iPhone Application Programming
Lecture 7: Touches & Sensor Input

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http://hci.rwth-aachen.de/iphone

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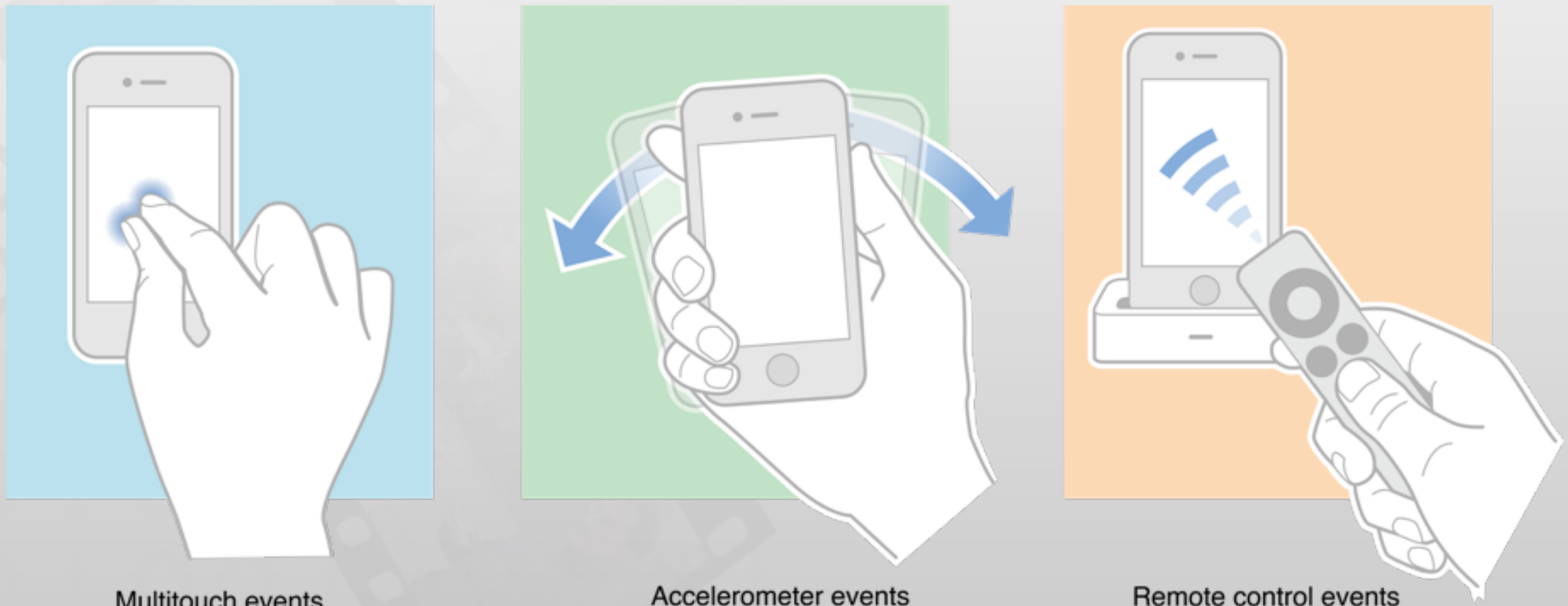
The First Segment

- Events
  - UIEvent object, types, responder chain
- Multitouch events
  - UITouch object, phases, response
- Gestures
  - Attach gesture recognizers, state machine, custom gestures

Events

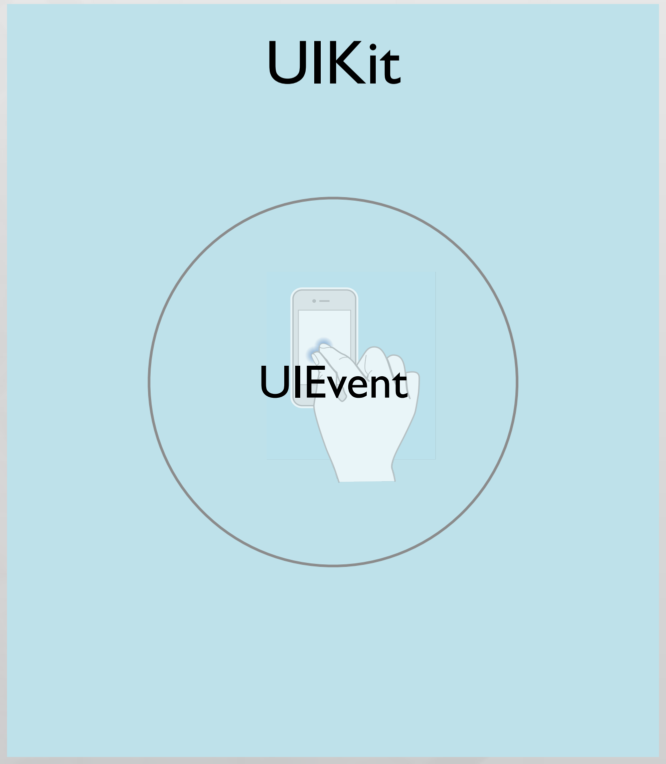
Events


Multitouch events
Accelerometer events
Remote control events
Apple

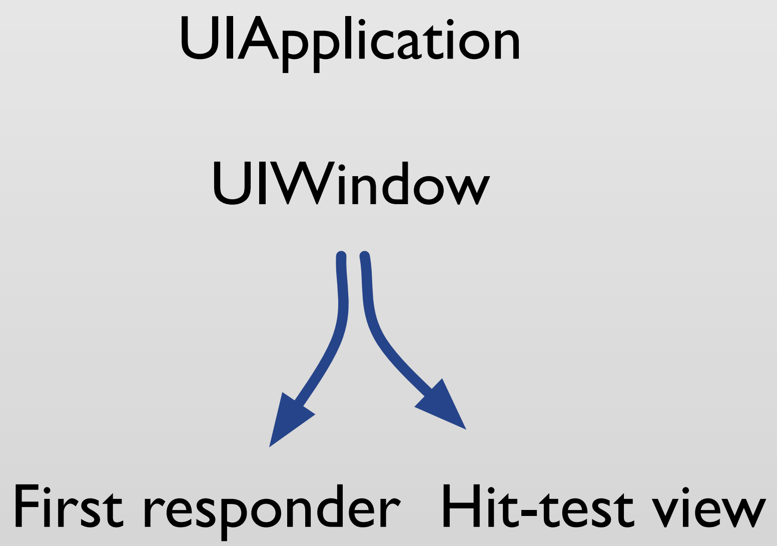
Event Delivery

User-generated event

Sysetm



Inside your app



UIEvent Types

```
typedef enum {
    UIEventTypeTouches,
    UIEventTypeMotion,
    UIEventTypeRemoteControl,
} UIEventType;

typedef enum {
    // available in iPhone OS 3.0
    UIEventSubtypeNone                              = 0,

    // for UIEventTypeMotion, available in iPhone OS 3.0
    UIEventSubtypeMotionShake                       = 1,

    // for UIEventTypeRemoteControl, available in iOS 4.0
    UIEventSubtypeRemoteControlPlay                 = 100,
    UIEventSubtypeRemoteControlPause                = 101,
    UIEventSubtypeRemoteControlStop                 = 102,
    UIEventSubtypeRemoteControlTogglePlayPause      = 103,
    UIEventSubtypeRemoteControlNextTrack            = 104,
    UIEventSubtypeRemoteControlPreviousTrack        = 105,
    UIEventSubtypeRemoteControlBeginSeekingBackward = 106,
    UIEventSubtypeRemoteControlEndSeekingBackward   = 107,
    UIEventSubtypeRemoteControlBeginSeekingForward  = 108,
    UIEventSubtypeRemoteControlEndSeekingForward    = 109,
} UIEventSubtype;
```

UIEvent.h

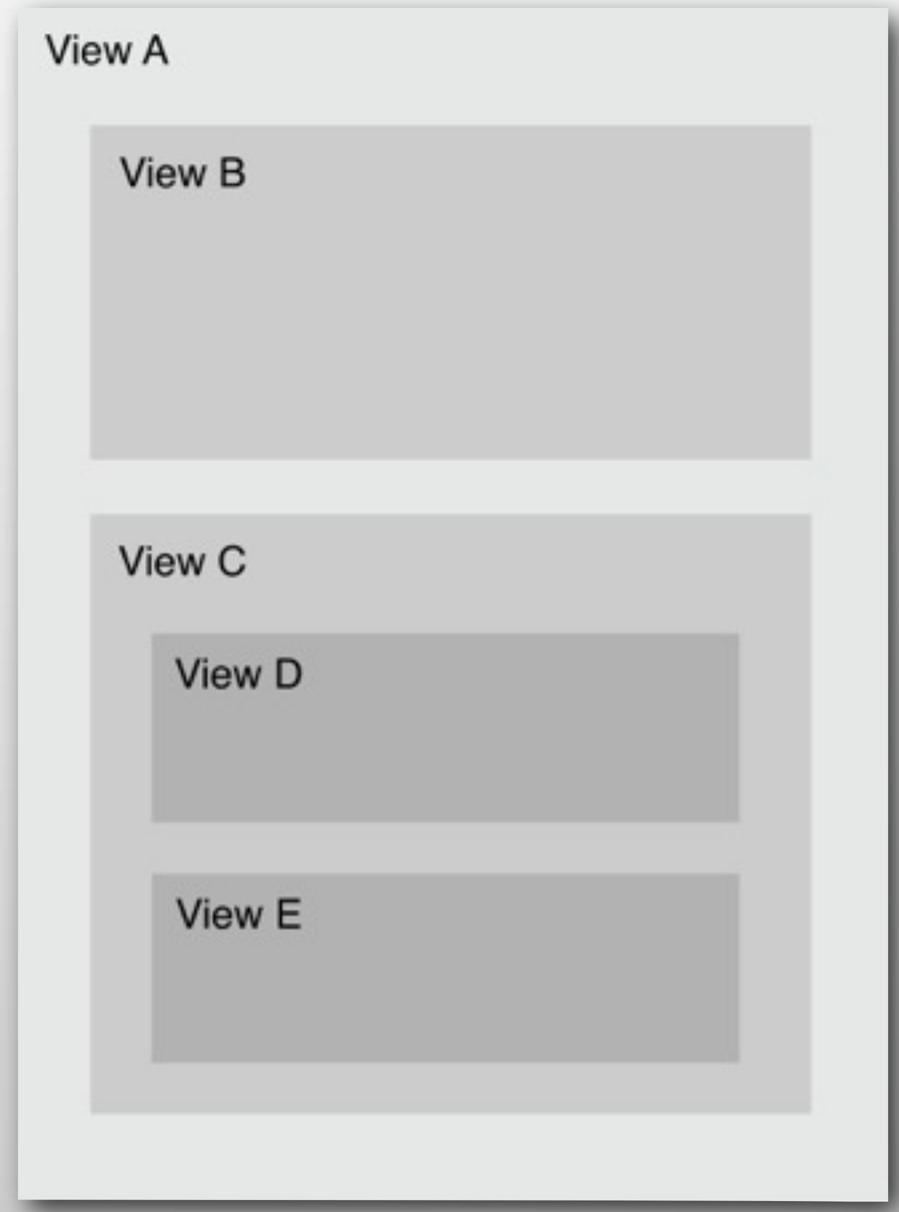
Hit-test View

- Hit-test view is the lowest view that contains the touch
- On top most view (A)
  - hitTest:withEvent:

    pointInside:withEvent:

