Sensing Device Motion in iOS 4

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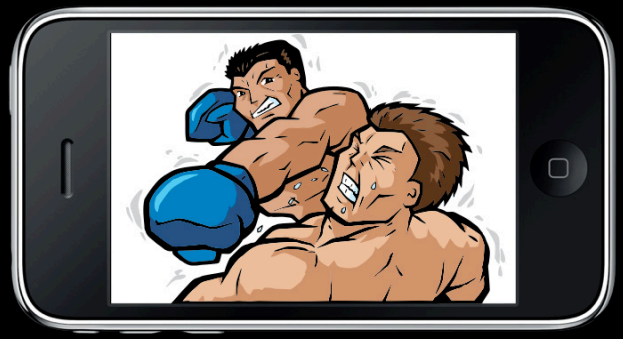
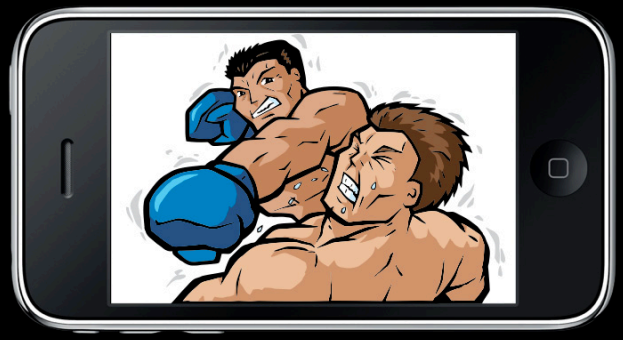
Agenda

1. What are the new features?
2. How can I access them?
3. Deep dive
4. Let's code!



Rotation = Attack



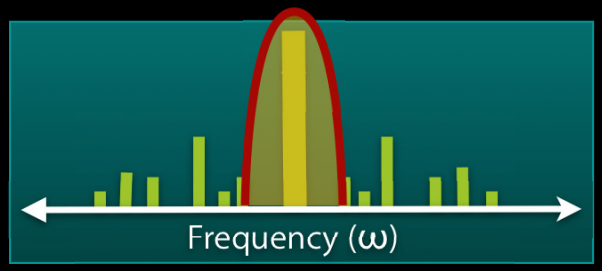
Fast translation = Dodge

Accelerometer

Measures gravity and user acceleration

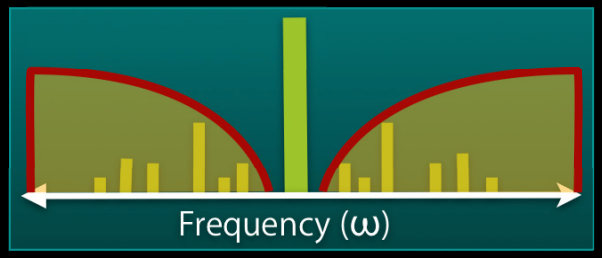
Accelerometer Responsibilities

- Gravity for rotations
- User acceleration for shakes



Low-pass filter isolates gravity

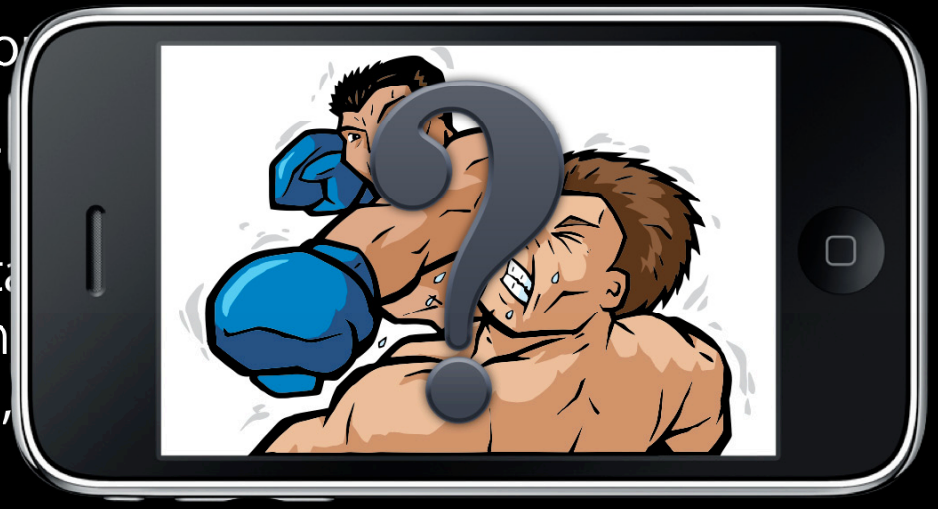
- No rotation about gravity



High-pass filter isolates
user acceleration/"shake"


3G
9:42 AM
Messages
Calendar
Tuesday
9
Photos
Camera
YouTube
Stocks
Maps
280
Weather
73°
Voice Memos
Notes
Clock
Calculator
Settings
iTunes
App Store
Compass
Phone
Mail
Safari
iPod

