Lecture 5:
Views, Drawing and Gestures

Developing Applications for iOS

Prof. Dr. Radu Ionescu
raducu.ionescu@gmail.com
Faculty of Mathematics and Computer Science
University of Bucharest
Views, Drawing and Gestures:

- Drawing Paths
- Drawing Text
- Drawing Images
- Error Handling
- Gesture Recognizers
Custom Views

When would I want to create my own UIView subclass?

- I want to do some custom drawing on screen.
- I need to handle touch events in a special way (i.e. different than a button or slider does).
- We will talk about handling touch events later. For now we are focussing on drawing.

Drawing is easy

- Create a UIView subclass and override one method:
  ```swift
  func draw(_ rect: CGRect)
  ```
- You can optimize by not drawing outside of the rect if you want (but not required).
Custom Views

NEVER call draw()!

- Instead, let iOS know that your view’s visual is out of date with one of these UIView methods:
  
  ```swift
  func setNeedsDisplay()
  func setNeedsDisplay(_ rect: CGRect)
  ```

- It will then set everything up and call draw() for you at an appropriate time.

- Obviously, the second version will call your draw() with only the rectangle that need updates.
Custom Views

- So how do I implement my own `draw()` method?
- We use the Core Graphics framework.

Concepts
- Get a context to draw into (iOS will prepare one each time your `draw()` method is called).
- Create paths (out of lines, arcs, etc).
- Set colors, fonts, textures, line widths, line caps, etc.
- Stroke or fill the above-created paths.
Context

The context determines where your drawing goes

- Screen (the only one we are going to talk about today)
- Offscreen Bitmap
- PDF
- Printer

For normal drawing, UIKit sets up the current context for you

- But it is only valid during that particular call to `draw()`.
- A new one is set up for you each time `draw()` is called. So never cache the current graphics context in `draw()` to use later!

How to get this magic context?

- Call the following function inside your `draw()` method to get the current graphics context:

```swift
let context = UIGraphicsGetCurrentContext()
```
Define a Path

- Begin the path:
  ```
  context.beginPath();
  ```
- Move around, add lines or arcs to the path:
  ```
  context.move(to: CGPoint(x: 85, y: 30))
  context.addLine(to: CGPoint(x: 160, y: 170))
  ```
Define a Path

- Begin the path:
  ```
  context.beginPath();
  ```

- Move around, add lines or arcs to the path:
  ```
  context.move(to: CGPoint(x: 85, y: 30))
  context.addLine(to: CGPoint(x: 160, y: 170))
  context.addLine(to: CGPoint(x: 10, y: 170))
  ```
Define a Path

- Begin the path:
  ```
  context.beginPath();
  ```

- Move around, add lines or arcs to the path:
  ```
  context.moveTo(CGPoint(x: 85, y: 30))
  context.lineTo(CGPoint(x: 160, y: 170))
  context.lineTo(CGPoint(x: 10, y: 170))
  ```

- Close the path (connects the last point back to the first):
  ```
  context.closePath() // not strictly required
  ```
Define a Path

- Begin the path:
  ```
  context.beginPath();
  ```

- Move around, add lines or arcs to the path:
  ```
  context.move(to: CGPoint(x: 85, y: 30))
  context.addLine(to: CGPoint(x: 160, y: 170))
  context.addLine(to: CGPoint(x: 10, y: 170))
  ```

- Close the path (connects the last point back to the first):
  ```
  context.closePath() // not strictly required
  ```

- Actually the above draws nothing (yet)!