    YES: recursively call hitTest:withEvent: on children (subviews)

    NO: the touch is not in this view or its children, back to super view



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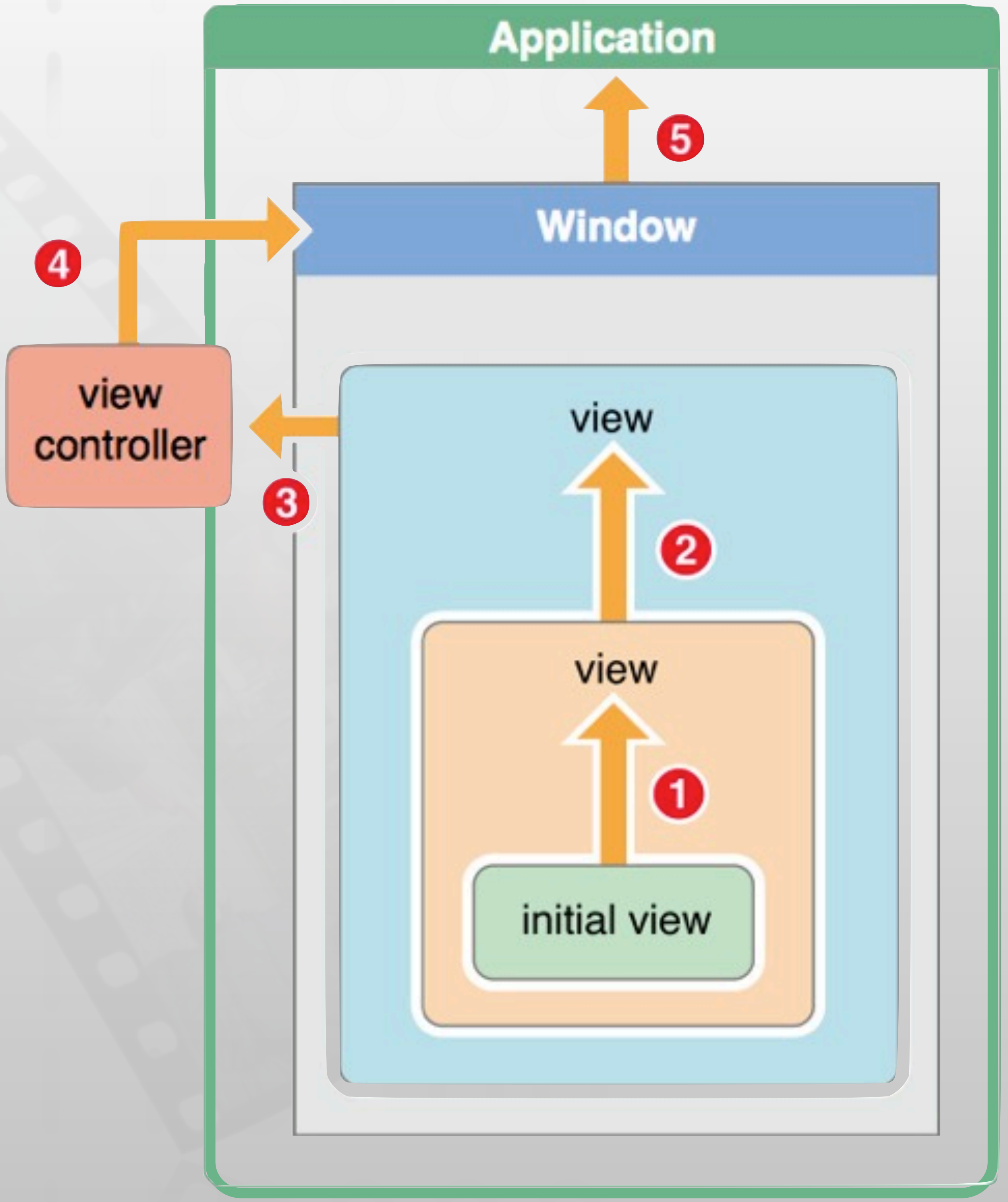
The First Responder

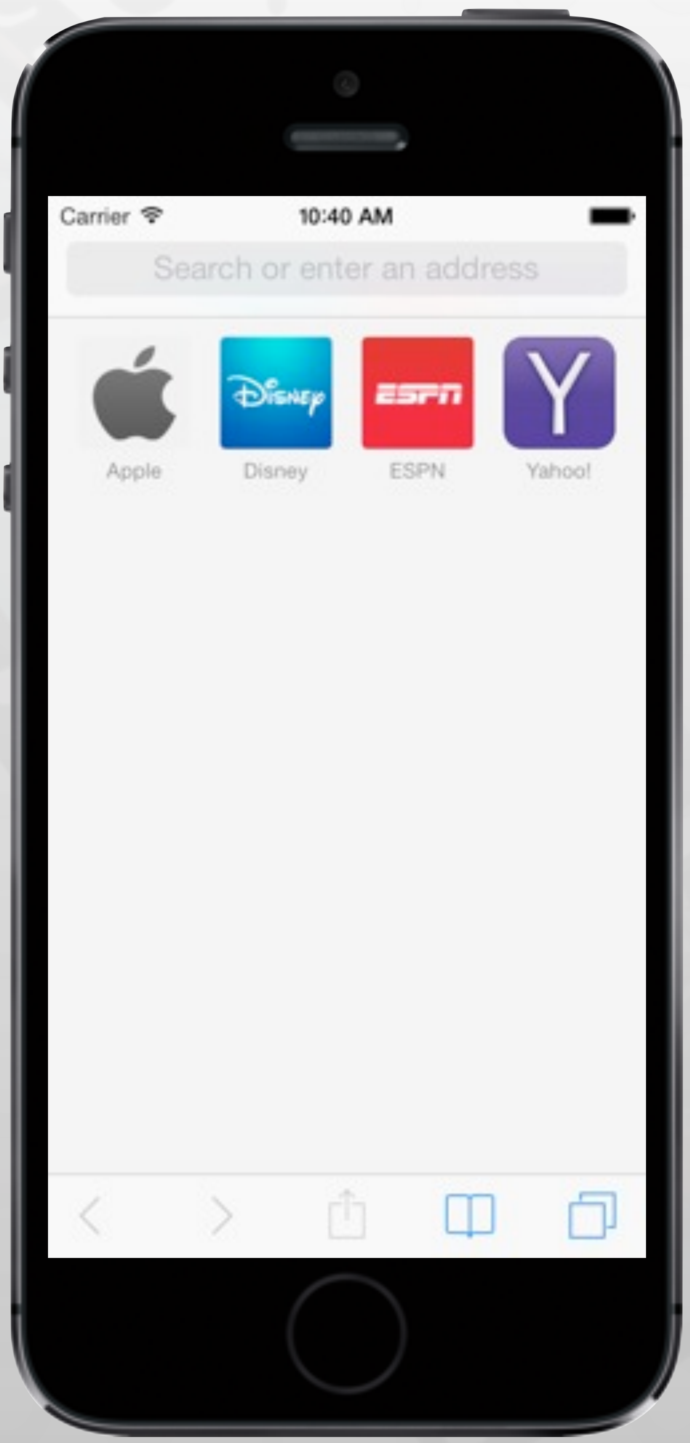
- Designated object to receive events first
- Called from UIWindow directly
- Receives the following events
    - Motion events, Remote-control events, Action messages, Editing-menu messages
- Explicit: override canBecomeFirstResponder method to return YES or receive a becomeFirstResponder message

Responder Chain

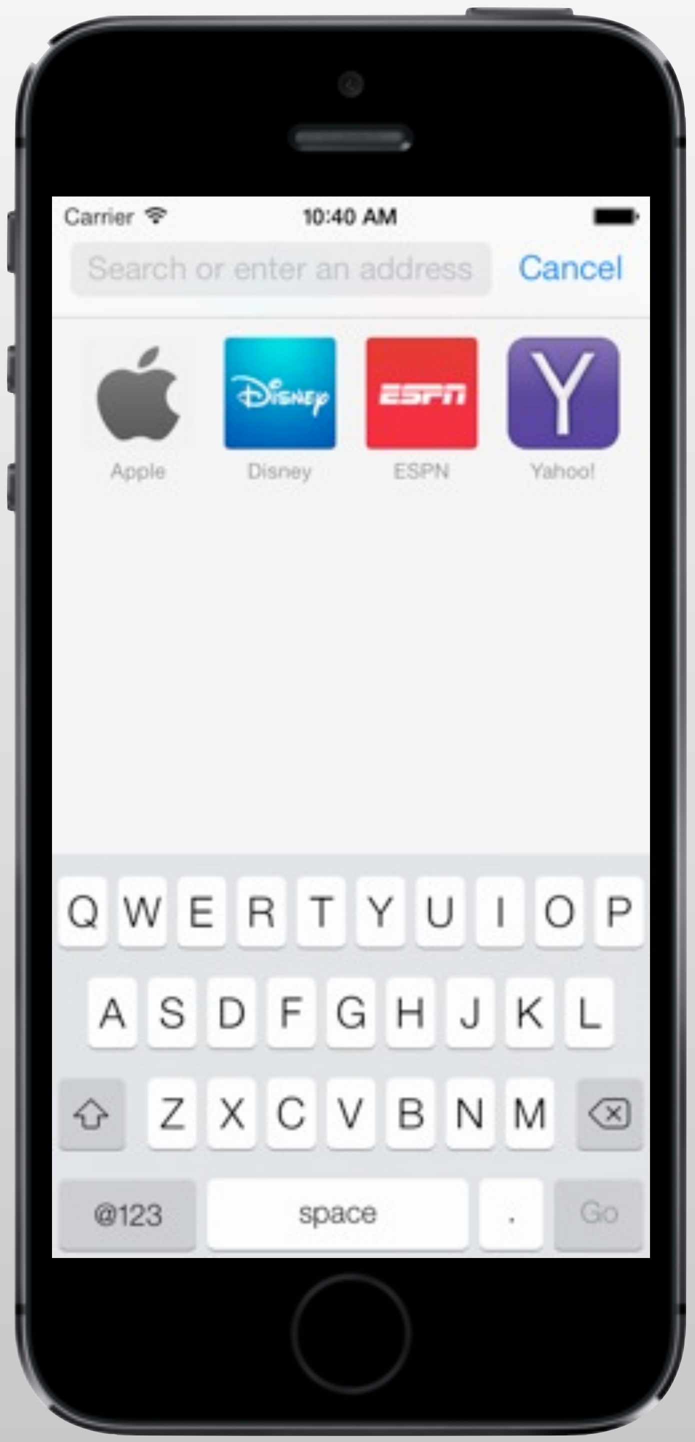


Apple

Input Views



Carrier
10:40 AM
Search or enter an address
Apple
Disney
ESPN
Yahoo!



