Model-View-Controller

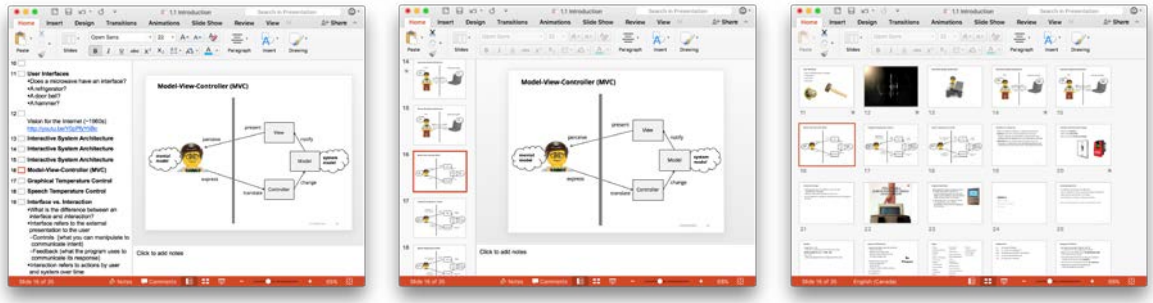
rationale

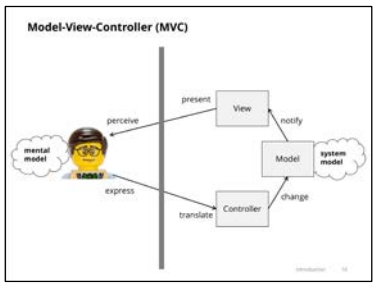
implementation

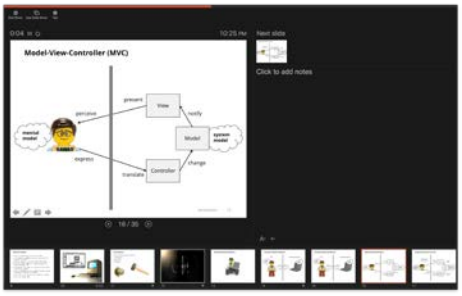
abstract model widgets

Multiple Views

- Many applications have multiple views of one “document”







Observations

1. When one view changes, the others should change as well.
2. UI code I soften modified more than the main application logic
   - (e.g. majority of recent updates to MS Office are in the UI)

- How do we design software to support these observations?

Possible Design: Data and UI in Same Object

- What if we want to display data from a different source?
- What if we want to add new ways to view the data?
- When data and UI are tightly coupled, hard to maintain code.

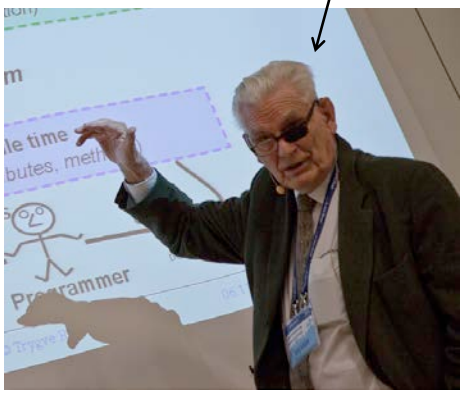
PresentationDocument
`Slide[] slides`
`void setSlide(int i, Slide s)`
`paintThumbnailTab(Graphics g)` `handleMouseClickInThumbnailTab()`
`paintPresentation(Graphics g)` `handleKeyPressInPresentation(Graphics g)`

`paintEditor(Graphics g)`
`handleMouseClickInEditor()`
`handleMouseDragInEditor()`

Model-View-Controller (MVC)

- MVC developed at Xerox PARC in 1979 by Trygve Reenskaug
  - for Smalltalk-80 language, the precursor to Java
- Now standard design pattern for GUIs
- Used at many levels
  - Overall application design
  - Individual components
- Many variations of MVC idea:
  - Model-View-Presenter
  - Model-View-Adapter
  - Hierarchical Model-View-Controller
- We use “standard” MVC in this course

