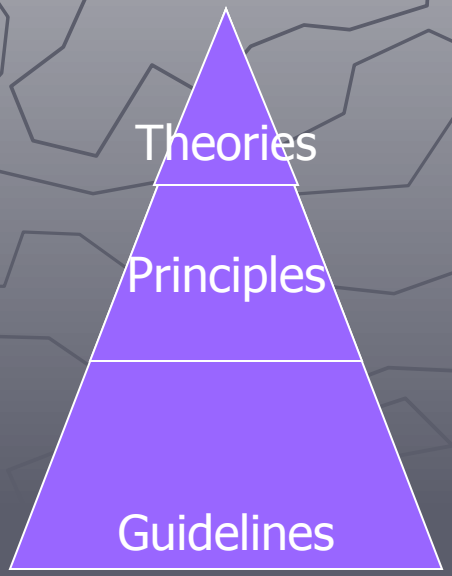
Guidelines, Principles, and Theories

Human Computer Interaction

CSCI 588

Introduction

- **Theories** – high level (includes models)
  - Describe systems, objects, actions with consistent terminology for teaching, education, and communication
  - Help predict performance
- **Principles** – mid-level
  - Analyze and compare competing designs
- **Guidelines** – specific and practical
  - Cures for design problems
  - Cautions for potential danger
  - Reminders based on experience
- Why have guidelines, principles, and theories?
  - Make efficient, proven decisions
  - Do not repeat mistakes of the past
  - In a rush, can make mistakes

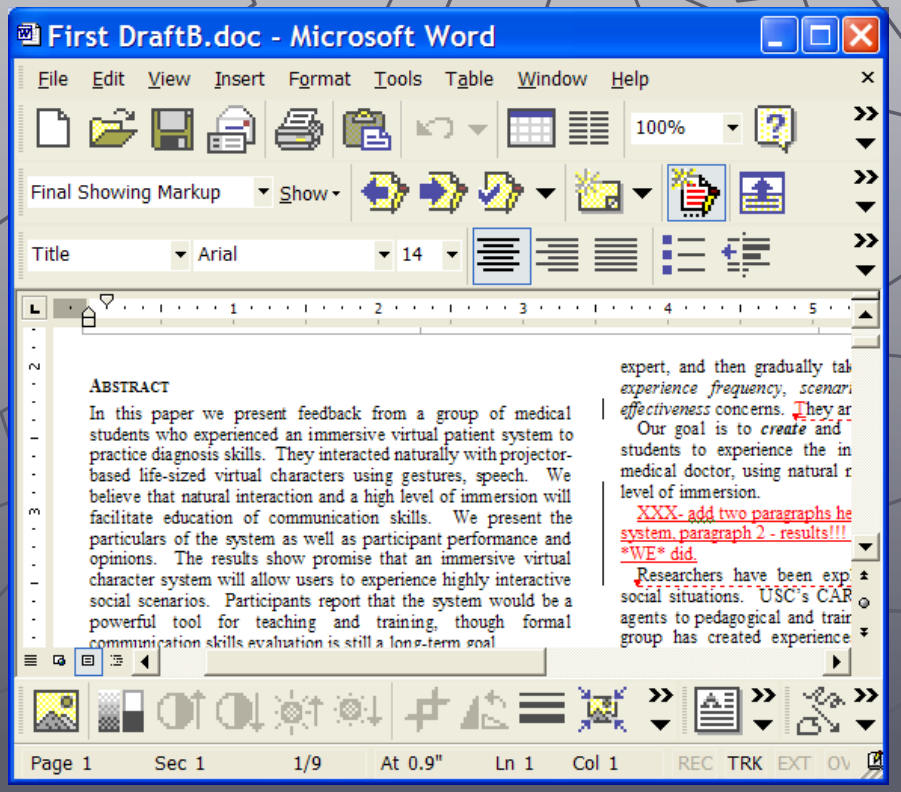


Guidelines

- Specific and practical
  - Cures for design problems
  - Cautions for potential danger
  - Reminders based on experience
- Example guidelines
  - GUI (Windows, Mac)
  - Linux
  - Web pages
  - PDA
  - Cellphones
- Guideline Document
  - Shared language
  - Consistency within a design team (good because of large visual component)

Guideline Document

- Input and output formats
- Action sequences
- Terminology
- Hardware devices/platforms
- Practical Experience
- Empirical studies
- Examples & counterexamples
- **Pros:**
  - Builds upon experience
  - Continued improvements
- **Cons:**
  - Too specific
  - Hard to innovate
  - Not applicable/realistic to the situation
  - Hard to apply
- When do you have an exception? Who makes the final decision?



Navigating the Interface

- Example from National Cancer Institute
  - http://www.nci.nih.gov/
  - Help government agencies with design and creation of web pages
  - 388 guidelines backed by research
  - What are some positives that we notice?
- For each of the following, let's evaluate for:
  - User: Novice, Intermediate, Expert
  - Task: Education, Search, Research
  - Benefit?
- Standardize task sequences
- Ensure that embedded links are descriptive
- Use unique and descriptive headings
- Use check boxes for binary choices
- Develop pages that will print properly
- Use thumbnail images to preview larger images

Guidelines for Disabled

- WWW Consortium adopted these guidelines for web pages for disabled
  - Text equivalent for every non-text element [images, image map, animations, applets, ascii art, frames, scripts, bullets, sounds, audio, video]
  - Any time-based multimedia, provide equivalent synchronized alternatives (captions, descriptions)
  - All color info is available without color
  - Title each frame
- Enables screen readers or other technologies to have multiple methods to obtain the webpage info
- How does this end up helping everyone?

Organizing the Display

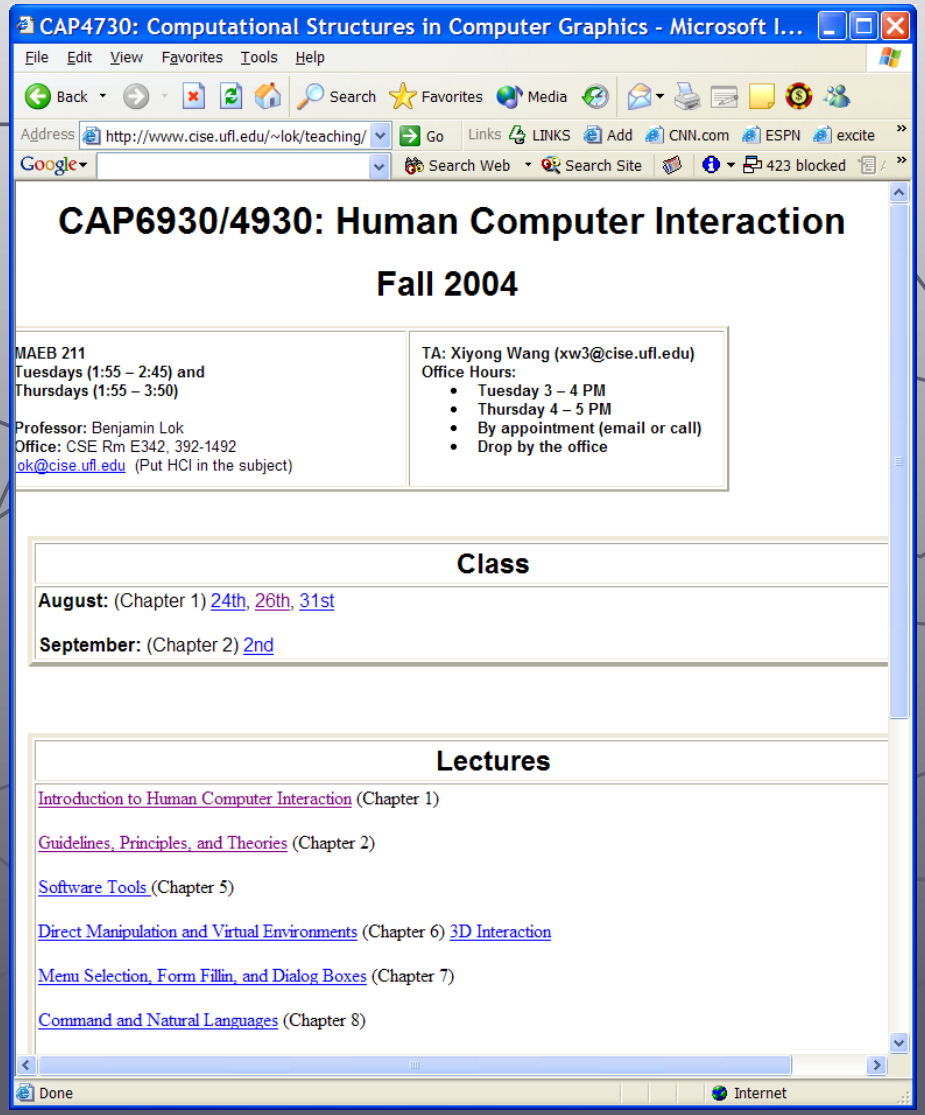
- Consistency of data display
  - Terminology, abbrev., formats, colors, grammar, capitalization
- Efficient information assimilation by the user
  - Familiar format
  - Related to tasks at hand
  - Ex. justification, alphanumeric, spacing, formatting, labels, units/measurements
- Minimal memory load on the user
  - Minimal carry information over from on screen to another
  - Fewer actions
  - Labels and common formats should be provided for novice (Ex. SSN/phone #)