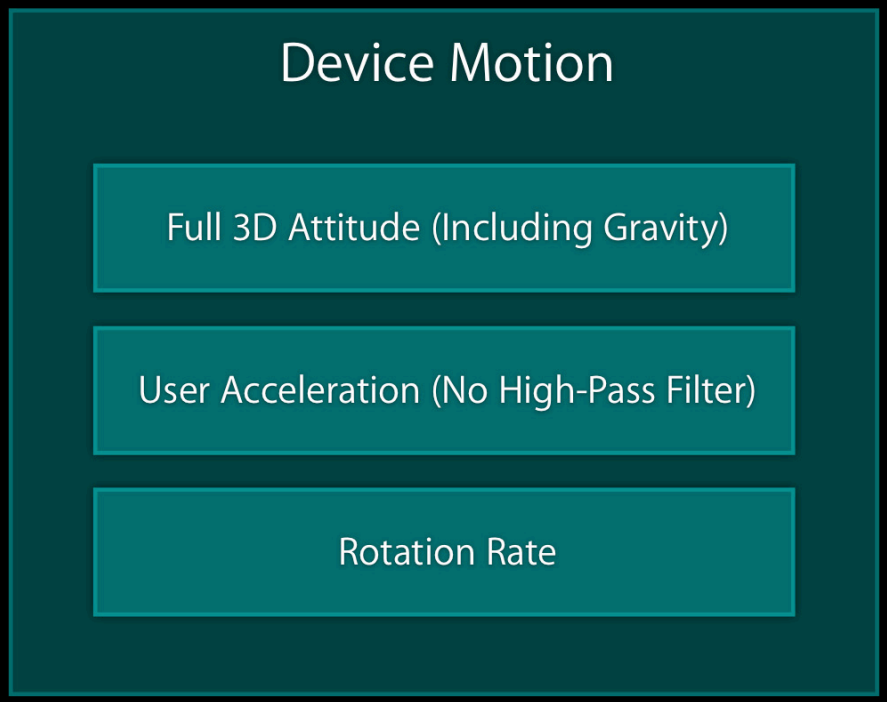
1. Rotation abo
2. Accurate for
3. Accurate rot
   the face of h
   acceleration,
   vice versa