Carrier
10:40 AM
Search or enter an address
Cancel
Apple
Disney
ESPN
Yahoo!
Q W E R T Y U I O P
A S D F G H J K L
Z X C V B N M
@123
space
.
Go

Handling Text Field Input

```
// UITextField Delegate Method

- (BOOL)textFieldShouldReturn:(UITextField *)textField
{
  // Give feedback if input is invalid,
  // e.g., not a valid email address

  // Give back the first responder status
  [textField resignFirstResponder];
  return YES;
}
```

Multitouch Events

Touch

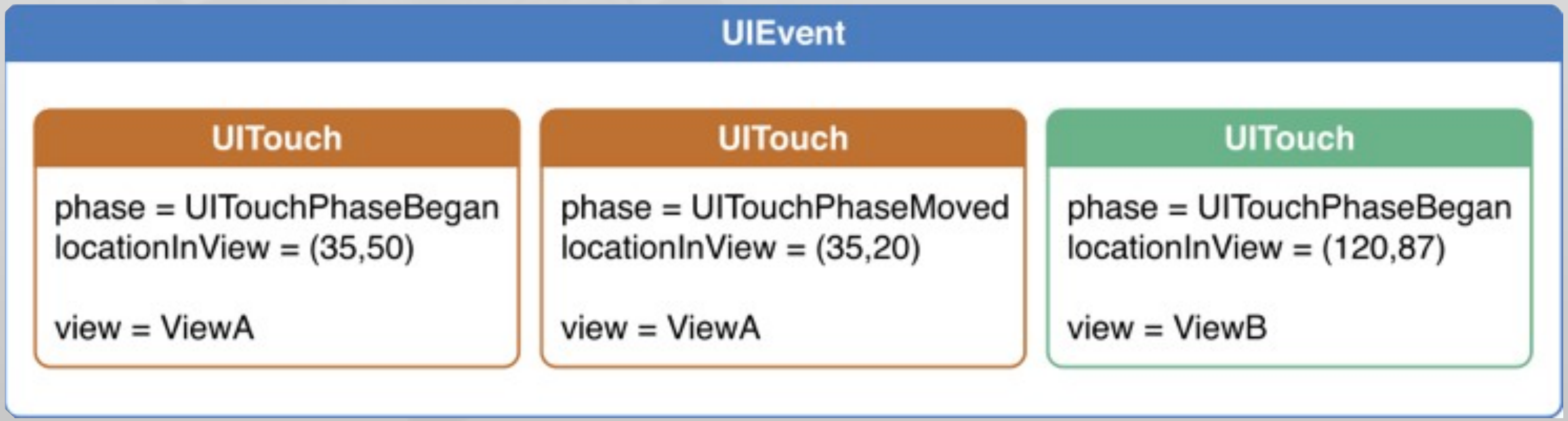
- Each touch is bound to a single finger on the screen
    - *when* and *where* (reduced to a single timestamp and a single point)

UITouch

- Represents single touch
- Location can be reported for a given view
- Previous location included
- Additional properties:
  - tapCount
  - timestamp
  - phase (began, moved, stationary, ended, cancelled)
- Attached gesture recognizers

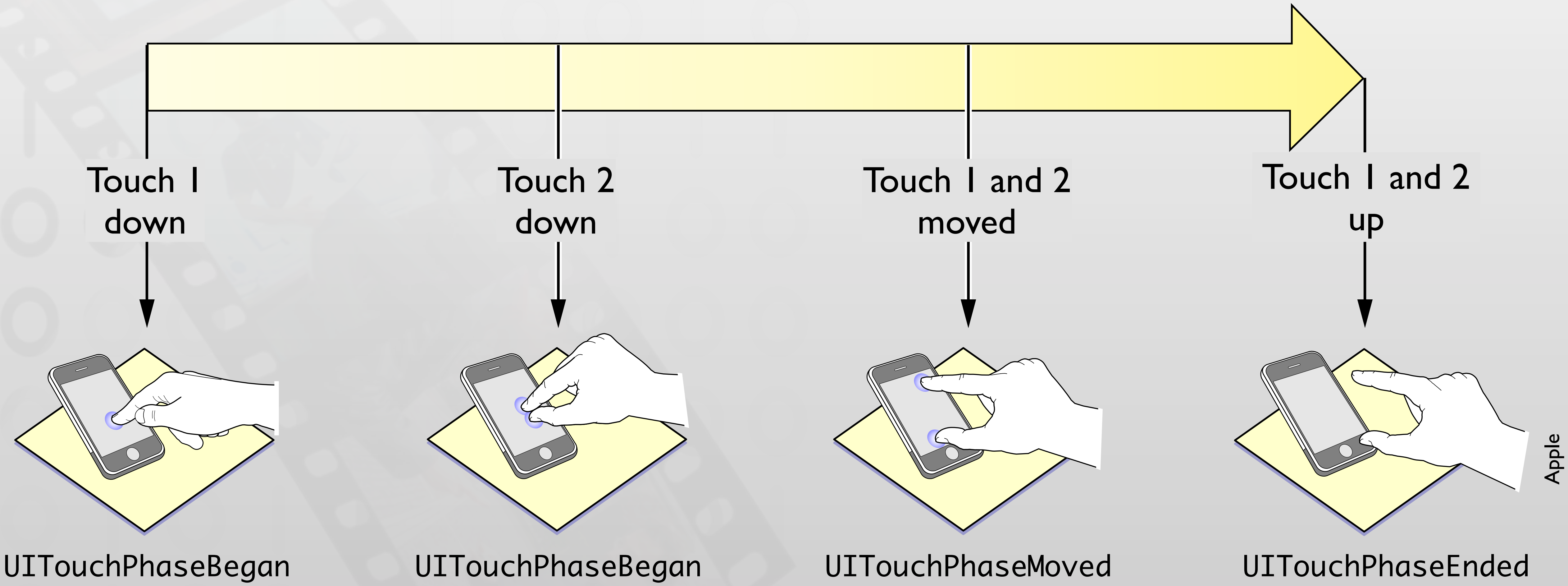
UITouch in UIEvent

- Stores touches
  - By view (hit-test view) and window
  - For gesture recognizers
- Additional properties:
  - Timestamp
  - Type: touches, motion, or remote-control
  - Subtype: event description for non-touch events



Apple

Touch Phases



Handling Touch Events

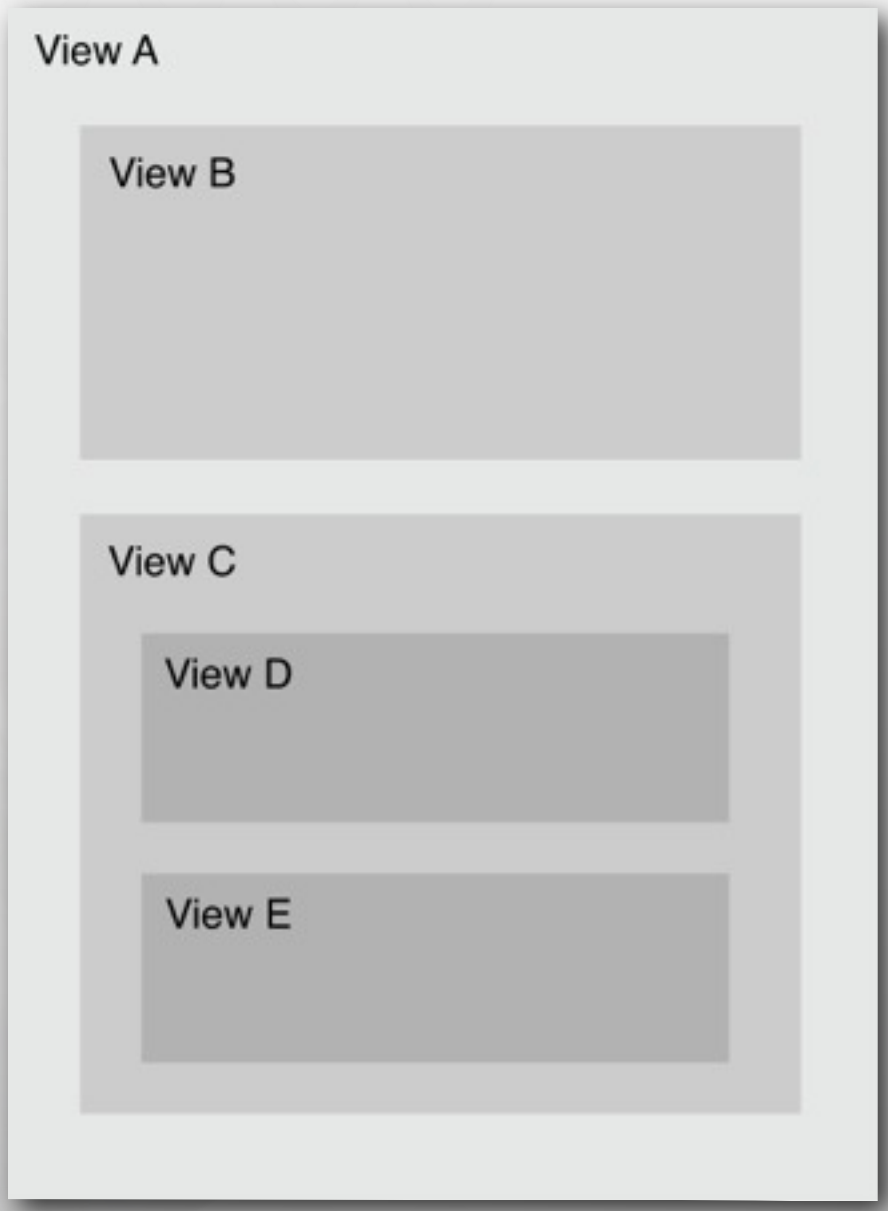
```
// initial touch
- (void)touchesBegan:(NSSet *)touches withEvent:(UIEvent *)event

// updated touch
- (void)touchesMoved:(NSSet *)touches withEvent:(UIEvent *)event

// cancelled touch (by external event)
- (void)touchesCancelled:(NSSet *)touches withEvent:(UIEvent
*)event

// finished touch
- (void)touchesEnded:(NSSet *)touches withEvent:(UIEvent *)event
```