- You have to set the graphics state and then fill/stroke the above path to see anything.
Define a Path

- Begin the path:
  ```
  context.beginPath()
  ```
- Move around, add lines or arcs to the path:
  ```
  context.move(to: CGPoint(x: 85, y: 30))
  context.addLine(to: CGPoint(x: 160, y: 170))
  context.addLine(to: CGPoint(x: 10, y: 170))
  ```
- Close the path (connects the last point back to the first):
  ```
  context.closePath() // not strictly required
  ```
- Actually the above draws nothing (yet)!
- You have to set the graphics state and then fill/stroke the above path to see anything.
  ```
  UIColor.green.setFill()
  UIColor.red.setStroke()
  /* object-oriented convenience methods
     (more in a moment) */
  context.drawPath(using: .fillStroke)
  // .fillStroke is an CGPathDrawingMode enum case
  ```
Define a Path

- You can draw arcs, rectangles, ellipses and so on.
- It is also possible to save a path and reuse it.
- There are similar functions to the previous slide that let you do this.
- We won’t be covering those, but you can certainly feel free to look up `CGPath` and `CGContext` in the documentation.
Graphics State

UIColor class for setting colors

- It has class methods for creating most common colors:

```swift
let red = UIColor.red
let invisible = UIColor.clear
```

- Custom colors can be created using initializers:

```swift
let custom = UIColor(red: 0.5,
                      green: 0.8,
                      blue: 1.0,
                      alpha: 0.8)
```

```swift
let woodTexture = UIImage(contentsOfFile: "wood.png")
let pattern = UIColor(patternImage: woodTexture!)
```

- To set the fill/stroke color in current graphics context:

```swift
pattern.setFill()
red.setStroke()
custom.set() /* sets both stroke and fill color to custom (would override the previous) */
```
View Transparency

Drawing with transparency in UIView

- Note the alpha component of UIColors. This is how you can draw with transparency in your drawRect:

- UIView also has a backgroundColor property which can be set to transparent values.

- Be sure to set Bool opaque property to false in a view which is partially or fully transparent.

- If you don’t, results are unpredictable (this is a performance optimization property, by the way).

- The UIView's CGFloat alpha property can make the entire view partially transparent.
View Transparency

What happens when views overlap?

- As mentioned before, subviews list order determines who's in front.
- Lower ones (earlier in subviews array) can “show through” transparent views on top of them.
- Default drawing is opaque. Transparency is not cheap when you think of performance.
- Also, you can hide a view completely by setting the Bool hidden property.
- The view will not be on screen and will not handle events if you set:

  ```
  myView.hidden = true;
  ```
- This is not as uncommon as you might think. On a small screen, keeping it de-cluttered by hiding currently unusable views makes sense.
Alpha is 0.7 so the view is transparent.

Clip to Bounds is false. Watch what happens with the button in iOS Simulator.
This view is hidden.
Graphics State

Some other graphics state settings

- Set line width (in points, not pixels):

  ```java
  context.setLineWidth(5.0)
  ```

- Set the fill pattern in specified graphics context:

  ```java
  context.setFillPattern(pattern: CGPattern,
                          colorComponents: UnsafePointer<CGFloat>)
  ```
Graphics State

Special considerations for defining drawing “subroutines”

- What if you wanted to have a utility method that draws something
- You don’t want that utility method to mess up the graphics state of the calling method.
- Use save and restore graphics state functions:

```swift
func drawBlueCircle(context: CGContext)
{
    context.saveGState()
    UIColor.blue.setFill()  
    let r = CGRect(x: 20, y: 150, width: 100, height: 100)
    context.addEllipse(in: r)
    context.drawPath(using: .fill)
    context.restoreGState()
}
override func draw(_ rect: CGRect)
{
    ...  
    self.drawBlueCircle(context: context)
    ...
}
```
Drawing Text

- Use **UILabel** to draw text, but if you feel you must ...
- Use **UIFont** object in **UIKit** to get a font:
  ```swift
  let f = UIFont.systemFont(ofSize: 18.0)
  let h = UIFont(name: "Helvetica", size: 36.0)
  let availableFonts = UIFont.familyNames
  ```
- Then use special **NSString** methods to draw the text:
  ```swift
  let text: NSString = "Text is drawn"
  text.draw(at: CGPoint(x: 20, y: 300),
            withAttributes: [NSAttributedString.Key.font : f])
  // NSString instance method
  ```
- How much space will a piece of text will take up when drawn?
  ```swift
  let textSize = text.size(attributes: [NSAttributedString.Key.font : h ?? f])
  // NSString instance method
  ```
You might be disturbed that there is a Foundation method for drawing (which is a UIKit thing).

