Lecture 24

GUI Applications

Announcements for This Lecture

Prelim 2

- **TONIGHT** at 7:30 pm
  - **A–F** in Uris G01
  - **G-H** in Malott 228
  - **I–L** in Ives 305
  - **M-Z** in Statler Aud.
- All review material online
  - Similar to previous years
  - Just changed "hard parts"

Next Week

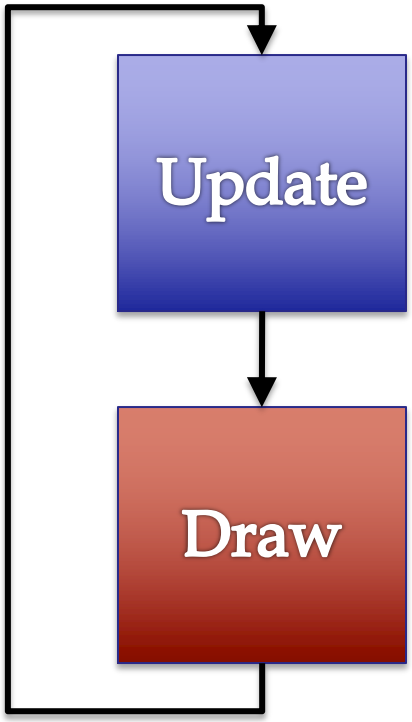
- There is no lab next week
  - But Tuesday hours are open
  - Open to **EVERYONE**
  - Go for help on lab or A7
- But lecture is **important**
  - Return to topic of invariants
  - Setting us up for sorting
- Try to finish lab 11 first
  - Frees remaining time for A7

Assignment 7

- Instructions are posted– start work **tomorrow**
- **Goal:** Move the player ship by Tuesday
  - This is where many people get stuck
  - Use the "lab" next week for help
- Due **Dec 10**, but extensions are possible
  - Contact your lab instructor (not me)
  - No questions-asked for Thursday, Dec 12
  - Need a solid excuse for Sunday, Dec 15