Trygve Reenskaug



No MVC: Motivating Example

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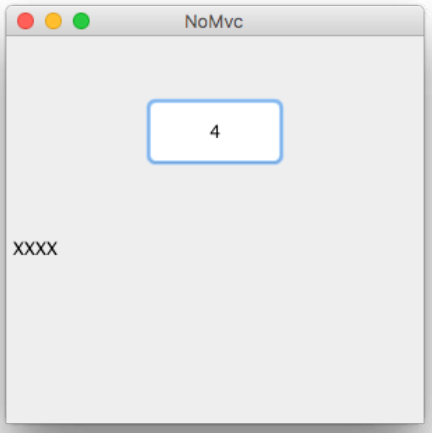
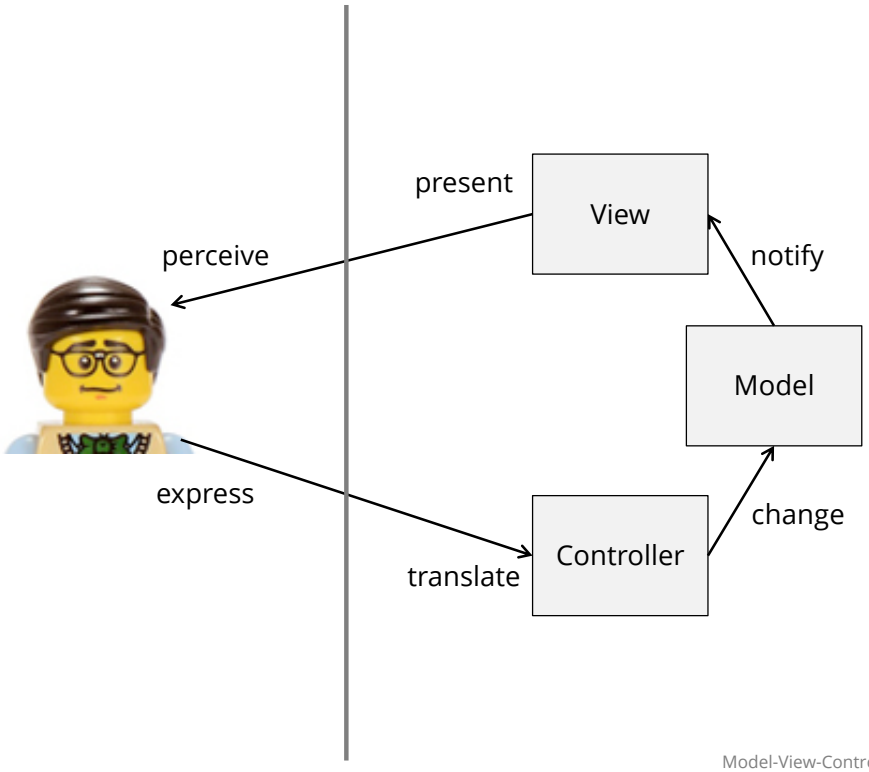
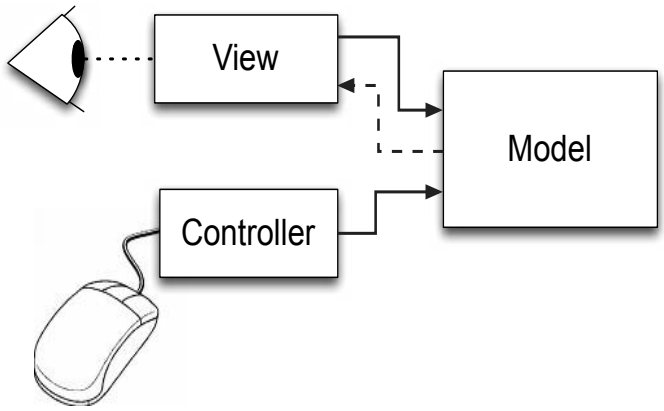


Model-View-Controller (MVC)



Model-View-Controller (MVC)

