



Stanford CS193p

Developing Applications for iOS
Winter 2017



Today

- 👁 Views
 - Custom Drawing
- 👁 Demo
 - FaceView



Views

- A view (i.e. `UIView` subclass) represents a rectangular area

 - Defines a coordinate space

 - For drawing

 - And for handling touch events

- Hierarchical

 - A view has only one superview ... `var superview: UIView?`

 - But it can have many (or zero) subviews ... `var subviews: [UIView]`

 - The order in the subviews array matters: those later in the array are on top of those earlier

 - A view can clip its subviews to its own bounds or not (the default is not to)

- UIWindow

 - The `UIView` at the very, very top of the view hierarchy (even includes status bar)

 - Usually only one `UIWindow` in an entire iOS application ... it's all about views, not windows



Views

- The hierarchy is most often constructed in Xcode graphically

Even custom views are usually added to the view hierarchy using Xcode

- But it can be done in code as well

```
func addSubview(_ view: UIView) // sent to view's (soon to be) superview
```

```
func removeFromSuperview() // sent to the view you want to remove (not its superview)
```

- Where does the view hierarchy start?

The top of the (useable) view hierarchy is the Controller's `var view: UIView`.

This simple property is a very important thing to understand!

This view is the one whose bounds will change on rotation, for example.

This view is likely the one you will programmatically add subviews to (if you ever do that).

All of your MVC's View's UIViews will have this view as an ancestor.

It's automatically hooked up for you when you create an MVC in Xcode.



Initializing a UIView

- As always, try to avoid an initializer if possible

But having one in UIView is slightly more common than having a UIViewController initializer

- A UIView's initializer is different if it comes out of a storyboard

```
init(frame: CGRect) // initializer if the UIView is created in code
```

```
init(coder: NSCoder) // initializer if the UIView comes out of a storyboard
```

- If you need an initializer, implement them both ...

```
func setup() { ... }
```

```
override init(frame: CGRect) { // a designated initializer
```

```
    super.init(frame: frame)
```

```
    setup()
```

```
}
```

```
required init(coder aDecoder: NSCoder) { // a required initializer
```

```
    super.init(coder: aDecoder)
```

```
    setup()
```

```
}
```



Initializing a UIView

- Another alternative to initializers in UIView ...

`awakeFromNib()` // this is only called if the UIView came out of a storyboard

This is not an initializer (it's called immediately after initialization is complete)

All objects that inherit from NSObject in a storyboard are sent this

Order is not guaranteed, so you cannot message any other objects in the storyboard here



Coordinate System Data Structures

CGFloat

Always use this instead of Double or Float for anything to do with a UIView's coordinate system
You can convert to/from a Double or Float using initializers, e.g., `let cgf = CGFloat(aDouble)`

CGPoint

Simply a struct with two CGFloats in it: x and y.

```
var point = CGPoint(x: 37.0, y: 55.2)
point.y -= 30
point.x += 20.0
```

CGSize

Also a struct with two CGFloats in it: width and height.

```
var size = CGSize(width: 100.0, height: 50.0)
size.width += 42.5
size.height += 75
```



Coordinate System Data Structures

• CGRect

A struct with a CGPoint and a CGSize in it ...

```
struct CGRect {
```

```
    var origin: CGPoint
```

```
    var size: CGSize
```

```
}
```

```
let rect = CGRect(origin: aCGPoint, size: aCGSize) // there are other inits as well
```

Lots of convenient properties and functions on CGRect like ...

```
var minX: CGFloat // left edge
```

```
var midY: CGFloat // midpoint vertically
```

```
intersects(CGRect) -> Bool // does this CGRect intersect this other one?
```

```
intersect(CGRect) // clip the CGRect to the intersection with the other one
```

```
contains(CGPoint) -> Bool // does the CGRect contain the given CGPoint?
```

... and many more (make yourself a CGRect and type . after it to see more)



(0,0)

View Coordinate System

increasing x

o (500, 35)

- Origin is upper left

- Units are points, not pixels

Pixels are the minimum-sized unit of drawing your device is capable of

Points are the units in the coordinate system

Most of the time there are 2 pixels per point, but it could be only 1 or even 3

How many pixels per point are there? UIView's `var contentScaleFactor: CGFloat`

- The boundaries of where drawing happens

`var bounds: CGRect` // a view's internal drawing space's origin and size

This is the rectangle containing the drawing space in its own coordinate system

It is up to your view's implementation to interpret what `bounds.origin` means (often nothing)

- Where is the UIView?

