

The Design of Interactive Computational Media

Class 7: 23 Oct. 2002

Interaction Design

Hour 1:
Interaction Devices and Styles

Hour 2:
Interaction Techniques

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.1

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)

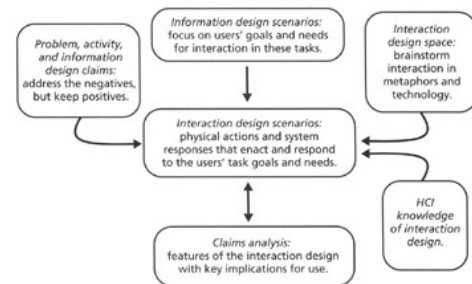
Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.2

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.

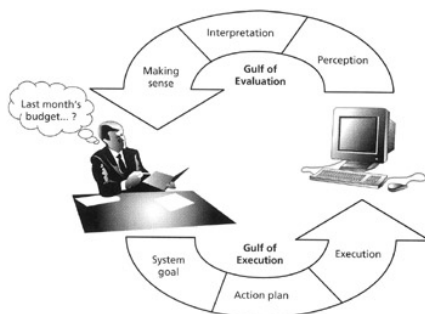
Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.3

Interaction Design (Rosson & Carroll)



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.4

Norman's Stages of Action in HCI



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.5

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.6

Interactive Dialogues

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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.7

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.)

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.8

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.9

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.

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.10

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*

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.11

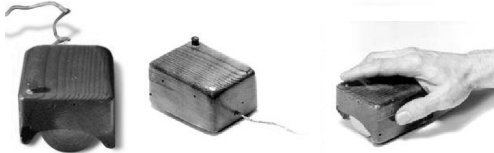
Interactive Device Hardware

- Graphical output technology
- Interactive input technology

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.12

The First Mouse

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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.19

33 years later



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.20

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.21

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.22

Command Names

- Hard to choose “best, most natural” command name
 - Example: `grep`
- Designers have difficulty choosing “best” name
 - $P(2 \text{ individuals generating same name}) = 0.07-0.18$ (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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.23

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.

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.24

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.25

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.26

Natural Language Input

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

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.27

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?

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.28

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.29

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#.....”

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.30

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.

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.31

Questions and Discussion

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.32

Break

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.33

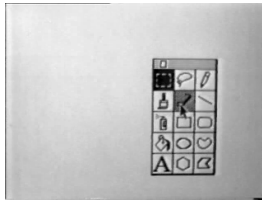
Interaction Techniques

- Icons
- Windows
- GUIs
- Direct manipulation
- Gestural interaction
- 3D interaction
- Audio I/O
- Multimodal interaction

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.34

Icons

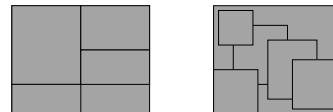
- Pros
 - “Universality!?”; not dependent upon one natural language
 - Compactness
 - Multi-dimensionality
- Cons
 - Not all concepts representable clearly
 - Hard to handle large # of similar objects (e.g., file 1, file 2, ...)
 - Need to learn a “new language”
- VIDEO — *Animated Icons* (Baecker, Small,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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.35

Windows

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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.36

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.37

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.38

Mouse and Pen on Tablet Dialogues

- 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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.39

Mouse and Pen on Tablet Dialogues

- 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)

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.40

Gestural Input

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

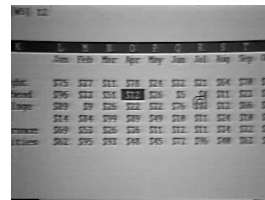


- Gestures as characters to recognize, e.g., Palm Pilot

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.41

Gestural Input

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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.42

Gestural Input

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

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.43

Comments

- Need for rapid and appropriate feedback during interaction
- Many different ways to perform tasks, e.g., demonstrative versus descriptive input
 - Specification by *description* (keyboared, 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”