But actually these `NSString` methods are defined in UIKit via extensions.

Remember: Extensions are the Swift's way to add methods to an existing class without subclassing.
Drawing Images

- Use **UIImageView** to draw images, but if you feel you must ...
  (Note that we will cover **UIImageView** later in the course)
- Create a **UIImage** object from a file in your Resources folder:
  ```swift
  let image = UIImage(named: "foo.jpg")
  ```
- Or create one from a named file or from raw data:
  (of course, we haven’t talked about the file system yet, but ...)
  ```swift
  let img1 = UIImage(contentsOfFile: path)
  let url = URL(string: "http://www.web.com/img.png")
  let data = try Data(contentsOf: url!)
  let img2 = UIImage(data: data)
  ```
- Or you can even create one by drawing with **CGContext** functions:
  ```swift
  UIGraphicsBeginImageContext(CGSize(width: 100, height: 100))
  // draw with CGContext functions
  let img = UIGraphicsGetImageFromCurrentImageContext()
  UIGraphicsEndImageContext()
  ```
Drawing Images

- To draw the `UIImage`'s bits into the current graphics context:

  ```swift
  let img = ...
  img?.draw(at: CGPoint(x: 20, y: 350))
  // at: is the upper left corner of the image
  ```

- Scale the image to fit in a `CGRect`:

  ```swift
  img?.draw(in: CGRect(x: 0, y: 0,
                       width: 80, height: 80))
  ```

- Tile the image into a `CGRect`:

  ```swift
  img?.drawAsPattern(in: CGRect(x: 0, y: 0,
                                width: 80, height: 80))
  ```

- You can also get a PNG or JPG data representation of `UIImage`:

  ```swift
  let jpgData = UIImageJPEGRepresentation(finalImage!, CGFloat(0.8))
  let pngData = UIImagePNGRepresentation(finalImage!)
  ```
Error Handling

- Some operations aren’t guaranteed to always complete execution or produce a useful output.
- Optionals are used to represent the absence of a value, but when an operation fails, it’s often useful to understand what caused the failure, so that your code can respond accordingly.
- In Swift, errors are represented by values of types that conform to the `Error` protocol.
- Swift enumerations are particularly well suited to modeling a group of related error conditions with associated values:

```swift
enum VendingMachineError: Error {
    case invalidSelection
    case insufficientFunds(coinsNeeded: Int)
    case outOfStock
}
```
Throwing and Handling Errors

- Throwing an error lets you indicate that something unexpected happened and the normal flow of execution can’t continue. You use a `throw` statement to throw an error:

  ```swift
  throw VendingMachineError.insufficientFunds(coinsNeeded: 5)
  ```

- When a function throws an error, it changes the flow of your program, so it is important that you can quickly identify places in your code that can throw errors. You do this by writing the `try` keyword before a piece of code that can throw an error.

There are four ways to handle errors in Swift:

- You can propagate the error from a function to the code that calls that function
- You can handle the error using a `do-catch` statement
- You can handle the error as an optional value
- You can assert that the error will not occur
Propagating Errors

- To indicate that a function, method, or initializer can throw an error, you write the `throws` keyword in the function’s declaration after its parameters. A function marked with throws is called a throwing function:

```swift
func vend(itemNamed name: String) throws {
    guard let item = inventory[name] else {
        throw VendingMachineError.invalidSelection
    }
    guard item.count > 0 else {
        throw VendingMachineError.outOfStock
    }
    guard item.price <= coinsDeposited else {
        throw VendingMachineError.insufficientFunds
            (coinsNeeded: item.price - coinsDeposited)
    }
    coinsDeposited -= item.price
    var newItem = item
    newItem.count -= 1
    inventory[name] = newItem
    print("Dispensing \(name)")
}
```
Handling Errors using do–catch