`var center: CGPoint` // the center of a UIView in its superview's coordinate system

`var frame: CGRect` // the rect containing a UIView in its superview's coordinate system

increasing y

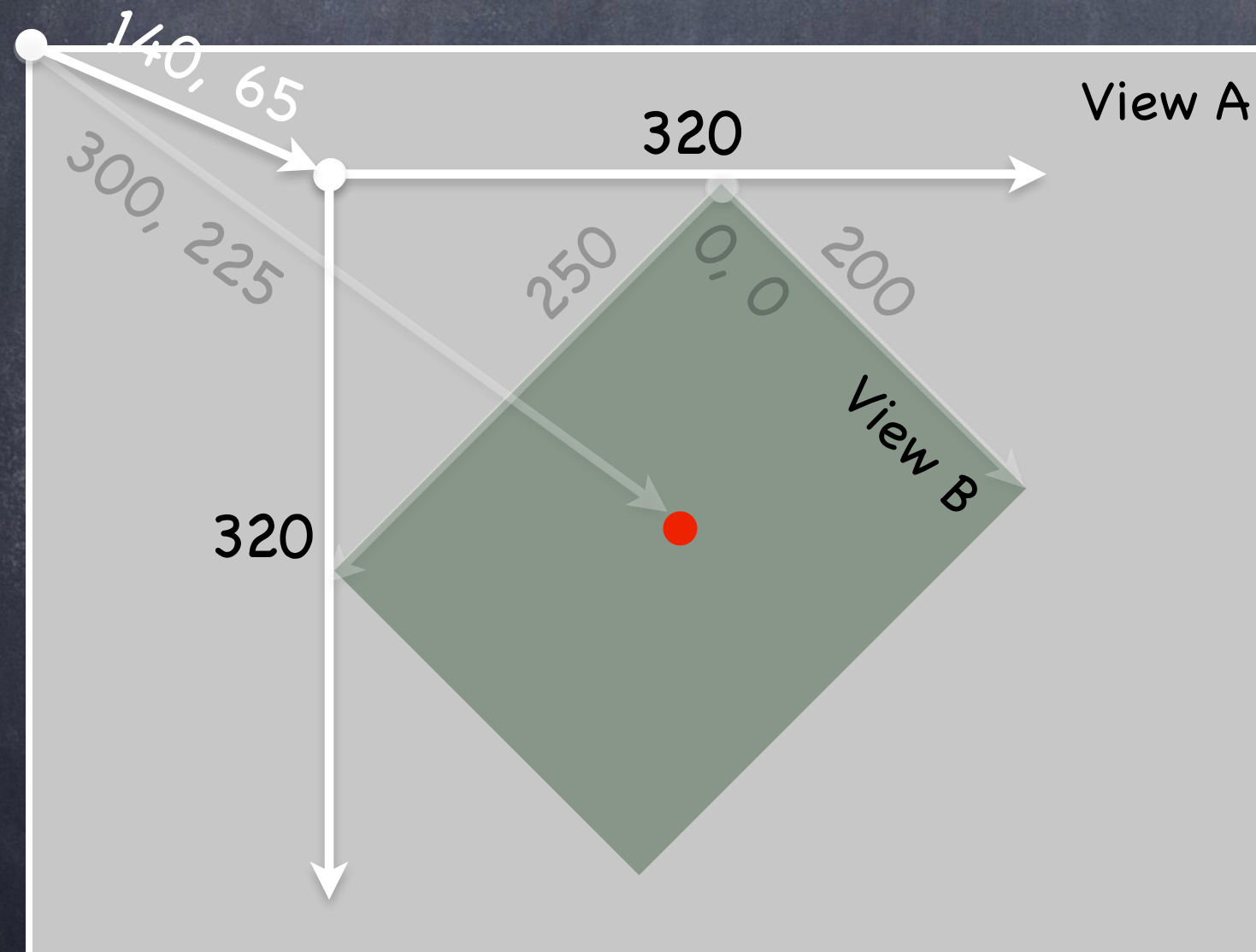


bounds vs frame

- Use **frame** and/or **center** to position a UIView

These are never used to draw inside a view's coordinate system

You might think `frame.size` is always equal to `bounds.size`, but you'd be wrong ...



