What's New In Camera Capture

iOS 6 API enhancements and performance improvements

Session 520

Brad Ford
Core Media Engineering

What You Will Learn

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- Performance improvements in Mac OS X 10.8

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- Review last year's WWDC capture sessions at developer.apple.com

Sample Code for This Session

- AVRecorder (OS X)
- AVScreenShack (OS X)
- ‘StacheCam 2 (iOS)
- VideoSnake (iOS)
- AVCam (iOS)

Materials available at:
https://developer.apple.com/library/wwdc/mac/
https://developer.apple.com/library/wwdc/ios/

New AV Foundation Capture APIs

Mac OS X 10.8 (Mountain Lion) enhancements

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See (updated) AVScreenShack sample code!

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See (updated) AVRecorder sample code

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SDK available at:
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The iOS Camera Ecosystem

How your app fits into the big picture

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- Handle errors!

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New AV Foundation Capture APIs

iOS 6 enhancements

New in iOS 6

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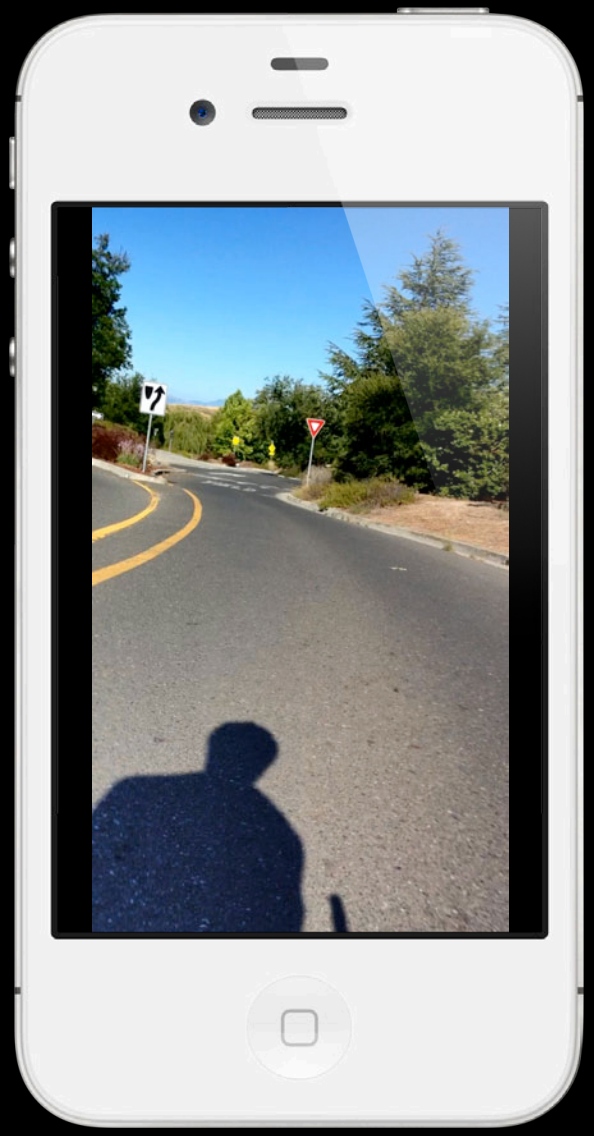

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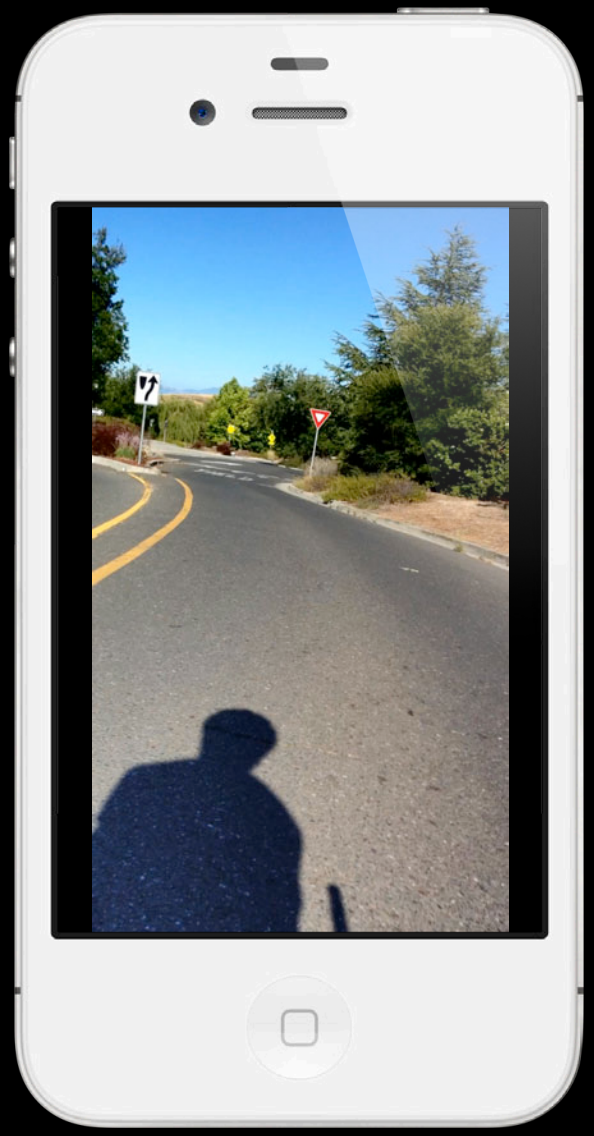