Organizing the Display

- Compatibility of data display with data entry
  - Entering data should look similar to the eventual viewing of the data
- Flexibility for user control of data display
  - User control for information display (sorting, ordering)
- Only a starting point
  - Has many special cases
  - Application specific (Ex. ATMs)

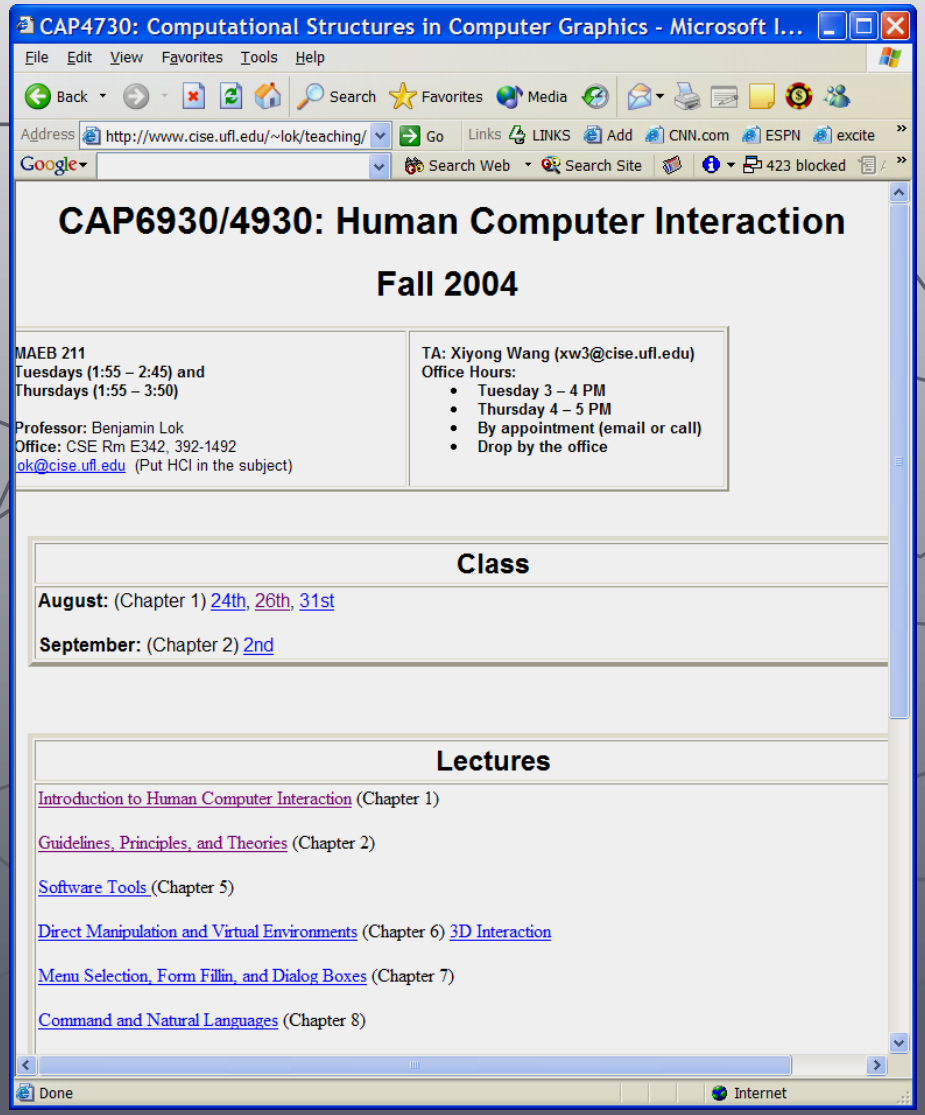
Get the user's attention

- User sees much data in front of them
- Urgent, exceptional, and time-dependent conditions need to be brought forward
- Ex. games and damage (visual, audio)
- Intensity – two levels only, limited use of high intensity
- Marking – underlines, box, arrows, asterisk, bullet, dash, X
- Size – Up to 4 sizes
- Fonts – three fonts



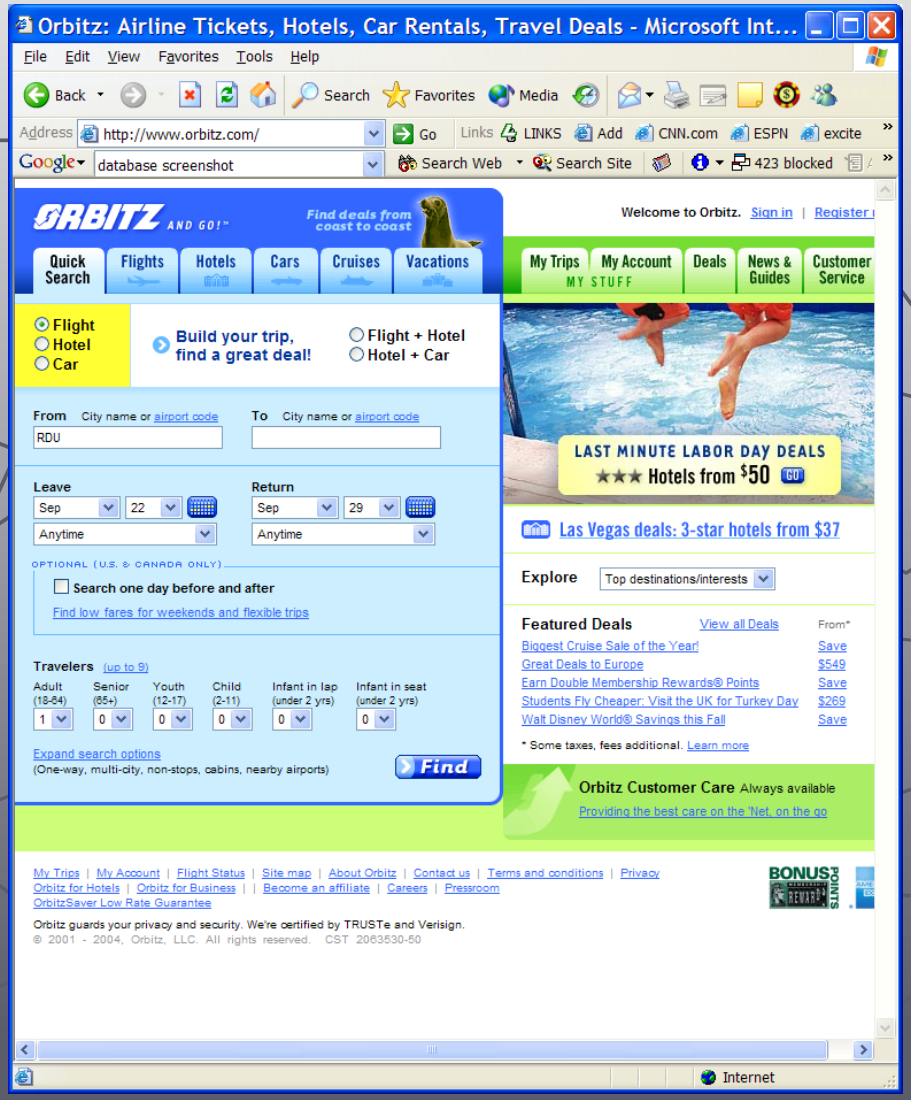
Get the user's attention

- Inverse video – inverse coloring
- Question – which two colors are most noticable to humans?
- Blinking (2-4 Hz), Color (4), Audio (soft tones – positive, harsh – emergency, multiple levels are difficult to distinguish, voice?)
- Danger in overusing the above
  - Animation should provide needed information (including progress)
  - Similarly highlighted items imply relationships
  - Novices: simple, logically organized, well-labeled displays
  - Experts: shorter labels, more flexibility, subtle highlight of changed values
- Test w/ user groups