Handling Touch Events



Apple

Tracing a UITouch

- UITouch objects don’t have an ID, and you cannot retain them in your code because they keep changing!

```
// keep a reference for a touch
for (UITouch *touch in touches]) {
  NSValue *key = [NSValue valueWithPointer:touch];
   [myTouches setValue:FirstFinger forKey:key];
}

// to retrieve a touch
for (UITouch *touch in touches) {
  NSValue *key = [NSValue valueWithPointer:touch];
  NSObject *valueFromDictionary = [myTouches valueForKey:key];
}
```

UIControl: Pre-defined Responses

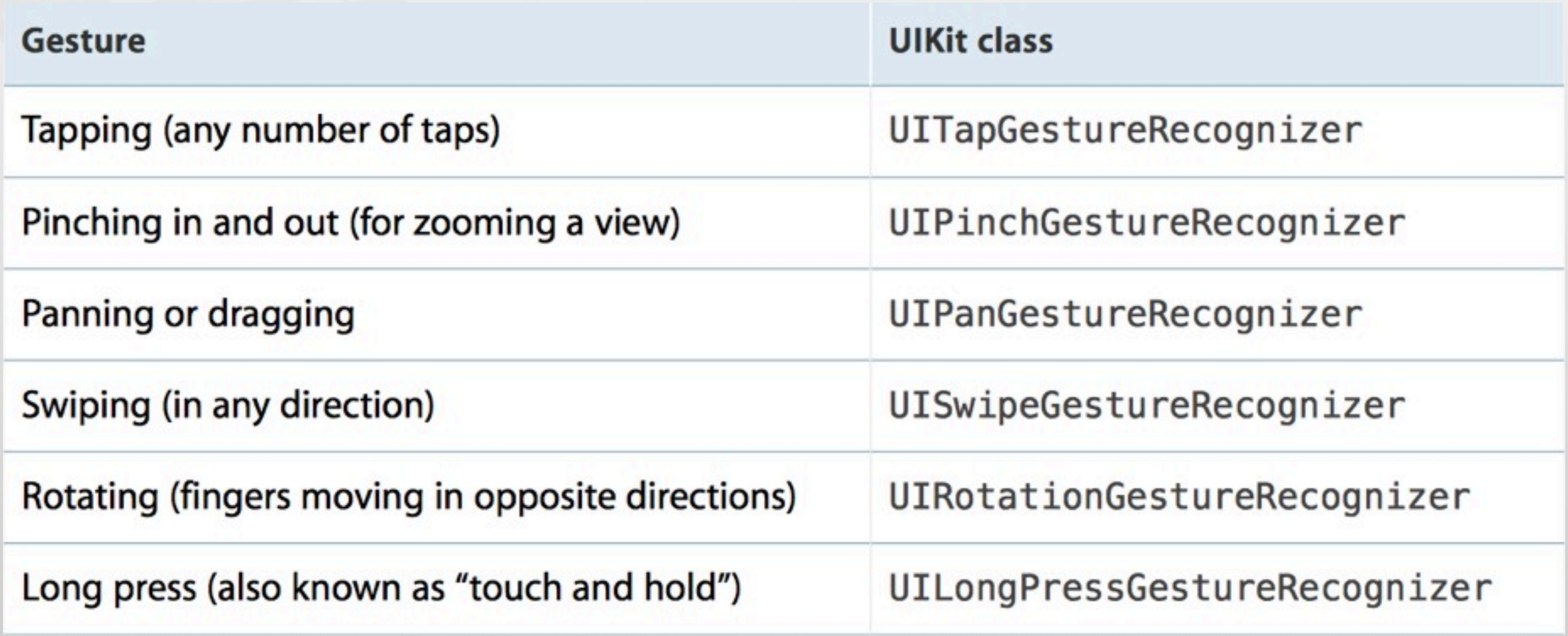
- Subclass of UIView
  - UI elements for control: buttons, sliders, etc.
- Send action messages
- Additional properties:
  - State: enabled, selected, highlighted

Demo: TouchEvents

Demo: DragSubView

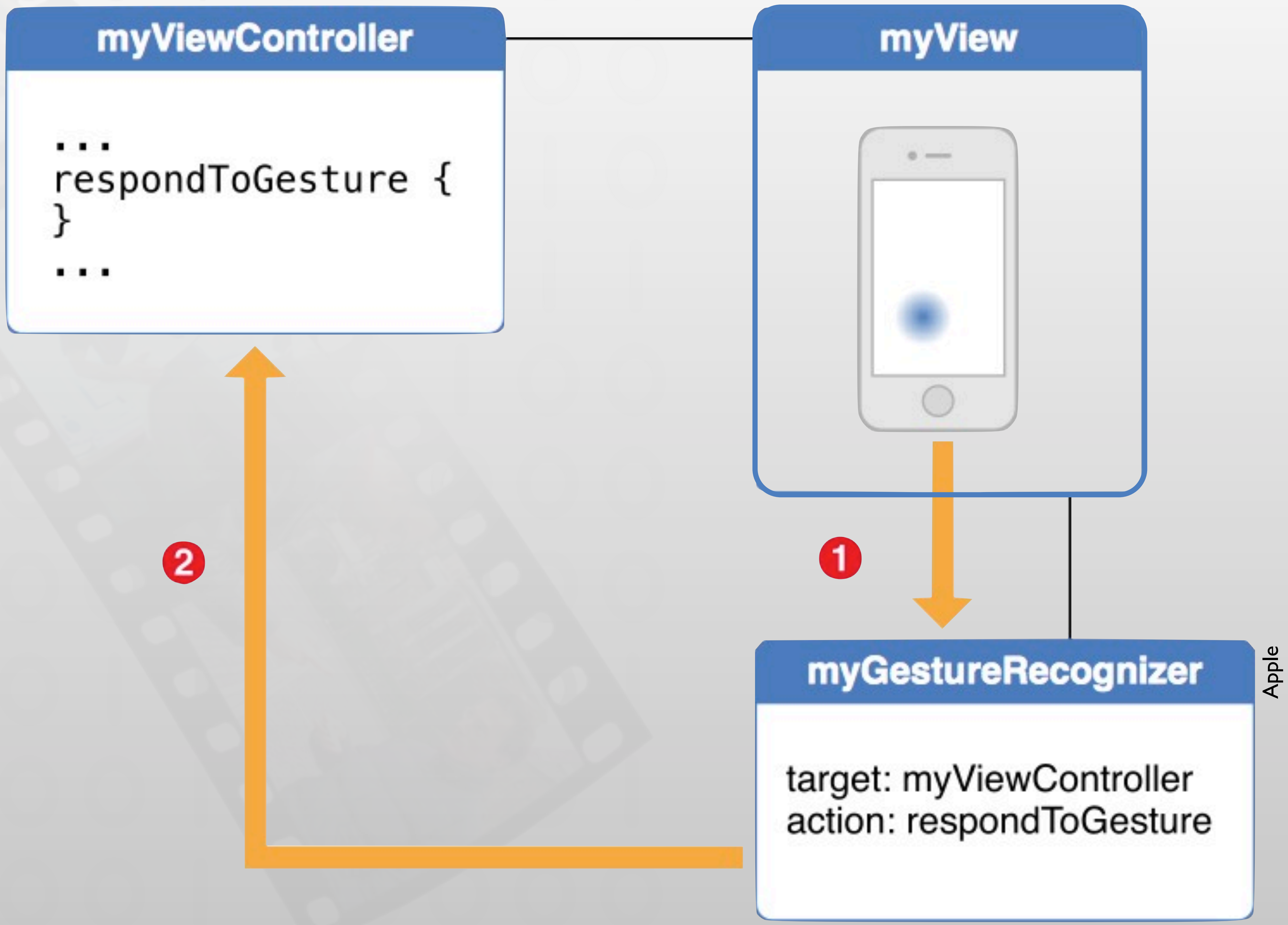
Gesture Recognizers

Predefined Gesture Recognizers



Gesture	UIKit class
Tapping (any number of taps)	`UITapGestureRecognizer`
Pinching in and out (for zooming a view)	`UIPinchGestureRecognizer`
Panning or dragging	`UIPanGestureRecognizer`
Swiping (in any direction)	`UISwipeGestureRecognizer`
Rotating (fingers moving in opposite directions)	`UIRotationGestureRecognizer`
Long press (also known as "touch and hold")	`UILongPressGestureRecognizer`

Attaching Gesture Recognizers



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Attaching a Gesture Recognizer

1. Create and initialize a gesture recognizer (in VC)

```
UITapGestureRecognizer *tapRecognizer = [[UITapGestureRecognizer alloc]
initWithTarget:self action:@selector(respondToTapGesture:)];
```

2. Configure that gesture

```
tapRecognizer.numberOfTapsRequired = 1;
```

3. Add the tap gesture recognizer to the view

```
[self.view addGestureRecognizer:tapRecognizer];
```

4. Implement the action method that handles the gesture (in V)

```
-(void) respondToTapGesture: (UITapGestureRecognizer*)recognizer {...}
```

