# Introduction to HCI
## - user interface design -

Introduction to Computer Graphics, 2008

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*Based on Lecture notes from MIT*

# The User Interface Is Important

- The user interface is the means by which the software presents itself to the world
- User interface strongly affects perception of software
  - Usable software sells better
  - Unusable web sites are abandoned
- Perception is sometimes superficial
  - Users blame themselves for UI failings
- User interfaces are hard to design
  - Most SW engineer is not the user
  - The user is always right
    - Consistent user's faults are the system's problem
- User interface accounts for ~50% of the SE life cycle.

# Usability Defined

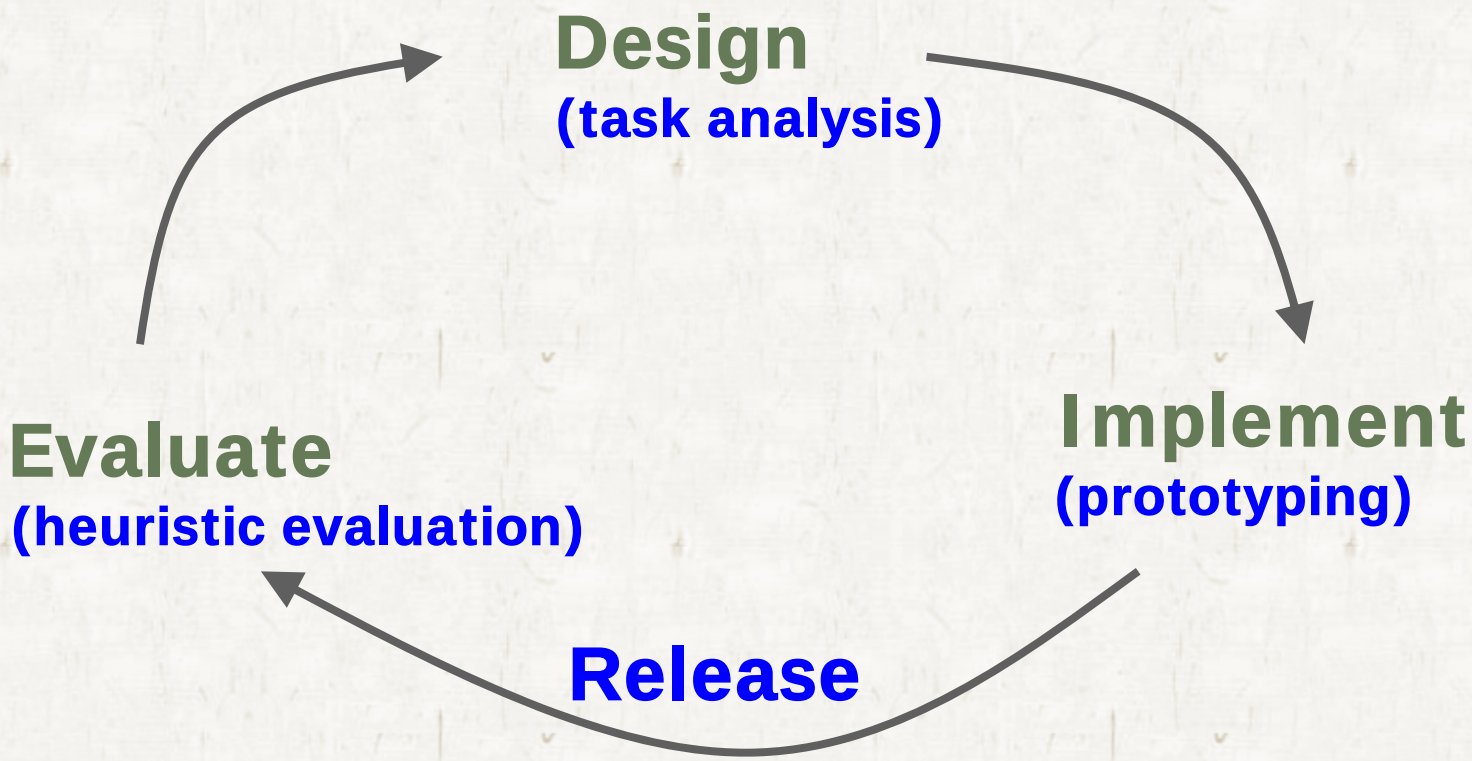
- Usability: how well users can use the system's functionality
- Dimensions of usability
  - Learnability: is it easy to learn?
  - Efficiency: once learned, is it fast to use?
  - Memorability: is it easy to remember what you learned?
  - Errors: are errors few and recoverable?
  - Satisfaction: is it enjoyable to use?
- Usability depends on the user
  - Novice users need learnability
  - Infrequent users need memorability
  - Experts need efficiency