• You use a `do–catch` statement to handle errors by running a block of code. If an error is thrown by the code in the `do` clause, it is matched against the `catch` clauses to determine which one of them can handle the error:

```swift
var vendingMachine = VendingMachine()
vendingMachine.coinsDeposited = 8
do {
    try buyFavoriteSnack(person: "Alice",
        vendingMachine: vendingMachine)
} catch VendingMachineError.invalidSelection {
    print("Invalid Selection.")
} catch VendingMachineError.outOfStock {
    print("Out of Stock.")
} catch VendingMachineError.insufficientFunds(let coins) {
    print("Insufficient funds. Insert \(coins) coins.")
}// Prints "Insufficient funds. Insert 2 coins."```
Converting Errors to Optional Values

- You use `try?` to handle an error by converting it to an optional value. If an error is thrown while evaluating the `try?` expression, the value of the expression is `nil`. For example, in the following code `x` and `y` have the same value and behavior:

```swift
func someThrowingFunction() throws -> Int {
    // ...
}

let x = try? SomeThrowingFunction()

let y: Int?

do {
    y = try someThrowingFunction()
} catch {
    y = nil
}
Specifying Cleanup Actions

- You use a `defer` statement to execute a set of statements just before code execution leaves the current block of code. This statement lets you do any necessary cleanup that should be performed regardless of how execution leaves the block of code.
- The deferred statements may not contain any code that would transfer control out of the statements, such as `break` or `return`, or by throwing an error.

```swift
func processFile(filename: String) throws {
    if exists(filename) {
        let file = open(filename)
        defer {
            close(file)
        }
        while let line = try file.readline() {
            // work with the file
        }
        // close(file) is called here
    }
}
```
Autorotation

If you support autorotation, what will happen when rotated?

- Rotations are treated as a change in the size of the view controller’s view and are therefore reported using the `viewWillTransition(to:with:)` method.

- When the interface orientation changes, UIKit calls this method on the window’s root view controller. That view controller then notifies its child view controllers, propagating the message throughout the view controller hierarchy.

- The `frame` of all subviews in your Controller’s View will be adjusted.

- The adjustment is based on their “struts and springs”.

- You set “struts and springs” in Interface Builder.

- When a view’s `bounds` changes because its `frame` is altered, does `drawRect:` get called again? No.
Set a view’s struts and springs in Size Inspector in Xcode
Struts and Springs

Set a view’s struts and springs in Size Inspector in Xcode

Grows and shrinks as its superview’s bounds grow and shrink because struts fixed to all sides and both springs allow expansion.
Set a view’s struts and springs in Size Inspector in Xcode

Grows and shrinks only horizontally as its superview's bounds grow and shrink and sticks to the top in its superview.
Struts and Springs

Set a view’s struts and springs in Size Inspector in Xcode

Sticks to upper left corner (fixed size).
Redraw on bounds change

- By default, there is no redraw when your UIView’s bounds change.
- Instead, the “bits” of your view will be stretched or squished or moved.
- Often this is not what you want. Luckily, there is a UIView property to control this:
  ```swift
  var contentMode: UIViewContentMode { get set }
  UIViewContentMode.{left, right, top, bottom, bottomLeft, bottomRight, topLeft, topRight, ...}
  ```
- The above is not springs and struts! This is after springs and struts have been applied!
- These content modes move the bits of your drawing to that location.
Redraw on bounds change

- For bit stretching or shrinking set `contentMode` to:
  `UIViewContentMode.scale{ToFill, AspectFill, AspectFit}`
- But many times you want just to call `drawRect:`. For this use:
  `UIViewContentMode.redraw`
- Default is `UIVViewContentMode.scaleToFill`.
Initializing a UIView

- Yes, you can override `init(frame:)`. Use previously explained syntax:
  ```swift
  super.init(frame: frame)
  ```
- But you will also want to set up stuff in `awakeFromNib`. This is because `init(frame:)` is **NOT** called for a `UIView` coming out of a storyboard!
  But `awakeFromNib` is. It’s called “`awakeFromNib`” for historical reasons.
- Typical code:
  ```swift
  func setup() { /* set up your custom view here */ }
  override func awakeFromNib() { self.setup() }
  override init(frame: CGRect) {
    super.init(frame: frame)
    self.setup()
  }
  ```
We've seen how to draw in our UIView, but how do we get touches?