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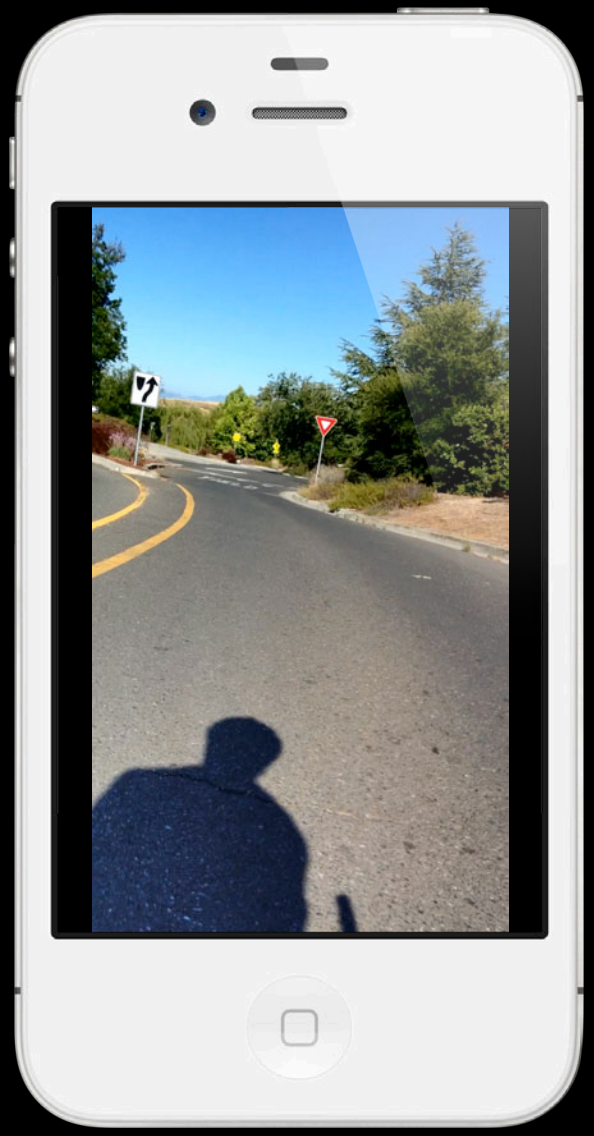

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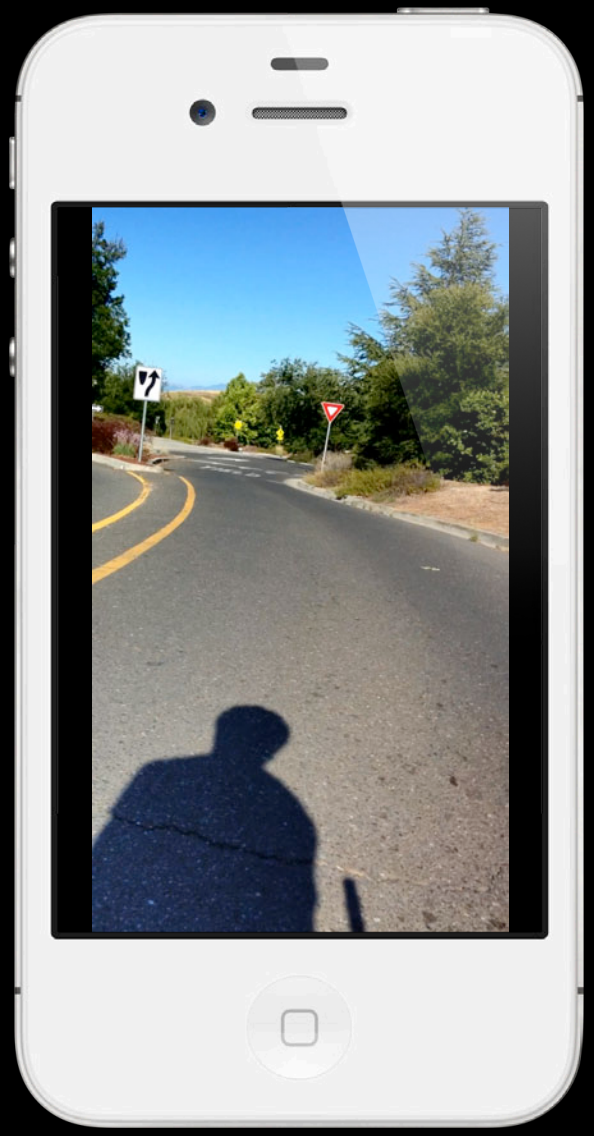