- Interface architecture decomposed into three parts:
  - **Model**: manages application data and its modification
  - **View**: manages interface to present data
  - **Controller**: manages interaction to modify data

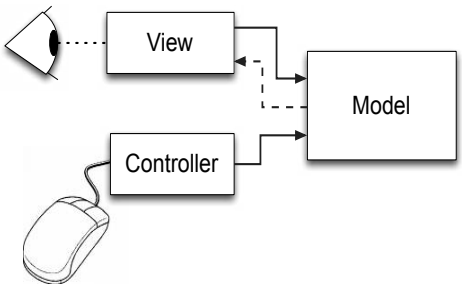


MVC Classes

- 3 classes: Model, View, Controller
- Model only knows about a **View Interface**
- View and Controller know *all* about model
- In practice, View and Controller are often coupled …
  - View knows to send events to Controller
  - Controller knows about View to interpret events

View Interface

```
interface IView {
    public void updateView();
}
```



View Class Outline

```
class View implements IView {
   private Model model; // the model this view presents

   View(Model model, Controller controller) {

      ... create the view UI using widgets ...

      this.model = model; // set the model
      // setup the event to go to the controller
      widget1.addListener(controller);
      widget2.addListener(controller);
   }

   public void updateView() {
      // update view widgets using values from the model
      widget1.setProperty(model.getValue1());
      widget2.setProperty(model.getValue2());
      ...
   }
}
```

Controller Class Outline

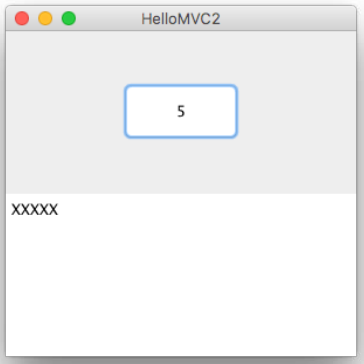
```
class Controller implements Listener {
   Model model; // the model this controller changes

   Controller(Model model) {
      this.model = model; // set the model
   }

   // events from the view's widgets
   // (often separated to 1 method per widget)
   public void action1Performed(Event e){
      // note the controller does need to know about view
      if (widget1 sent event)
         model.setValue1();
      else if (widget2 sent event)
         model.setValue2();
      ...
   }
}
```


Model Class Outline

```
class Model {
   List<IView> views; // multiple views
   public void addView(IView view) {...} // add view observer

   // get model values
   public type getModelValue1() { return value1; }
   public type getModelValue2() { return value2; }
   ... more value getters ...

   // set model values
   public void setModelValue1(type value) {
      value1 = value; notifyObservers();
   }

   ... more setters, each calls notifyObservers() ...

   // notify all IView observers
   private void notifyObservers() {
      for (IView view: views) view.updateView();
   }
}
```

hellomvc1/
1 view

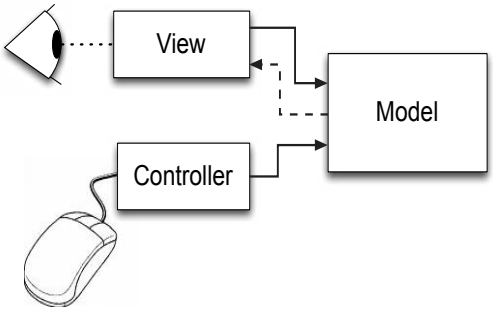
hellomvc2/
2 (or more) views



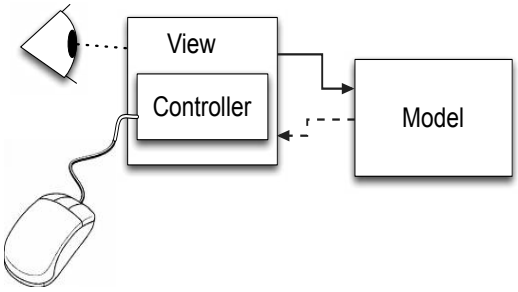
inspired by Joseph Mack: http://www.austintek.com/mvc/
- (also a good MVC explanation, shows how to use Java Observer class)

Theory and Practice

- **MVC in Theory**
  - View and Controller are separate and loosely uncoupled



- **MVC in Practice**
  - The View and Controller are tightly coupled. Why?