- We can get notified of the raw touch events (touch down, moved, up).
- Or we can react to certain, predefined “gestures”. This latter is the preferable way to go.

Gestures are recognized by the class UIGestureRecognizer

- This class is “abstract”. We only actually use “concrete subclasses” of it.
- There are two sides to using a gesture recognizer:
  1. Adding a gesture recognizer to a UIView to ask it to recognize that gesture.
  2. Providing the implementation of a method to “handle” that gesture when it happens.
**UIGesture Recognizer**

Usually #1 is done by a Controller

- Though occasionally a `UIView` will do it to itself if it just doesn’t make sense without that gesture.

Usually #2 is provided by the `UIView` itself

- But it would not be unreasonable for the Controller to do it.
- Or for the Controller to decide it wants to handle a gesture differently than the view does.
Adding a gesture recognizer to a `UIView` from a Controller

```swift
func setPannable(view: UIView)
{
    let panGR = UIPanGestureRecognizer(target: view,
                                       action: #selector(CustomView.pan(recognizer:))))
}
```

This is a concrete subclass of `UIGestureRecognizer` that recognizes “panning” (moving something around with your finger). There are, of course, other concrete subclasses (for swipe, pinch, tap, etc).
Adding a gesture recognizer to a UIView from a Controller

```swift
func setPannable(view: UIView)
{
    let panGR = UIPanGestureRecognizer(target: view, action: #selector(CustomView.pan(recognizer:)))
}
```

Note that we are specifying the view itself as the target to handle a pan gesture when it is recognized. Thus the view will be both the recognizer and the handler of the gesture. The UIView does not have to handle the gesture. It could be, for example, the Controller that handles it. The View would generally handle gestures to modify how the View is drawn. The Controller would have to handle gestures that modify the Model.
func setPannable(view: UIView)
{
  let panGR = UIPanGestureRecognizer(target: view,
         action: #selector(CustomView.pan(recognizer:)))
}

This is the action method that will be sent to the target (the pannable view) during the handling of the recognition of this gesture. This version of the action message takes one argument (which is the UIGestureRecognizer that sends the action), but there is another version that takes no arguments if you would prefer it. We’ll look at the implementation of this method in a moment.
func setPannable(view: UIView)
{
    let panGR = UIPanGestureRecognizer(target: view, action: #selector(CustomView.pan(recognizer:)))
    view.addGestureRecognizer(panGR)
}
**UI Gesture Recognizer**

Adding a gesture recognizer to a `UIView` from a Controller

```swift
func setPannable(view: UIView)
{
    let panGR = UIPanGestureRecognizer(target: view,
        action: #selector(CustomView.pan(recognizer:)))
    view.addGestureRecognizer(panGR)
}
```

- Only `UIView` instances can recognize a gesture (because `UIView`s handle all touch input).
- But any object can tell a `UIView` to recognize a gesture (by adding a recognizer to the `UIView`).
- And any object can handle the recognition of a gesture (by being the target of the gesture’s action).
How do we implement the target of a gesture recognizer? Each concrete class provides some methods to help you do that.

For example, `UIPanGestureRecognizer` provides 3 methods:

```swift
func velocity(in view: UIView?) -> CGPoint
func translation(in view: UIView?) -> CGPoint
func setTranslation(_ translation: CGPoint, in view: UIView?)
```
UIGestureRecognizer