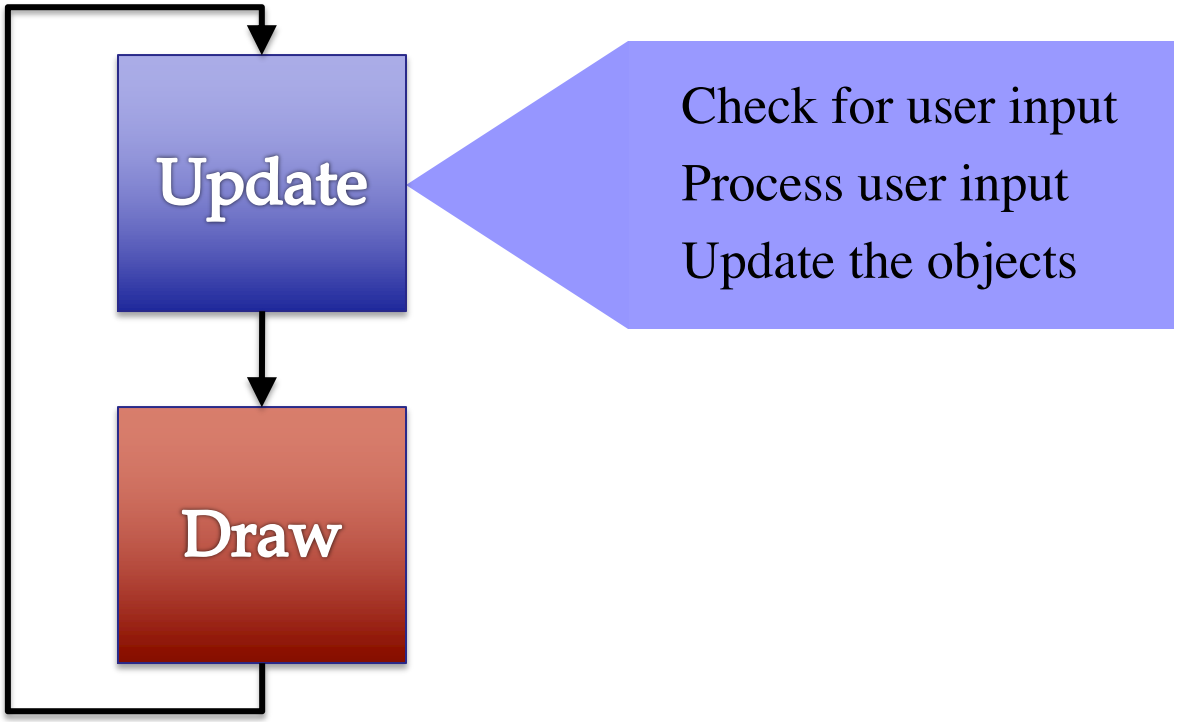
A Standard GUI Application

Animates the application, like a movie



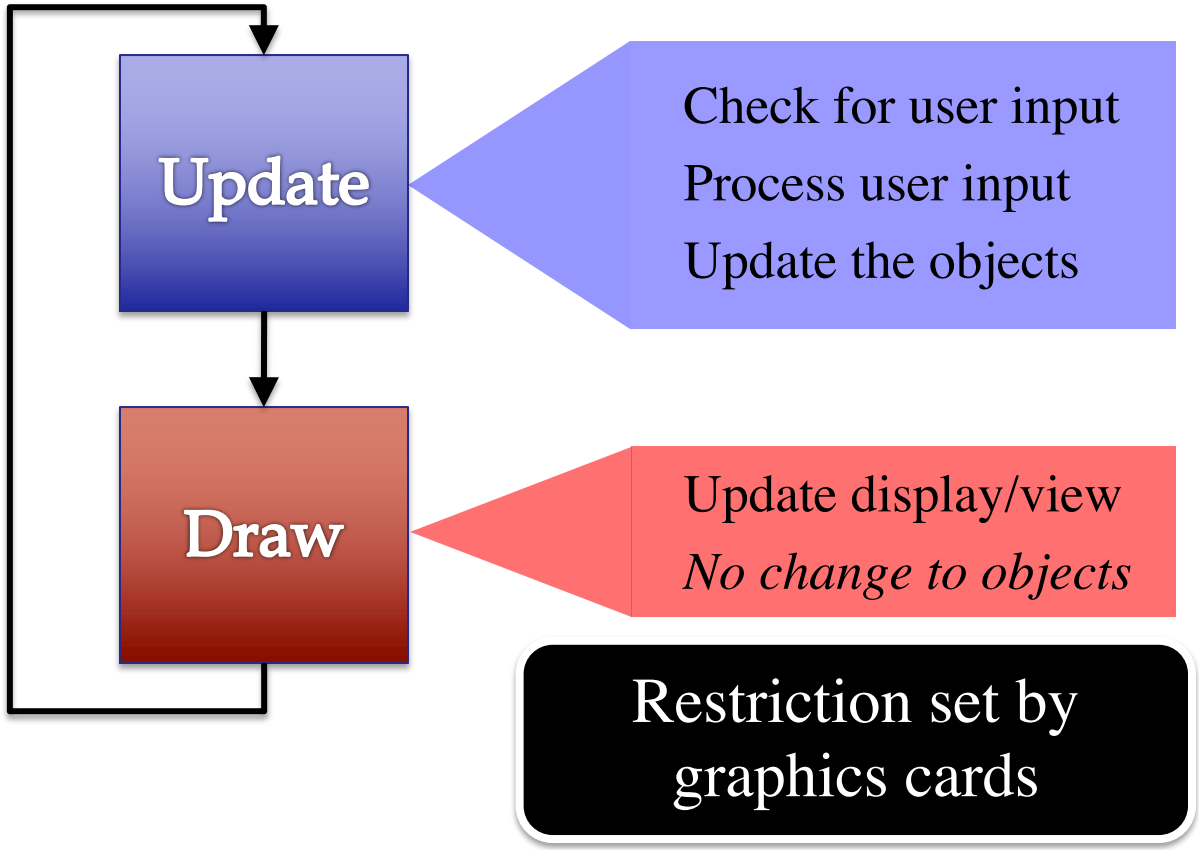
A Standard GUI Application

Animates the application, like a movie



A Standard GUI Application

Animates the application, like a movie



Must We Write this Loop Each Time?

```
while program_is_running:
    # Get information from mouse/keyboard
    # Handled by OS/GUI libraries

    # Your code goes here



    # Draw stuff on the screen
    # Handled by OS/GUI libraries
```

Must We Write this Loop Each Time?

```
while program_is_running:
    # Get information from mouse/keyboard
    # Handled by OS/GUI libraries

    # Your code goes here



    # Draw stuff on the screen
    # Handled by OS/GUI libraries
```

Would like to "plug in" code

Why do we need to write this each time?

Must We Write this Loop Each Time?

```
while program_is_running:
    # Get information from mouse/keyboard
    # Handled b
    # Your code
    application.update()
    #
    #                                    es
```

Method call (for loop body)

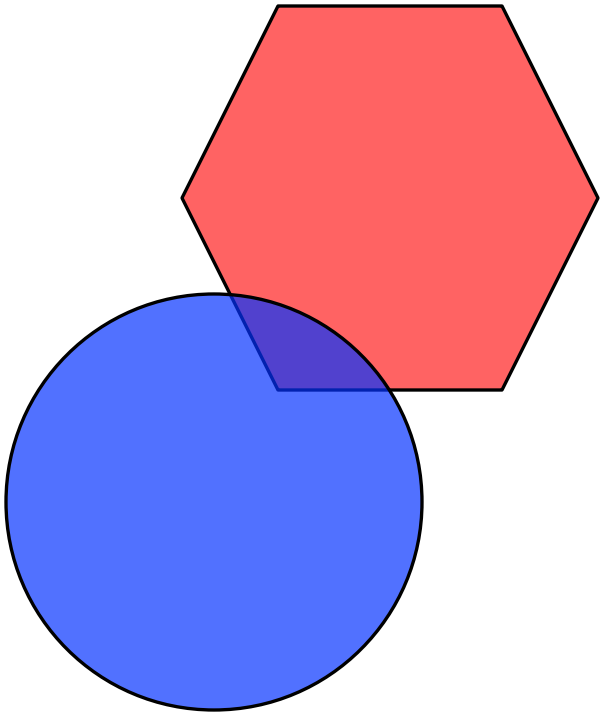
- Write loop body in an app class.
- OS/GUI handles everything else.