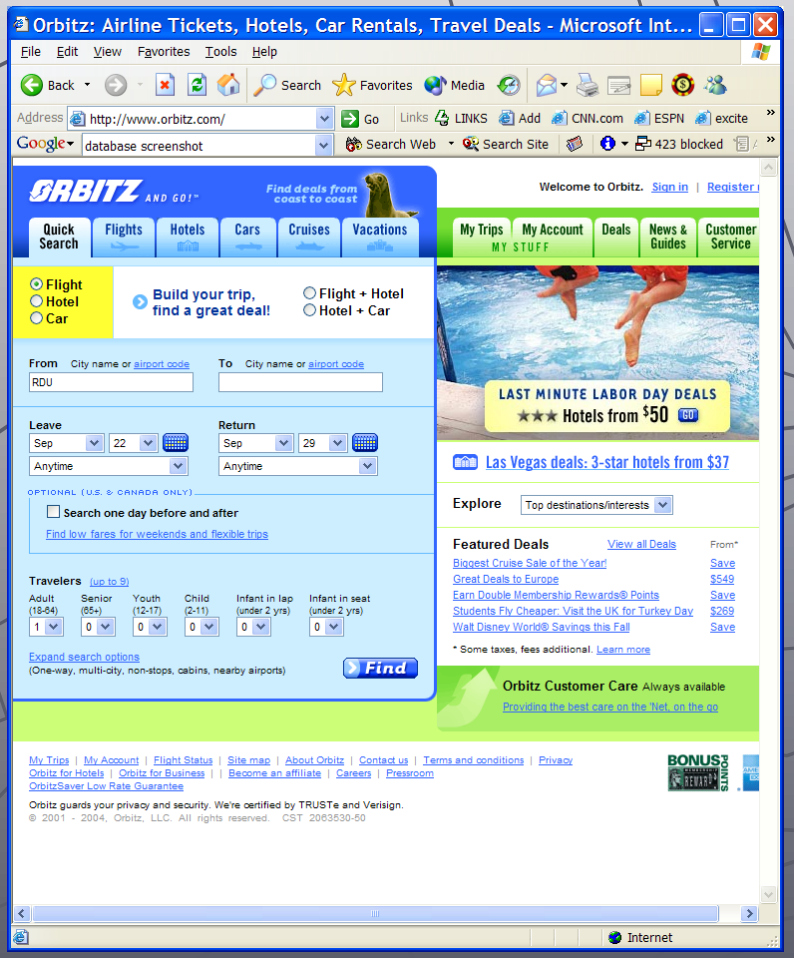
Facilitate Data Entry

- Can constitute substantial portion of user's time
- Consistency of data-entry transactions – similar sequence of actions, delimiters, abbrev.
- Minimal input actions by user – fewer actions = greater productivity and less error.
  - Single key-stroke vs. mouse selection
  - Typing is typically better
  - Command line vs. GUI
  - Too much hand movement is not good.
    - Experts prefer to type 6-8 characters instead of moving a mouse, joystick, etc.
  - Avoid redundant data entry (waste of time, perceived effort, increased error). System should aid but allow overriding



Facilitate Data Entry

- Minimal memory load
  - Don't use codes, complex syntactic strings. Ex. county on a web form
  - Selecting from a list – don't need to memorize choices
- Compatibility of data entry with data display – again
- Flexibility for user control –
  - Experienced vs. novice.
  - Organize entry based on situation (ex. flight controllers).
  - Can conflict with consistency requirement

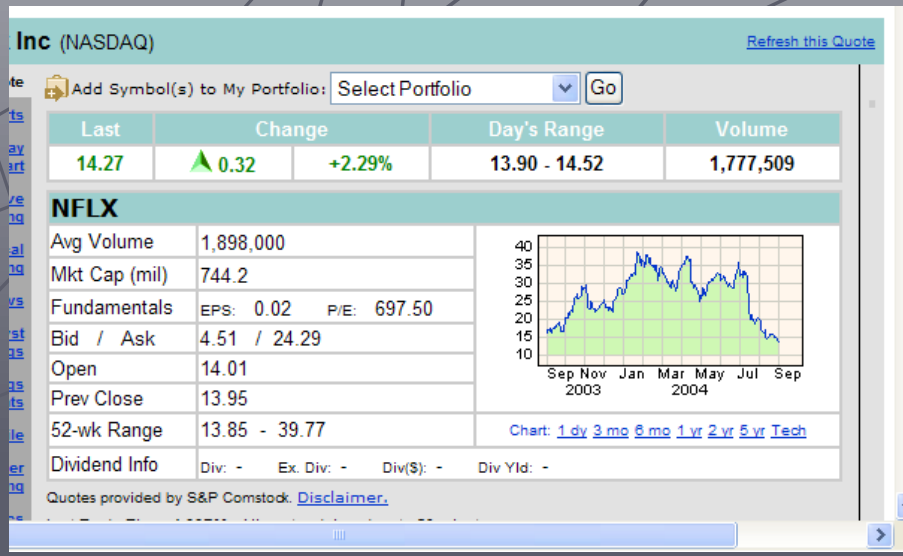


Principles

- More fundamental and applicable than guidelines
- Ex. how important is diversity
- Consider
  - Expertise
  - Task requirements

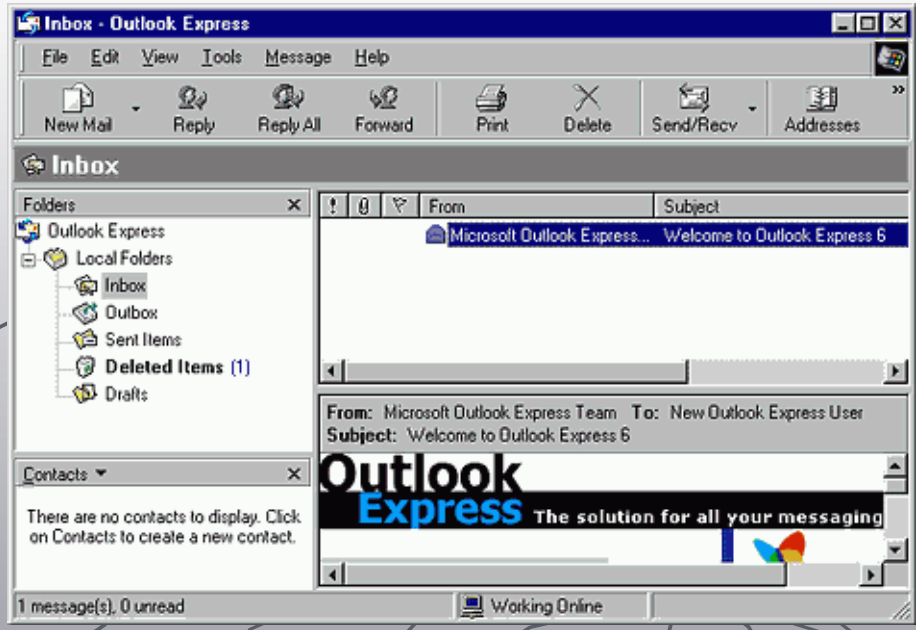
Determine User Skill Levels

- Know thy user - Wilfred Hansen (1971)
- Many assume they understand users and their tasks
- Many think differently than you
- Graphs vs. Tables, words vs. numbers, open-ended vs. structure
- Start with a population profile
  - Primary: age, gender, physical and cognitive abilities, education, motivation, training, goals, personality
  - Secondary: location, economics, attitudes