Magnetometer

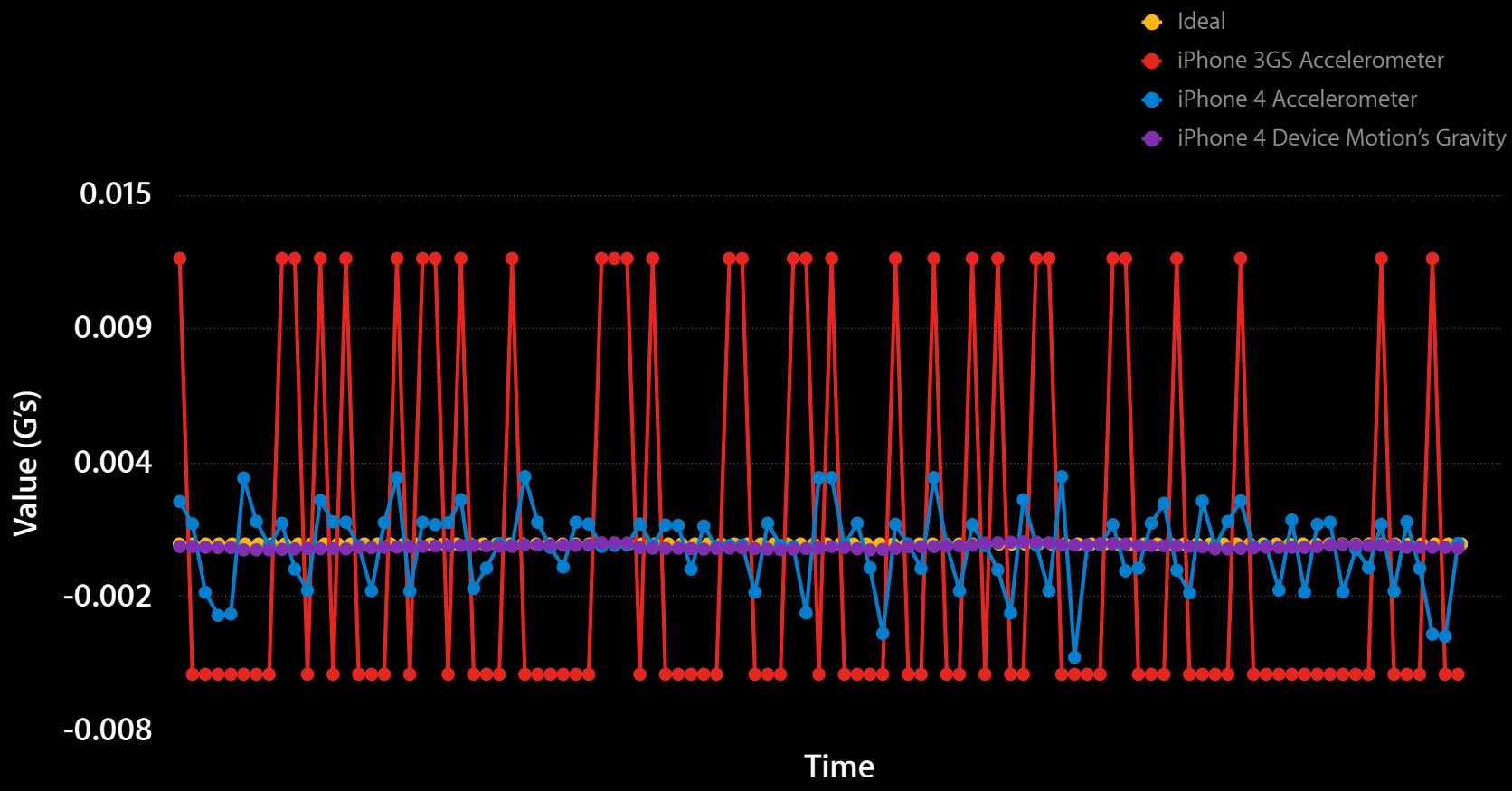
Gyroscope

Gyro and Accelerometer Fusion



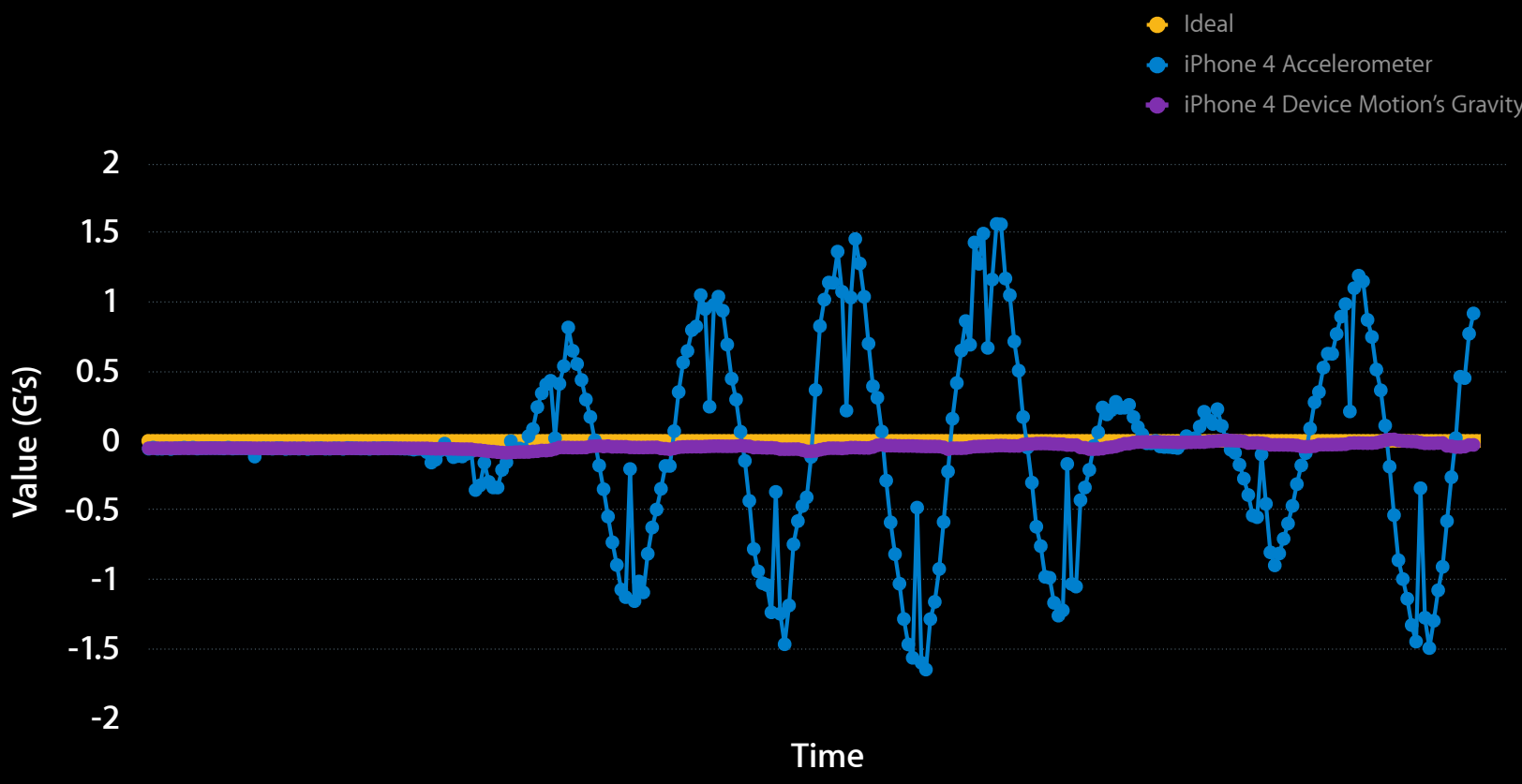
Accelerometer vs. Device Motion's Gravity

Noise



Accelerometer vs. Device Motion's Gravity

Sensitivity to user acceleration



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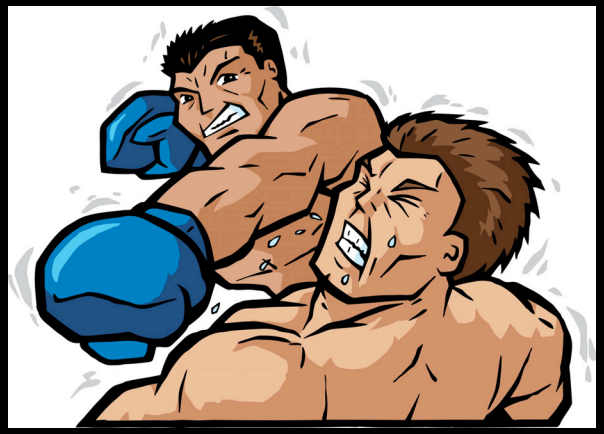