Custom Application class with its own **attributes**

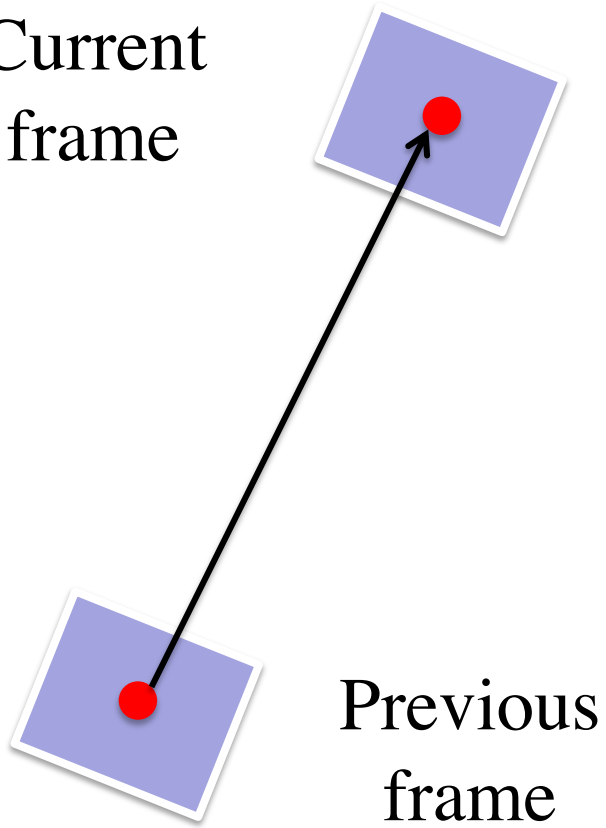
Programming Animation

Intra-Frame

- Computation within frame
  - Only need current frame
- **Example:** Collisions
  - Need current position
  - Use to check for overlap
- Can use **local variables**
  - All lost at `update()` end
  - But no longer need them



Programming Animation



Inter-Frame

- Computation across frames
  - Use values from *last* frame
- **Example:** Movement
  - Need old position/velocity
  - Compute next position
- Requires **attributes**
  - Attributes never deleted
  - Remain after `update()` ends

Variables and the Loop

```
while program_is_running:
    # Get information from mouse/keyboard
    # Handled by OS/GUI libraries

    # Your code goes here
    application.update()

    # Draw stuff on the screen
    # Handled by OS/GUI libraries
```

Local variables erased.
But **attributes** persist.

Programming Animation

Intra-Frame

- Computation within frame
  - Only need current frame
- **Example:** Collisions
  - Need current position
  - Use to check for overlap
- Can use **local variables**
  - All lost at `update()` end
  - But no longer need them

Inter-Frame

- Computation across frames
  - Use values from last frame
- **Example:** Movement
  - Need old position/velocity
  - Compute next position
- Requires **attributes**
  - Attributes never deleted
  - Remain after `update()` ends

Attributes = Loop Variables

Normal Loops

Variables "external" to the loop body

```
x = 0
i = 2
# x = sum of squares of 2..i-1
while i <= 5:
    x = x + i*i
    i = i +1
# x = sum of squares of 2..5
```

Application

Attributes are the "external" variables

```
while program_running:
    # Get input
    # Your code called here
    application.update()
    # Draw
```

Class Invariant = Loop Invariants

- Look at the **game loop**
  - Loop **body** is update()
  - Loop **vars** are attributes
- Class invariant is true
  - At update()/body start
  - At update()/body end
  - Just like loop invariants
- Invariants are important!
  - To reason about game
  - Help us debug problems

```
# Constructor
game = GameApp(...)
...
# inv: game attribs are ...
while program_running:
    # Get input
    # Your code goes here
    game.update()
# post: game attribs are ...
```

The Actual Game Loop

```
# Constructor
game = GameApp(...)
...
game.start() #Loop initialization
while program_running:
    # Get input
    # Your code goes here
    game.update(time_elapsed)
    game.draw()
```

To *early* to initialize everything

Actual loop initialization

Separate update() and draw() methods

Designing a Game Class: Animation

```
class Animation(game2d.GameApp):
    """App to animate an ellipse in a circle."""

    def start(self):
        """Initializes the game loop."""
        ...

    def update(self,dt):
        """Changes the ellipse position."""
        ...

    def draw(self):
        """Draws the ellipse"""
        ...
```

See animation.py

Designing a Game Class: Animation

```
class Animation(game2d.GameApp):
    """App to animate an ellipse"""

    def start(self):
        """Initializes the game loop."""
        ...

    def update(self,dt):
        """Changes the ellipse position."""
        ...

    def draw(self):
        """Draws the ellipse"""
        ...
```

Parent class that does hard stuff

See animation.py

Designing a Game Class: Animation

```
class Animation(game2d.GameApp):
    """App to animate an ellipse"""

    def start(self):
        """Initializes the game loop."""
        ...

    def update(self,dt):
        """Changes the ellipse position."""
        ...

    def draw(self):
        """Draws the ellipse"""
        ...
```