Views can be rotated (and scaled and translated)

View B's bounds = $((0,0), (200,250))$

View B's frame = $((140,65), (320,320))$

View B's center = $(300,225)$

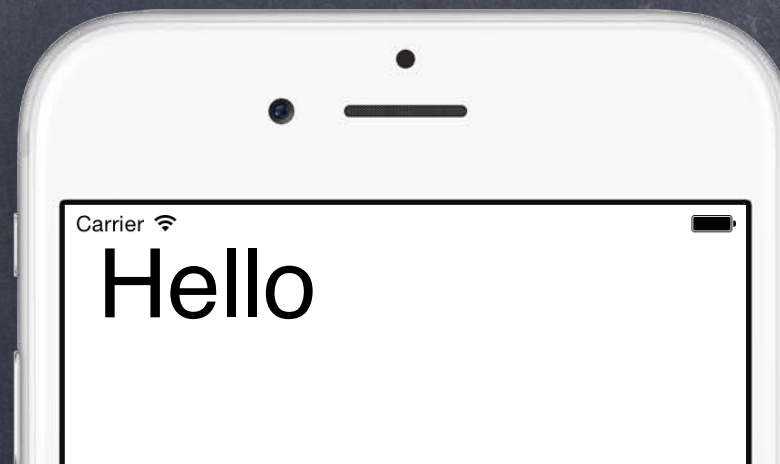
View B's middle in its own coordinates is ...
 $(\text{bounds.midX}, \text{bounds.midY}) = (100, 125)$

Views are rarely rotated, but don't misuse frame or center anyway by assuming that.



Creating Views

- Most often your views are created via your storyboard
 - Xcode's Object Palette has a generic UIView you can drag out
 - After you do that, you must use the **Identity Inspector** to changes its class to your subclass
- On rare occasion, you will create a UIView via code
 - You can use the frame initializer ... `let newView = UIView(frame: myViewFrame)`
 - Or you can just use `let newView = UIView()` (frame will be CGRect.zero)
- Example
 - // assuming this code is in a UIViewController
 - `let labelRect = CGRect(x: 20, y: 20, width: 100, height: 50)`
 - `let label = UILabel(frame: labelRect) // UILabel is a subclass of UIView`
 - `label.text = "Hello"`
 - `view.addSubview(label)`



Custom Views

- When would I 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'll talk about handling touch events in a bit. First we'll focus on drawing.

- To draw, just create a UIView subclass and override `draw(CGRect)`

 - `override func draw(_ rect: CGRect)`

 - You can draw outside the `rect`, but it's never required to do so.

 - The `rect` is purely an optimization.

 - It is our UIView's `bounds` that describe the entire drawing area (the `rect` is a subarea).

- **NEVER** call `draw(CGRect)!!` EVER! Or else!

 - Instead, if you view needs to be redrawn, let the system know that by calling ...

 - `setNeedsDisplay()`

 - `setNeedsDisplay(_ rect: CGRect)` // `rect` is the area that needs to be redrawn

 - iOS will then call your `draw(CGRect)` at an appropriate time



Custom Views

• So how do I implement my `draw(CGRect)`?

You can either get a drawing context and tell it what to draw, or ...

You can create a path of drawing using `UIBezierPath` class (which is how we'll do it)

• Core Graphics Concepts

1. You get a context to draw into (other contexts include printing, off-screen buffer, etc.)

The function `UIGraphicsGetCurrentContext()` gives a context you can use in `draw(CGRect)`

2. Create paths (out of lines, arcs, etc.)

3. Set drawing attributes like colors, fonts, textures, linewidths, linecaps, etc.

4. Stroke or fill the above-created paths with the given attributes

• `UIBezierPath`

Same as above, but captures all the drawing with a `UIBezierPath` instance

`UIBezierPath` automatically draws in the "current" context (`draw(CGRect)` sets this up for you)

`UIBezierPath` has methods to draw (line to, arcs, etc.) and set attributes (linewidth, etc.)