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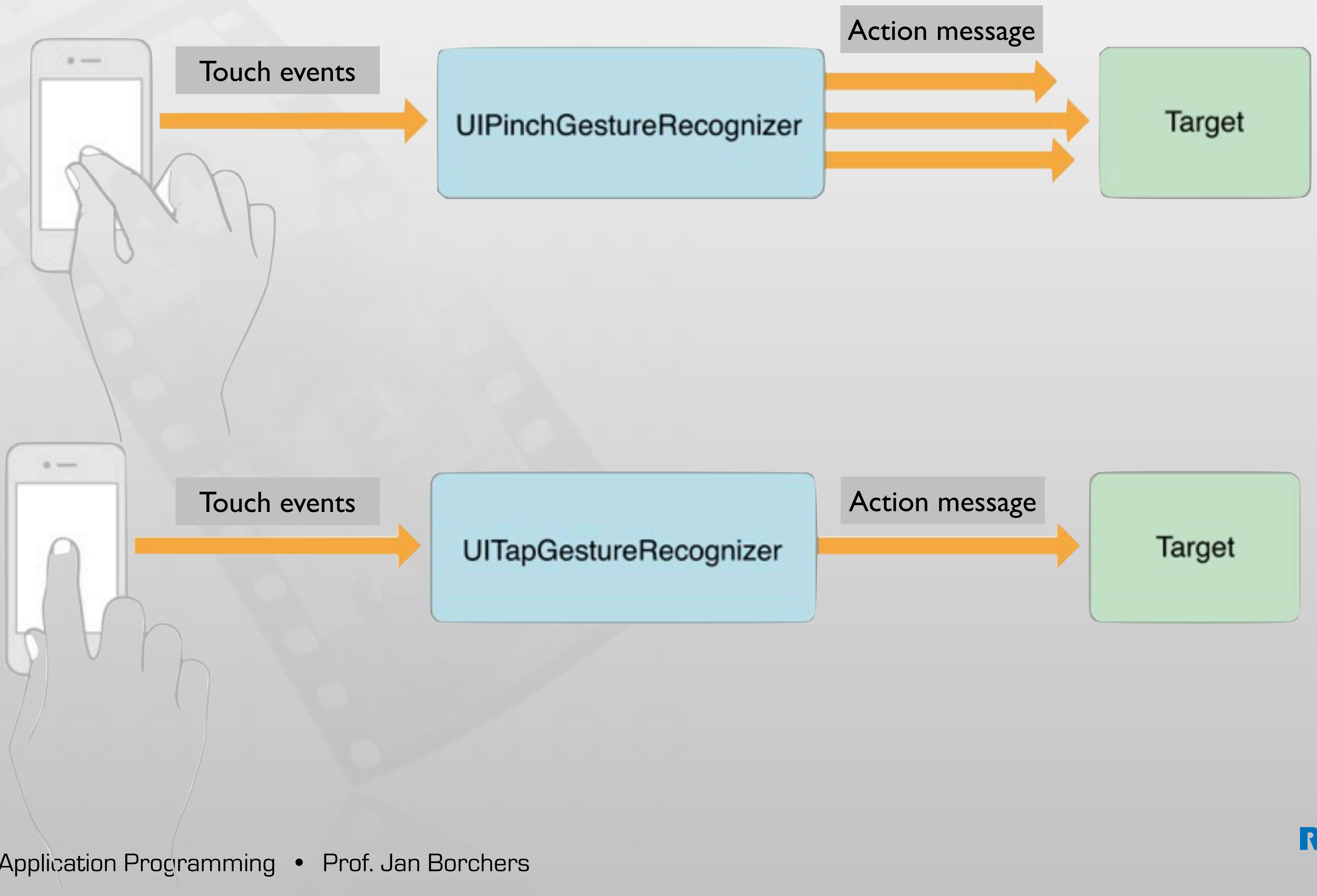
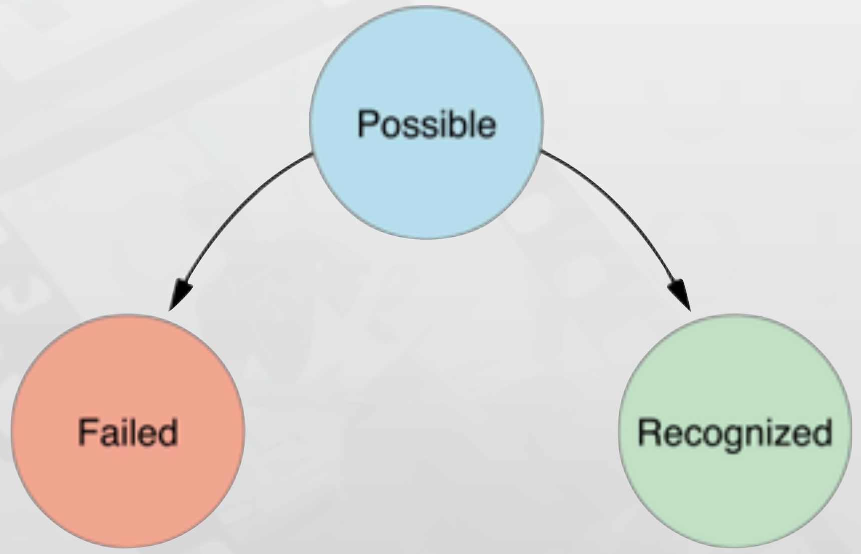
Continuous and Discrete Gestures



Apple

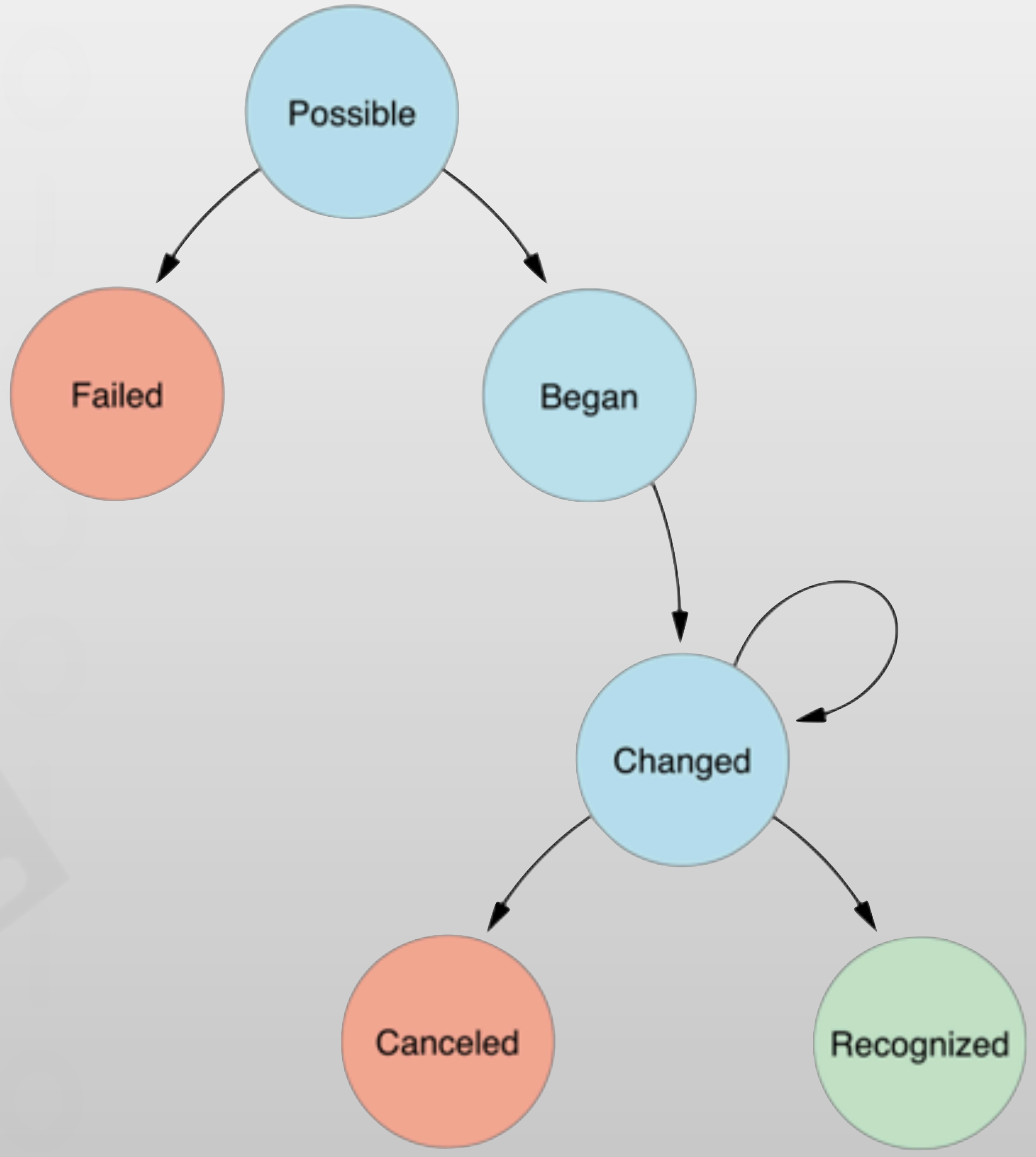
State Machines for Gesture Recognizers

Discrete



```
UIGestureRecognizerStatePossible
UIGestureRecognizerStateRecognized
UIGestureRecognizerStateBegan
UIGestureRecognizerStateChanged
UIGestureRecognizerStateEnded
UIGestureRecognizerStateCancelled
UIGestureRecognizerStateFailed
```

Continuous



Apple

Custom Gesture Recognizers

1. Create a subclass of UIGestureRecognizer in Xcode
2. Add to header: #import <UIKit/UIGestureRecognizerSubclass.h>
3. Add to your implementation file:
   - touchesMoved:withEvent:
   - touchesEnded:withEvent:
   - touchesCancelled:withEvent:
   - touchesBegan:withEvent:
4. Reset internal state

   reset
5. Avoid conflicting gestures
   - canBePreventedByGestureRecognizer:
   - canPreventGestureRecognizer:

Demo: GestureRecognizer

Core Motion

Motion Events

- Much simpler than using sensor data
- Only a shake-motion is defined
- Usage
  - Make your view first responder
  - Implement the following methods

```
- (void)motionBegan:(UIEventSubtype)motion withEvent:(UIEvent *)event
- (void)motionEnded:(UIEventSubtype)motion withEvent:(UIEvent *)event
- (void)motionCancelled:(UIEventSubtype)motion withEvent:(UIEvent *)event
```

- ApplicationSupportsShakeToEdit

Device Orientation

- Tell UIDevice to generate device orientation notifications

  beginGeneratingDeviceOrientationNotifications

- Register to receive these notification

  UIDeviceOrientationDidChangeNotification

- Turn off device orientation notifications

  endGeneratingDeviceOrientationNotifications

UIAccelerometer

- Alternative to Core Motion
  - Only for acceleration
- Usage:
  - Get shared instance (singleton)
  - Configure update frequency
  - Assign delegate
  - Acceleration reported as UIAcceleration

    Objects are updated for performance reasons

UIAccelerometer

```
- (void)viewWillAppear:(BOOL)animated
{
  UIAccelerometer *a = [UIAccelerometer sharedAccelerometer];
  a.updateInterval = 0.1;
  a.delegate = self;
}

- (void)accelerometer:(UIAccelerometer *)accelerometer didAccelerate:
                                             (UIAcceleration *)acceleration
{
  NSLog(@"%f %f %f", acceleration.x, acceleration.y, acceleration.z);

}
```

