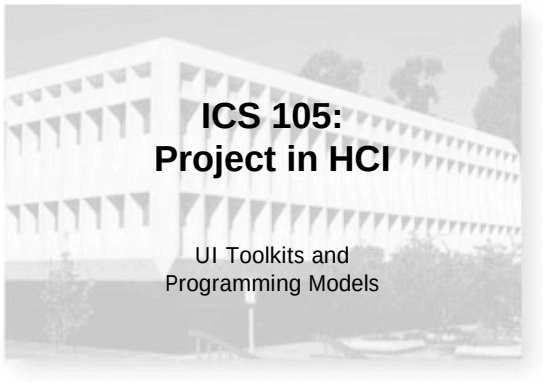


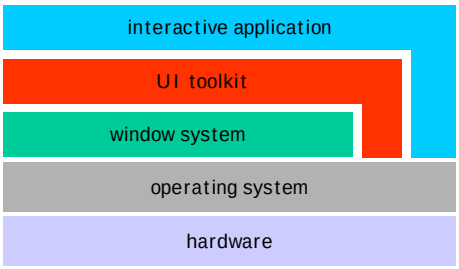
ICS 105: Project in HCI

UI Toolkits and Programming Models

where are we?

- lectures
  - done with evaluation techniques
  - a couple of lectures on toolkits and programming
  - other topics:
    - graphical design and screen layout
    - current hot research issues
    - case study
- projects
  - first set of paper prototypes done, rest tomorrow
  - reports due next Friday
  - redesign and implementation

ui toolkits



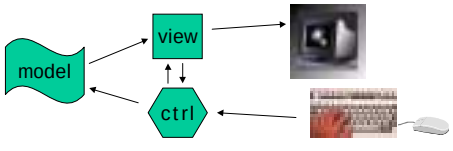
what does the toolkit do?

- interaction with window system
- layout and component management
- offers a programming model
- unified approach to input and output
- reusable solutions

- we'll mainly be concerned with the last three

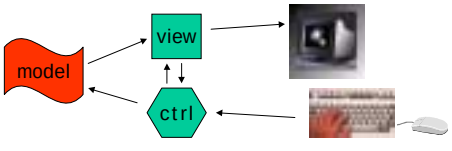
model-view-controller

- MVC is a common structure for components
  - separation of concerns
    - separates input, output, internal logic
  - originally developed for SmallTalk



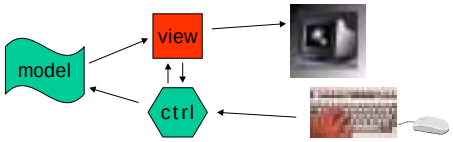
model-view-controller

- model is internal representation
  - information the application is manipulating
    - mailbox in a mail reader, document in a word processor, etc.
    - concentrates internal logic and consistency management



model-view-controller

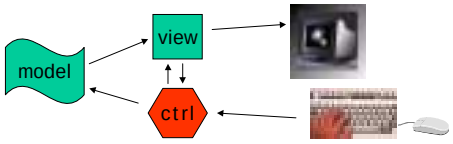
- view is the visual representation
  - may have multiple views
    - e.g. graphical and textual depictions
  - notifications from model when it changes
    - maintains consistency



multiple views

model-view-controller

- controller
  - handles all interaction with the user
    - receives input events, decides what they mean
  - makes changes to view and to model
    - e.g. edits vs scrolling



model-view-controller

- advantages
  - separation of concerns supports better software engineering
    - easy to modify and maintain
  - allows replication
    - makes it easier to add new views and controls later
- variations
  - many systems combine view and controller
    - in *direct manipulation*, view *is* controller

rendering models

- three components to ui toolkits
  - architecture (e.g. MVC)
  - input (to come)
  - output (focus for now)
- output
  - primary distinction is the *rendering model*
    - how images are described and constructed

raster models

- fundamental structure is the raster image
  - array of color values
  - array of pixel coordinates from (0,0) to size of screen
    - typically top left to bottom right
  - great for images, less good for structured graphics
    - toolkit maintains minimal information about structure
      - e.g. the lines and objects that gave rise to pixel image

stroked models

- fundamental structures are paths and strokes
  - higher level than individual pixels
    - resolution independence
  - originated in printer Page Description Languages
    - Press, InterPress, PostScript
      - Display Postscript used in NeWS and NeXT
      - PDF-based rendering model in Apple's MacOS X

