Taking Core Location Indoors

Session 708
Nav Patel
Software Engineer
Overview

Indoor Positioning
How do you use it?
Indoor Positioning and iBeacon Technology
Next steps
Today’s Technology

Cellular, GPS, Wi-Fi
Today’s Technology

Cellular

Area in a city
Low power
Always available
Today’s Technology

GPS

Accurate enough for navigation
Available globally
Less accurate in urban canyons
Today’s Technology

Wi-Fi

Within a city block
Augments GPS positioning
Wi-Fi only devices
Existing Location

Navigation outdoors
Works well globally
Problem

Not great indoors
Altitude, not floor
Indoor Positioning
Indoor Positioning

RF Parametric data
Motion sensors
How Does It All Work?

Getting indoors

Cell
GPS
Wi-Fi
How Does It All Work?

Getting indoors

- Cell
- GPS
- Wi-Fi
- Motion

Location Fix
How Does It All Work?

Getting indoors

Cell  GPS  Wi-Fi  Motion
How Does It All Work?

Getting indoors

- Cell
- GPS
- Wi-Fi
- Motion

Indoor Location Fix
Why Indoors?
Why Indoors?

Directories
Why Indoors?

Directories
Venue maps
Why Indoors?

Directories
Venue maps
Some interactivity
Why Indoors?

Location is context
Why Indoors?

Location is context

Way-finding
Why Indoors?

Location is context
Why Indoors?
Location is context

Find each other
Why Indoors?
Location is context

Find each other
Find you
Why Indoors?

Location is context
Why Indoors?

Location is context

Last piece of the puzzle
How Do You Use It?

Core Location
How Do You Use It?

Core Location

Wi-Fi on, device unlocked
How Do You Use It?

Core Location

Wi-Fi on, device unlocked
Exact same Core Location API
How Do You Use It?

Core Location

Wi-Fi on, device unlocked
Exact same Core Location API
Floor number
How Do You Use It?

CLFloor
How Do You Use It?

CLFloor

@property(readonly, nonatomic, copy) CLFloor *floor

@interface CLFloor
    @property(readonly, nonatomic) NSInteger level;
@end
Building an Indoor Application
Overcoming spherical coordinate challenges

Vitali Lovich
Geographic Coordinate System

Latitude/longitude
Common
Convenient
Difficult to work with
Floorplan Image

Easy for display
Convenient graphical coordinates
Display coordinate frame
Conversion

Three coordinate frames to consider
Watch out for spherical distortion
Conversion

Three coordinate frames to consider
Watch out for spherical distortion
Helper Functions

MKMapPointForCoordinate
MKMetersBetweenMapPoints
MKMetersPerMapPointAtLatitude
CGAffineTransformMakeScale
CGAffineTransformMakeRotation
CGPointApplyAffineTransform
Required Data

Two anchor points
Anchor point = latitude/longitude + floorplan pixels
Scale

We need pixelsPerMeter

- $P_2 = \text{MKMapPointForCoordinate}(A1.\text{Geo})$
- $P_1 = \text{MKMapPointForCoordinate}(A2.\text{Geo})$
- $\text{MKMetersBetweenMapPoints}(P_1, P_2)$

$$\text{hypot}(A2.\text{Pixels}.x - A1.\text{Pixels}.x, A2.\text{Pixels}.y - A2.\text{Pixels}.y)$$
Orientation
Conversion

East

South

X

Y
Conversion

South

East

Y

X

East
Conversion

- South
- East
Conversion
Conversion

South

East

Y

X
Conversion

\[ \theta_r = \theta_f - \theta_g \]
Putting It Together

\[ \text{Point}_{\text{user}} = \text{MKMapPointForCoordinate(}\text{UserPosition}) \]
\[ \text{MetersScale} = \text{MKMetersPerMapPointAtLatitude(A1.Geo)} \]
\[ \text{Meters}_{\text{user}} = (\text{Point}_{\text{user}} - \text{PointA1}) \times \text{MetersScale} \]
\[ \text{CGPointApplyAffineTransform}(\text{Meters}_{\text{user}}, \text{CGAffineTransformMakeScale}(\text{Pixels}/\text{Meter})) \]
\[ \text{CGPointApplyAffineTransform}(\text{Pixels}_{\text{user}}, \text{CGAffineTransformMakeRotation}(\theta_r)) \]
Availability
Coming soon
Availability

