



Stanford CS193p

Developing Applications for iOS
Winter 2017



Today

👁️ Timer

Periodically execute a block of code

Blinking FaceIt Demo

👁️ Animation

Animating changes to UIViews

Smoother Blinking FaceIt

Head-shaking FaceIt

Animating using simulated physics (time permitting)



Timer

- Used to execute code periodically

You can set it up to go off once at some time in the future, or to repeatedly go off

If repeatedly, the system will not guarantee exactly when it goes off, so this is not “real-time”

But for most UI “order of magnitude” activities, it’s perfectly fine

We don’t generally use it for “animation” (more on that later)

It’s more for larger-grained activities

- Run loops

Timers work with run loops (which we have not and will not talk about)

So for your purposes, you can only use `Timer` on the main queue

Check out the documentation if you want to learn about run loops and timers on other queues



Timer

- Fire one off with this method ...

```
class func scheduledTimer(  
  withTimeInterval: TimeInterval,  
  repeats: Bool,  
  block: (Timer) -> Void  
) -> Timer
```

- Example

```
private weak var timer: Timer?  
timer = Timer.scheduledTimer(withTimeInterval: 2.0, repeats: true) {  
  // your code here  
}
```

Every 2 seconds (approximately), the closure will be executed.

Note that the var we stored the timer in is **weak**.

That's okay because the run loop will keep a strong pointer to this as long as it's scheduled.



NSTimer

• Stopping a repeating timer

We need to be a bit careful with repeating timers ... you don't want them running forever. You stop them by calling `invalidate()` on them ...

```
timer.invalidate()
```

This tells the run loop to stop scheduling the timer.

The run loop will thus give up its strong pointer to this timer.

If your pointer to the timer is weak, it will be set to `nil` at this point.

This is nice because an invalidated timer like this is no longer of any use to you.

• Tolerance

It might help system performance to set a tolerance for "late firing".

For example, if you have timer that goes off once a minute, a tolerance of 10s might be fine.

```
myOneMinuteTimer.tolerance = 10 // in seconds
```

The firing time is relative to the start of the timer (not the last time it fired), i.e. no "drift".



NSTimer

- 👁 Demo
 - Blinking FaceIt



Kinds of Animation

- Animating UIView properties
Changing things like the frame or transparency.
- Animating Controller transitions (as in a UINavigationController)
Beyond the scope of this course, but fundamental principles are the same.
- Core Animation
Underlying powerful animation framework (also beyond the scope of this course).
- OpenGL and Metal
3D
- SpriteKit
"2.5D" animation (overlapping images moving around over each other, etc.)
- Dynamic Animation
"Physics"-based animation.



UIView Animation

- Changes to certain UIView properties can be animated over time

`frame/center`

`transform` (translation, rotation and scale)

`alpha` (opacity)

`backgroundColor`

- Done with UIView class method(s) using closures

The class methods takes animation parameters and an animation block as arguments.

The animation block contains the code that makes the changes to the UIView(s).

The changes inside the block are made immediately (even though they will appear “over time”).

Most also have another “completion block” to be executed when the animation is done.



UIView Animation

- Animation class method in UIView

```
class func animate(withDuration: TimeInterval,  
                    delay: TimeInterval,  
                    options: UIViewAnimationOptions,  
                    animations: () -> Void,  
                    completion: ((finished: Bool) -> Void)?)
```



UIView Animation

Example

```
if myView.alpha == 1.0 {
    UIView.animate(withDuration: 3.0,
                   delay: 2.0,
                   options: [.curveLinear],
                   animations: { myView.alpha = 0.0 },
                   completion: { if $0 { myView.removeFromSuperview() } })
    print("myView.alpha = \(myView.alpha)")
}
```

This would cause myView to “fade” out over 3 seconds (starting 2s from now).

Then it would remove myView from the view hierarchy (but only if the fade completed).

If, within the 5s, someone animated the alpha to non-zero, the removal would not happen.

The output on the console would be ...

```
myView.alpha = 0.0
```

... even though the alpha on the screen won't be zero for 5 more seconds!



UIView Animation

• UIViewAnimationOptions

<code>beginFromCurrentState</code>	// pick up from other, in-progress animations of these properties
<code>allowUserInteraction</code>	// allow gestures to get processed while animation is in progress
<code>layoutSubviews</code>	// animate the layout of subviews with a parent's animation
<code>repeat</code>	// repeat indefinitely
<code>autoreverse</code>	// play animation forwards, then backwards
<code>overrideInheritedDuration</code>	// if not set, use duration of any in-progress animation
<code>overrideInheritedCurve</code>	// if not set, use curve (e.g. ease-in/out) of in-progress animation
<code>allowAnimatedContent</code>	// if not set, just interpolate between current and end "bits"
<code>curveEaseInEaseOut</code>	// slower at the beginning, normal throughout, then slow at end
<code>curveEaseIn</code>	// slower at the beginning, but then constant through the rest
<code>curveLinear</code>	// same speed throughout