Why doesn't the Controller just directly tell the View to update? Why "go through" the Model?

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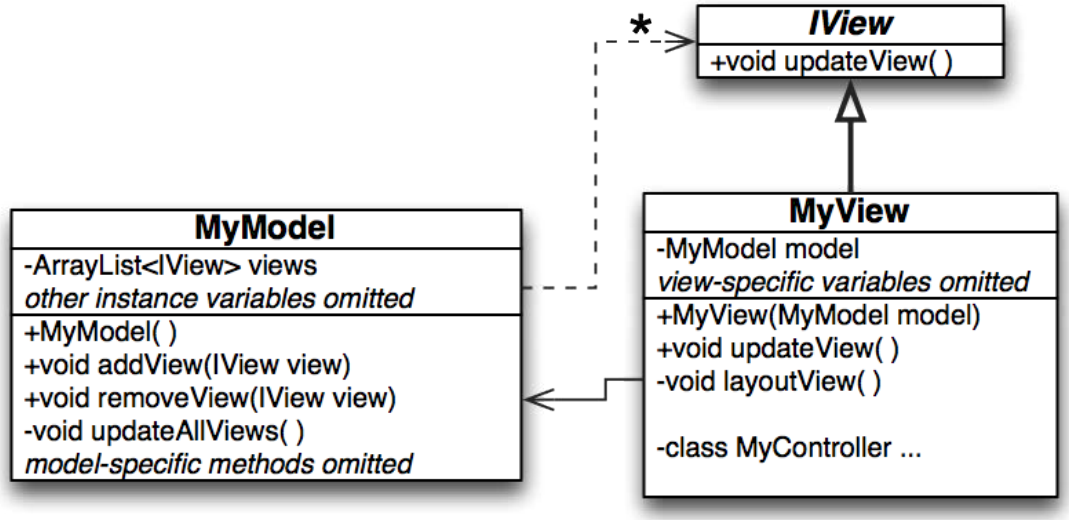
Controller code in View

Model Updates Can be Considered an Event

- View can use an anonymous inner class of type IView to create a "ModelListener" for Model to register

