbols, trackers, cursors
  - Is normally where attention is focused
  - Therefore, mode indicators & messages (e.g., error messages) should appear at that location
  - Use icons when possible, e.g., hourglass, thumbs down symbol
- Pointing and selection
  - Menu selection (“point and click”)
  - Light buttons and paint pots (as in Selection-Positioning video)
- Positioning
  - Entering positions
  - Dragging to new position (“drag and drop”)
  - Positioning constraints and guidelines: grids and scales

Tablet Dialogues with Mouse and Pen

- Setting values
  - Graphical potentiometers
  - Rubber band lines, rectangles, or anythings
  - Application of constraints (see video)
- Inking and painting
  - Equal space, equal time, rubber band
  - Thickness, colour controls, etc.
  - Inking and painting with constraints
- *VIDEO: Film Finder (Univ. of Maryland, CHI’94 Videos)*

Gestural Input

- Gestures as data, e.g., objects and movements
- VIDEO — GENESYS Animation (Baecker, MIT, 1971)

- Gestures as characters to recognize, e.g., Palm Pilot

Gestural Input

- Gestures as annotations
- Also voice annotations
- *VIDEO — Wang Freestyle (1989)*

Gestural Input

- Gestures as command language: Command and argument in one sketch
- *VIDEO — Tablets, gestures (Buxton et al., UofT, early 80s); 3D camera control (Mike Chan, UofT)*

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

Comments

- Need for rapid and appropriate feedback during interaction
- Many different ways to perform tasks, e.g., demonstrative versus descriptive input
  - Specification by *description* (keyboarded, symbolic)
  - Specification by *demonstration* (sketched
- Tasks are nearly always compound (e.g., selection + positioning)
- Important to have the actions “bind” naturally into a sentence, i.e., “chunking,” “appropriate gesture”

Modes

- “Modeless” versus “moded” systems
- Modeless — Can issue any command at any time
- Moded — Set of legal commands dependent upon current state, or mode

Two-handed Input

- *VIDEO — Toolglasses and Magic Lenses (Xerox PARC, Siggraph Video Review 97, CHI’94)*

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

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- *VIDEO — Bricks (Fitzmaurice, UofT, CHI’95)*

Questions and Discussion