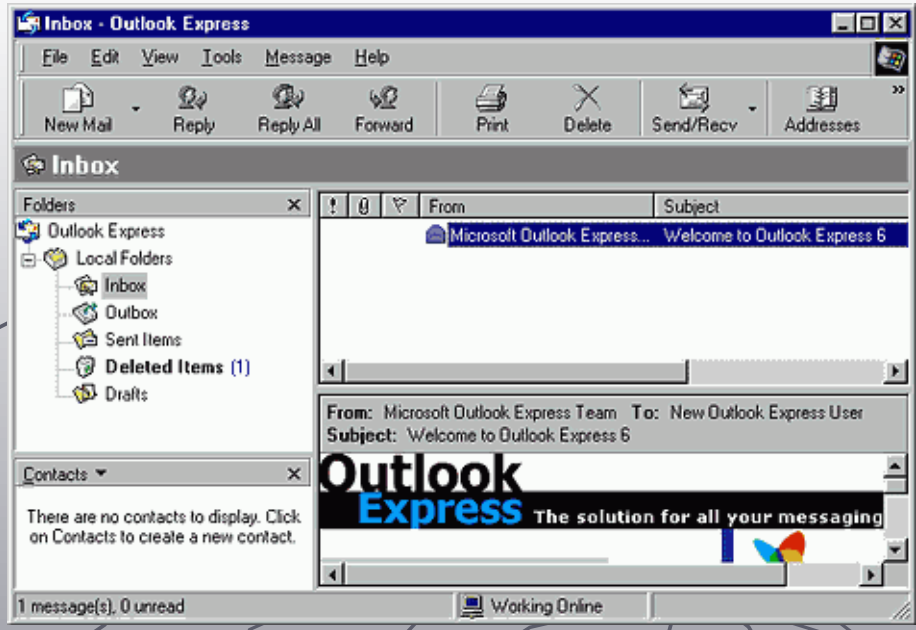
Novice/First-Time Users

- What would you need to consider for
  - Grandparents sending first email
  - Airport check-in kiosks
- Inexperience with interface
- Anxiety
- Solutions
  - Restrict vocabulary
  - Instructions, dialog boxes, know who to turn to for help, multiple languages, consistent terms
  - Small number of actions
  - Positive reinforcement
  - Feedback (Ex. BOA ATM often does not give you any feedback)
  - Good Error messages
  - Video demonstrations, online tutorials, good manuals



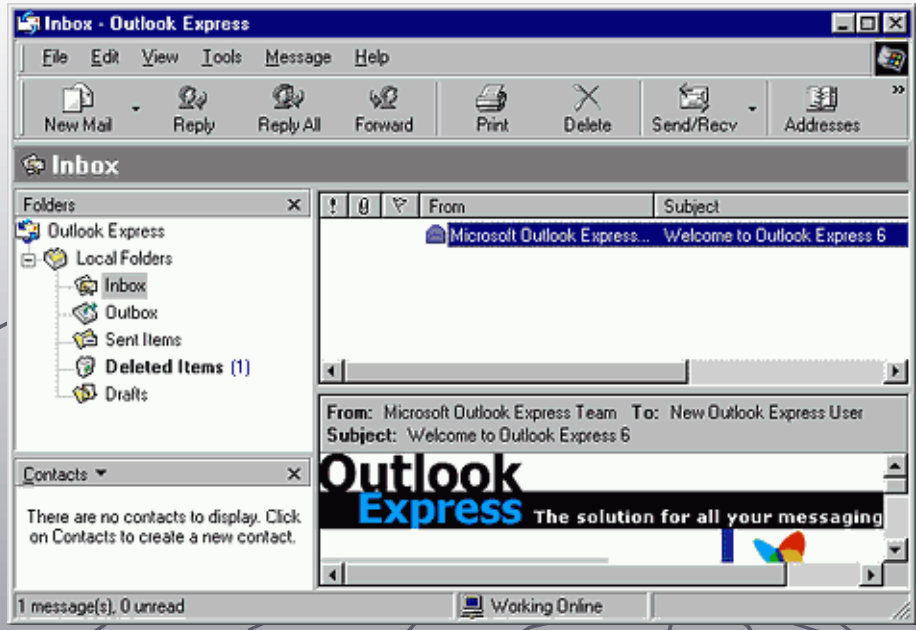
Knowledge-able Intermittent Users

- Ex. Frequent travelers, managers and code/word processors. Me and the UF travel forms
- Understand task concepts, and interface basics
- Retaining menu structure, location of features
- Solutions:
  - Consistent sequences of actions
  - Meaningful messages
  - Guides to frequent patterns of usage
  - Protection from danger (encourage exploration)
  - Context dependent help

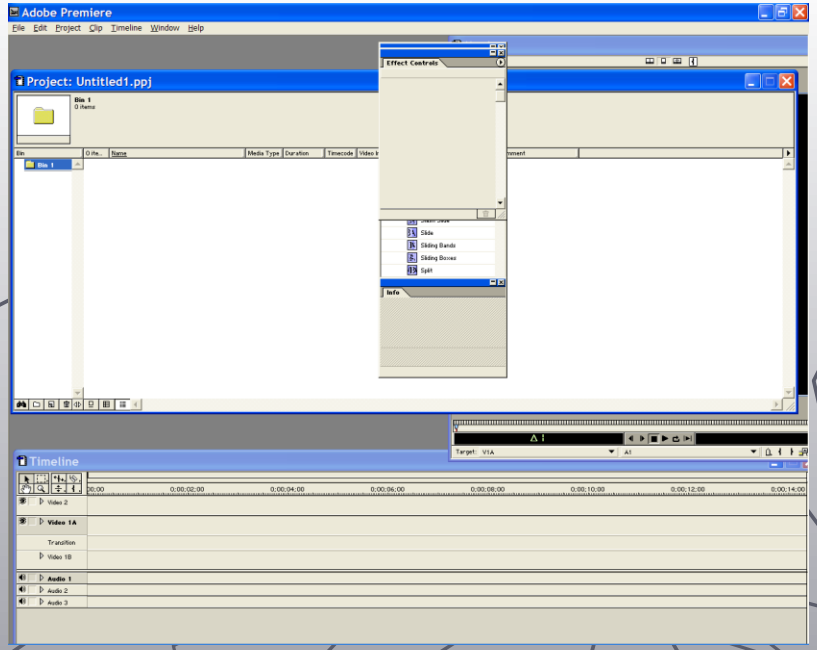


Expert/Frequent Users

- Thoroughly familiar with task and interface
- Goal is efficiency (high speed, low error)
- Solutions:
  - Rapid response time
  - Brief feedback
  - Shortcuts
  - Macros



Multiple Classes



- You might be designing for more than one of these classes
- Approach is typically a *multi-layer* (aka *level-structured* or *spiral*)
  - Novices use a subset of commands, actions, and objects
  - Can move up when they feel comfortable
- Ex. Cellphones
  - Novices: phone calls easy to make
  - Experts: store #s, web, contact info
- Also involves manuals, help screens, errors messages, tutorials, feedback
- Most games

Identify the Tasks

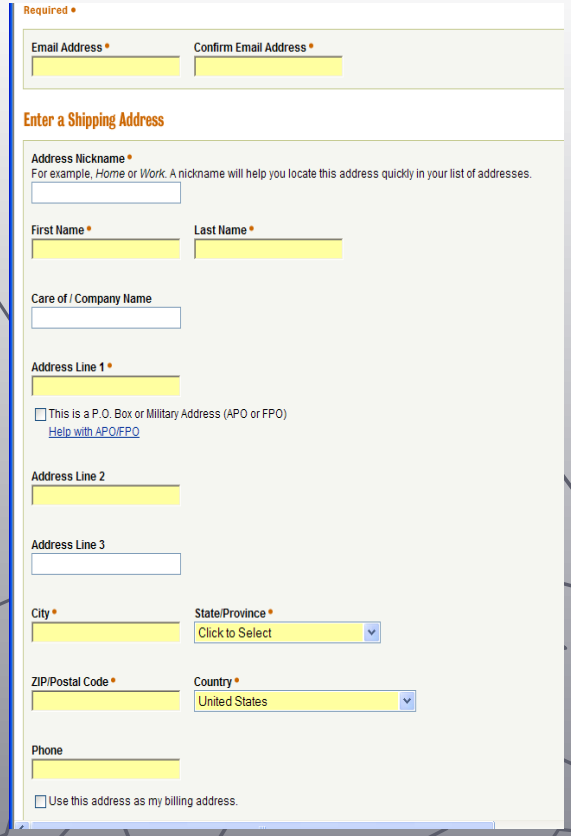
- How?
  - Brainstorm
  - Observe and interview users (esp. newer versions)
- Ex. Palm Pilot
  - Limited functionality = universal usability
- Atomicity of tasks is important to consider
  - Ex. making a left turn
  - Too small = too many steps (inefficient, frustrating)
  - Too many = need special cases, inflexible, frustrating
- Task frequency
  - High frequency = simple, quick, even if it slows other tasks down
  - Special keys vs. Ctrl + key vs. menu selections
- Task vs. Job Frequency Matrix (Fig. 2.1 in book)
- Task analysis and task objects and objects defined