hellomvc3b/
ModelListener

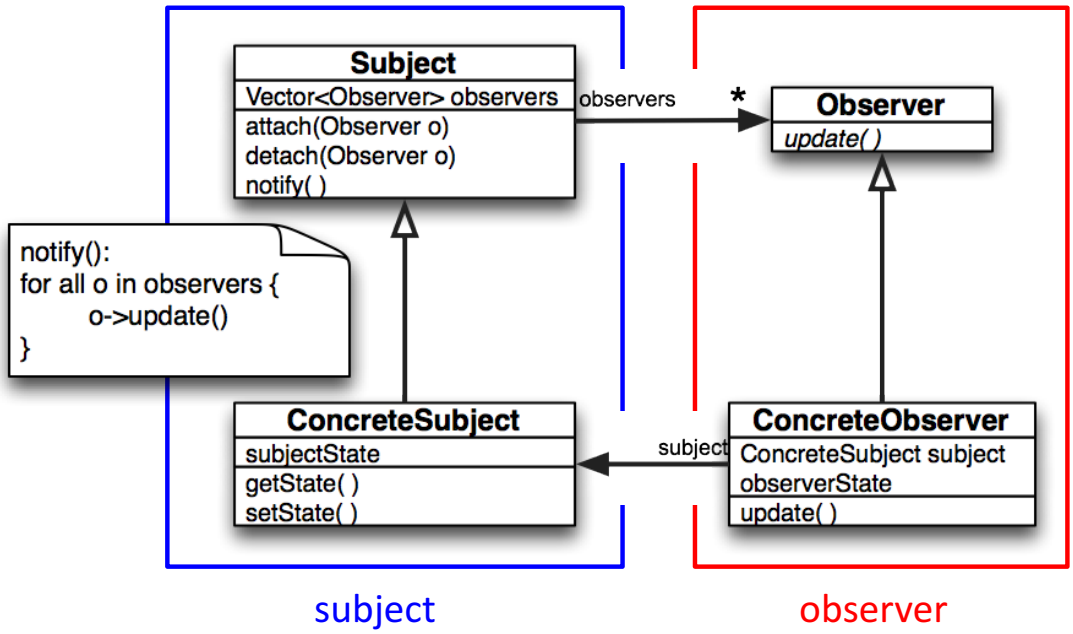
MVC as UML



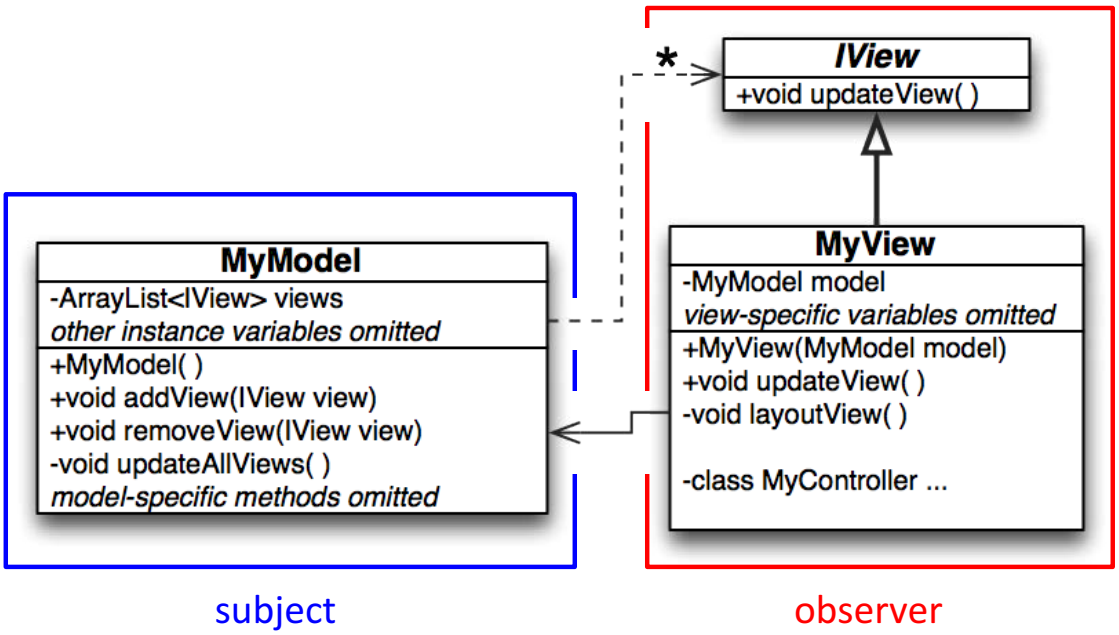
Observer Design Pattern

- MVC is an instance of the Observer design pattern
- Provides a well-defined mechanism that allows objects to communicate without knowing each others' specific types
  - Promotes loose coupling
- related to:
  - "publish-subscribe" pattern
  - "listeners"
  - delegates in C#

Observer Design Pattern



MVC as Observer Pattern



hellomvc4/

- java.util provides Observer interface and Observable class
  - Observer is like IView, i.e. the View implements Observer
  - Observable is the “Subject” being observed
    i.e. the Model extends Observable
  - base class has list of Observers and method to notify them

Triangle MVC Code Demos

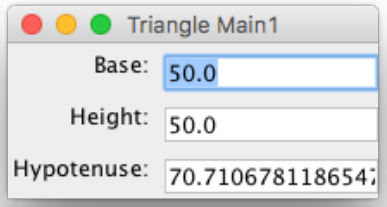
- Program requirements:
  - vary base and height of right triangle, display hypotenuse
- TriangleModel
  - stores base and height, calculates hypotenuse
  - constrains base and height values to acceptable range