# Usability Is Only One Attribute of a System

- Software designers have a lot to worry about:
  - Functionality
  - **Usability**
  - Performance
  - Size
  - Cost
  - Reliability
  - Security
  - Standards
- Many design decisions involve tradeoffs among different attributes

# Usability Engineering -Iterative Design

The current best-practice process for developing user interfaces



# Iterative Design of User Interfaces

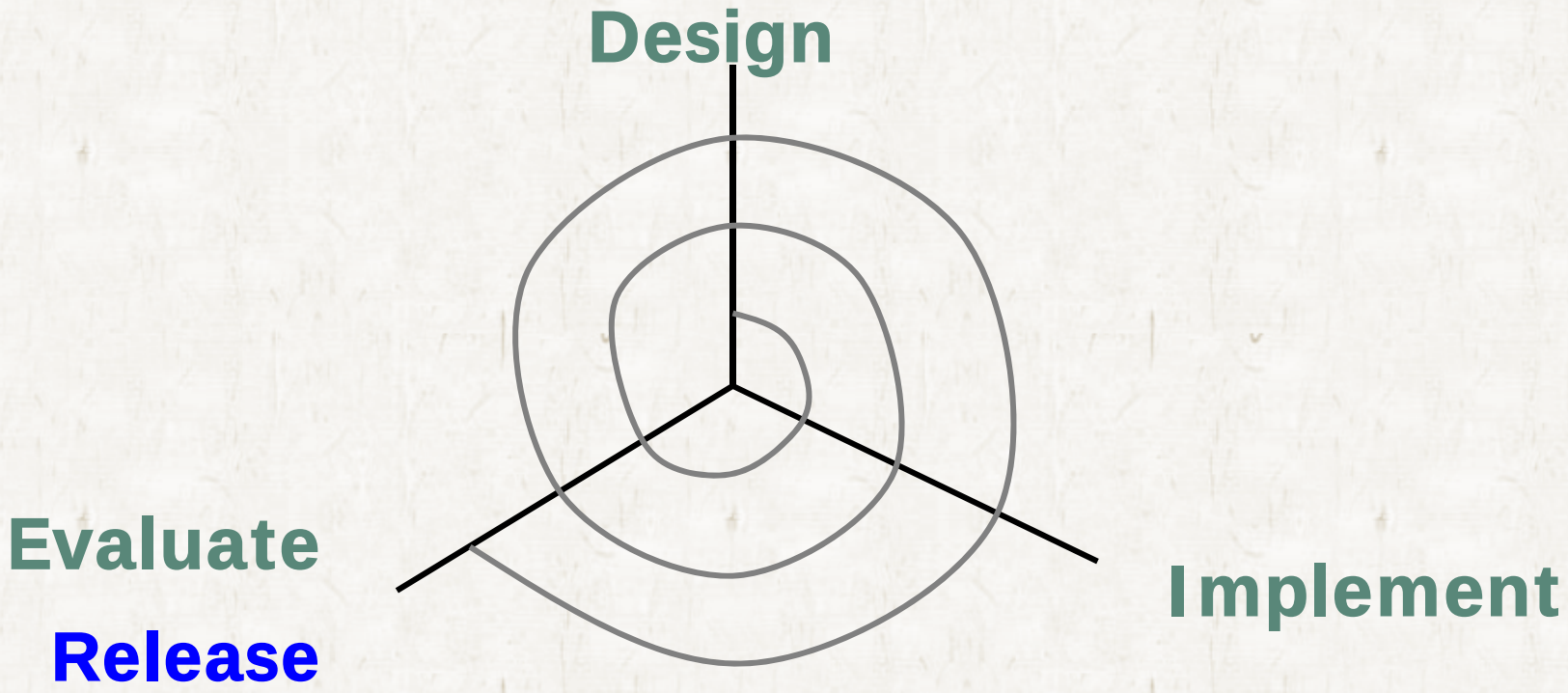
- Design
  - Focus on users and tasks
    - user analysis: who the users are
    - task analysis: what they need to do
- Implement
  - Prototyping
- Constant evaluation
  - Users are involved in every iteration
  - Every prototype is evaluated somehow