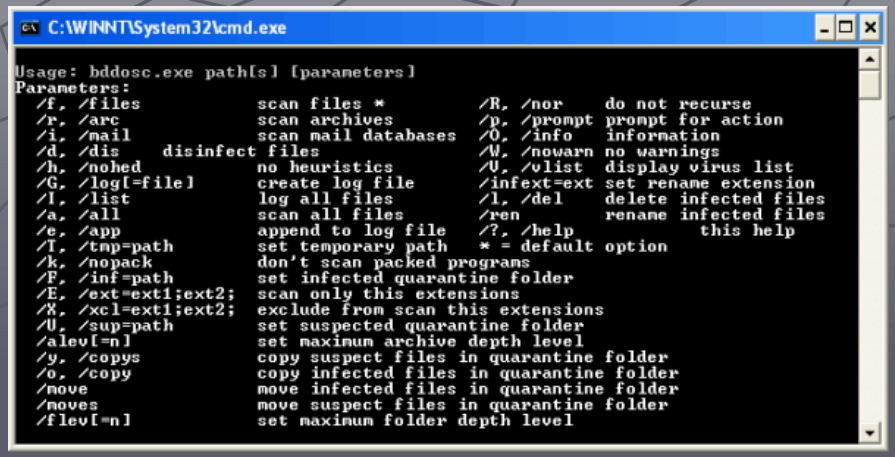
Choose an Interaction Style

- **Direct Manipulation**
  - Manipulate visual representations
  - **Ex.** Desktop metaphor, CAD, games
  - **Pros:** fast, feedback, easy to understand and retain (ex. icons on your desktop), exploration encouraged, good for novices, and can be good for other classes, visual data
  - **Cons:** hard to program, interaction devices are harder to design or modify
- **Menu Selection**
  - User reads a list of items, and selects one
  - **Pros:** no memorization, few actions, clear structure, tools for validity and consistency exist
  - **Cons:** Make actions understandable not easy, careful task analysis

Choose an Interaction Style

- **Form Fill-in**
  - Data entry into fields
  - **Pros:** rapid, for more advanced users, tools available for forms
  - **Cons:** must understand labels and request format, be able to respond to errors, training required
- **Command Language**
  - **Pros:** feeling of control, most advanced users like it, rapid, histories and macros are easy, flexibility
  - **Cons:** high error rates, training required, poor retention rate, hard to create error messages





Choose an Interaction Style

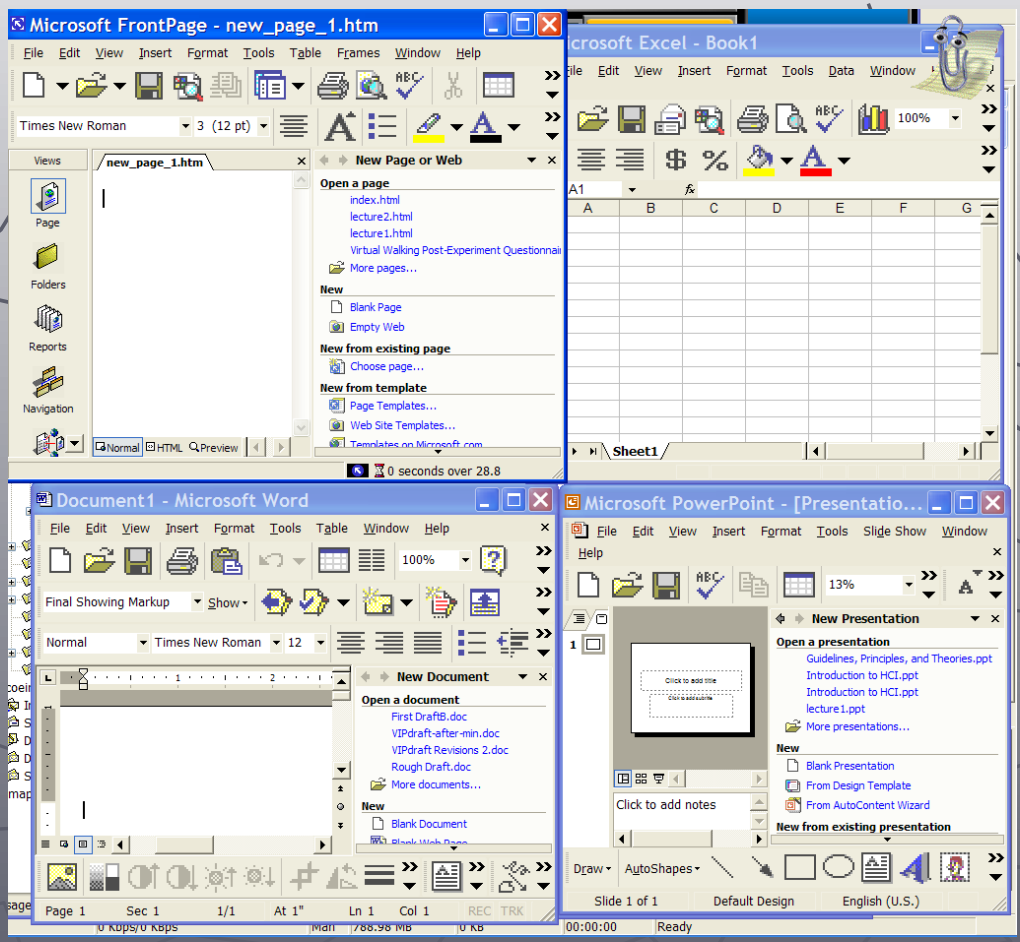
- Natural Language
  - **Pros:** easy to learn
  - **Cons:** unpredictable, requires clarification dialog, require more work to clean up
- **Ex.** let's figure out how to specify the date in each of the above methods.
- Could use more than one

Eight Golden Rules of Interface Design

- 1. Strive for Consistency
- 2. Cater to universal Usability
- 3. Offer informative feedback
- 4. Design dialogs to yield closure
- 5. Prevent errors
- 6. Permit easy reversal of actions
- 7. Support internal locus of control.
- 8. Reduce short-term memory load.
- **Homework 2**: Find an example of a UI that conforms to each of the above, and one that does not.

Strive for Consistency

- Consistent sequence of actions for similar situations
- Identical Terminology (prompts, menus, help)
- Consistent visual layout (fonts, color, etc.)
- Exceptions:
  - Confirmation of deletion
  - No password echoing
  - Limited



Cater to Universal Usability

- Recognize the needs of a diverse user group
- Design for *plasticity* (transformation of content)
- Novice -> Expert
- Disabled
- Ex. cnn.com

Offer Informative Feedback

- For every user action, the system should provide feedback
- Frequency of task affects feedback type
  - Common tasks – modest feedback
  - Errors/uncommon tasks – substantial feedback
- Visual approaches make feedback easy
- Funny error messages: http://worsethanfailure.com/Articles/Pop-up_Potpourri_0x3a__Julialicious.aspx
- What's wrong the message when you type in a wrong web address?