Use `UIColor` to set stroke and fill colors

`UIBezierPath` has methods to stroke and/or fill



Defining a Path

- Create a UIBezierPath

```
let path = UIBezierPath()
```

- Move around, add lines or arcs to the path

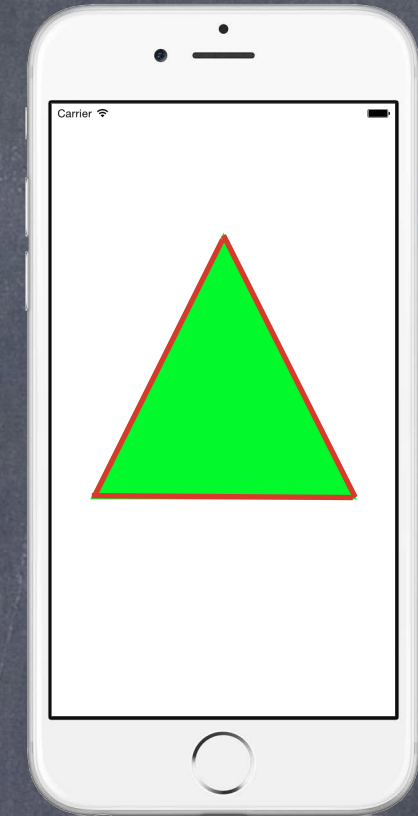
```
path.move(to: CGPoint(80, 50))  
path.addLine(to: CGPoint(140, 150))  
path.addLine(to: CGPoint(10, 150))
```

- Close the path (if you want)

```
path.close()
```

- Now that you have a path, set attributes and stroke/fill

```
UIColor.green.setFill() // note setFill is a method in UIColor, not UIBezierPath  
UIColor.red.setStroke() // note setStroke is a method in UIColor, not UIBezierPath  
path.linewidth = 3.0 // linewidth is a property in UIBezierPath, not UIColor  
path.fill() // fill is a method in UIBezierPath  
path.stroke() // stroke method in UIBezierPath
```



Drawing

- You can also draw common shapes with `UIBezierPath`

```
let roundRect = UIBezierPath(roundedRect: CGRect, cornerRadius: CGFloat)
```

```
let oval = UIBezierPath(ovalIn: CGRect)
```

... and others

- Clipping your drawing to a `UIBezierPath`'s path

```
addClip()
```

For example, you could clip to a rounded rect to enforce the edges of a playing card

- Hit detection

```
func contains(_ point: CGPoint) -> Bool // returns whether the point is inside the path
```

The path must be closed. The winding rule can be set with `usesEvenOddFillRule` property.

- Etc.

Lots of other stuff. Check out the documentation.



UIColor

- Colors are set using UIColor

There are type (aka static) vars for standard colors, e.g. `let green = UIColor.green`
You can also create them from RGB, HSB or even a pattern (using UIImage)

- Background color of a UIView

```
var backgroundColor: UIColor // we used this for our Calculator buttons
```

- Colors can have alpha (transparency)

```
let semitransparentYellow = UIColor.yellow.withAlphaComponent(0.5)
```

Alpha is between 0.0 (fully transparent) and 1.0 (fully opaque)

- If you want to draw in your view with transparency ...

You must let the system know by setting the UIView `var opaque = false`

- You can make your entire UIView transparent ...

```
var alpha: CGFloat
```



View Transparency

- What happens when views overlap and have transparency?

As mentioned before, `Subviews` list order determines who is in front

Lower ones (earlier in the array) can “show through” transparent views on top of them

Transparency is not cheap, by the way, so use it wisely

- Completely hiding a view without removing it from hierarchy

`var hidden: Bool`

A hidden view will draw nothing on screen and get no events either

Not as uncommon as you might think to temporarily hide a view



Drawing Text

- Usually we use a UILabel to put text on screen

But there are certainly occasions where we want to draw text in our draw(CGRect)

- To draw in draw(CGRect), use NSAttributedString

```
let text = NSAttributedString(string: "hello")
```

```
text.draw(at: aCGPoint)
```

```
let textSize: CGSize = text.size // how much space the string will take up
```

- Mutability is done with NSMutableAttributedString

It is not like String (i.e. where let means immutable and var means mutable)

You use a different class if you want to make a mutable attributed string ...

```
let mutableText = NSMutableAttributedString(string: "some string")
```

- NSAttributedString is not a String, nor an NSString

You can get its contents as an String/NSString with its `string` or `mutableString` property



Attributed String

• Setting attributes on an attributed string

```
func setAttributes(_ attributes: [String:Any]?, range: NSRange)
```

```
func addAttributes(_ attributes: [String:Any]?, range: NSRange)
```

Warning! This is a pre-Swift API. NSRange is not a Range.