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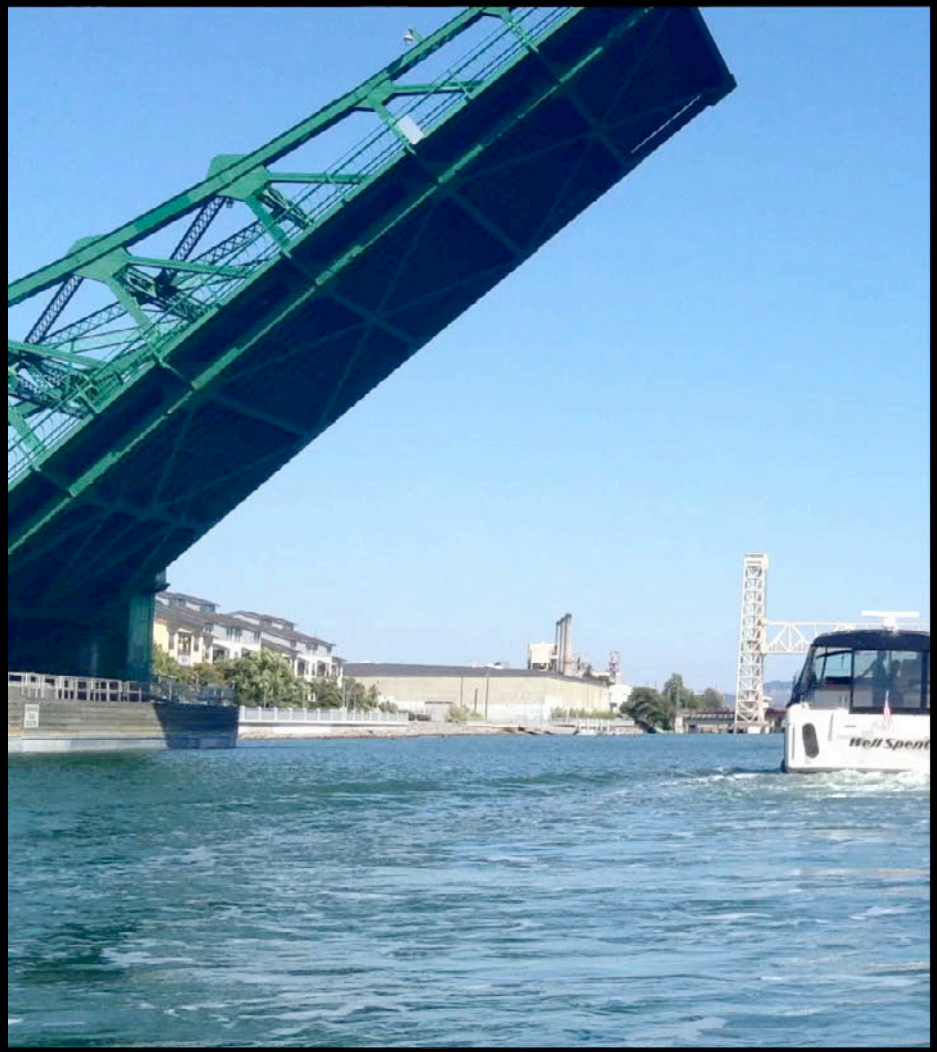
Demo

Video stabilization



Before

After

Video Stabilization

Why use it?

Video Stabilization

Why use it?

- Camera phones are susceptible to shake

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- HD resolution recordings are especially susceptible to rolling shutter

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- Stabilization saves otherwise unusable footage
- It works in real-time

Video Stabilization

Why not use stabilization?

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- Stabilization alters the pixels

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- Stabilization adds latency to video data output

Video Stabilization

Supported platforms

iPhone 4S	✓
The new iPad	✓

Video Stabilization

Compatibility

Video Stabilization

Compatibility

- All HD video resolutions are compatible

```
AVCaptureSessionPresetHigh
AVCaptureSessionPreset1920x1080
AVCaptureSessionPreset1280x720
AVCaptureSessionPresetiFrame1280x720
AVCaptureSessionPresetiFrame960x540
```

Video Stabilization

Compatibility

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Compatibility

- Does NOT work with front camera

Video Stabilization

Compatibility

- Does NOT work with front camera
- Does NOT work with AVCaptureStillImageOutput

Video Stabilization

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- Does NOT work with front camera
- Does NOT work with AVCaptureStillImageOutput
- Does NOT work with AVCaptureVideoPreviewLayer

Video Stabilization

iOS 5 behavior

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iOS 5 behavior

- AVCaptureMovieFileOutput always stabilizes 1080p video

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- AVCaptureMovieFileOutput always stabilizes 1080p video
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iOS 5 behavior

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- No API to opt in or out

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- Apps linked before iOS 6 continue to get the iOS 5 behavior

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Video Stabilization

iOS 6 behavior

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- Apps linked on or after iOS 6 must opt in for stabilization
- Both movie file output and video data output support stabilization

Video Stabilization

Opting in

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Opting in

- Create an AVCaptureSession

Video Stabilization

Opting in

- Create an AVCaptureSession
- Add an AVCaptureDeviceInput

Video Stabilization

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- Add an AVCaptureDeviceInput
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Video Stabilization

Opting in

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- Add an AVCaptureDeviceInput
- Add an AVCaptureMovieFileOutput or AVCaptureVideoDataOutput
- Get the output's video connection

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AVCaptureConnection *c = [output connectionWithMediaType:AVMediaTypeVideo];
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Video Stabilization

Opting in

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- Add an AVCaptureMovieFileOutput or AVCaptureVideoDataOutput
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- Opt in for video stabilization when available

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```

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- Key-value observe the connection's `@"videoStabilizationEnabled"` property

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Gotchas

- When inputs or outputs are added, connections are implicitly formed between compatible input ports and outputs