Parent class that does hard stuff

See animation.py

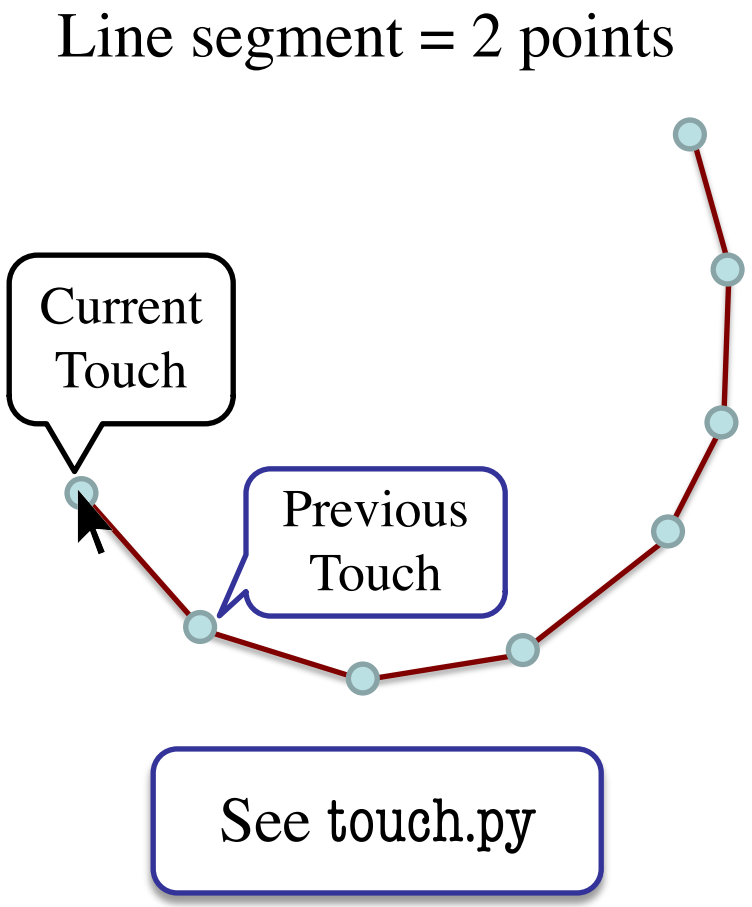
Loop initialization
Do NOT use __init__

Loop body

Use method draw() defined in GObject

Comparing Attributes: Touch

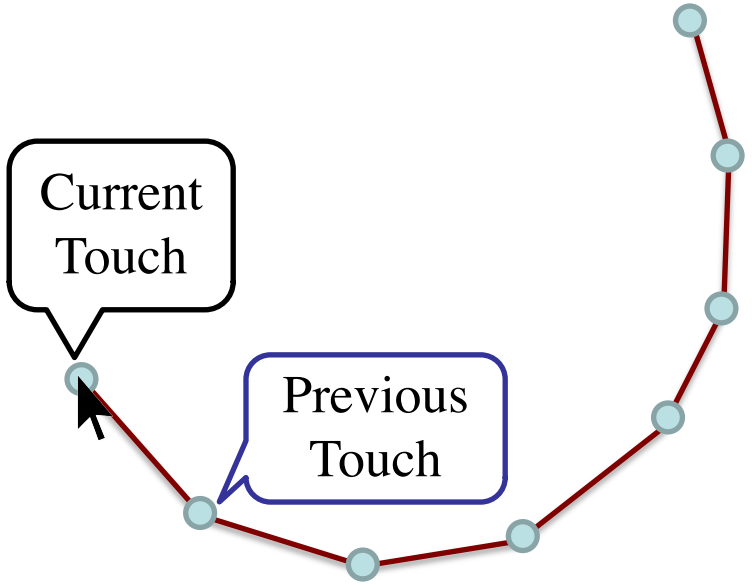
- Attribute touch in GInput
  - The mouse press position
  - Or **None** if not pressed
  - Access with self.input.touch
- Compare touch, last position
  - Mouse button **pressed:**
    last None, touch not None
  - Mouse button **released:**
    last not None, touch None
  - Mouse **dragged**:
    last and touch not None



Input and Invariants

- Attribute input is…
  - A GInput object
- Attribute input.touch is…
  - Either a Point2 or None
  - Location of mouse cursor (if it is pressed)
- Attribute last is…
  - Either a Point2 or None
  - input.touch in prev. frame

Line segment = 2 points



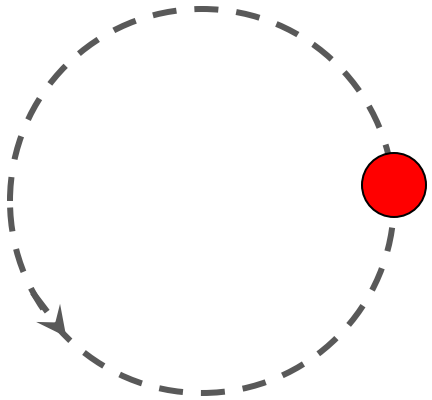
See touch.py

Relationship between two variables.