Optimizing View Updates

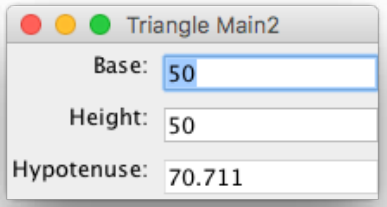
- Each viewUpdate, *everything* in *every view* is refreshed from model
- Could add parameters to viewUpdate to indicate *what* changed
  - if view knows it isn't affected by change, can ignore it
- But, **simpler is better**
  - early optimization only introduces extra complexity that causes bugs and adds development time
  - don't worry about efficiency until you have to: just update the entire interface

Triangle: Main1.java and Main2.java

`SimpleTextView`

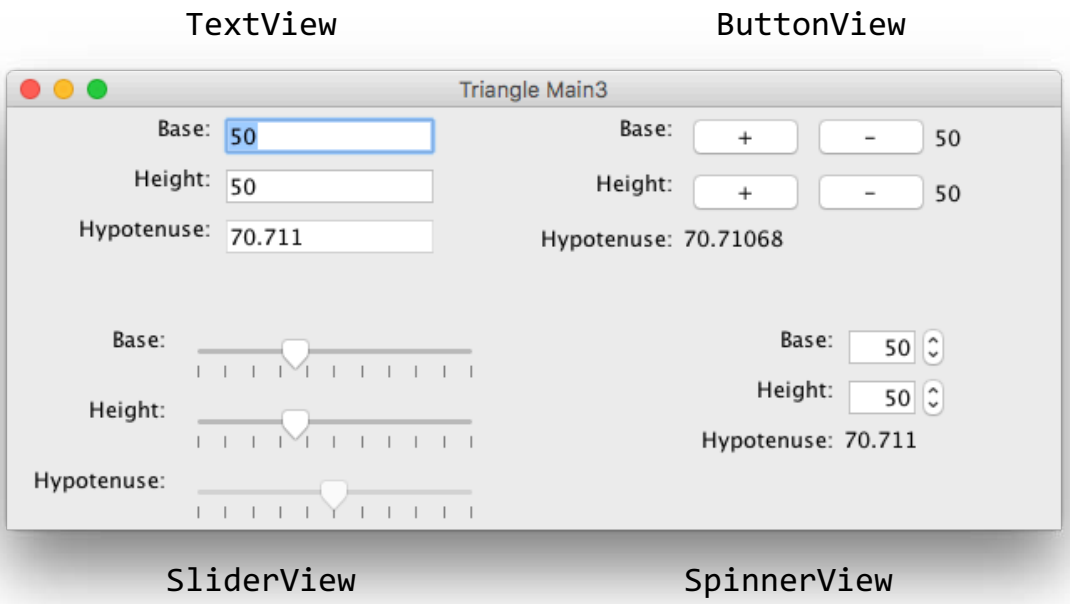


`TextView`



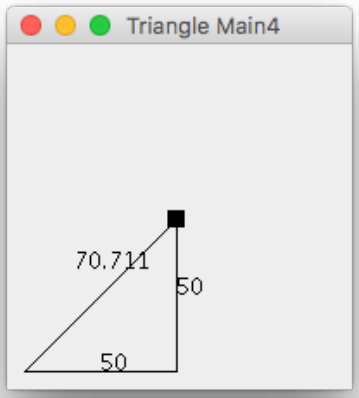
Triangle: Main3.java

Combines Multiple Views using `GridLayout`



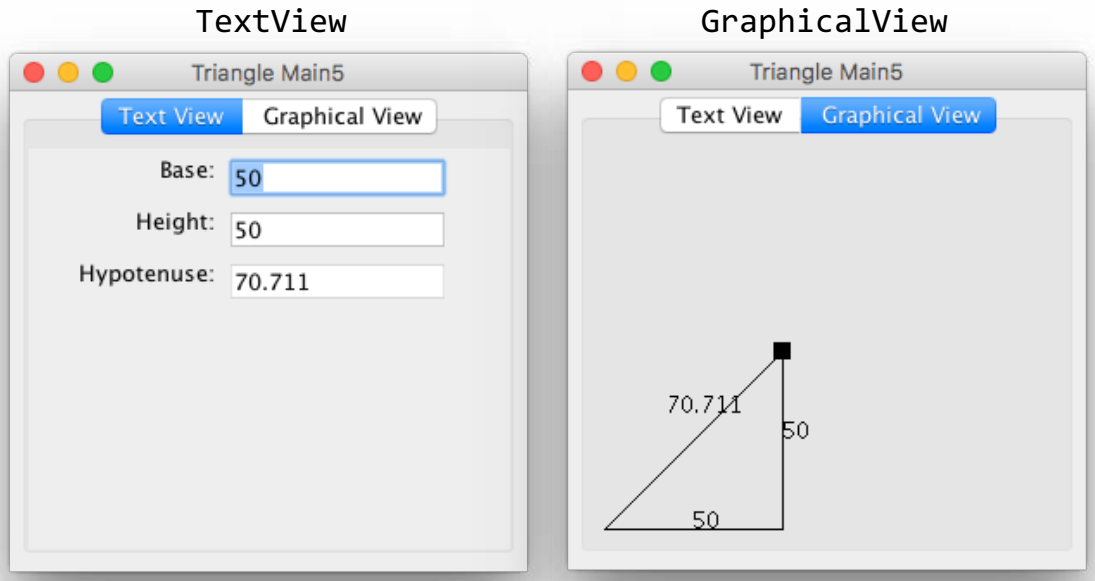
Triangle: Main4.java

`GraphicalView`



Triangle: Main5.java

Combines Multiple Views using Tab Panel



MVC Implementation Process

Setup the basic code infrastructure

- the Model class
- one or more View/Controller classes (extends JComponent or JPanel)
- a class containing the main method and application JFrame

- In the main method:
  - create an instance of the model
  - create instances of the Views/Controllers, add add to them the model
  - display the View(s) in a frame

MVC Implementation Process (cont.)

Build and test the Model

- Design, implement, and test the model
  - add commands used by Controllers to *change* the model
  - add queries used by View to *update* their state
- Call `updateAllViews` just before exiting all public methods that change data

Build the Views and Controllers

- Design the UI as one or more Views. For each View:
  - Construct widgets
  - Lay the widgets out in the view
  - Write and register appropriate controllers for each widget
  - Write `updateView` to get and display info from the model