# Why Waterfall Model is Bad for UI Design

- UI design is hard
- Users are not involved in validation until acceptance testing
- UI flaws often cause changes in requiremnts and design

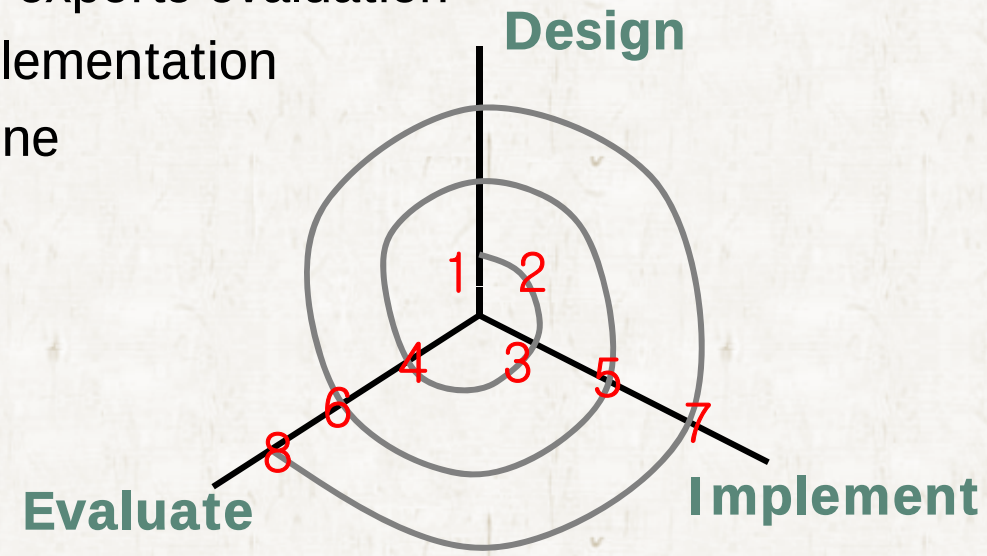
# Spiral Model

Iterative design may release too many version and customers do not want to pay the evaluation costs.



# Design in Spiral Model

1. Task analysis: collecting the requirements for the UI
2. Design sketches: paper sketches of UI design
3. Paper prototype: an interactive prototype
4. In-class user testing
5. Computer prototype: an interactive software prototype
6. Heuristic evaluation: usability exports evaluation
7. Implementation: the real implementation
8. User testing: users test & refine



# Usability Guidelines

- Fitts's Law
  - A fundamental law of the human sensory-motor system
  - the time for pointing a target from the current position

$$T = a + b \log(2D/S)$$

a: reaction time

b: index of difficulty

target size S at distance D away

  - Size and proximity of controls should relate to their importance
  - Tiny controls are hard to hit
  - Targets at screen edge are easy to hit
    - Provides infinite size

# Usability Guidelines (cont’)

- Working memory
  - Small capacity: golden number 7
  - Fast decay : 7 sec.
- Color Blindness guidelines
  - Don’t depend solely on color distinctions (color blindness)
  - Avoid red on blue text (chromatic aberration)
  - Avoid small blue details

# Direct manipulation Cues

- Norman’s principles of direct manipulation
  - Affordances: perceived and actual properties of a thing that determine how the thing could be used
    - A button is for pushing
    - Chair is for sitting
  - Natural mapping: physical arrangement of controls should match arrangement function
    - The orientation of turn switches
  - Visibility : relevant parts of a system should be visible
    - show important control menus
  - Feedback: action should be immediate, visible effects
    - Push buttons
    - Scrollbars
    - Drag & drop