Demo

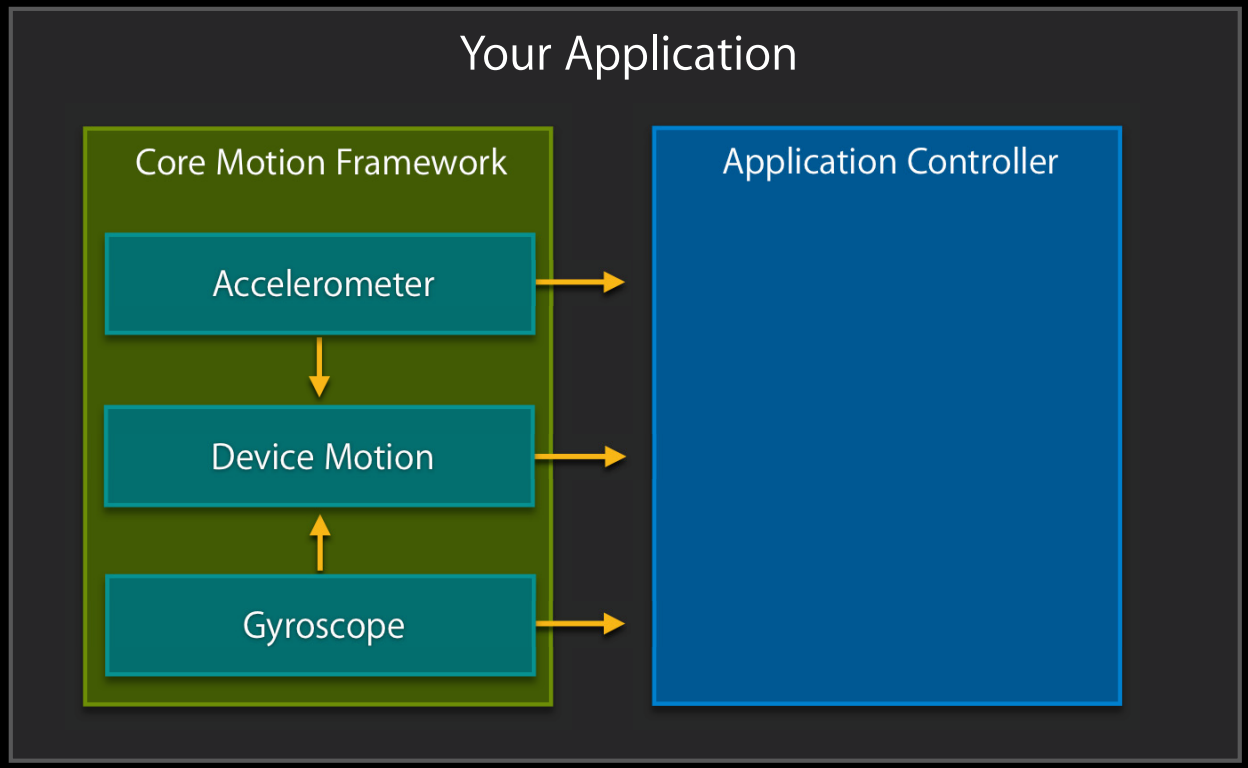
Patrick Piemonte
iPhone OS Software Engineer

