Designing The User Interface

1 Systems Engineering Goals

Designing an object to be simple and clear takes at least twice as long as the usual way. It requires concentration at the outset on how a clear and simple system would work, followed by the steps required to make it come out that way – steps which are often much harder and more complex than the ordinary ones. It also requires relentless pursuit of that simplicity even when obstacles appear which would seem to stand in the way of that simplicity [Nels 77].

- Achieve required performance by operator, control and maintenance personnel
- Minimize skill and personnel requirements and training time
- Achieve required reliability of personnel-equipment combinations
- Foster design standardization within and among systems

1. Proper functionality
2. Reliability
3. Availability
4. Security
5. Data Integrity
6. Standardization
7. Integration
8. Consistency
9. Portability

2 User-Interface Design Goals

- Time to learn
- Speed of performance
- Rate of user errors
- Retention over time
- Subjective satisfaction

1. Motivation for Human Factors in Design

   (a) Life-critical systems

   Air traffic control, nuclear reactor operations, power utility control, space stations, police-fire dispatch, military command operations, medical instrument control, etc.

   (b) Industrial and Commercial applications

   Banking, insurance, order entry, inventory management, airline and hotel reservation, car rental, utility billing, credit card systems, point of sales systems, etc.

   (c) Office, home and entertainment applications

   Personal computing applications, games, educational packages, information retrieval, e-mail, conferencing, accounting applications, etc.

   (d) Exploratory, creative and cooperative systems

   Distributed web databases, collaborative writing, statistical hypothesis formation, business decision making, etc.

3 Accommodation of Human Diversity

1. Physical Abilities
   - Physical size and strength of individuals
   - Size of hands
   - Response of the eye to color, brightness, flicker, contrast, motion, depth
2. Physical Workplaces
   - Work-surface and display support height
   - Clearance under work surface for legs

- Work-surface width and depth
- Adjust-ability of heights and angles for chairs and work surfaces
- Posture–seating depth and angle; back-rest height and lumbar support
- Availability of arm-rests, foot-rests and palm-rests
- Use of chair casters

3. Cognitive and Perceptual Abilities
    - Short-term memory
    - Long-term memory
    - Learning and problem solving
    - Decision making
    - Attention and scope of concern
    - Search and scanning
    - Time perception
    - Arousal and vigilance
    - Fatigue
    - Perceptual load
    - Knowledge of results
    - Monotony and boredom
    - Sensory deprivation
    - Anxiety and fear
    - Isolation
    - Aging
    - Drugs and alcohol
    - Circadian rhythms
4. Personality Differences
    - *Myers-Briggs Type Indicator*
    - Extroversion versus introversion
    - Sensing versus intuition
    - Perceptive versus judging
    - Feeling versus thinking
5. Cultural and International Diversity
    - Characters, numerals, special characters and diacriticals
    - Left-to-right versus right-to-left versus vertical input

- Date and time formats
- Numeric and currency formats
- Weights and measures
- Telephone numbers and addresses
- Names and titles
- Numeric identifiers (social-security, national id, passport, driver's license)
- Capitalization and punctuation
- Collating sequences
- Icons, buttons and colors
- Pluralization, grammar and spelling
- Etiquette, policies, tone, formality, metaphors

6. Users with Disabilities
    - Vision impairment
    - Hearing impairment
    - Other impairment

7. Elderly Users
    - Visual and auditory decline
    - Strength and speed of response
    - Perceptual ability

4 Research Goals

1. Academic and Industrial Researchers
    - Understanding of a practical problem and related theory
    - Lucid statement of a testable hypothesis
    - Manipulation of a small number of independent variables
    - Measurement of specific dependent variables
    - Careful selection and assignment of subjects
    - Control for bias in subjects, procedures and materials
    - Application of statistical tests
    - Interpretation of results
    - Refinement of theory
    - Guidance for experimenters

2. Reduced anxiety and fear of computer usage
3. Graceful evolution
4. Specification and implementation of interaction
5. Direct manipulation
6. Input devices
7. Online assistance
8. Information exploration

5 Theory

5.1 Conceptual, Semantic, Syntactic and Lexical Model (Foley and van Dam)

- User's mental model of the interactive system
- Meaning of command input and computer output
- Sentence construction rules
- Input device dependencies

5.2 GOMS and the keystroke-level model (Card, Moran and Newell)

- Goals
- Operators
- Methods
- Selection rules

5.3 Action Models (Norman)

- Form the goal
- Forming the intention
- Specifying the action
- Executing the action
- Perceiving the system state
- Interpreting the system state

- Evaluating the outcome

1. Gulf of execution (mismatch of user's intentions and allowable actions)
2. Gulf of evaluation (mismatch of system's representation and user's expectations)
3. Visible state and action alternatives
4. Good conceptual model with consistent system image
5. Good mappings which reveal relationships between stages
6. Continuous feedback