And indexing into the attributed string is using Int indexing (not String.Index).

It might be helpful to use String's utf16 var to get a String.UTF16View.

A UTF16View represents the String as a sequence of 16 bit Unicode characters.

The characters in a UTF16View will then "line up" with an attributed string's characters.

But UTF16View is still indexed by String.Index.

So you'll need to get the UTF16View's characters and use startIndex with index(offsetBy:).

• Attributes

```
NSForegroundColorAttributeName : UIColor
```

```
NSStrokeWidthAttributeName : CGFloat
```

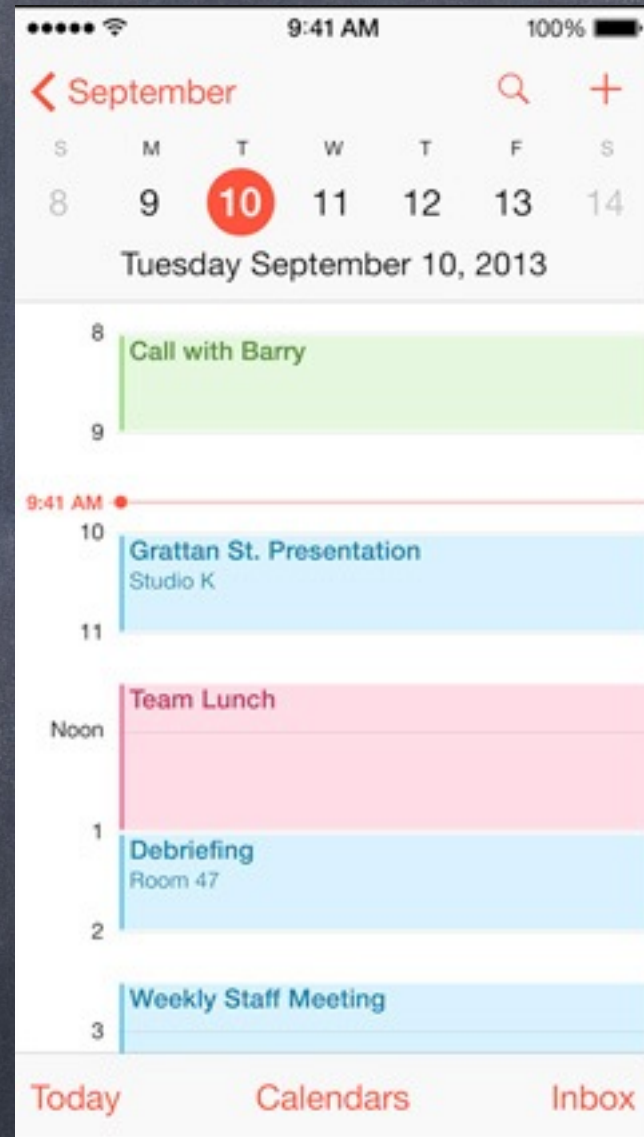
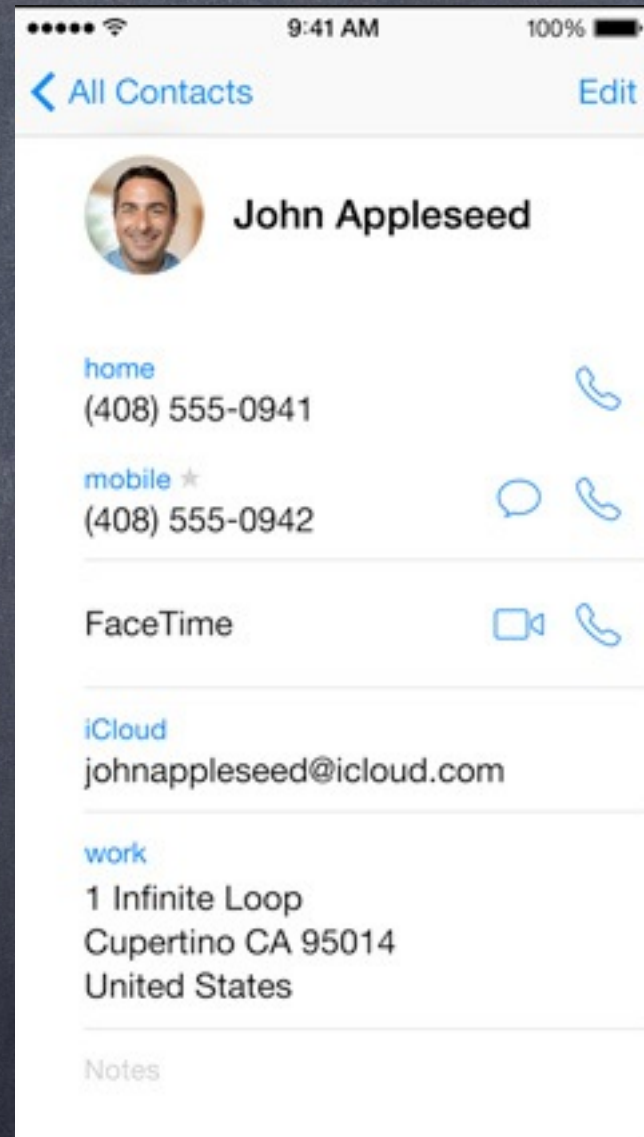
```
NSFontAttributeName : UIFont
```