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AVCaptureSession

AVCaptureMovieFileOutput

Video Stabilization

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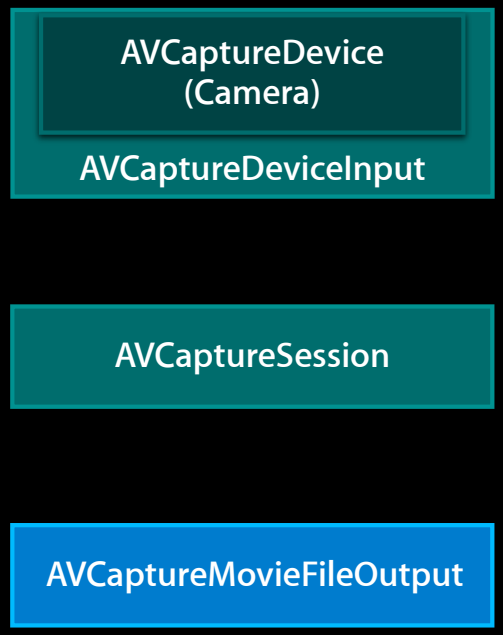

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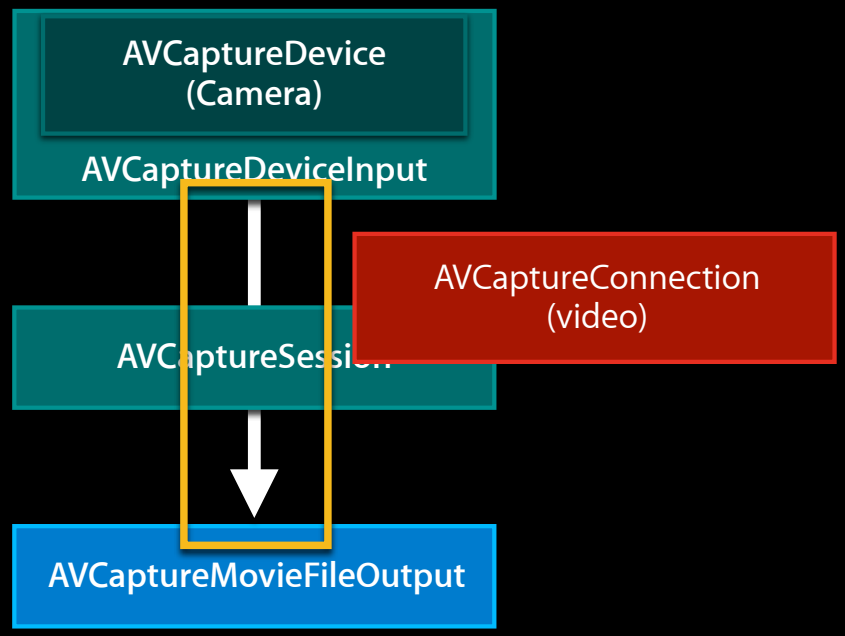

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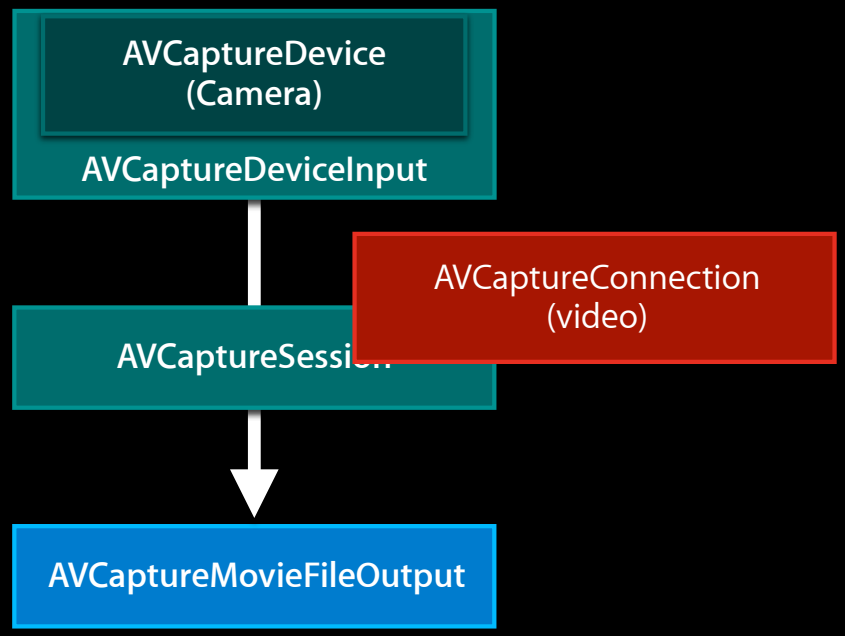