UIView Animation

- Sometimes you want to make an entire view modification at once

In this case you are not limited to special properties like alpha, frame and transform

Flip the entire view over `UIViewAnimationOptions.transitionFlipFrom{Left,Right,Top,Bottom}`

Dissolve from old to new state `.transitionCrossDissolve`

Curling up or down `.transitionCurl{Up,Down}`

- Use closures again with this UIView class method

```
UIView.transition(with: UIView,  
                 duration: TimeInterval,  
                 options: UIViewAnimationOptions,  
                 animations: () -> Void,  
                 completion: ((finished: Bool) -> Void)?)
```



UIView Animation

• Example

Flipping a playing card over ...

```
UIView.transition(with: myPlayingCardView,  
                duration: 0.75,  
                options: [.transitionFlipFromLeft],  
                animations: { cardIsFaceUp = !cardIsFaceUp }  
                completion: nil)
```

Presuming myPlayingCardView draws itself face up or down depending on cardIsFaceUp
This will cause the card to flip over (from the left edge of the card)



UIView Animation

- Animating changes to the view hierarchy is slightly different

In other words, you want to animate the adding/removing of subviews (or (un)hiding them)

```
UIView.transition(from: UIView,  
                 to: UIView,  
                 duration: TimeInterval,  
                 options: UIViewAnimationOptions,  
                 completion: ((finished: Bool) -> Void)?)
```

`UIViewAnimationOptions.showHideTransitionViews` if you want to use the `hidden` property.

Otherwise it will actually remove `fromView` from the view hierarchy and add `toView`.



View Animation

👁 Demos

Smoother blinking in FaceIt

“Head shake” in FaceIt



Dynamic Animation

- A little different approach to animation than UIView-based

Set up physics relating animatable objects and let them run until they resolve to stasis.

Easily possible to set it up so that stasis never occurs, but that could be performance problem.

- Steps

Create a `UIDynamicAnimator`

Add `UIDynamicBehaviors` to it (gravity, collisions, etc.)

Add `UIDynamicItems` (usually `UIViews`) to the `UIDynamicBehaviors`

(`UIDynamicItem` is an protocol which `UIView` happens to implement)

That's it! Things will instantly start animating!



Dynamic Animation

- Create a UIDynamicAnimator

```
var animator = UIDynamicAnimator(referenceView: UIView)
```

If animating views, all views must be in a view hierarchy with referenceView at the top.

- Create and add UIDynamicBehavior instances

```
e.g., let gravity = UIGravityBehavior()
```

```
animator.addBehavior(gravity)
```

```
e.g., collider = UICollisionBehavior()
```

```
animator.addBehavior(collider)
```



Dynamic Animation

- Add UIDynamicItems to a UIDynamicBehavior

```
let item1: UIDynamicItem = ... // usually a UIView
let item2: UIDynamicItem = ... // usually a UIView
gravity.addItem(item1)
collider.addItem(item1)
gravity.addItem(item2)
```

item1 and item2 will both be affect by gravity

item1 will collide with collider's other items or boundaries, but not with item2



Dynamic Animation

- UIDynamicItem protocol

Any animatable item must implement this ...

```
protocol UIDynamicItem {  
    var bounds: CGRect { get } // note that the size cannot be animated  
    var center: CGPoint { get set } // but the position can  
    var transform: CGAffineTransform { get set } // and so can the rotation  
}
```

UIView implements this protocol

If you change center or transform while the animator is running,
you must call this method in UIDynamicAnimator ...

```
func updateItemUsingCurrentState(item: UIDynamicItem)
```



Behaviors

- `UIGravityBehavior`

```
var angle: CGFloat // in radians; 0 is to the right; positive numbers are counter-clockwise
var magnitude: CGFloat // 1.0 is 1000 points/s/s
```

- `UIAttachmentBehavior`

```
init(item: UIDynamicItem, attachedToAnchor: CGPoint)
```

```
init(item: UIDynamicItem, attachedTo: UIDynamicItem)
```

```
init(item: UIDynamicItem, offsetFromCenter: CGPoint, attachedTo[Anchor]...)
```

```
var length: CGFloat // distance between attached things (this is settable while animating!)
```

```
var anchorPoint: CGPoint // can also be set at any time, even while animating
```

The attachment can oscillate (i.e. like a spring) and you can control frequency and damping



Behaviors

- `UICollisionBehavior`

```
var collisionMode: UICollisionBehaviorMode // .items, .boundaries, or .everything
```

If `.Items`, then any items you add to a `UICollisionBehavior` will bounce off of each other

If `.Boundaries`, then you add `UIBezierPath` boundaries for items to bounce off of ...

```
func addBoundary(withIdentifier: NSCopying, for: UIBezierPath)
```

```
func addBoundary(withIdentifier: NSCopying, from: CGPoint, to: CGPoint)
```

```
func removeBoundary(withIdentifier: NSCopying)
```

```
var translatesReferenceBoundsIntoBoundary: Bool // referenceView's edges
```

`NSCopying` means `NSString` or `NSNumber`, but remember you can `as` to `String`, `Int`, etc.