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.44

Modes

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.45

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

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.46

Speech as Data

- Example: Voice messaging
- Example: Voice annotations as in Wang Freestyle

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.47

Input via Speech Recognition

- Ideal applications
 - Hands busy or covered in “gunk”
 - Manual input already overloaded
 - Disabled users
- Simplified method of operation
 - Recognition vocabulary represented as stored patterns
 - Speech sampled and digitized
 - Waveforms or their parameters compared against patterns

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.48

Speech Recognition: Dimensions of Success

- Size of vocabulary: A few words to tens of thousands
- Accuracy, recognition percentage: >>95%, >99%
- Repeatability of performance
- Cost
- Speaker-dependent vs. speaker-independent
- Training not required or easily trainable
- Location of microphone
- Acoustic environment, quiet or noisy environment
- Discrete words or continuous speech

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.49

Speech Recognition Example

- *VIDEO — The OM System Spoken Language Interface (CMU, SGVR 64, CHI'91)*
 - Methods of user error correction
 - Recognition architecture
 - Usage of lexical and syntactic information (certain words and sentence structure are legal and therefore expected)

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.50

Output via Speech Synthesis

- Why is the problem hard? Examples:
 - How to pronounce "gh"?
 - No sound in "thorough"
 - "f" in "enough"
 - "g" in "ghost"
 - How to pronounce "invalid"?
 - Not valid ==> Accent on second syllable
 - Disabled ==> Accent on first syllable
 - How to stress (intonation)?
 - "I told you" meaning different depending upon word that is stressed
 - Method of operation
 - Digitized (stored) versus synthesized speech
 - Synthesize speech: Phoneme-to-speech, text (ASCII)-to-speech
 - Retrieve or generate waveform, convert to analog, output

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.51

Speech Synthesis: Dimensions of Success

- Size of vocabulary
- Bandwidth, data rate
- Intelligibility
- Cost
- Naturalness
- Discrete words versus connected speech

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.52

Speech Synthesis Example

- *VIDEO — Talking to Machines (University of Wales, SGVR 88, InterCHI'93)*
 - Speech input and output
 - Consequences of failure to anticipate user errors
 - Example of a real application
 - Design "principles"



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.53

Roles for Auditory Displays

- Alarms and warnings
- Status and monitoring indicators
 - e.g., feedback from control inputs
- Messages and data (perhaps encoded)
 - e.g., responses to user queries

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.54

Visual versus Auditory Displays

- From Deatheridge, 1972, p. 124, in BGBG, p. 532

| <i>Use auditory presentation if:</i> | <i>Use visual presentation if:</i> |
|---------------------------------------|--|
| Message is simple | Message is complex |
| Message is short | Message is long |
| Message will not be referred to later | Message will be referred to later |
| Message deals with events in time | Message deals with location in space |
| Message calls for immediate action | Message does not call for immediate action |
| Visual system of person overburdened | Auditory system of person overburdened |
| Location too bright or dark | Location too noisy |
| Person moving continually | Person stationary |

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.55

Non-speech Audio Output

- Motivation
 - Consider role of sound in video games, driving
 - Warnings (e.g., sound of blowout)
 - Status indicators (e.g., revving engine)
 - Feedback (e.g., grinding gears)
- Example — Sonic Finder (Gaver, UCSD, mid-80s)
 - Hear the trash can through a “tinny crash”
 - Hear amount of space on disk through reverberation
 - Hear status of scrolling through ascending or descending tones
- Issues
 - Appropriate acoustic design
 - Storage requirements or real-time processing
 - Acoustic pollution

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.56

Examples of Non-speech Audio

- VIDEO — LogoMedia (DiGiano, Baecker, UofT, 1993)
 - Use of sound in software visualization
- VIDEO — Arkola Simulation (Smith et al., Xerox EuroPARC, early 90s)
 - Sound for understanding complex system, collaborating

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



Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.57

Multi-modal Interaction

- VIDEO — Put That There (MIT, CHI'83 Videos)

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

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.58

Other Advances

- Word spotting for speech skimming
- Speeding up digitized speech output
- Uses of “good enough” recognition

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.59

Questions and Discussion

Design of Interactive Computational Media Sep.-Dec. 2002 ©1992-2002, Ronald M. Baecker Slide 7.60