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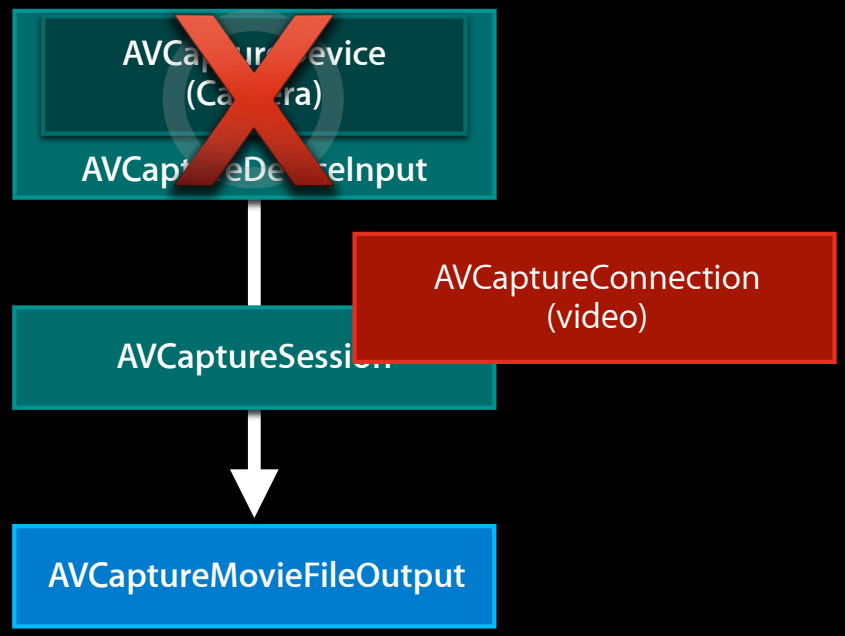

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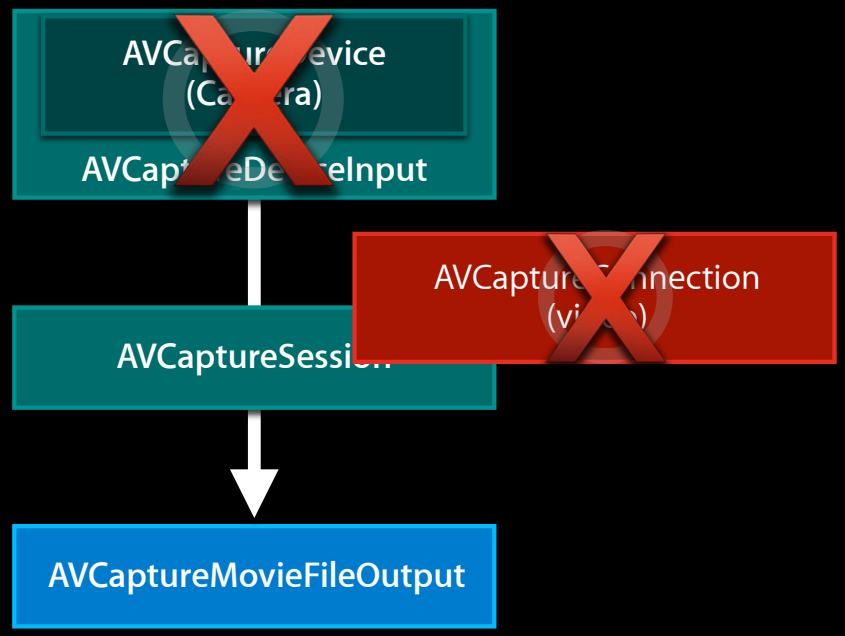

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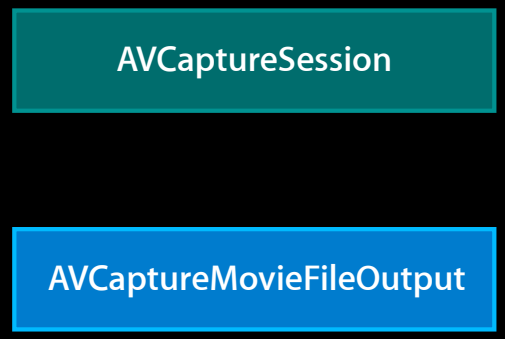

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See updated AVCam sample code

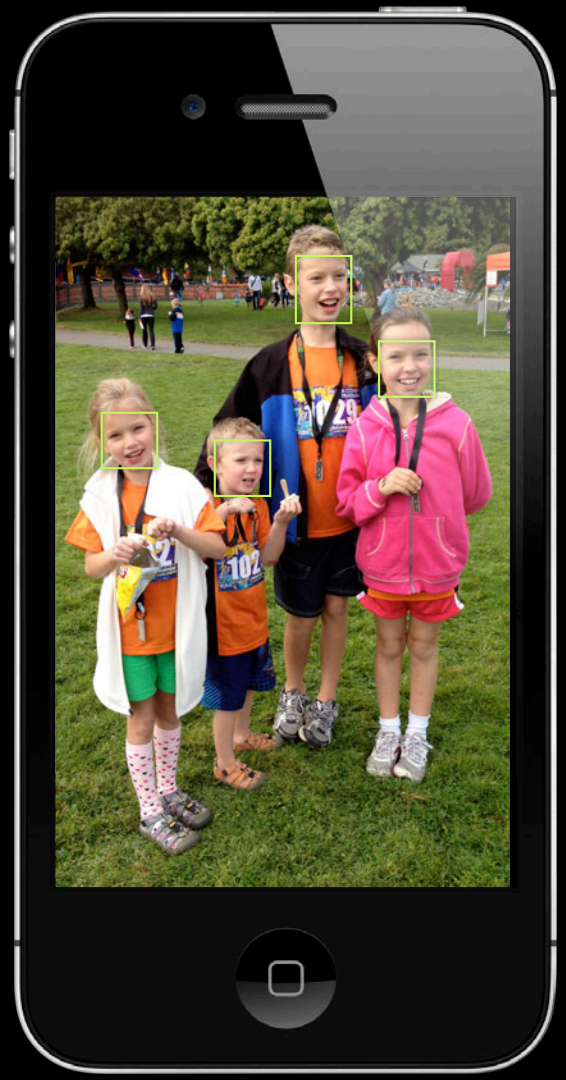
New in iOS 6

- Video stabilization
- Real-time face detection
- AVCaptureVideoPreviewLayer enhancements