Accelerometer Update Frequency

10–20	Orientation detection
30–60	Real-time input (e.g., games)
70–100	high-frequency motion (e.g., hitting or shaking the device quickly)

Accelerometer vs. Gyroscope

- Accelerometer
  - Measures proper acceleration
  - Relative to free fall
  - 1.0 = 1G (earth's acceleration)
- Gyroscope
  - Measure rotation

Accelerometer vs. Gyroscope

Core Motion

- Obtain motion data from available sensors
  - Accelerometer (alternative to UIAccelerometer)
  - Gyroscope
- Framework
  - CMMotionManager
  - CMAccelerometerData
  - CMGyroData
  - CMDeviceMotion

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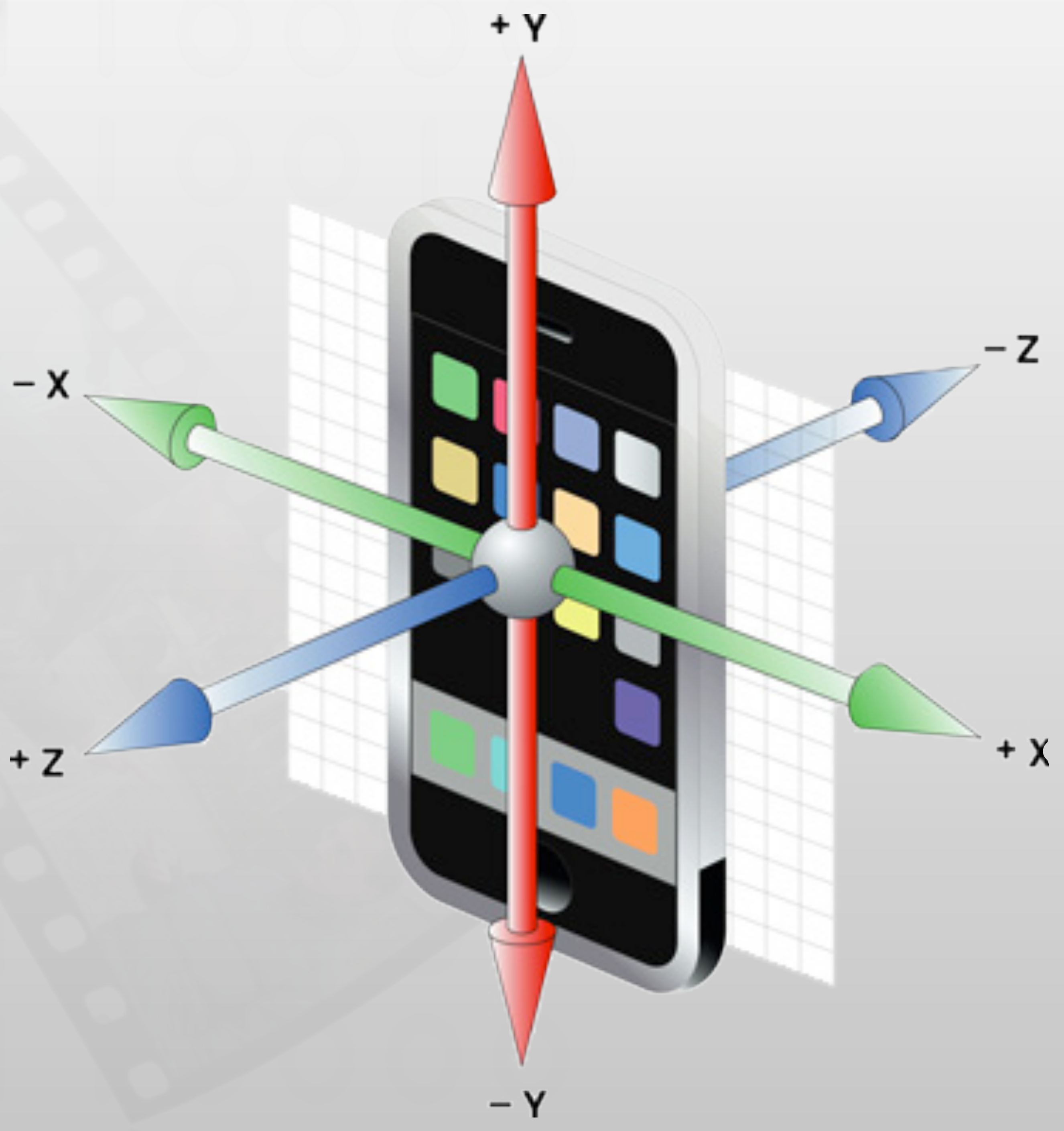
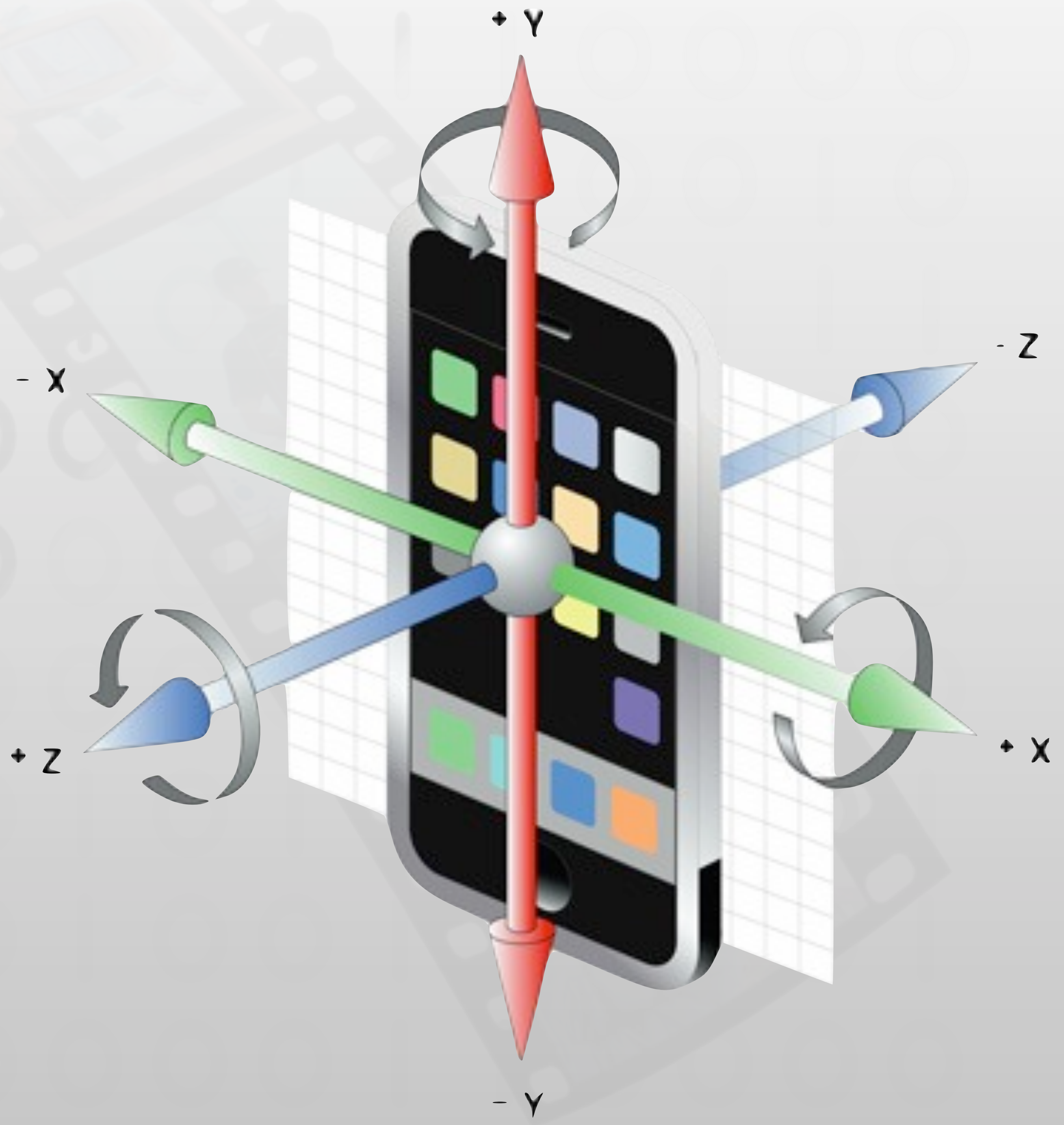
CMMotionManager

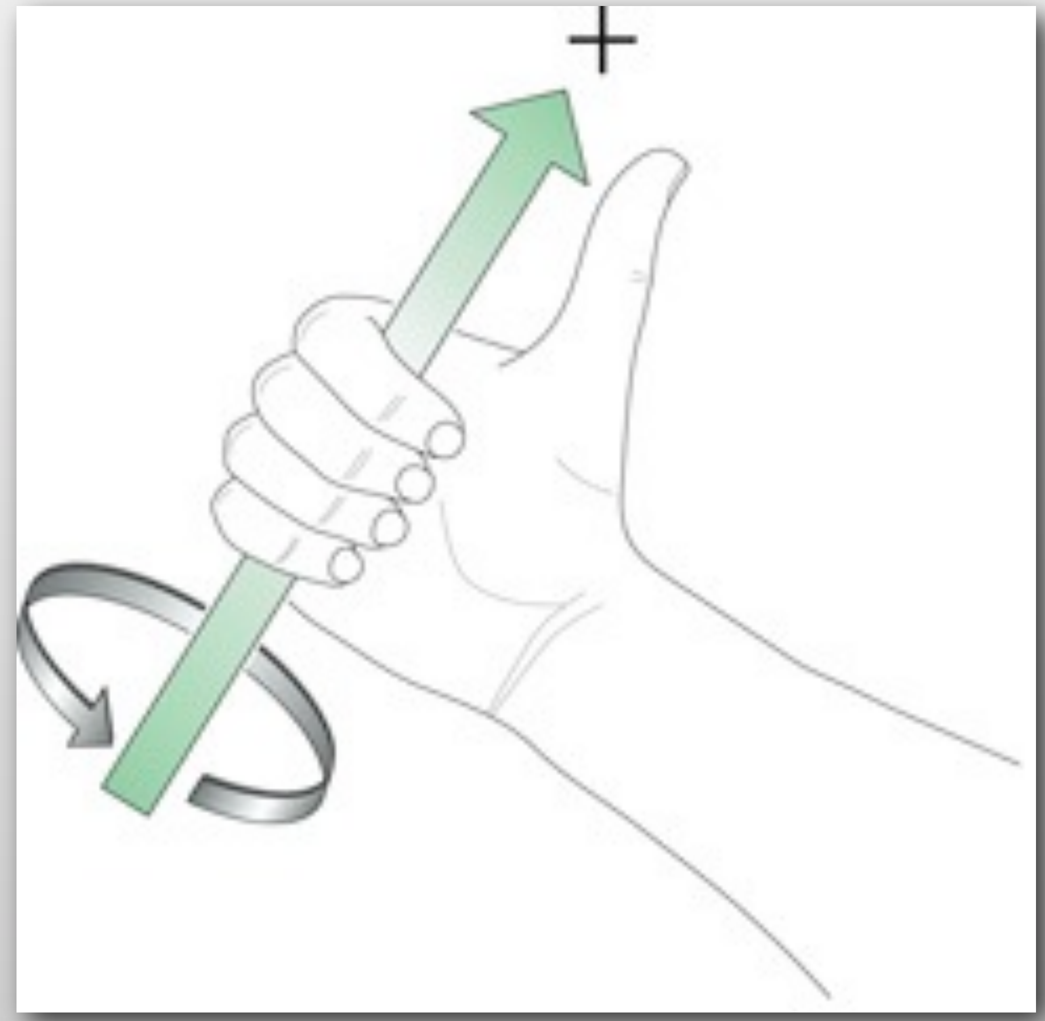
- Operates on accelerometer, gyro, or both
- Updating with handler:
  - startXUpdates
  - startXUpdatesToQueue:withHandler:
  - Block is added to NSOperationQueue
- Updating without handler:
  - startXUpdates
  - Query sensor data when needed (e.g., through timer)
- X = [Accelerometer | Gyro | DeviceMotion]