  - Register `updateView` with the model

MVC Benefit: Change the UI

- View separation enables alternative interfaces
- Controller separation enables alternative input methods
- Data and application logic in Model does not have to change
- Examples:
  - porting to new OS platforms
  - porting to different hardware platforms
  - adapting to new UI toolkits
  - taking advantage of new widgets
  - …

MVC Benefit: Multiple Views

- View separation enables multiple, simultaneous views of data
- A separate Model means views can independently use same data
  - Each view is unencumbered by the details of the other views
  - Reduces dependencies on the GUI that could change
- Examples:
  - viewing numeric data as a table, a line graph, a pie chart, …
  - displaying simultaneous “overview” and “detail” views
  - enabling “edit” and “preview” views
  - …

MVC Benefit: Code Reuse

- Separation enables programmers to more easily use same stock set of widgets to manipulate unique application data.
- Examples:
  - JTable has a “pluggable” Model to manipulate many kinds of data
  - A View-based graph widget can be re-used with different Models
  - A mouse-gesture Controller can be re-used with other Views
  - …

MVC Benefit: Testing

- Separation enables independent development of application logic and user interface elements
  - can test the Model without any UI
  - can test View/Controller without any Model
- Examples:
  - write JUnit tests using Model's API
  - use Java UI automation to test View/Controller APIs

Apple "MVC" Pattern

- Apple IOS and Cocoa emphasize the Controller as an intermediary link between the Model and View
- In my opinion, this is really a Model-View-Presenter (MVP) Pattern (though lots of debate about this ...)