Coming soon

California Academy of Sciences, San Francisco
Westfield San Francisco Centre, San Francisco
Mineta San Jose International Airport, San Jose
Discover Your App
Discover Your App

Advertise at your venue
Discover Your App

Advertise at your venue
App Store—Near Me
Discover Your App

Advertise at your venue
App Store—Near Me
Continuity
Discover Your App

Advertise at your venue
App Store—Near Me
Continuity
Indoor Positioning and iBeacon Technology
Position and proximity
iBeacon Technology

Review
<table>
<thead>
<tr>
<th>Indoor Positioning</th>
<th>iBeacon Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>Proximity</td>
</tr>
<tr>
<td>Navigation</td>
<td>Notification</td>
</tr>
</tbody>
</table>
Art Gallery Example
Art Gallery Example
Region entrance

CLCircularRegion
Art Gallery Example
Region entrance
Art Gallery Example
Region entrance
Art Gallery Example
Region entrance
Art Gallery Example

Beacon regions
Art Gallery Example

Beacon at entrance—Region monitoring

[self.locationManager startMonitoringForRegion:beaconRegion];

- (void)locationManager:(CLLocationManager *)manager
didEnterRegion:(CLRegion *)region
Art Gallery Example

Beacon at entrance—Region monitoring

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Art Gallery Example
Navigation and commentary
Art Gallery Example
Navigation and commentary

Display user position on map
Art Gallery Example

Navigation and commentary

Display user position on map
Art Gallery Example
Navigation and commentary

Display user position on map
Navigate
Art Gallery Example

Navigation and commentary

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Art Gallery Example
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Display user position on map
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Art Gallery Example
Navigation and commentary

Display user position on map
Navigate
Relevant content based on exhibits nearby
Art Gallery Example

Proximity to exhibits
Art Gallery Example

Proximity to exhibits
Art Gallery Example

Proximity to exhibits
Art Gallery Example
Proximity to exhibits
Art Gallery Example

Proximity to exhibits
Art Gallery Example
Proximity to exhibits
Art Gallery Example

Beacon at exhibit—Proximity

```swift
[self.locationManager startRangingBeaconsInRegion:beaconRegion];

- (void)locationManager:(CLLocationManager *)manager
didRangeBeacons:(NSArray *)beacons
    inRegion:(CLBeaconRegion *)region

beacon.proximity

beacon.major

beacon.minor
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Art Gallery Example

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beacon.minor
With Great Power
Strict security and privacy guidelines

Request location only as you need it
When In Use authorization
Have a clear purpose string
Next Steps

Sign up

**Maps Connect**
Indoor Positioning—Sign up
http://mapsconnect.apple.com

Maps
Maps & Core Location API
http://developer.apple.com/maps

iBeacon
iBeacon Technology & Licensing
http://developer.apple.com/ibeacon
Summary
Indoor Positioning

Precise Indoor Positioning
Core Location APIs
Indoor Positioning and iBeacon Technology
More Information

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MFi and I/O Technologies Evangelist
keithley@apple.com

Documentation
Location and Maps Programming Guide
http://developer.apple.com

Apple Developer Forums
http://devforums.apple.com
### Related Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>What's New in Core Location</td>
<td>Marina</td>
<td>Tuesday 2:00PM</td>
</tr>
<tr>
<td>User Privacy in iOS and OS X</td>
<td>Nob Hill</td>
<td>Thursday 2:00PM</td>
</tr>
</tbody>
</table>
Labs

- Core Location Lab

Core OS Lab B
Thursday 12:45PM