Design Dialogs to Yield Closure

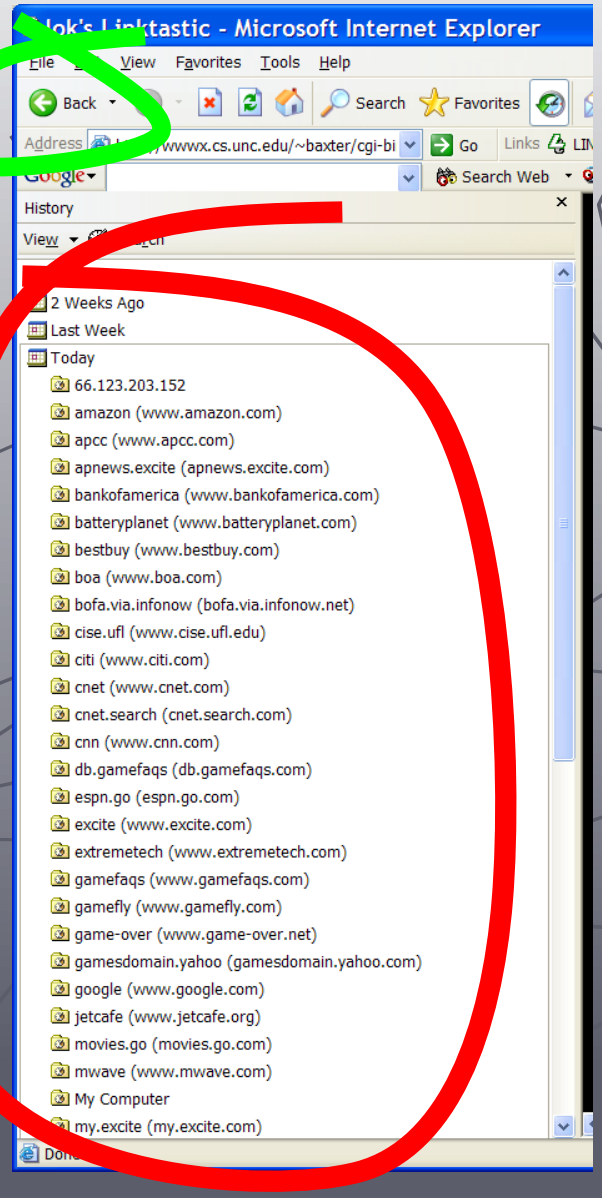
- Action sequences should have a beginning, middle, and end.
- Feedback provides sense of accomplishment
- Ex. Purchasing items via internet has a clearly defined step-by-step process

amazon.com.

SIGN IN SHIPPING & PAYMENT GIFT-WRAP PLACE ORDER

Permit easy reversal of actions

- As much as possible, actions should be reversible
  - Trash can
  - Relieves anxiety
- Design decision should include
  - History size
  - What does it mean to undo something?
- Let the user ***know*** they can reverse an action



Support Internal Locus of Control

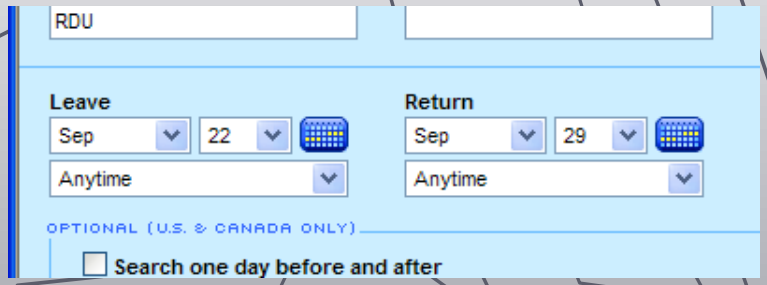
- Experiences operators want to feel in control
  - User is in charge of the interface
  - Interface rapidly responds to the user
- Builds anxiety and dissatisfaction
  - Surprising interface actions
  - Tedious actions
  - Difficulty in obtaining necessary ability
  - Difficulty in producing action
  - Ex. Lag
- **Good rules:** Avoid acausality, make users initiators rather than responders
  - Ex. Sound when clicking on a link

Reduce Short-term Memory Load

- Rule of thumb: Humans can remember 7 +/- 2 chunks of information
- Displays kept simple
- Multiple page displays should be consolidated
- Training if using codes, mnemonics, long sequence of actions
- Online access to command-syntax, abbreviations, codes, etc.

Prevent Errors

- Limit errors a user can make
  - Gray out menu items that don't apply
  - No characters in a numeric field
- In case of errors
  - Detect error
  - Simple, constructive, and specific instructions
  - Do not change system state

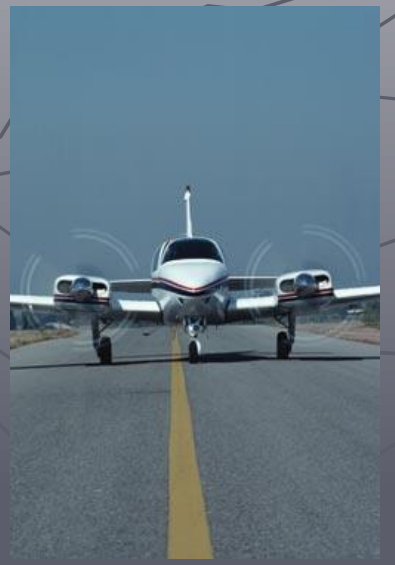


Prevent Errors

- Error rate is typically higher than expected
  - What are common errors for us?
    - Coding, typing, dialing, grammar
- How can we design software to reduce them?
  - Better error messages
    - Specific, positive, and constructive
      - "Printer is off, please turn on" instead of "Illegal Operation" Helps fix current error
    - Helps reduce similar errors
    - Increases satisfaction
  - Reduce chance for error
    - Organizing info, screens, menus
    - Commands and menu choices should be distinctive
    - State of the interface should be known (change cursor when busy)
    - Consistency of actions (Yes/No order of buttons)

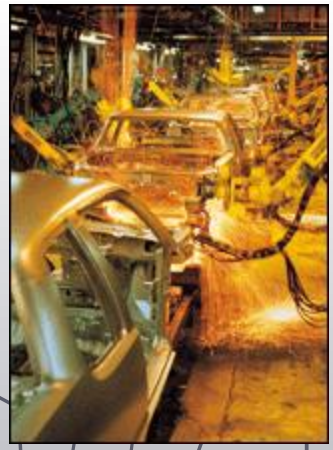
Prevent Errors

- Correct actions
  - Elevator – can't open doors until not moving
  - Aircraft engines – can't go in reverse unless landing gear is down
  - Choose a date from a visual calendar instead of having them type it in
  - Cellphones let you choose from recently dialed #s or received calls
  - Automatic command completion
  - Spell checker



Prevent Errors

- Complete Sequences
  - One action can perform a sequence of events
    - Ex. Left turn signal
      - Same concept for interfaces
    - Ex. Dialing in, scripts, macros, making a passage or all headings "bold"
    - Waypoints
    - Relieve operator attention/possibilities for error
    - What are atomic operations and what are sequences that can be automatically strung together?
  - Study usage, error patterns, and user preferences via user groups, studies
  - Log errors
- Universal Usability can help lower errors
  - Large buttons helps with readability, and reduces error



Integrating Automation while Preserving User Control

- Automation
  - Increases familiarity
  - Increases over time
  - Improves speed
  - Reduces error
- Why have humans if we can automate tasks?
  - Real world is an *open system*
  - Computers are a *closed system*
- Humans are there for
  - Unexpected situations
  - Preserve safety
  - Avoid failures
  - Increase product quality

What's the right level of automation in this app?