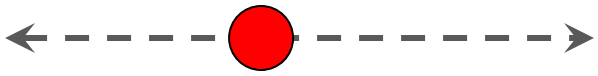
State: Changing What the Loop Does

- **State**: Current loop activity
  - Playing game vs. pausing
  - Ball countdown vs. serve
- Add an attribute `state`
  - Method `update()` checks state
  - Executes correct helper
- How do we store state?
  - State is an *enumeration*; one of several fixed values
  - Implemented as an int

State `ANIMATE_CIRCLE`



State `ANIMATE_HORIZONTAL`



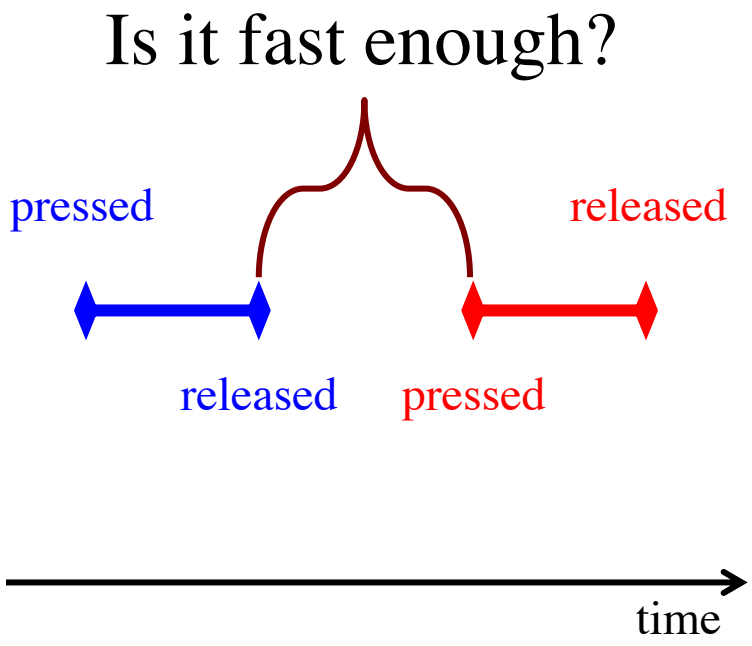
See `state.py`

Designing States

- Each state has its ***own set*** of invariants.
  - **Drawing?** Then `touch` and `last` are not None
  - **Erasing?** Then `touch` is None, but `last` is not
- Need rules for when we switch states
  - Could just be "check which invariants are true"
  - Or could be a *triggering event* (e.g. key press)
- Need to make clear in class specification
  - What are the invariants ***for each state***?
  - What are the rules to switch to a new state?

Triggers: Checking Click Types

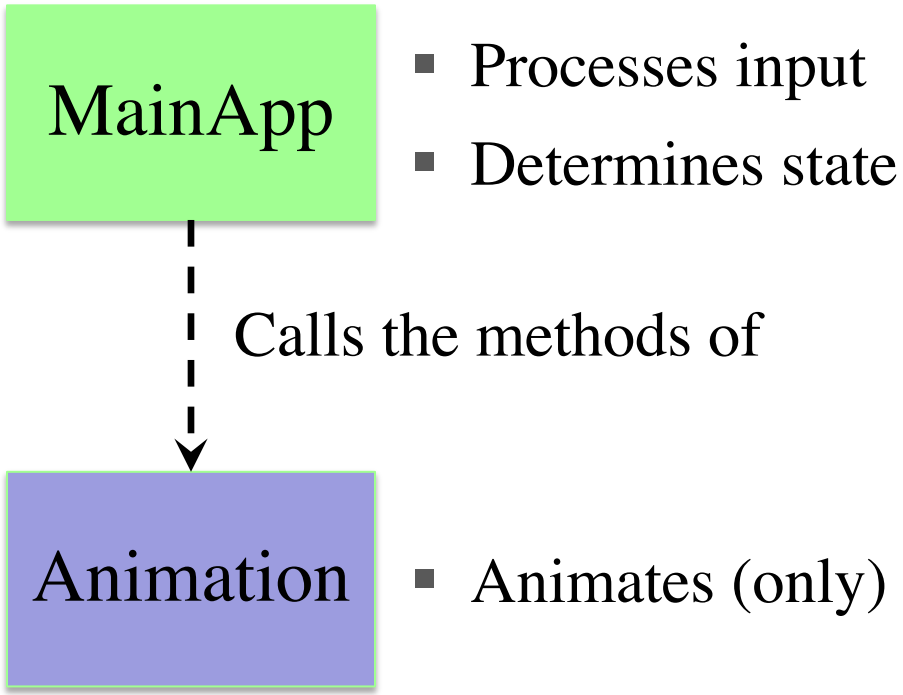
- Double click = 2 fast clicks
- Count number of fast clicks
  - Add an attribute `clicks`
  - Reset to 0 if not fast enough
- Time click speed
  - Add an attribute `time`
  - Set to 0 when mouse released
  - Increment when not pressed (e.g. in loop method `update()`)
  - Check `time` when next pressed



See `touch.py`

Designing Complex Applications

- Applications can become extremely complex
  - Large classes doing a lot
  - Many states & invariants
  - Specification unreadable
- **Idea**: Break application up into several classes
  - Start with a "main" class
  - Other classes have roles
  - Main class delegates work