stroked models

- joins

- complex paths

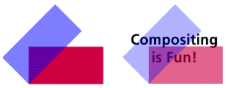
other advanced features

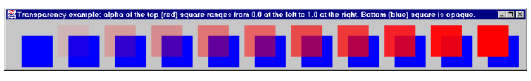
- font support and antialiasing
  - font support can be minimal in raster models
  - need to get from "letter+size" to raster image
    - originally, stored fonts simply as bitmaps
    - these days, use programmatic font support (TrueType)
  - antialiasing makes fonts easier to read

other advanced features

other advanced features

- alpha channel





Java 2D

- Java graphics originally based on AWT
  - minimal
    - clearly just enough to ship...
- Java now supports two-level design
  - JFC is the user interface component
  - Java2D is the underlying graphics component
    - much richer rendering model

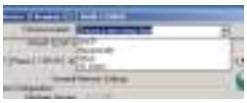
Java2D demo

widgets

- Macintosh (1984) first commercial GUI system
  - two aspects
    - user interface to the system itself
    - Mac Toolbox made components available to others
  - seven basic widgets
    - buttons
    - sliders (also implement scrollbars)
    - pull-down menus
    - checkboxes
    - radio buttons
    - text fields
    - file open/save dialog
      - other widgets (e.g. window decorations) not in toolbox

widgets

- second Mac release added more
  - hierarchical (pull-right) menus
  - in-place menus (drop-down selection boxes)
  - lists (single and multiple selections)



widgets

- more recent additions (Macs and others)
  - tabbed dialogs
  - hierarchical lists (trees)
  - "combo boxes" (combination menu, list, text)
- this set pretty much covers conventional UI
  - not all that's there – e.g. pie menus
  - different models for different
    - interfaces for PDAs?
    - interfaces for interaction on TV?

widget model

- convenience for both users and developers
  - users get familiar interaction styles
    - established "genres" of user interface design
    - eases transfer of skills from one application to another
  - programmers get predefined units
    - eases conformance to UI guidelines
    - saves repetition of effort
- only part of the story, though
  - widgets are components
  - how do components fit together?
  - how are behaviors defined?

event-based programming

- basic program structures
  - non-interactive applications
    - start, do something, stop
  - simple interactive applications
    - main loop – await instructions, carry them out, repeat
- most interactive applications more complex
  - lots of state
  - many operations
    - operations of many different sorts
    - how many different operations can you carry out?

event-based programming

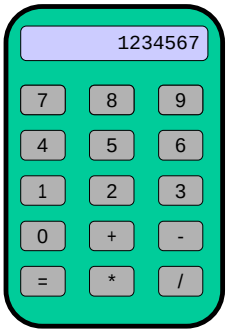
event-based programming

- modal solutions
  - restrict operations that can take place at any time
  - places the burden on the user
    - which mode are you in now?
    - how do you get from mode to mode?
    - easier to make errors
    - barriers in the way of operations
- complexity grows
  - effective design requires more sophisticated model

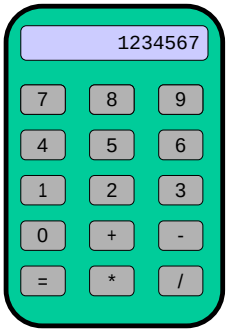
event-based programming

- turn things around
  - instead of user waiting on system, have system wait on user
  - this is the *event based approach*
    - declarative approach to programming
    - user actions generate *events*
      - e.g. mouse clicked, button pressed, scroll bar moved
    - set up object structure
      - describe structure of solution
      - describe how objects will respond to events
    - implicit main loop
      - collects events, determines targets, sends events

interactor tree

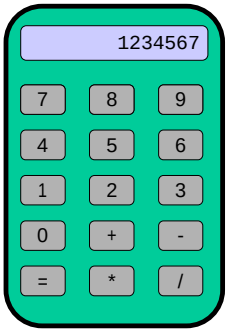


interactor tree



outer window (black)

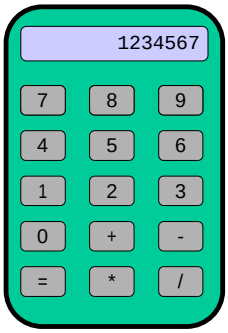
interactor tree



outer window (black)