Using Core Motion

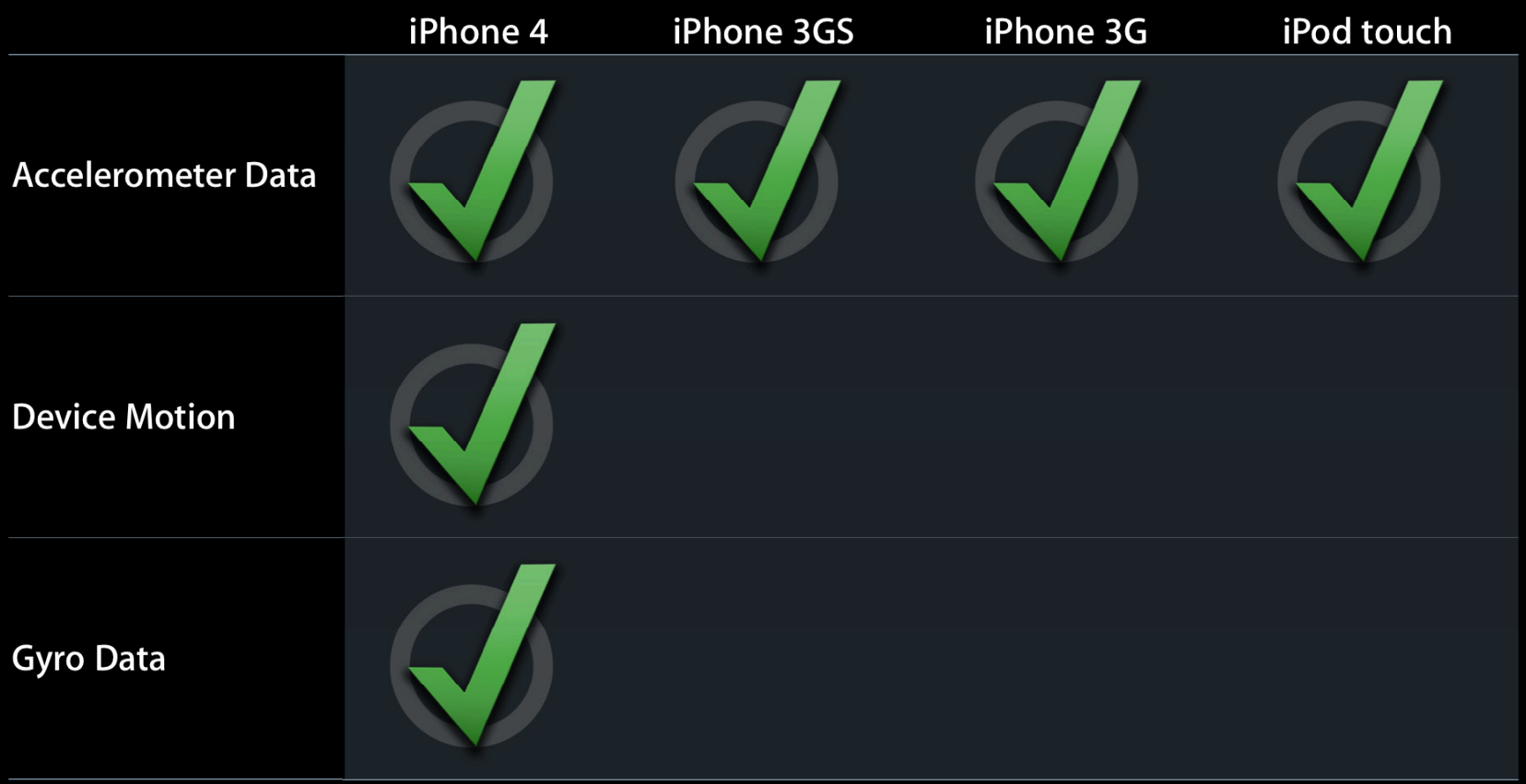
Core Motion

New framework in iOS 4

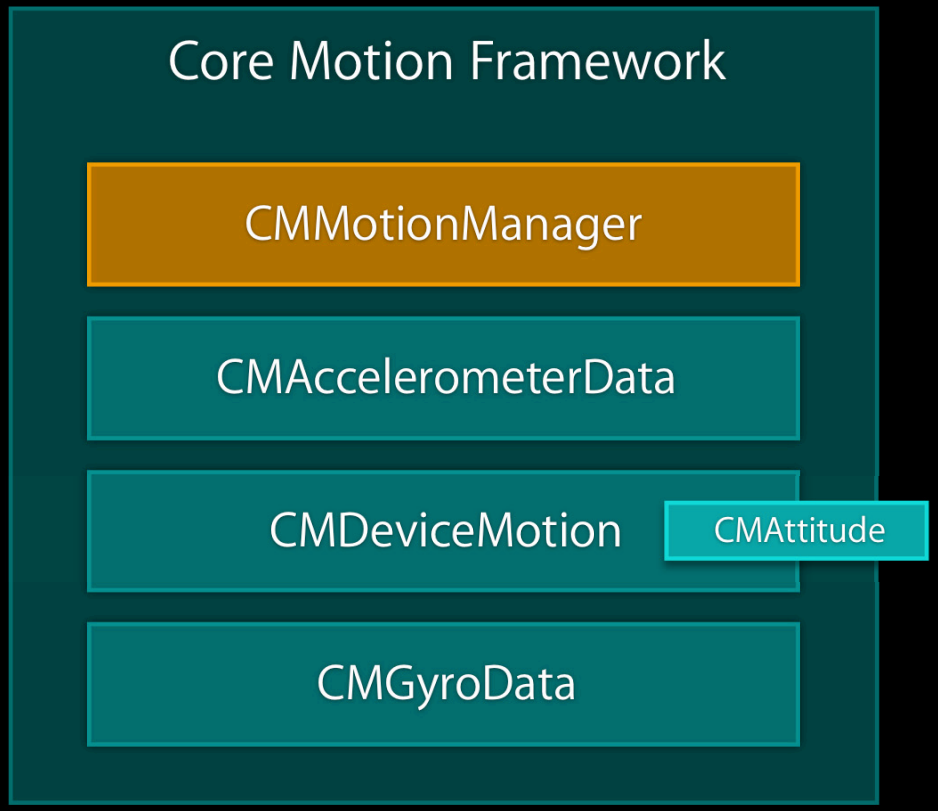
What Does Core Motion Provide?