5.4 Consistency and grammars

- delete/insert character
- delete/insert word
- delete/insert line
- delete/insert paragraph
- move-cursor-one-character-forward [Dir = forward, Unit = char]
- move-cursor-one-character-backward [Dir = backward, Unit = char]
- move-cursor-one-word-forward [Dir = forward, Unit = word]
- move-cursor-one-word-backward [Dir = backward, Unit = word]
- task[Dir,Unit] → symbol[Dir]+letter[Unit]
- symbol[Dir=forward] → CTRL
- symbol[Dir=backward] → ESC
- letter[Unit=word] → W
- letter[Unit=char] → C

5.5 Widgets

- Example, scrolling widget

5.6 Object-Action Interface Model

1. Task hierarchies of objects and actions
2. Interface hierarchies of objects and actions
3. Disappearance of Syntax

5.7 Recognizing Diversity

1. Usage profiles
   - Novice users
   - Knowledgeable intermittent users
   - Expert frequent users
2. Task profiles
3. Interaction styles
   - Direct manipulation
   - Menu selection
   - Form fill-in
   - Command language
   - Natural language

5.8 Golden Rules of Interface Design

1. Strive for consistency
2. Enable frequent users to use shortcuts
3. Offer informative feedback
4. Design dialogs to yield closure
5. Offer error prevention and simple error handling
6. Permit easy reversal of actions
7. Support internal locus of control
8. Reduce short-term memory load

5.9 Prevent Errors

1. Correct matching pairs
2. Complete sequences
3. Correct commands

5.10 Displaying data

1. Organization
   (a) Consistency of data display
   (b) Efficient information assimilation by the user
   (c) Minimal memory load on user
   (d) Compatibility of data display with data entry
   (e) Flexibility of user control of data display
   (f) Be consistent in labeling and graphics
   (g) Standardize abbreviations
   (h) Use consistent format; headers, footers, paging, menus
   (i) Page number displays, and allow direct navigation to a page
   (j) Present data only if they assist the operator
   (k) Present data graphically if possible
   (l) Use digital values only when necessary
   (m) Use high resolution display monitors
   (n) Resist unnecessary use of color; use mono-chromatic schemes
   (o) Involve uses in the design of new displays
2. Get the user's attention
   (a) Intensity
   (b) Marking
   (c) Size
   (d) Choice of fonts
   (e) Inverse video
   (f) Blinking
   (g) Color
   (h) Color blinking
   (i) Audio

5.11 Data Entry Guidelines

1. Consistency of data-entry transactions; delimiters, abbreviations, etc.
2. Minimal input actions by user
3. Minimal memory load on user
4. Compatibility of data entry with data display
5. Flexibility for user control of data entry

5.12 Balance automation and human control

1. Humans better at:
    - Sense low level stimuli
    - Detect stimuli in noise
    - Recognize constant patterns in varying situations
    - Sense unusual and unexpected events
    - Remember principles and strategies
    - Retrieve pertinent details a priori
    - Draw on experience and adapt decisions
    - Select alternatives
    - Reason inductively; generalize from observations
    - Act in emergency or novel situations
    - Apply principles
    - Make subjective evaluations
    - Concentrate on important tasks when overload occurs
    - Adapt physical response
2. Machines better at:
    - Sense stimuli outside human range
    - Count or measure physical quantities
    - Store quantities of coded information accurately
    - Monitor specified (and infrequent) events
    - Make rapid and consistent responses to input signals
    - Recall quantities of detailed information accurately
    - Process quantitative data
    - Reason deductively; infer from principles
    - Perform repetitive preprogrammed actions reliably
    - Exert high forces
    - Perform simultaneous activities
    - Maintain operation under heavy load
    - Maintain performance over extended periods of time

6 APPLE Human Interface Guidelines, The Apple Desktop Interface

6.1 A view of the User

The Apple Desktop Interface provides a consistent and familiar computer environment in which people can perform their many tasks. People aren't trying to *use computers*, they're trying to get their jobs done.

Given this focus on people and their tasks, the Apple Desktop Interface has had to assume a model of people, in order to suit the interface to them. People, however, are delightfully complex and varied, which assures that a theory of human activity that would provide a complete framework for the design of human-computer interaction is a long way off. Such a theory would be oversimplified anyway, because computers themselves change the way we think, feel and behave. Computer design and human activity must therefore evolve together. Apple believes that caring how people behave will help computer designers provide a consistent world that a person can enter with ease and effectiveness, even though many of the details of human activity are not understood.

The Apple Desktop Interface is based on the assumption that people are instinctively curious: they want to learn and they learn best by active self-directed exploration of their environment. People strive to master their environment: they like to have a sense of control over what they are doing, to see and understand the results of their own actions. People are also skilled a manipulating symbolic representations: they love to communicate in verbal, visual and gestural languages. Finally, people are both imaginative and artistic when they are provided with a comfortable context; they are most productive and effective when the environment in which they work and play is enjoyable and challenging [Appl 87].

6.2 General Design Principles

1. Metaphors from the real world
    - Use concrete metaphors and make them plain, so that users have a set of expectations to apply to computer environments
    - Whenever appropriate, use audio and visual effects that support the metaphor
2. Direct manipulation
    - Users want to feel that they are in charge of the computer's activities
3. See and point (instead of remember and type)
    - Users select actions from alternatives presented on the screen
    - The general form of user actions is noun-then-verb, or "Hey, you – do this."