# Usability Guidelines (“Heuristics”)

- Plenty to choose from
  - Nielsen’s 10 principles
    - One version in his book
    - A more recent version on his website
  - Tognazzini’s 16 principles
  - Norman’s rules from Design of Everyday Things
  - Mac, Windows, Gnome, KDE guidelines
    - Platform-specific guidelines give consistency but limited
- Heuristics can be used for
  - Help designers choose design alternatives
  - Help evaluators find problems in interfaces

# Nielsen's 10 principles
# 1. Match the Real World

- Use common words, not techie jargon
  - But use domain-specific terms where appropriate
  - What is the meaning of "Type mismatches"
- Don't put limits on user defined names
- Allow aliases/synonyms in command languages
- Metaphors are useful but may mislead
  - Word processor vs. typewriter

# Nielsen's 10 principles
# 2. Consistency and Standards

- Principle of Least Surprise
  - Similar things should look and act similar
  - Different things should look different
- Other properties
  - Size, location, color, wording, ordering, ...
- Command/argument order
  - Noun-verb order: first select the command then invoke the command
  - Verb-noun order: first invoke the command then select command
- Follow platform standards

# Nielsen's 10 principles
# 3. Help and Documentation

- Users don't read manuals
  - Prefer to spend time working toward their task goals, not learning about your system
- But manuals and online help are vital
  - Usually when user is frustrated or in crisis
- Help should be:
  - Searchable
  - Context-sensitive
  - Task-oriented
  - Concrete
  - Short

# Nielsen's 10 principles
# 4. User Control and Freedom

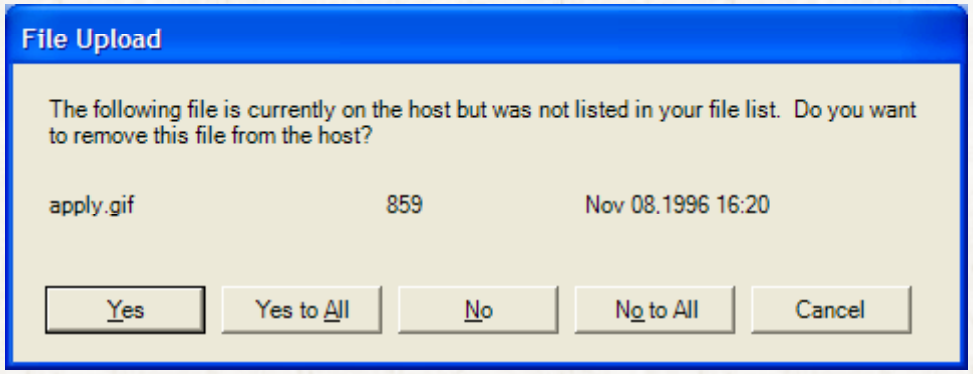
- Provide undo
- Long operations should be cancelable
- All dialogs should have a cancel button

# Nielsen's 10 principles
# 5. Visibility of System Status

- Keep user informed of system state
  - Cursor change: hand over a hyperlink, drag/drop
  - Selection highlight
  - Status bar
  - Don't overdo it...
- Response time
  - < 0.1 s: seems instantaneous
  - 0.1-1 s: user notices, but no feedback needed
  - 1-5 s: display busy cursor
  - > 1-5 s: display progress bar

# Nielsen's 10 principles
# 6. Flexibility and Efficiency

- Provide easily-learned shortcuts for frequent operations
  - Keyboard accelerators
  - Command abbreviations
  - Styles
  - Bookmarks
  - History




Good for repeated operations

# Nielsen's 10 principles
# 7. Error Prevention

- Selection is less error-prone than typing
  - But don't go overboard...