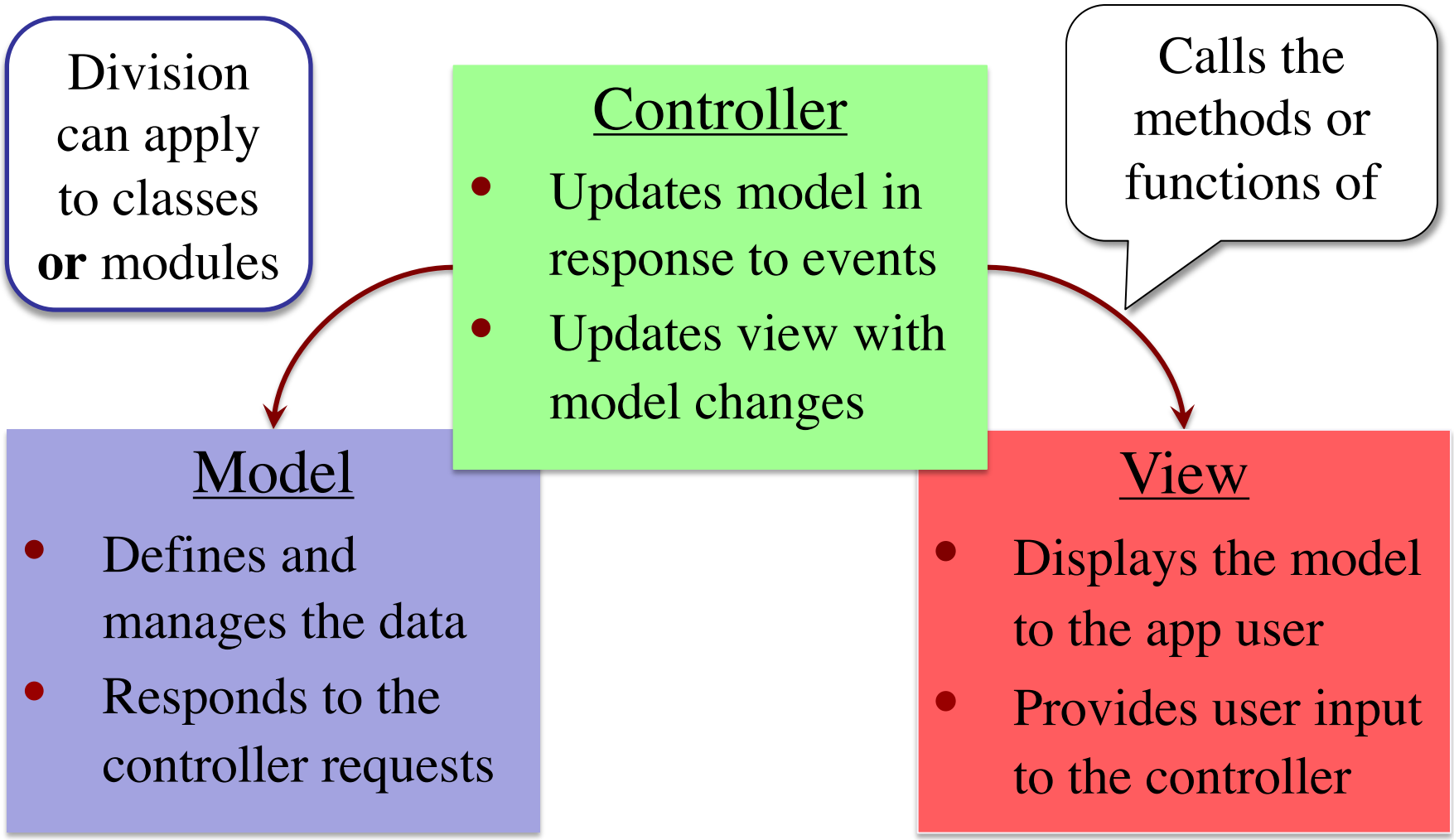
See `subcontroller.py`

How to Break Up: Software Patterns

- **Pattern**: reusable solution to a common problem
  - Template, not a single program
  - Tells you how to design your code
  - Made by someone who ran into problem first
- In many cases, a pattern gives you the interface
  - List of headers for non-hidden methods
  - Specification for non-hidden methods
  - Only thing missing is the implementation

Just like this course!

Model-View-Controller Pattern



MVC in this Course

Model

- **A3**: Color classes
  - RGB, CMYK & HSV
- **A4**: Turtle, Pen
  - Window is **View**
- **A6**: Image
  - Data is always in model
- **A7**: Ship, Alien, etc..
  - All shapes/geometry

Controller

- **A3**: a3app.py
  - Hidden classes
- **A4**: Functions in a4.py
  - No need for classes
- **A6**: Filter, Encoder
  - Also our custom modules
- **A7**: Invaders, Wave
  - Main part of assignment!