Behaviors

- `UICollisionBehavior`

How do you find out when a collision happens?

```
var collisionDelegate: UICollisionBehaviorDelegate
```

... this delegate will be sent methods like ...

```
func collisionBehavior(behavior: UICollisionBehavior,  
                      began/endedContactFor: UIDynamicItem,  
                      withBoundaryIdentifier: NSCopying // with:UIDynamicItem too  
                      at: CGPoint)
```

The `withBoundaryIdentifier` is the one you pass to `addBoundary(withIdentifier:)`.



Behaviors

- UISnapBehavior

```
init(item: UIDynamicItem, snapTo: CGPoint)
```

Imagine four springs at four corners around the item in the new spot.

You can control the damping of these “four springs” with `var damping: CGFloat`

- UIPushBehavior

```
var mode: UIPushBehaviorMode // .continuous or .instantaneous
```

```
var pushDirection: CGVector
```

... or ...

```
var angle: CGFloat // in radians and ...
```

```
var magnitude: CGFloat // magnitude 1.0 moves a 100x100 view at 100 pts/s/s
```

Interesting aspect to this behavior

If you push `.instantaneous`, what happens after it's done?

It just sits there wasting memory.

We'll talk about how to clear that up in a moment.



Behaviors

- `UIDynamicItemBehavior`

Sort of a special “meta” behavior.

Controls the behavior of items as they are affected by other behaviors.

Any item added to this behavior (with `addItem`) will be affected by ...

```
var allowsRotation: Bool
```

```
var friction: CGFloat
```

```
var elasticity: CGFloat
```

... and others, see documentation.

Can also get information about items with this behavior ...

```
func linearVelocity(for: UIDynamicItem) -> CGPoint
```

```
func addLinearVelocity(CGPoint, for: UIDynamicItem)
```

```
func angularVelocity(for: UIDynamicItem) -> CGFloat
```

Multiple `UIDynamicItemBehaviors` affecting the same item(s) is “advanced” (not for you!)



Behaviors

- UIDynamicBehavior

Superclass of behaviors.

You can create your own subclass which is a combination of other behaviors.

Usually you override `init` method(s) and `addItem` and `removeItem` to call ...

```
func addChildBehavior(UIDynamicBehavior)
```

This is a good way to encapsulate a physics behavior that is a composite of other behaviors.

You might also have some API which helps your subclass configure its children.

- All behaviors know the UIDynamicAnimator they are part of

They can only be part of one at a time.

```
var dynamicAnimator: UIDynamicAnimator? { get }
```

And the behavior will be sent this message when its animator changes ...

```
func willMove(to: UIDynamicAnimator?)
```



Behaviors

- UIDynamicBehavior's action property

Every time the behavior acts on items, this block of code that you can set is executed ...

```
var action: (() -> Void)?
```

(i.e. it's called action, it takes no arguments and returns nothing)

You can set this to do anything you want.

But it will be called a lot, so make it very efficient.

If the action refers to properties in the behavior itself, watch out for memory cycles.



Stasis

- UIDynamicAnimator's delegate tells you when animation pauses

Just set the delegate ...

```
var delegate: UIDynamicAnimatorDelegate
```

... and you'll find out when stasis is reached and when animation will resume ...

```
func dynamicAnimatorDidPause(UIDynamicAnimator)
```

```
func dynamicAnimatorWillResume(UIDynamicAnimator)
```



Memory Cycle Avoidance

• Example of using action and avoiding a memory cycle

Let's go back to the case of a `.Instantaneous UIPushBehavior`

When it is done acting on its items, it would be nice to remove it from its animator

We can do this with the `action` method, but we must be careful to avoid a memory cycle ...

```
if let pushBehavior = UIPushBehavior(items: [...], mode: .instantaneous) {
    pushBehavior.magnitude = ...
    pushBehavior.angle = ...
    pushBehavior.action = {
        pushBehavior.dynamicAnimator!.removeBehavior(pushBehavior)
    }
    animator.addBehavior(pushBehavior) // will push right away
}
```

The above has a memory cycle because its `action` captures a pointer back to itself
So neither the action closure nor the `pushBehavior` can ever leave the heap



Memory Cycle Avoidance

• Example of using action and avoiding a memory cycle

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When it is done acting on its items, it would be nice to remove it from its animator

We can do this with the `action` method, but we must be careful to avoid a memory cycle ...

```
if let pushBehavior = UIPushBehavior(items: [...], mode: .instantaneous) {
    pushBehavior.magnitude = ...
    pushBehavior.angle = ...
    pushBehavior.action = { [unowned pushBehavior] in
        pushBehavior.dynamicAnimator!.removeBehavior(pushBehavior)
    }
    animator.addBehavior(pushBehavior) // will push right away
}
```

Now it no longer captures `pushBehavior`

This is safe to mark `unowned` because if the `action` closure exists, so does the `pushBehavior`

When the `pushBehavior` removes itself from the animator, the `action` won't keep it in memory

So they'll both leave the heap because the animator no longer points to the behavior