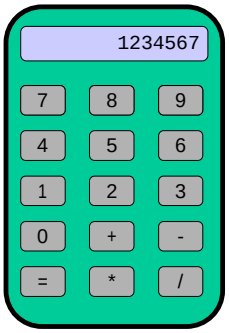
inner window (green)

interactor tree



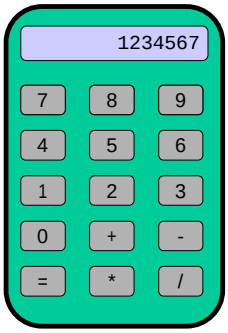
- outer window (black)
  - inner window (green)
    - display
    - keypad

interactor tree



- outer window (black)
  - inner window (green)
    - display
    - keypad
      - button #0
      - button #1
      - button #2
      - button #3

interactor tree



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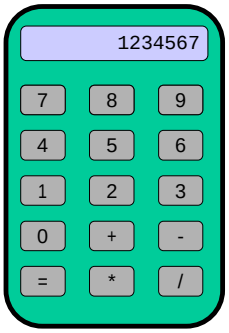
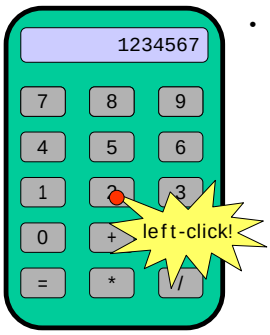
interactor tree



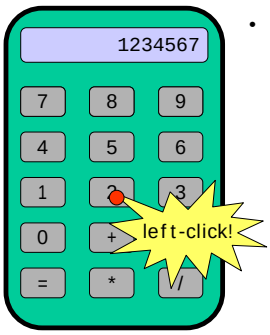
- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently

interactor tree



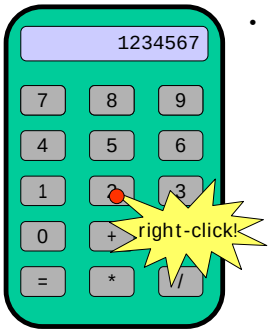
- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - left-click?

interactor tree



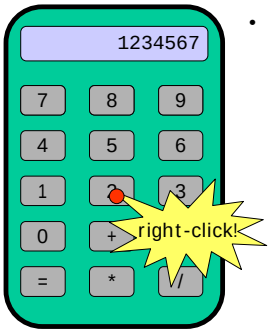
- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - left-click?
    - deliver to button

interactor tree



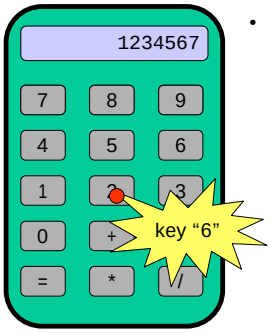
- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - right-click?

interactor tree



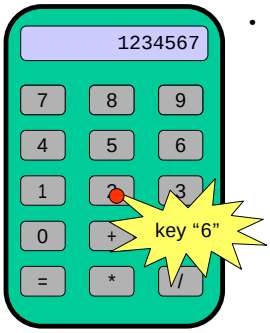
- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - right-click
    - button not interested
    - deliver to keypad
      - keypad menu

interactor tree



- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - keypress?

interactor tree



- events delivery
  - starts at the bottom of the tree
  - walks up until some object expresses interest
  - different events might be delivered differently
  - keypress?
    - button not interested
    - keypad not interested
    - deliver to window
      - global input handling

ui and oop

- event-based model meshes naturally with OOP
  - objects and containment structures
  - keep “behavior” close to “data”
  - delegate event processing between objects

constraints

- event model is the conventional approach
  - another common approach is to use constraints
- constraint-based programming
  - declarative approach to programming
  - constraint is a desired invariant
    - a := b * 2
    - a <-> b * 2
  - complexity
    - satisfaction engine ensures all constraints maintained
    - single and multi-way constraints

constraints

- constraints apply naturally to UI
  - think of MVC
    - view must track model
    - controller must keep view in sync
    - examples
      - manage a scrollbar by expressing a constraint between the location of the scroll box and the current view port
      - keep item centered in window as it resizes by expressing constraint about the size of padding on either side

constraints

- advantages of constraint approach?
  - declarative programming style
    - express what you want to happen once and for all
    - event-based programming distributes activity
      - hard to find the one place where things happen
  - express natural regularities
    - people understand causation naturally
    - constraint-based designs can be very intuitive
- disadvantages?
  - computationally expensive
  - not yet mainstream (but we're working on it)

next week

- more in-depth on Swing/JFC