Availability Matrix



Main Core Motion Objects



No Simulator Support

Retrieving Data

Push and pull

- Push
  - Must provide NSOperationQueue and block
- Pull
  - Periodically ask CMMotionManager for latest sample
  - Often done when view is updated

Retrieving Data

Push vs. pull tradeoffs

	Advantages	Disadvantages	Recommendation
Push	Never miss a sample	Increased overhead Often best to drop samples	Data collection apps
Pull	More efficient Less code required	May need additional timer	Most apps and games

Threading

- Core Motion creates its own thread to:
  - Handle raw data from sensors
  - Run device motion algorithms
- Pushing data:
  - Only your block will execute on your threads
- Pulling data:
  - Core Motion will never interrupt your threads

Outline for Using Core Motion

1. Setup
2. Retrieve data
3. Clean-up

Step 1: Setup

```
-(void) startAnimation
{
    // Create a CMMotionManager instance
    motionManager = [[CMMotionManager alloc] init];

    // Ensure that the data we're interested in is available
    if (!motionManager.isDeviceMotionAvailable) {
        // Fail gracefully
    }

    // Set the desired update interval (60Hz in this case)
    motionManager.deviceMotionUpdateInterval = 1.0 / 60.0;

    // Start updates
    // Note: We could call the following here instead:
    // [motionManager startDeviceMotionUpdatesToQueue:withHandler:]
    [motionManager startDeviceMotionUpdates];

}
```

Step 2: Retrieving Data

```
-(void) drawView:(id)sender
{

    CMDeviceMotion *newestDeviceMotion = motionManager.deviceMotion;

    // ...
}
```

Step 3: Cleaning Up

```
-(void) stopAnimation
{
    [motionManager stopDeviceMotionUpdates];
    [motionManager release];

    //...
}
```

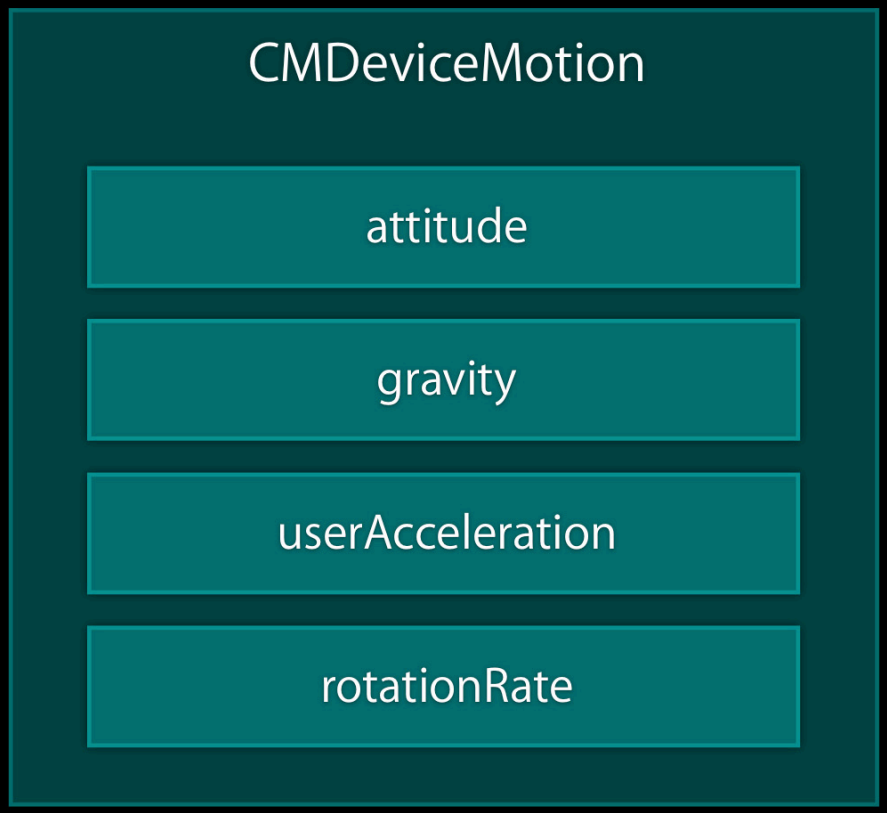
Using Core Motion

Summary

- Two methods to receive data:
  - Push
  - Pull
- Processing done on Core Motion's own thread
- Three steps to use Core Motion:
  - Setup
  - Retrieve data
  - Cleanup

Deep Dive into Device Motion

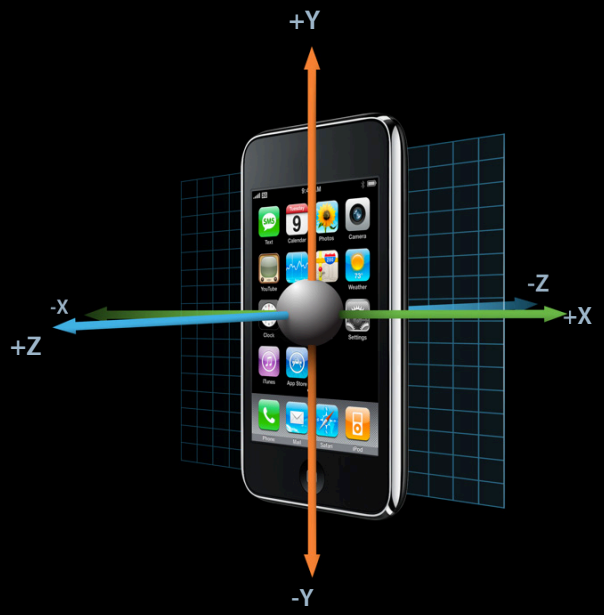
CMDeviceMotion Properties



Gravity and User Acceleration

```
@property(readonly, nonatomic) CMAcceleration gravity;
@property(readonly, nonatomic) CMAcceleration userAcceleration;
```

```
// Units are G's
typedef struct {
 double x;
 double y;
 double z;
} CMAcceleration;
```



Low-Pass Filtering User Acceleration

```
static const double kFilterConst = 0.1;
```