Face Detection

Face Detection

- Scans for faces in real-time



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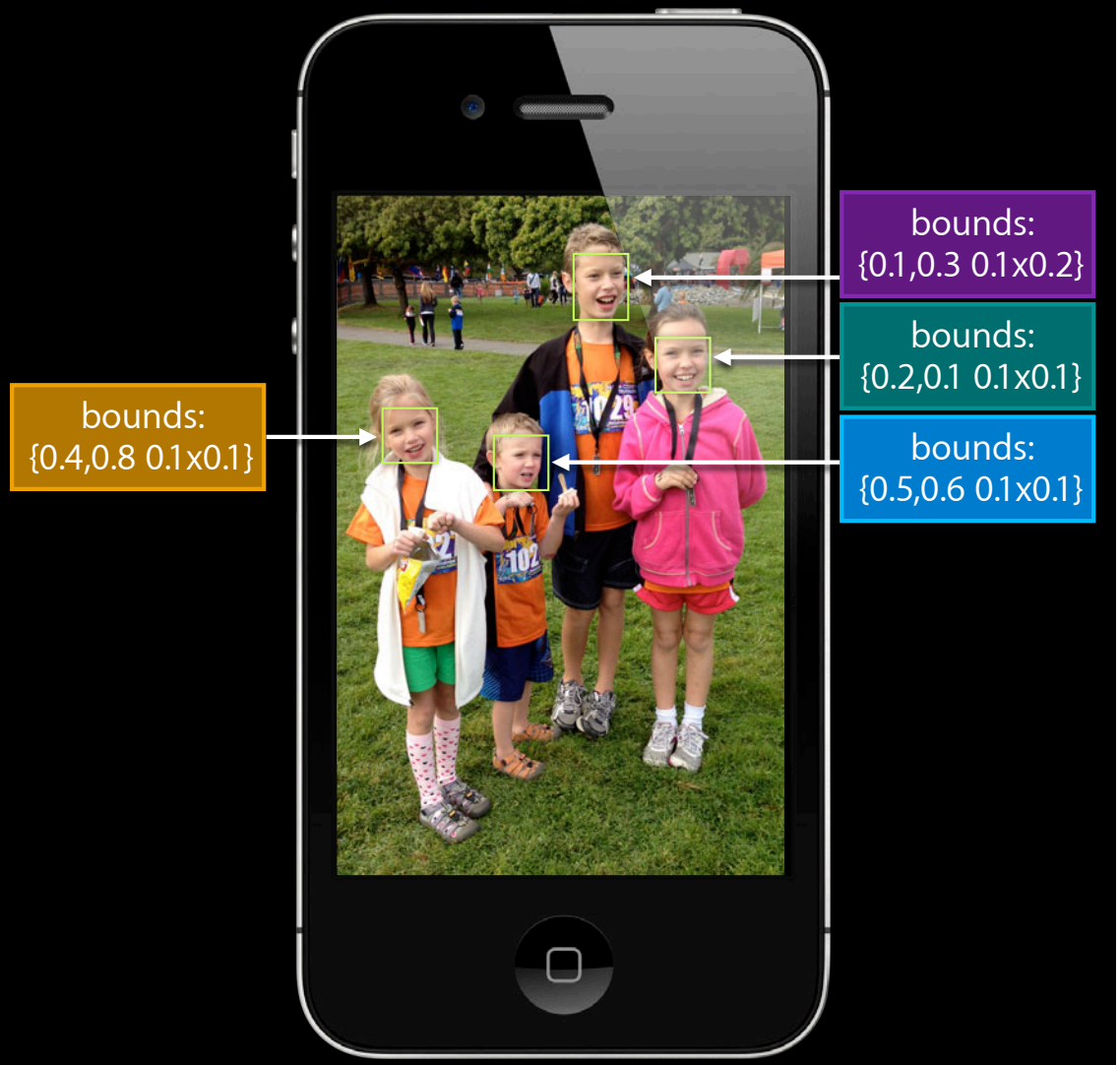

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- Scans for faces in real-time
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- Assigns a unique ID to each face
- Provides a timestamp for each face
- Finds the rectangle bounding each face
- Determines the roll angle
- Determines the yaw angle
- Works with front and back camera (all presets!)