See the documentation under UIKit for (many) more.



Fonts

- Fonts in iOS are very important to get right
They are fundamental to the look and feel of the UI



Fonts

- The absolutely best way to get a font in code

Get preferred font for a given text style (e.g. body, etc.) using this UIFont type method ...

```
static func preferredFont(forTextStyle: UIFontTextStyle) -> UIFont
```

Some of the styles (see UIFontDescriptor documentation for more) ...

```
UIFontTextStyle.headline
```

```
    .body
```

```
    .footnote
```

- There are also “system fonts”

These appear usually on things like buttons

```
static func systemFontOfSize(ofSize: CGFloat) -> UIFont
```

```
static func boldSystemFont(ofSize: CGFloat) -> UIFont
```

Don't use these for your user's content. Use preferred fonts for that.

- Other ways to get fonts

Check out UIFont and UIFontDescriptor for more, but you should not need that very often



Drawing Images

- There is a UILabel-equivalent for images

`UIImageView`

But, again, you might want to draw the image inside your `draw(CGRect)` ...

- Creating a UIImage object

```
let image: UIImage? = UIImage(named: "foo") // note that its an Optional
```

You add `foo.jpg` to your project in the `Assets.xcassets` file (we've ignored this so far)

Images will have different resolutions for different devices (all managed in `Images.xcassets`)

- You can also create one from files in the file system

(But we haven't talked about getting at files in the file system ... anyway ...)

```
let image: UIImage? = UIImage(contentsOfFile: aString)
```

```
let image: UIImage? = UIImage(data: aData) // raw jpg, png, tiff, etc. image data
```

- You can even create one by drawing with Core Graphics

See documentation for `UIGraphicsBeginImageContext(CGSize)`



Drawing Images

- Once you have a UIImage, you can blast its bits on screen

```
let image: UIImage = ...  
image.draw(at point: aCGPoint) // the upper left corner put at aCGPoint  
image.draw(in rect: aCGRect) // scales the image to fit aCGRect  
image.drawAsPattern(in rect: aCGRect) // tiles the image into aCGRect
```



Redraw on bounds change?

- By default, when a UIView's bounds changes, there is no redraw

Instead, the "bits" of the existing image are scaled to the new bounds size

- This is often not what you want ...

Luckily, there is a UIView property to control this! It can be set in Xcode too.

```
var contentMode: UIViewContentMode
```

- UIViewContentMode

Don't scale the view, just place it somewhere ...

```
.left/.right/.top/.bottom/.topRight/.topLeft/.bottomRight/.bottomLeft/.center
```

Scale the "bits" of the view ...

```
.scaleToFill/.scaleAspectFill/.scaleAspectFit // .scaleToFill is the default
```

Redraw by calling draw(CGRect) again (costly, but for certain content, better results) ...

```
.redraw
```