*An example of overboard*

  - Disable illegal commands

# Nielsen's 10 principles
# 7. Error Prevention (cont')

- Description Error: Intended action is replaced by another action with many features in common
  - Pouring orange juice into your cereal
  - Do not locate similar action buttons at the same position
- Capture Error: A sequence of actions is replaced by another sequence that starts the same way
- Modes Error: states in which actions have different meanings
  - E.g., Caps lock

# Nielsen's 10 principles
# 8. Recognition, Not Recall

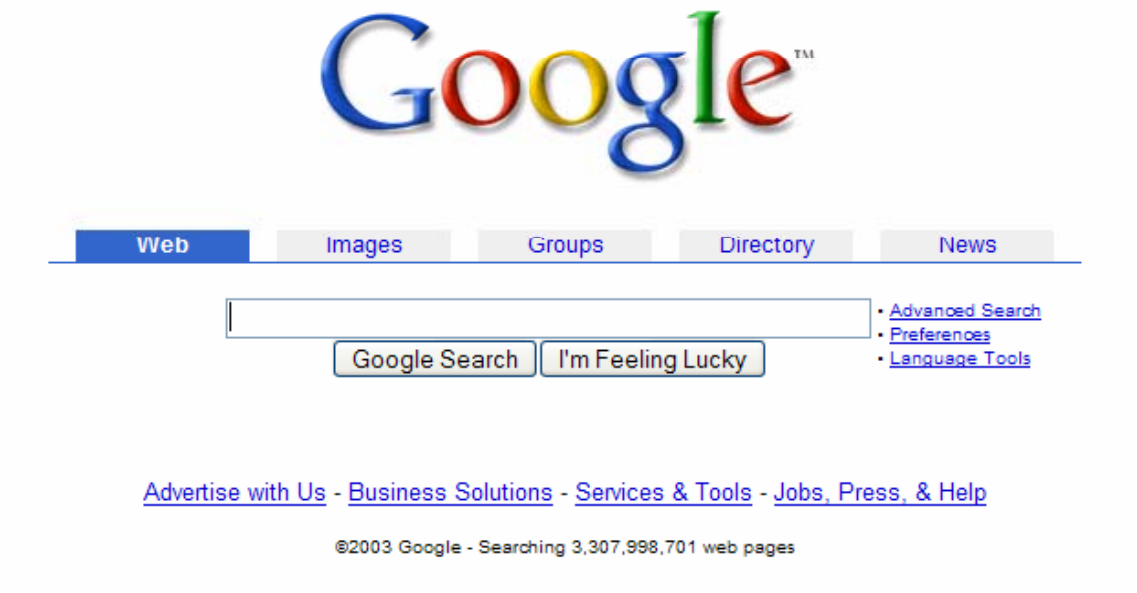
- Minimize the user's memory load
- Use menus, not command languages
- Use combo boxes, not textboxes
- Use generic commands where possible (Open, Save, Copy, Paste)
- All needed information should be visible
- "selection is better than typing"

# Nielsen's 10 principles
# 9. Error Reporting, Diagnosis, Recovery

- Be precise=exact ; restate user's input
  - Not "Cannot open file",
    but "Cannot open file named paper.doc"
- Give constructive help
  - why error occurred and how to fix it
- Be polite and non blaming
  - Not "fatal error", not "illegal"
- Hide technical details (stack trace) until requested

# Nielsen's 10 principles
# 10. Aesthetic and Minimalist Design

- "Less is More"
  - Omit extraneous information, graphics, features



# Nielsen's 10 principles
# 10. Aesthetic and Minimalist Design (cont')

- Good graphic design
  - Few, well-chosen colors and fonts


  - Group with white space
  - Align controls sensibly
- Use concise language
  - Choose labels carefully

# Nielsen's Heuristics

- Meet expectations
  1. Match the real world
  2. Consistency & standards
  3. Help & documentation
- User is boss
  4. User control & freedom
  5. Visibility of system status
  6. Flexibility & efficiency
- Errors
  7. Error prevention
  8. Recognition, not recall
  9. Error reporting, diagnosis, and recovery
- Keep it simple
  10. Aesthetic & minimalist design

# How To Do Heuristic Evaluation

- One application of Nielson's 10 heuristic
- Justify every problem with a heuristic
  - "Too many choices on the home page"
  - Can't just say "I don't like the colors"
- List every problem
  - Even if an interface element has multiple problems
- Go through the interface at least twice
  - Once to get the feel of the system
  - Again to focus on particular interface elements
- Don't limit yourself to the 10 heuristics
  - We've seen others: affordances, visibility, Fitts's law, perceptual fusion, color principles
  - But the 10 heuristics are easier to compare against