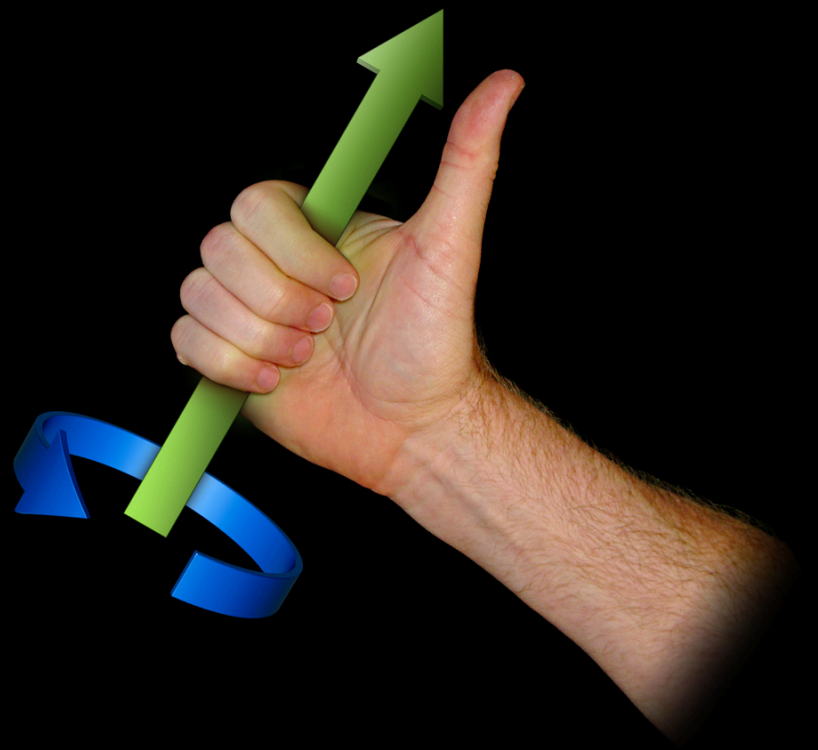
```
// motionManager is an instance of CMMotionManager
CMAcceleration accel = motionManager.deviceMotion.userAcceleration;
```

```
// userAccel is an instance of CMAcceleration
userAccel.x = userAccel.x*(1.0 - kFilterConst) + accel.x* kFilterConst;
userAccel.y = userAccel.y*(1.0 - kFilterConst) + accel.y* kFilterConst;
userAccel.z = userAccel.z*(1.0 - kFilterConst) + accel.z* kFilterConst;
```

Rotation Rate

```
@property(readonly, nonatomic) CMRotationRate rotationRate;
```

```
// Units are radians/second
typedef struct {
 double x;
 double y;
 double z;
} CMRotationRate;
```



How CMDeviceMotion's rotationRate Property Differ from CMGyroData?

bias!

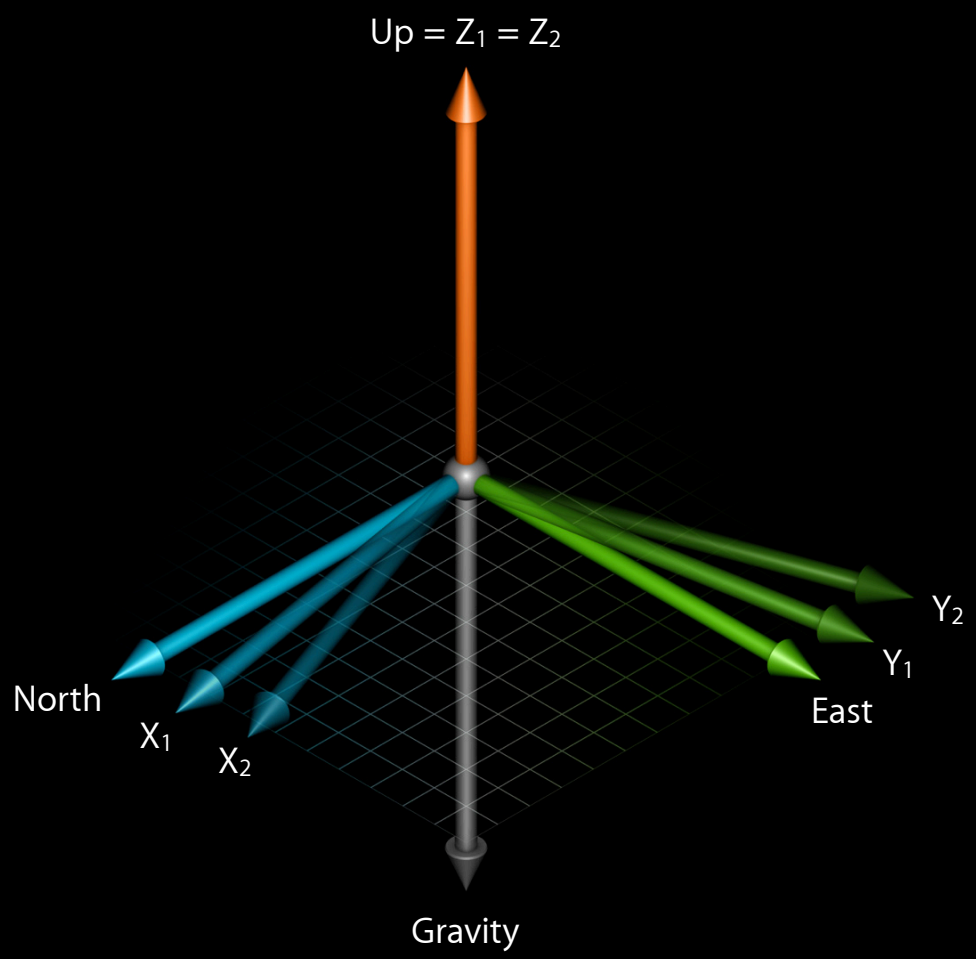
Attitude

```
@property(readonly, nonatomic) CMAttitude *attitude;
```