CMAcceleration



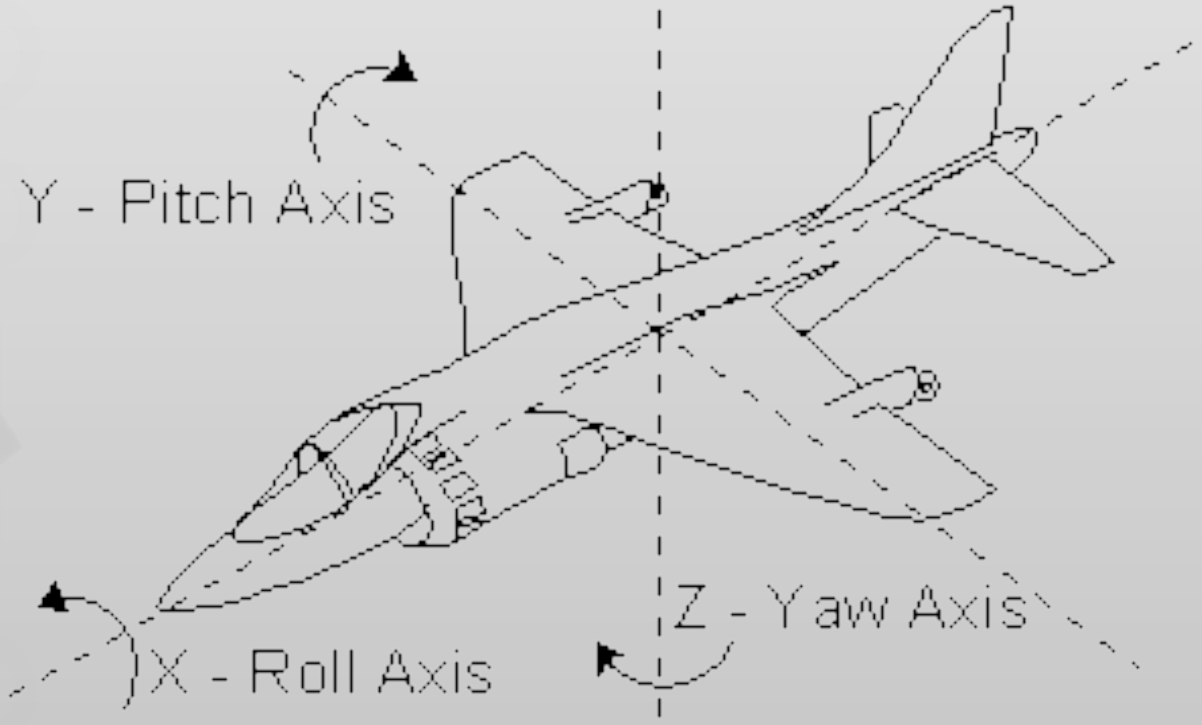
CMGyroData





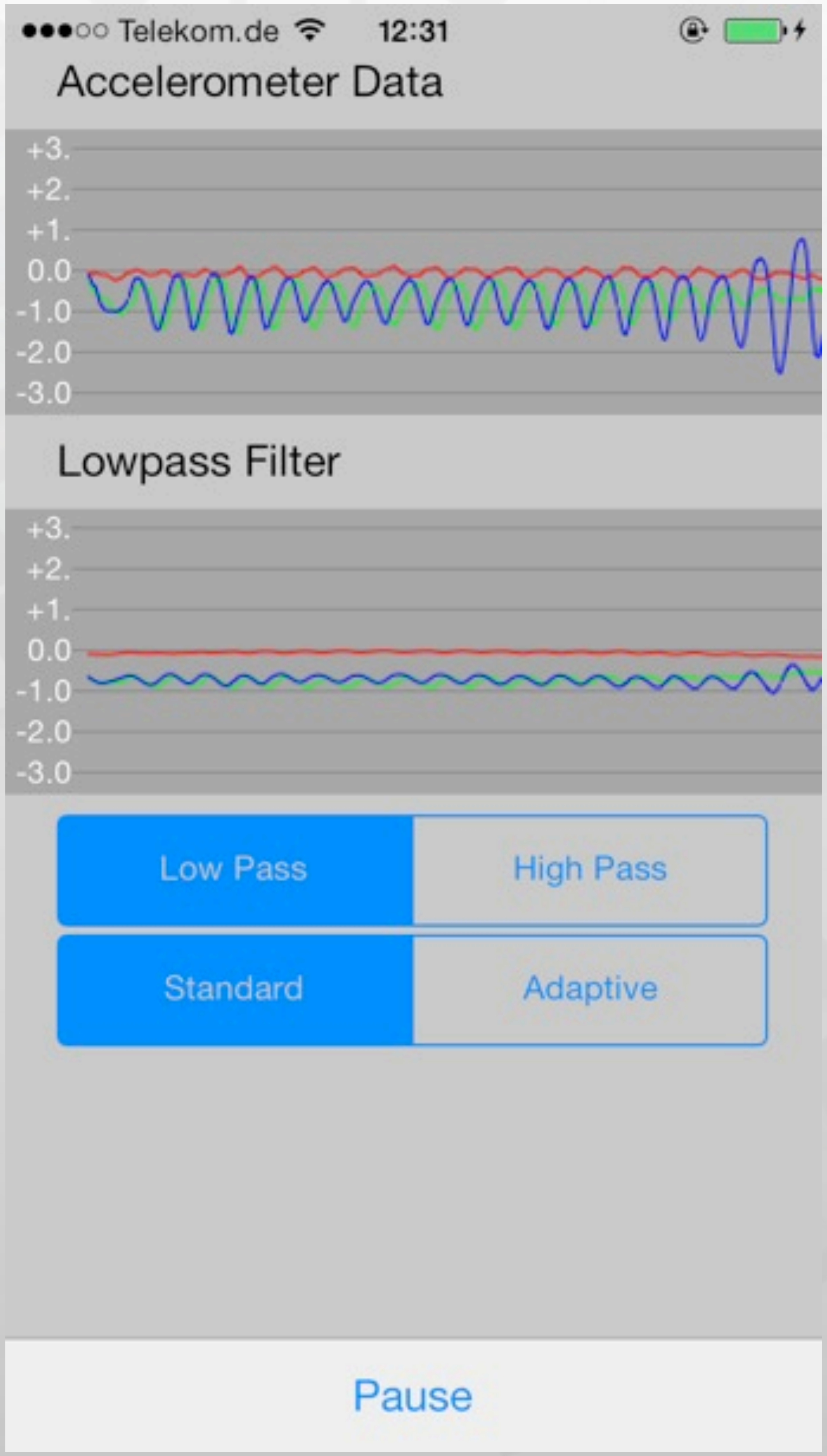
CMDeviceMotion

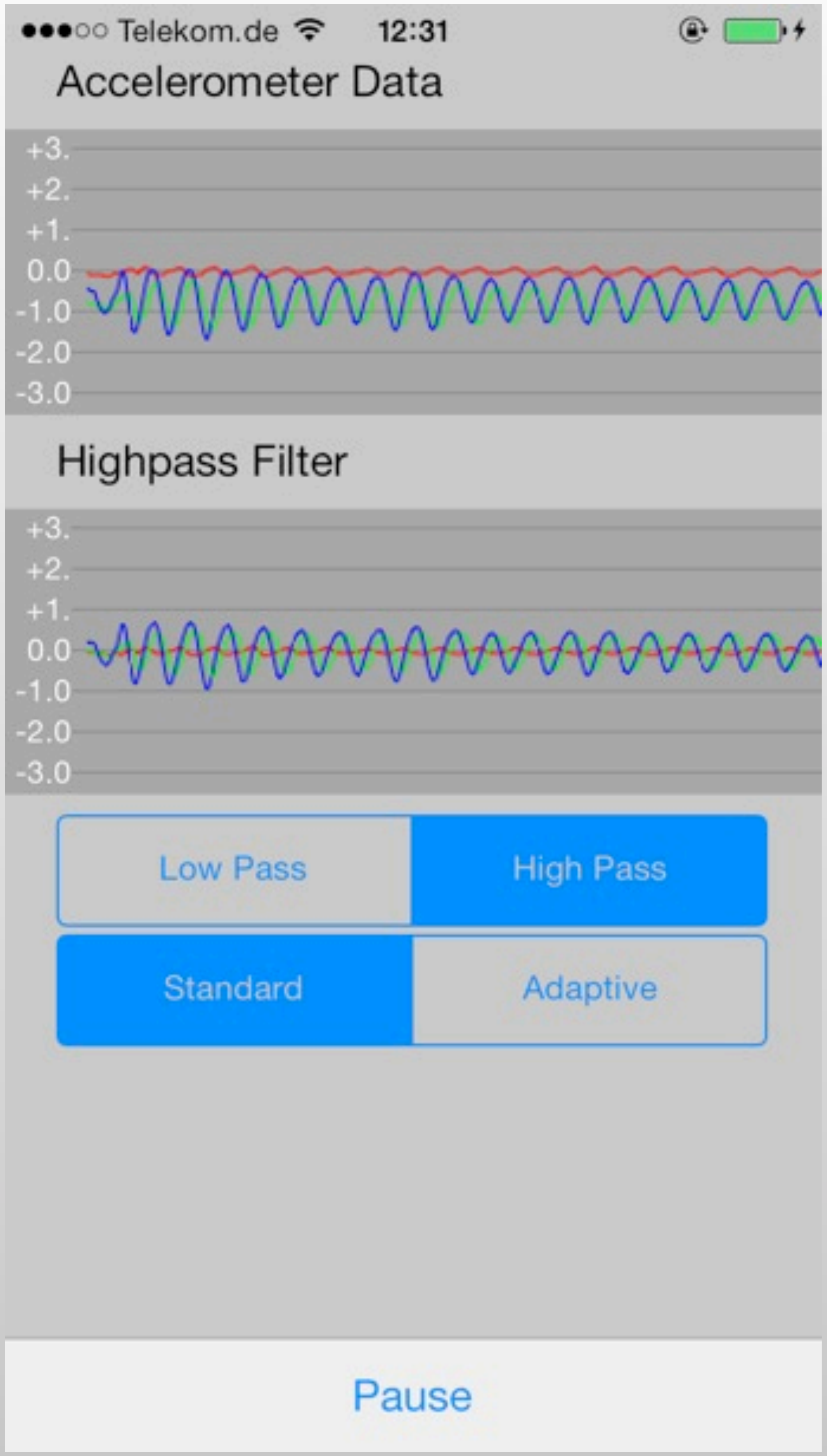
- Only available with Gyroscope
- Position in 3D Space
  - Attitude: roll, pitch, yaw, or rotationMatrix, or quaternion
  - x, y, z rotation
- Acceleration
  - Gravity vector
  - User acceleration vector



Filtering Data

- Low-pass filter
  - Pass low-frequency, cut off high-frequency signals
  - Detect orientation changes
  - Reduces jittering
- High-pass filter
  - Pass high-frequency, cut off low-frequency signals
  - Detect jittering
  - Returns relative value


●●●○○ Telekom.de 12:31
Accelerometer Data
+3.
+2.
+1.
0.0
-1.0
-2.0
-3.0
Lowpass Filter
+3.
+2.
+1.
0.0
-1.0
-2.0
-3.0
Low Pass
High Pass
Standard
Adaptive
Pause


●●●○○ Telekom.de 12:31
Accelerometer Data
+3.
+2.
+1.
0.0
-1.0
-2.0
-3.0
Highpass Filter
+3.
+2.
+1.
0.0
-1.0
-2.0
-3.0
Low Pass
High Pass
Standard
Adaptive
Pause

Low-Pass / High-Pass Filter

```
// low-pass filter
CGFloat lowpassFilter(CGFloat value, CGFloat filterFactor) {
  static CGFloat lowpassValue;
  lowpassValue = value*filterFactor + lowpassValue*
    (1.0 - filterFactor);
  return lowpassValue;
}

// high-pass filter
CGFloat highpassFilter(CGFloat value, CGFloat filterFactor) {
  static CGFloat prevValue, highpassValue;
  highpassValue = filterFactor * (highpassValue+value-
prevValue);
  prevValue = value;
  return highpassValue;
}
```

Demo: Marble

iOS7: M7 Coprocessor

- Only for iPhone 5S, iPad Air, and iPad mini with Retina display
- Accelerometer, gyroscope, compass
- Measures motion data continuously without running down the battery
- Used for step counting, fitness/health apps
- Check Core Motion Framework Reference

New Classes for M7

- Use CMMotionActivityManager to start/stop activity updates
- Updates are delivered as instances of CMMotionActivity objects
- A CMMotionActivity object contains all data for each motion event
  - Boolean properties: stationary, running, walking, automotive
  - Other properties: startDate, confidence

New Classes for M7

- CMStepCounter: record the user's steps
    - Use isStepCountingAvailable method to check whether device supports step counting (YES) or not (NO)
- Start listening for steps:

```
- (void)startStepCountingUpdatesToQueue:(NSOperationQueue *)queue
                               updateOn:(NSInteger)stepCounts