Integrating Automation while Preserving User Control

- Example Air Traffic Control
  - Easy to automate
  - Unpredictable events (weather, emergencies, etc.). Need 'context', can't jump in cold
- Some real world situations are just too complex to model
- What happens if some parts of the system go down?
- How can you be sure that the system can handle what will happen?
  - Regression testing
  - User testing
- Look at Box 2.3 on pg. 79

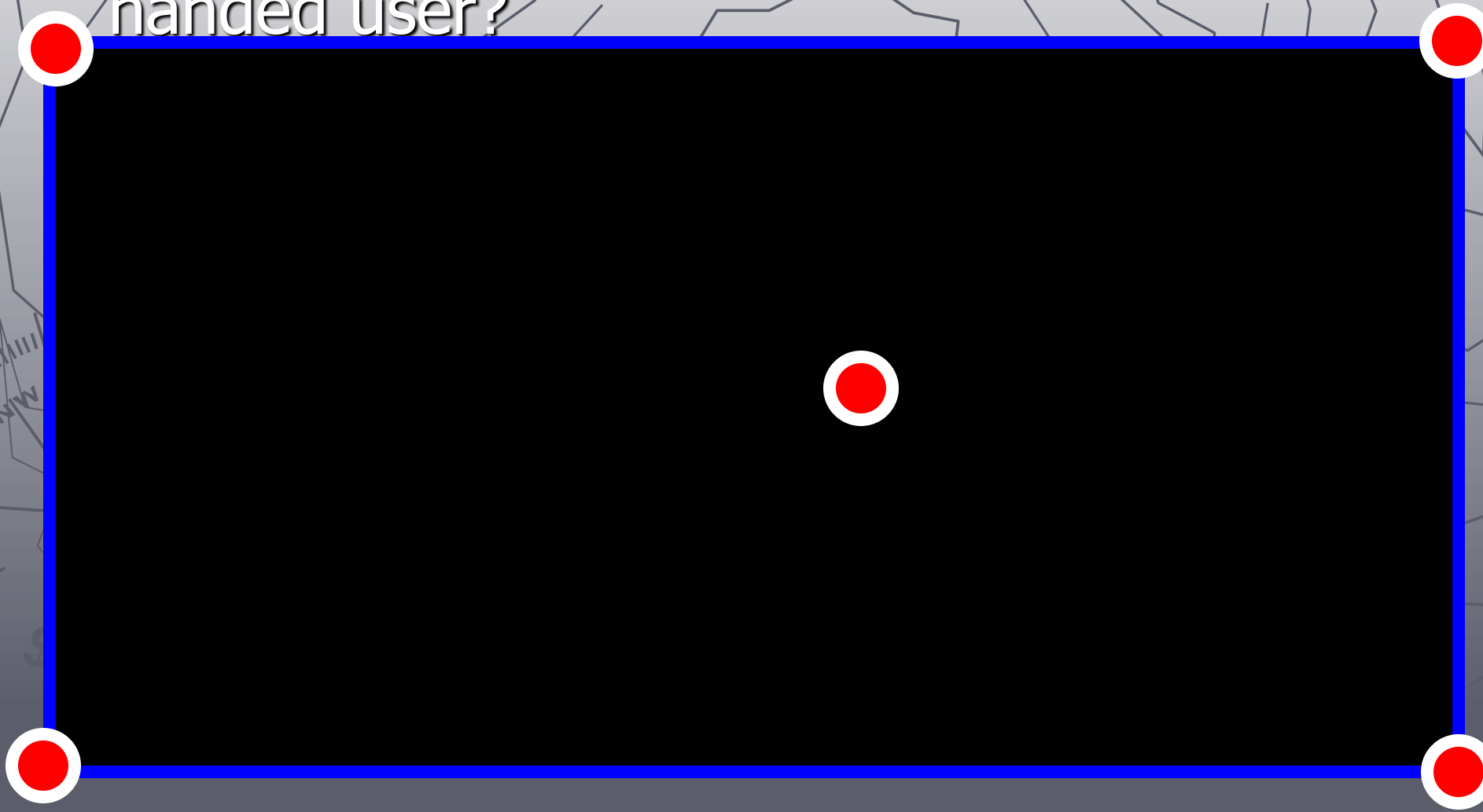
What's the right level of automation in this app?

Automation

- Create tools to help w/ interfaces?
- Create anthropomorphic agents that track user tendencies
  - Based on human-human interaction
  - Apple Computer bow-tied helper
  - Microsoft's BOB and Clippy
  - Actually a long line of failures (ATMs, cars, online help)
- Change interface based on user choices
  - Adaptive menus
    - Pros: If using a few choices, makes it faster
    - Cons: Retention is poor, if user uses many choices, this becomes much slower, users might miss an interface change
  - Email SPAM filters
  - Amazon.com's page that you built
- Ethical concerns (agents that break security, etc.)

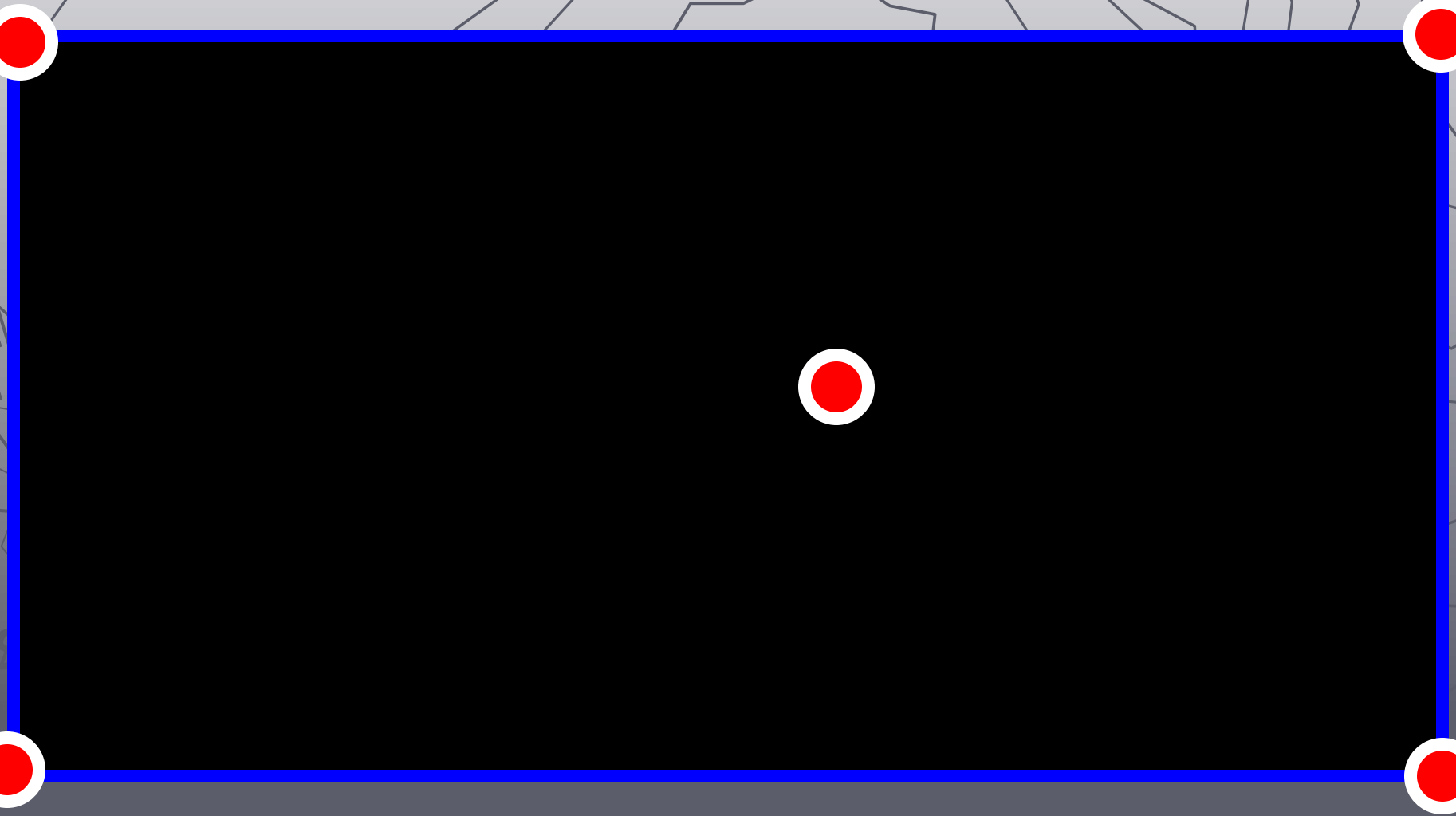
Example

- Five fastest places to click on for a right-handed user?