Face Detection

- Does NOT find alien or pet faces

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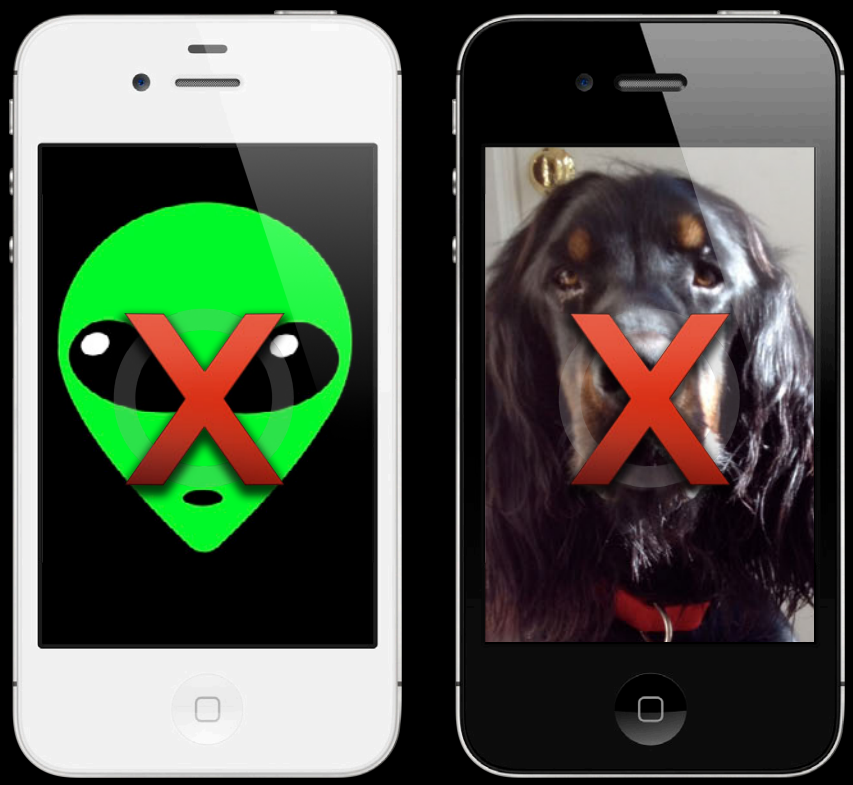

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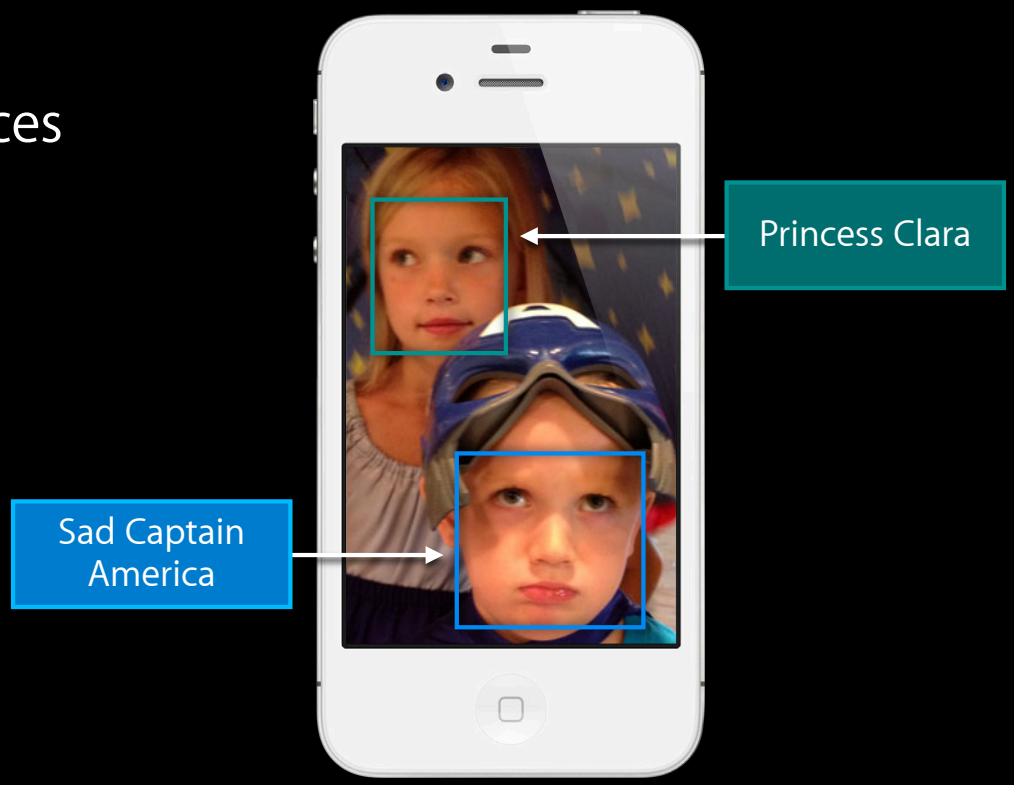