MVC in this Course

Model

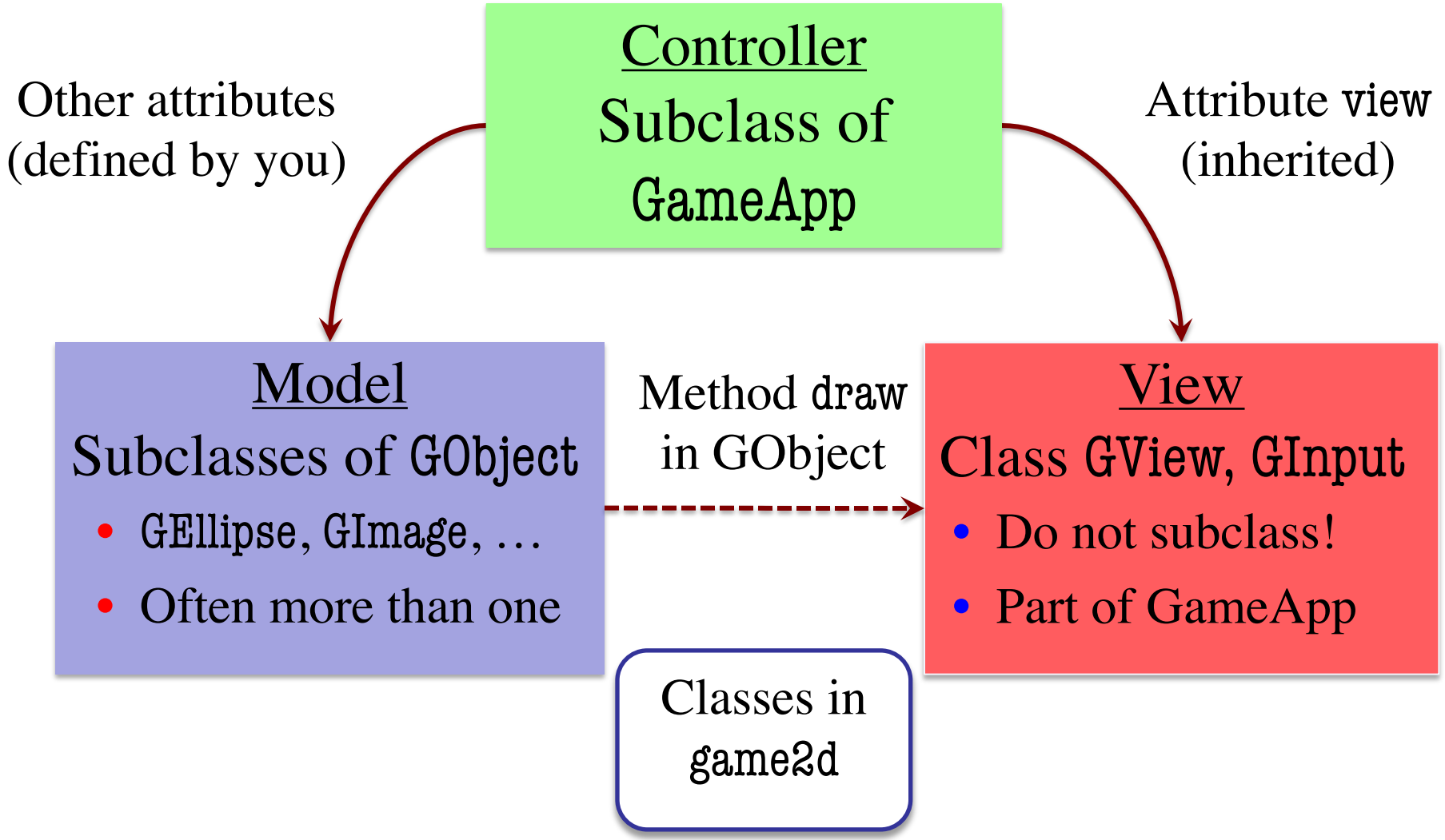
- **A3**: Color classes
  - RGB, CMYK & HSV
- **A4**: Turtle, Pen
  - Window is **View**
- **A**
  -
- **A7**: Ship, Alien, etc..
  - All shapes/geometry

Why **classes** sometimes and **functions** others?