                            withHandler:(CMStepUpdateHandler)handler;
```

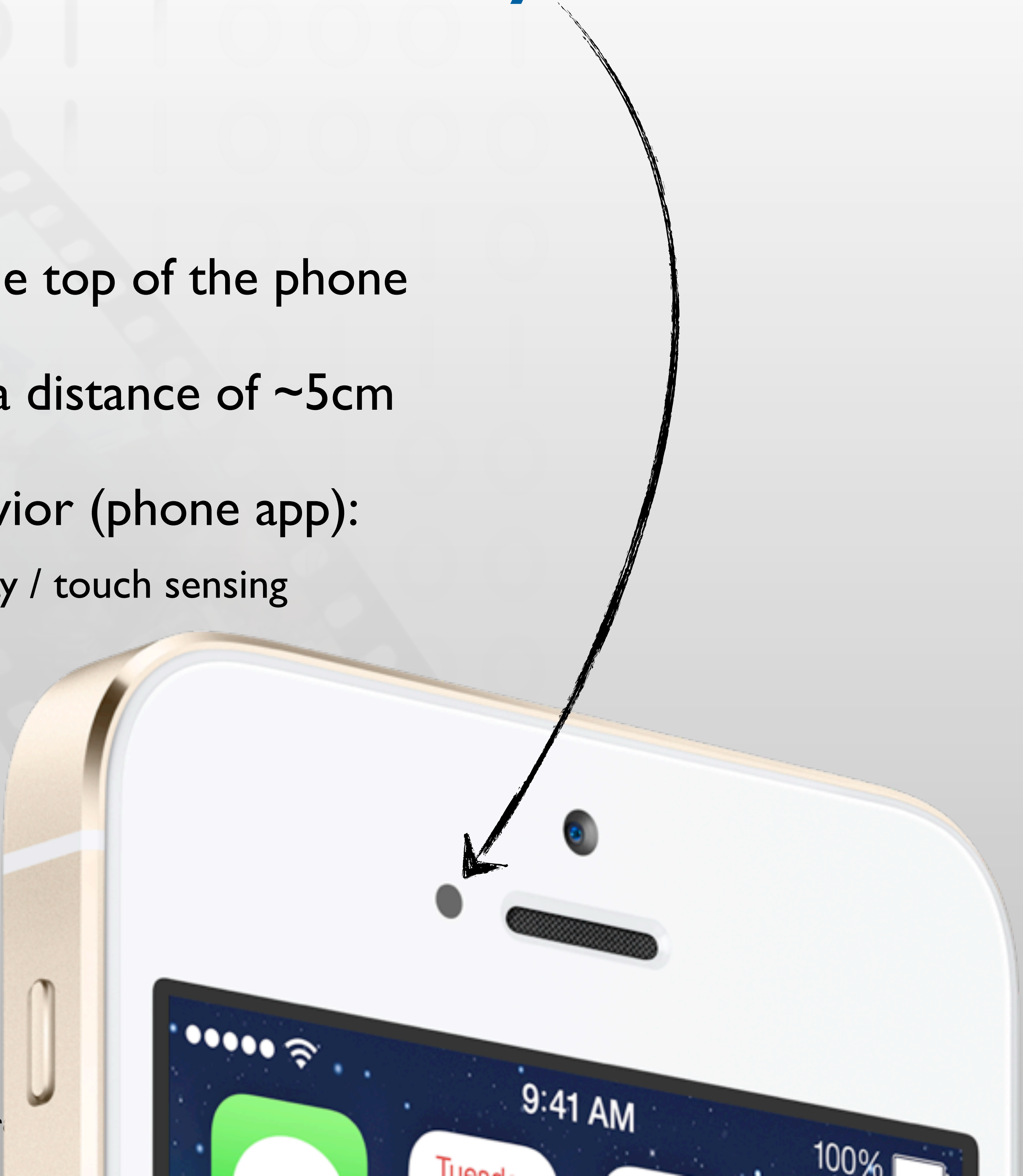
- updateOn:(NSInteger)stepCounts to determine after how many steps your app should be notified about step updates
- M7 records steps even if the app is not asking for them

Demo:
Motion Activity & Step Counting

Other Input

Proximity Sensor

- Located at the top of the phone
- Triggered at a distance of ~5cm
- Default behavior (phone app):
    - Turn off display / touch sensing



Using the Proximity Sensor

```
// enable proximity monitoring
[[UIDevice currentDevice] setProximityMonitoringEnabled:YES];

// register for notifications
[[NSNotificationCenter defaultCenter] addObserver:self
  selector:@selector(proximityChanged:)
  name:UIDeviceProximityStateDidChangeNotification
  object:[UIDevice currentDevice]];

// handle proximity change
- (void)proximityChanged:(NSNotification *)notification {
  BOOL proximityState = [[notification object] proximityState];
  NSLog(@"Proximity Changed: %@", proximityState);
}
```

Remote-Control

- Become first responder
- Turn on remote-control events

```
[[UIApplication sharedApplication]
beginReceivingRemoteControlEvents];
```

- Implement

```
- (void) remoteControlReceivedWithEvent:
  (UIEvent *) receivedEvent
```

- Turn off remote-control events

```
[[UIApplication sharedApplication]
endReceivingRemoteControlEvents];
```

Remote-Control

```
  - (void)viewDidAppear:(BOOL)animated {
   [super viewDidAppear:animated];
   [[UIApplication sharedApplication] beginReceivingRemoteControlEvents];
   [self becomeFirstResponder];
}

- (void) remoteControlReceivedWithEvent: (UIEvent *) receivedEvent {
   if (receivedEvent.type == UIEventTypeRemoteControl) {
       switch (receivedEvent.subtype) {
          case UIEventSubtypeRemoteControlTogglePlayPause:
             [self playOrStop: nil];
             break;
          case UIEventSubtypeRemoteControlPreviousTrack:
             [self previousTrack: nil];
             break;
          case UIEventSubtypeRemoteControlNextTrack:
             [self nextTrack: nil];
             break;
          default: break;
}}}
```

Summary

- Touch & gesture recognizers
- Core Motion
  - Accelerometer
  - Gyroscope
  - Device motion
  - M7 coprocessor
- Other: proximity, remote-control
- Reading assignment

Event Handling Guide

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