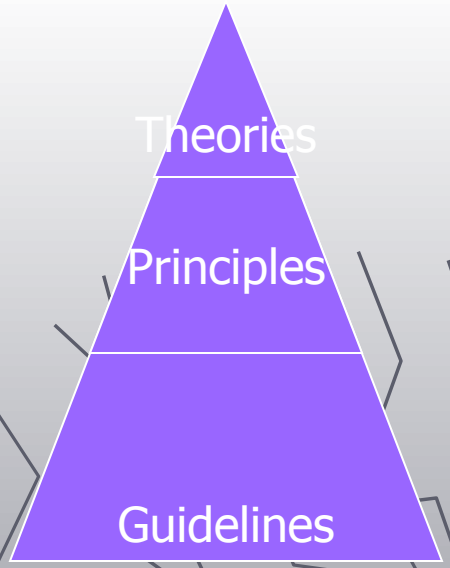


Example

- What affects time?



Theories



- Tested, reliable, broadly applicable
- Descriptive and explanatory
  - Help develop consistent terminology, actions, and objects
- Predictive
  - Execution time, pointing time, error rates
  - Satisfaction, emotional reaction
  - Small group behavior, organizational dynamics, sociology -> collaboration interfaces
- Types of Theories based on task
  - Motor-task
    - Click on an icon
    - Fitt's Law example
  - Perception
    - Finding the computer icon
    - Predicting reading time for a task, visual task, etc.
  - Cognitive
    - Deciding which icon to click on
    - Memory of actions, problem solving, f(response time) = productivity

What makes good Design so Important

- Ratio completion time of novice to expert users can be as high as:
  - **100 to 1**
- Not many other fields or problems have this disparity (Try to think of a comparable task!)

Web design theory

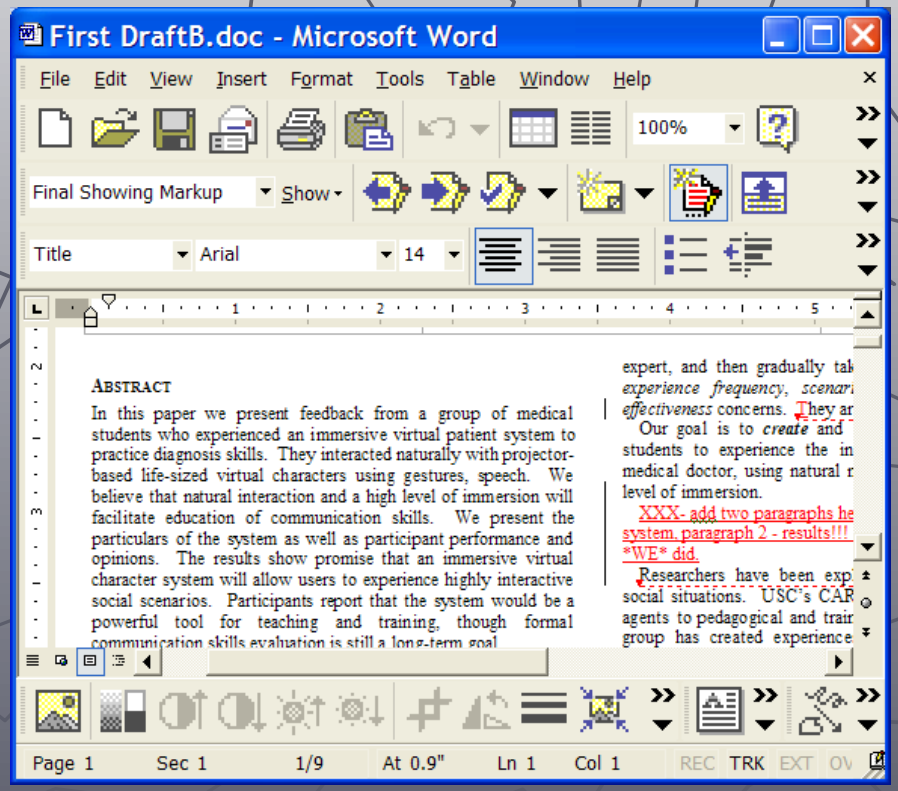
- Information-architecture model with navigation
- Users typically forage for information, and thus designers leave information scents (via links) to help users find what they want.
- ex. download demo
- Information-foraging theory attempts to predict user success rates given a set of tasks and a web site.

Taxonomy

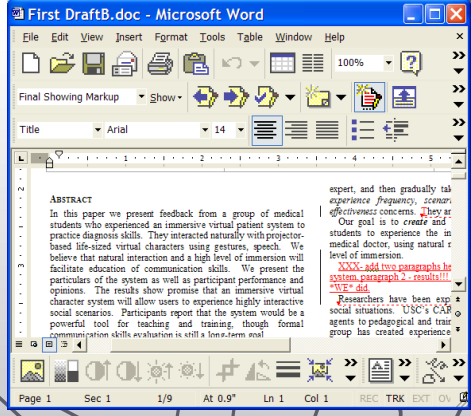
- Part of a descriptive theory
- Classify a real world system into categories
- Let's classify input devices
  - Direct vs. indirect
  - Linear vs. rotary
  - Dimensions (1-3D)
- Task (virtual characters), personality, user experience, technical aptitude, taxonomies
- Useful comparisons, organize topics, guide design, show where new ideas might be needed

Levels of Analysis Theories

- Separate concepts into levels (software engineering, network design)
- Foley (late 1970s)
- **Conceptual level** – user's mental modal. High level of what we are working with. (ex. painting programs – either pixel or object based [Powerpoint vs. paint])
- **Semantic level** – meanings conveyed by user input and computer output (ex. ways to delete an object. delete-object action OR undo)
- **Syntactic level** – user actions convey semantics (ex. select files, hit delete key OR click file->edit->delete, then confirm)
- **Lexical level** – device dependencies, precise mechanisms (ex. 200 ms double click)
- Let's create an example for the 3d problem of moving an object in VR
- Not as useful for today's GUI based systems



Stages of Action



- Donald Norman (1988)
- Simulate the stages of action that users go through
  - Form the goal — I want to do something
  - Form the intention
  - Specify the action — Here's how I need to do interact with the system to accomplish it
  - Execute the action — Do it
  - Perceive the system state
  - Interpret the system state
  - Evaluate the outcome — See how it turned out
- Ex. Insert a word into a document
- Cycle of action and evaluation
- **Gulf of execution** (what you want vs. what you could do)
- **Gulf of evaluation** (what you got vs. what you wanted)

Stages of Action

- Four Components of Good Design
  - 1. Make the system state and all action alternatives visible
  - 2. Good conceptual model with consistent system image
  - 3. Interface should have good mappings between stages
  - 4. Continuous feedback
- Errors occur when transitioning from goals->intentions->actions->outcome
  - User forms inadequate goals
  - Cannot find the correct interface action to accomplish goal
  - Do not know how to specify correct set of actions
  - User receives poor feedback
- Which of them can be affected by good design?

Stages of Action

- Other domains
  - Information-seeking
    - Recognize and accept an information problem
    - Define the problem
    - Choose a search system
    - Form a query
    - Execute the search
    - Examine the results
    - Make judgments
    - Extra info
    - Iterate/stop
  - Think about searching on the internet for a document or looking for a restaurant

GOMS and Keystroke-Level Model

- CMU (1980-1983)
- Two models
  - GOMS – goals, operators, methods, and selection rules
    - User forms goals and subgoals (write a paper, insert word)
    - User develop a series of operators – elementary acts (hit delete key, move hand to mouse, etc.)
    - User executes methods – highlights text, hits a key
    - Selection relates to how the user selects between several methods (several ways to delete a paragraph)
  - Keystroke-Level
    - Predicts time for error-free expert performance
    - Sum up times for keystrokes, pointing, homing, drawing, thinking, and waiting for the system
    - Mainly for experts, otherwise variance gets too large to be useful
    - Does not say how useful the system is to accomplish a goal (problem solving, cognitive amplification, satisfaction, etc.)
- Let's look at a GOMS sheet on Pg. 89
- Advances include conditional statements, incorporating judgment calls
- Breaking things down like this allows for tools to be built to evaluate systems
- Case study: Using CPM-GOMS [cognitive, perceptual, motor] modeling, a telephone company saved $2million per year in operating costs.

Challenges to HCI Theories

- Theories should be more central to research and practice
  - Understand relationship between concepts and results
  - Help designers understand tradeoffs
  - Short term for predictive theories, long term for descriptive
- Theories should lead rather than lag behind practice
  - Help design, refine, and **suggest** new products