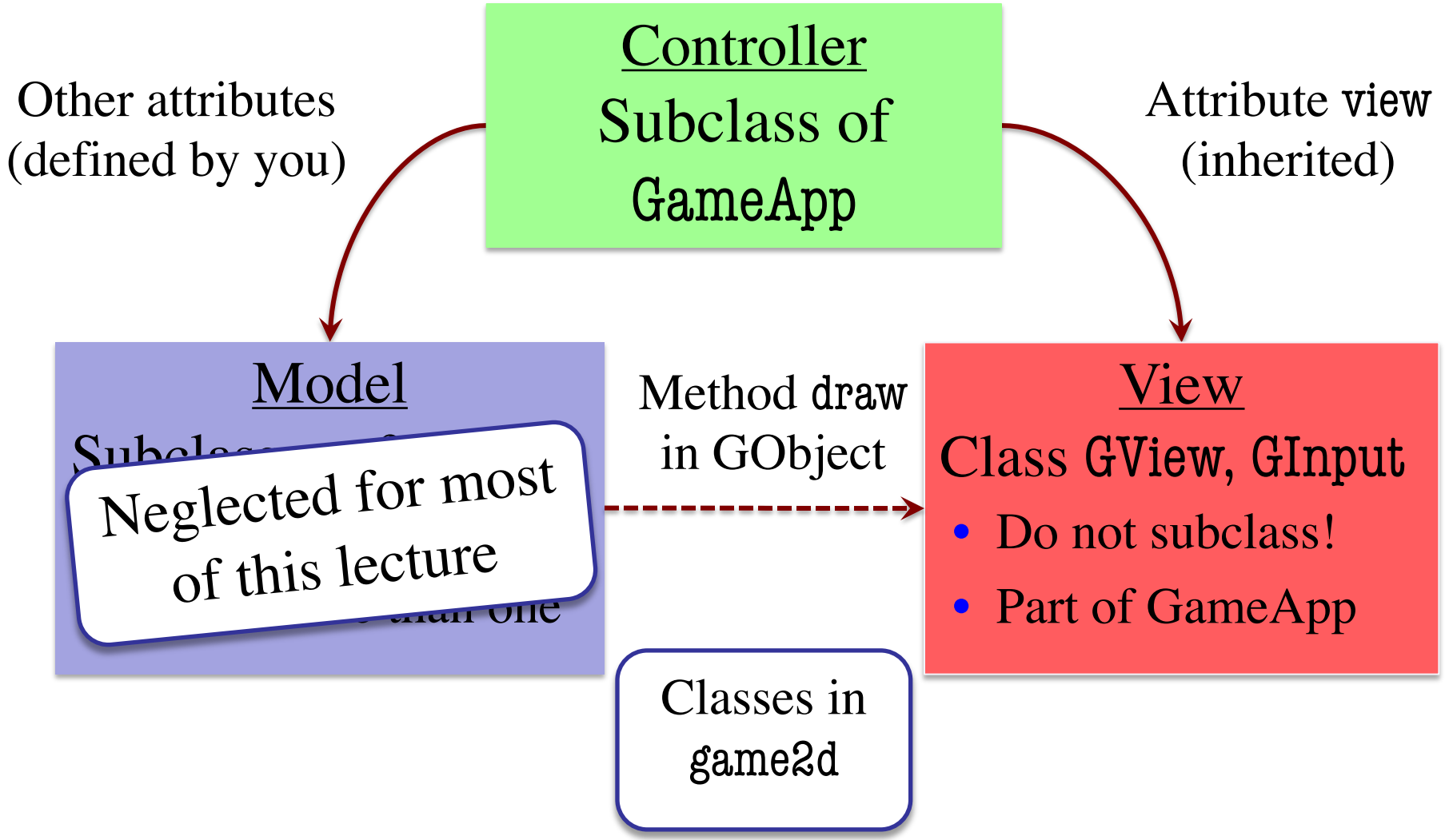
Controller

- **A3**: a3app.py
  - Hidden classes
- **A4**: Functions in a4.py
  - No need for classes
- **A6**: Filter, Encoder
  - Also our custom modules
- **A7**: Invaders, Wave
  - Main part of assignment!

Model-View-Controller in CS 1110

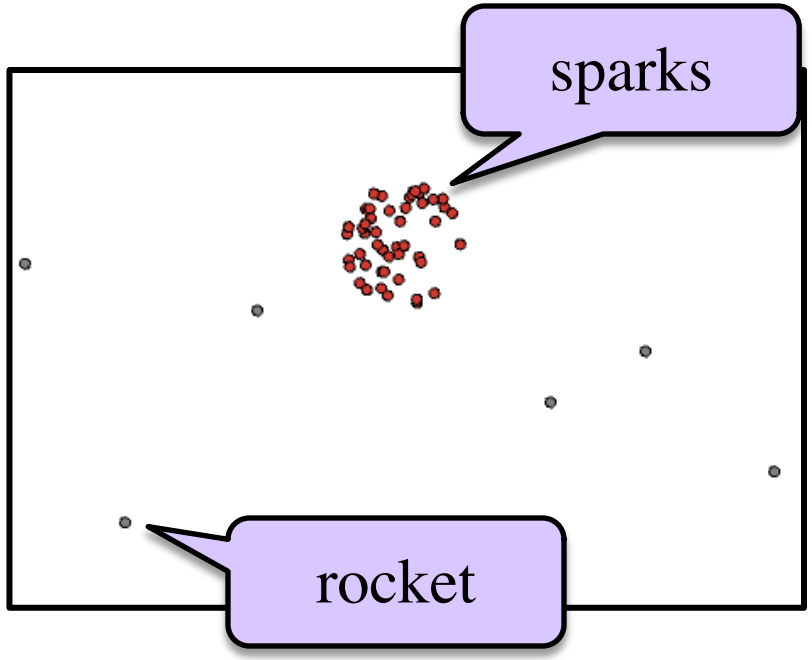


Model-View-Controller in CS 1110



Models in Assignment 7

- Often subclass of `GObject`
  - Has built-in draw method
- Includes groups of models
  - **Example**: rockets in `pyro.py`
  - Each rocket is a model
  - But so is the entire list!
  - `update()` will change both
- **A7**: Several model classes
  - `Ship` to animate the player
  - `Alien` to represent an alien



See `pyro.py`