- The base class `UIGestureRecognizer` provides this property:
  ```swift
  var state: UIGestureRecognizerState { get set }
  ```
- Gesture Recognizers sit around in the state `.possible` until they start to be recognized.
- Then they either go to `.recognized` (for discrete gestures like a tap).
- Or they go to `.began` (for continuous gestures like a pan).
- At any time, the state can change to `.failed` (so watch out for that).
- If the gesture is continuous, it will move on to the `.changed` and eventually the `.ended` state.
- Continuous gestures can also go to `.cancelled` state (if the recognizer realizes it’s not this gesture after all).
So, given these methods, what would `pan:` look like?

```swift
func pan(recognizer: UIPanGestureRecognizer) {
```
So, given these methods, what would `pan` look like?

```swift
func pan(recognizer: UIPanGestureRecognizer) {
    if recognizer.state == .changed || recognizer.state == .ended {
        We are going to update our view every time the touch moves (and when the touch ends). This is “smooth panning”.
    }
}
```
Given these methods, what would `pan` look like?

```swift
func pan(recognizer: UIPanGestureRecognizer) {
    if recognizer.state == .changed || recognizer.state == .ended {
        let translation = recognizer.translation(in: self)
    }
}
```

This is the cumulative distance this gesture has moved.
So, given these methods, what would `pan:` look like?

```swift
func pan(recognizer: UIPanGestureRecognizer) {
    if recognizer.state == .changed || recognizer.state == .ended {
        let translation = recognizer.translation(in: self)

        /* Move something in myself (I’m a UIView) by translation.x and translation.y.
         * For example, if I were a graph and my origin was set by a property called origin. */
        self.origin.x += translation.x
        self.origin.y += translation.y
    }
}
```
UIGestureRecognizer

So, given these methods, what would `pan:` look like?

```swift
func pan(recognizer: UIPanGestureRecognizer) {
    if recognizer.state == .changed ||
       recognizer.state == .ended {
        let translation = recognizer.translation(in: self)

        /* Move something in myself (I’m a UIView)
         * by translation.x and translation.y.
         * For example, if I were a graph and my origin
         * was set by a property called origin. */
        self.origin.x += translation.x
        self.origin.y += translation.y
        recognizer.setTranslation(CGPoint(x: 0, y: 0),
                                   in: self)
    }
}
```

Here we are resetting the cumulative distance to zero. Now each time this is called, we’ll get the “incremental” movement of the gesture (which is what we want). If we wanted the “cumulative” movement of the gesture, we would not include this line of code.
Other Concrete Gestures

UIPinchGestureRecognizer

var scale: CGFloat { get set }

//note that this is not readonly (can reset each movement)

var velocity: CGFloat { get }

//note that this is readonly; scale factor per second

UIRotationGestureRecognizer

var rotation: CGFloat { get set }

//note that this is not readonly; in radians

var velocity: CGFloat { get }

//note that this is readonly; in radians per second
Other Concrete Gestures

**UISwipeGestureRecognizer**

- This one you “set up” (with the following) to find certain swipe types, then look for Recognized state:

```swift
var direction: UISwipeGestureRecognizerDirection {get set}
// what direction swipes you want
var numberOfTouchesRequired: Int { get set }
// two finger swipes? or just one finger? or more?
```

**UITapGestureRecognizer**

- Set up (with the following) then look for Recognized state:

```swift
var numberOfTapsRequired: Int { get set }
// single tap or double tap or triple tap, etc.
var numberOfTouchesRequired: Int { get set }
// e.g., require two finger tap?
```
Other Concrete Gestures

UIScreenEdgePanGestureRecognizer

• Inherits from UIPanGestureRecognizer:
  
  ```swift
  var edges: UIRectEdge { get set }
  // the acceptable starting edges for the gesture
  ```

UILongPressGestureRecognizer

```swift
  var minimumPressDuration: CFTimeInterval { get set }
  // time interval in seconds; default is 0.5 seconds
  var numberOfTouchesRequired: Int { get set }
  // e.g., require two finger long press?
  var numberOfTapsRequired: Int { get set }
  var allowableMovement: CGFloat { get set }
  // maximum movement of fingers before the gesture fails
  ```
Next Time

View Controllers and Storyboarding:

- MVCs Working Together
- Segues
- Navigation Controllers
- View Controllers
- Tab Bar Controller