# Formal Evaluation Process

1. Training
   - meeting for design team & evaluator
   - Introduce application
   - Explain user population, domain, scenarios
2. Evaluation
   - Evaluators work separately
   - Generate written report, or oral recorded by an observer
   - Focus on generating problems, not on ranking their severity yet
   - 1-2 hours per evaluator

# Formal Evaluation Process

3. Severity Rating
   - Evaluators prioritize all problems found (not just their own)
   - Take the mean of the evaluators' rating
4. Debriefing
   - Evaluators & design team discuss results, brainstorm solutions

# Kinds of User Tests

- Formative evaluation
  - Find problems for next iteration of design
  - Evaluates prototype or implementation, in lab, on chosen tasks
  - Qualitative observation (usuability)
- Field study
  - Find problems in context
  - Evaluates working implementation, in real context , on real tasks
  - Mostly qualitative observations
- Controlled experiment
  - Test a hypothesis (interface A is faster than interface B)
  - Evaluates working implementation, in controlled lab environment, on chosen tasks
  - Mostly quantitative observation (time, error rate, satisfaction)

# Recording Observations

- Pen & paper notes
- Audio recording
- Video recording
- Screen capture & event logging

# How Many Users?

- How many users do you need for **formative evaluation**?
- Landauer-Niesen model
  - Every tester finds a fraction L of usability problems (typical L= 31%)
  - n users will find a fraction $1-(1-L)^n$ so 5 users will find 85% of problems
  - *But L may be much smaller and variant.*
- Which is better?
  - 15 users to find 99%of problems with one design
  - 5 users to find 85% of problems with each of three design iterations, this is better
- For multiple use classes, get 3-5 users from each class

# Controlled Experiment

- Start with a testable **hypothesis**
  - Interface A is faster than interface B
- Manipulate **independent variables**
  - different interfaces, user classes, tasks
- Measure **dependent variables**
  - times, errors, satisfaction
- Use statistical techniques to accept or reject the hypothesis

# Controlled Experiment Example

- Fitts's law for menu bar
  1. hypothesis: Mac menu bar is faster than Windows menu bar
  2. Independent: position of menu bar (whatever the height of the title bar is)
  3. dependent: time to reach menu bar (how long the user to move the mouse up to the menu bar n click on a particular target menu)

# Concerns Driving Experiment Design

- Internal validity
  - Are observed results actually cased by the independent variables?
- External validity
  - Can observed results be generalized to the world outside the lab?
- Reliability
  - Will consistent results be obtained by repeating the experiment?

# Threats to internal validity

- Ordering effects
  - First people learn, second people get tired or bored.
  - Don’t present tasks or interfaces in same order for all users
  - Solution: Randomize or counterbalance the ordering
- Selection effects
  - Randomly assign users to independent variables
  - Unknown variables are kept the constant states
- Experimental bias

# Threats to external validity

- Population
  - Draw a random sample from your real target population
- Ecological validity
  - Make lab conditions as realistic as possible in important respects
- Training validity
  - Training should mimic how real interface would be encountered and learned
- Task validity
  - Base your task on task analysis

# Threats to Reliability

- Uncontrolled variation
  - Previous experience: novices and experts
  - User differences: fastest users are 10 times faster
  - Task design: population's problems (questions, distractions, coughing )
  - Measurement error
- Solution
  - Eliminate uncontrolled variation
  - Repetition: many users *n* many trials

# Between Subjects

- Users are divided into two group
  - One sees only interface A
  - Other sees only interface B
- Results are compared between different groups
  - Is mean(A) > mean(B)?
- No variation due to ordering effects
  - User only uses one interface

# Within Subjects

- Each user sees both interface A and B (in random order)
- Results are compared within each user
  - For user i, compute the difference $a_i$-$b_i$
  - Is mean($a_i$ -$b_i$)>0 ?
- Eliminates variation due to user difference, but may have reliability problem due to ordering effects

# Usability Engineering