- Users rely on recognition, not recall; they shouldn't have to remember anything the computer already knows
- Most programmers have no trouble working with a command-line interface that requires memorization and Boolean logic. The average user is not a programmer.

4. Consistency
   - Effective applications are both consistent within themselves and consistent with one another
5. WYSIWYG (What You See Is What You Get)
   - There should be no secrets from the user, no abstract commands that only promise future results
   - There should be no significant difference between what the user sees on the screen and what eventually gets printed
6. User control
   - The user, not the computer, initiates and controls all actions
7. Feedback and dialog
   - Keep the user informed
   - Provide immediate feedback
   - User activities should be simple at any moment, though they may be complex taken together
8. Forgiveness
   - Users make mistakes; forgive them
   - The user's actions are generally reversible–let users know about any that aren't
9. Perceived stability
   - Users feel comfortable in a computer environment that remains understandable and familiar rather than changing randomly
10. Aesthetic integrity
    - Visually confusing or unattractive displays detract from the effectiveness of human-computer interactions
    - Different "things" look different on the screen
    - Users should be able to control the superficial appearance of their computer workplaces–to display their own style and individuality
    - Messes are acceptable only if the user makes them–applications aren't allowed this freedom

6.3 Principles of graphic communication

1. Good design must communicate, not just dazzle. It must inform, not just impress
2. The services of a skilled graphic designer are worth the expense
3. Visual Consistency
4. Simplicity
5. Clarity

6.4 A strategy for programming

1. Modelessness
    - With few exceptions, a give action on the user's part should always have the same result, irrespective of past activities
    - Long-term modes, such as doing word processing as opposed to graphics editing. In this sense, each application is a mode
    - Short-term "spring-loaded" modes in which the user must constantly do something to maintain the mode.
    - Alert modes
    - Emulation of a familiar real-life situation that is itself modal
    - Changing the attributes of something, but not its behavior
    - Blocking most other normal operations to emphasize modality
2. The event loop
    - Applications are prepared for the user to do anything at any time
3. Reversible actions
    - Always provide a way out
4. The screen
    - The screen is the stage for human-computer interactions
5. Plain language
    - Communicate with the user in concise and simple forms

6.5 The Desktop Interface

1. Desktop

   Visually the desktop appears as a background on which objects are placed. The desktop may be customized (color, texture, etc). The user controls the location of objects on this desktop and the size of certain objects.

   Icons, small pictures representing available objects, sit directly on the desktop. To select a disk, folder, application, or document, the user selects the corresponding icon, rather than having to type the name of the object it represents.

   When a disk icon is selected, it can be opened to become a window, which also appears to rest on the desktop. The window presents a surface of its own, where the user sees icons representing the folders, documents and applications that the disk contains. The user can open a number of disk windows on the desktop and view their contents simultaneously.

   The Finder is the application that controls the desktop, provides a view of available documents and applications, and lets the user organize, copy, move, rename and delete them. The Finder also lets the user launch an application, which typically opens up its own window. An application is launched by opening either the application icon itself, or the icon for a document or stationery template created with that application.

2. Windows

   A window is a frame for viewing something, as determined by the application. Windows may be arranged and sized on the desktop by the user. Because windows can overlap, users can "set aside" information yet still have ready access to it.

   Manipulating windows – moving them, overlapping them, resizing them – does not affect the content of the window, on the user's view of it. This lets users tailor their work environment without fundamentally changing the elements in this environment.

   Standard windows have:

   (a) Close box
   (b) Title bar
   (c) Vertical scroll bar
   (d) Size box
   (e) Horizontal scroll bar
   (f) Scroll box
   (g) Scroll aarows

(h) Zoom box

There are very standard conventions for opening, closing, moving, sizing, scrolling, and zooming windows. No matter what application is being used, users know how to control the appearance of windows on the screen, and how to adjust the workspace for particular tasks and to their tastes.

When a user manipulates windows on the screen, visual feedback is immediate.

Special windows include:

(a) Dialog boxes
(b) Alert boxes
(c) Controls

3. Menus

Menus are central to the "noun-verb" principle of the Apple Desktop Interface: the user first selects an object (noun), either on the desktop or in a window, then chooses from a menu, the operation (verb) to be applied to this object.

Pull-down menus present choices of available operations. The user's task is recognition, not recall.

A single menu bar is presented at the top of the desktop which is changed from application to application but always includes (in order):

(a) Apple menu
(b) File menu
(c) Edit menu

Items in the File and Edit menus appear in standard order for every application.

References

[Appl 87] Apple Computer, *Apple Human Interface Guidelines: The Apple Desktop Interface*, Addison Wesley, 1987.

[Nels 77] Nelson, Ted, *The Home Computer Revolution*, 1977.

[Shne 98] Shneiderman, Ben, *Designing the User Interface*, Addison-Wesley, 1998.