- Orientation of the device in 3D
- Ways to express:
  - Rotation matrix
  - Quaternion
  - Euler angles (pitch, roll, yaw)

Reference Frame

- Chosen when your app starts device motion updates
- Z axis is always vertical
  - Gravity is always [0, 0, -1]
- X and Y axes are both orthogonal to gravity



Example

```
CMDeviceMotion *deviceMotion = motionManager.deviceMotion;
```

```
CMRotationMatrix R = deviceMotion.attitude.rotationMatrix;
```

```
CMAcceleration gravityReference = {0.0, 0.0, -1.0};
```

```
// gravityDevice == deviceMotion.gravity
gravityDevice = multiplyMatrixAndVector(R, gravityReference);
```

$$\texttt{deviceMotion.gravity} = R \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$$

Changing Reference Frame

- Why
  - Provide comfortable “resting” orientation
- How

```
-[CMAttitude multiplyByInverseOfAttitude:]
```

Changing Reference Frame

Time

```
// Frame 1: Set Reference Frame

referenceAttitude = [motionManager.deviceMotion.attitude retain];
```

```
// Frame N

attitude = motionManager.deviceMotion.attitude;
[attitude multiplyByInverseOfAttitude: referenceAttitude];
```

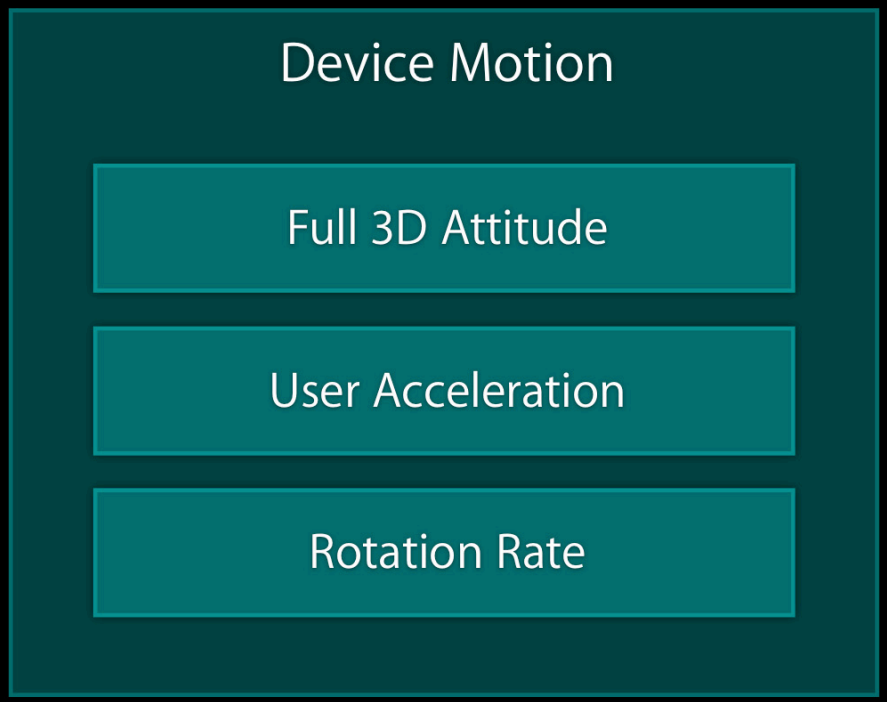
Demo

Patrick Piemonte
iPhone OS Software Engineer

Let's Code!

Wrapping Up

New Information



What Do We Do with This?

- GPS aiding
- Compass aiding

What Can You Do with This?

- Games
  - Simulations
  - Racing games
  - Boxing/fighting games
- Augmented reality
- 3D visualization
- Much, much more!

More Information

Allan Schaffer
Graphics Evangelist
aschaffer@apple.com

Documentation
Event Handling Guide for iPhoneOS
http://developer.apple.com

Apple Developer Forums
http://devforums.apple.com

Related Sessions

Game Design and Development for iPhone OS, Part 1 (Repeat)	Presidio Friday 9:00AM
Game Design and Development for iPhone OS, Part 2 (Repeat)	Presidio Friday 10:15AM
Introducing Blocks and Grand Central Dispatch on iPhone	Russian Hill Wednesday 11:30AM
OpenGL ES Overview for iPhone OS	Presidio Wednesday 2:00PM
Using Core Location in iOS 4	Presidio Wednesday 10:15AM

Labs

Core Motion Lab	Graphics and Media Lab D Thursday 11:30AM
Game Design for iPhone OS Lab	Graphics and Media Lab A Friday 11:30AM
OpenGL ES Lab	Graphics and Media Lab A Thursday 9:00AM

Q&A


WWDC10