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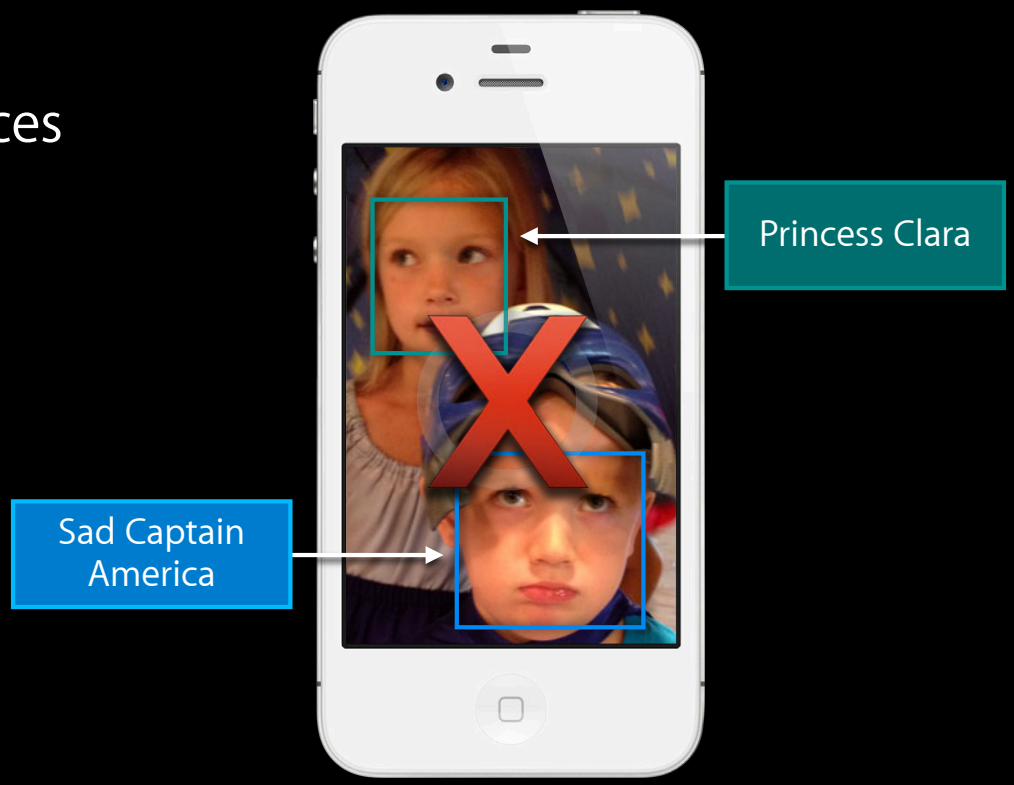

Face Detection

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- Does NOT recognize particular faces
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- Does NOT find alien or pet faces
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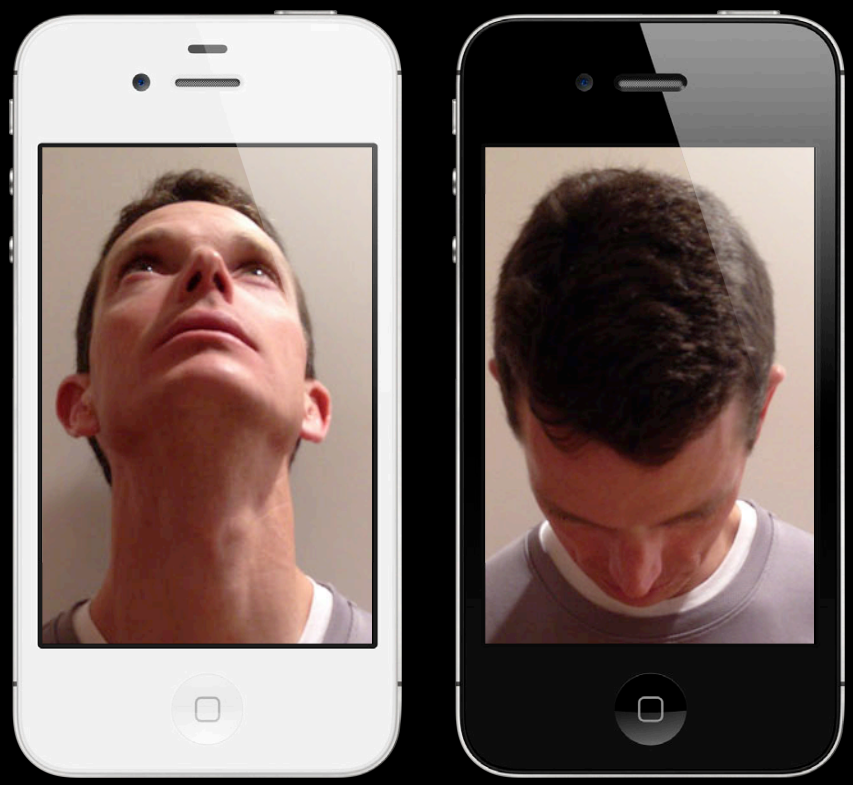
- Does NOT determine pitch



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- Does NOT recognize particular faces
- Does NOT remember faces
- Does NOT determine pitch
- Does NOT find faces with a yaw angle between 91 and 269 degrees

Face Detection

Why use AV Foundation Face Detection?

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- Incurs very little CPU
- Capture resolution independent

Face Detection

Why use AV Foundation Face Detection?

- Optimized for real-time capture
- Incurs very little CPU
- Capture resolution independent
- Supports tracking faces over time

Face Detection

Why use Core Image's CIFaceDetector

Face Detection

Why use Core Image's CIFaceDetector

- Available on all supported iOS devices

Face Detection

Why use Core Image's CIFaceDetector

- Available on all supported iOS devices
- "Push" interface suitable for arbitrary source images

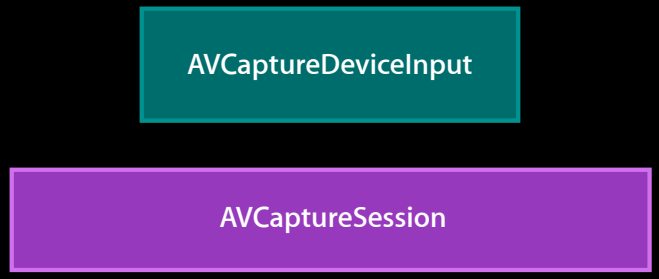
Demo

‘StacheCam 2

Ethan Tira-Thompson
Core Media Engineering

‘StacheCam 2 (CIFaceDetector path)

‘StacheCam 2 (CIFaceDetector path)



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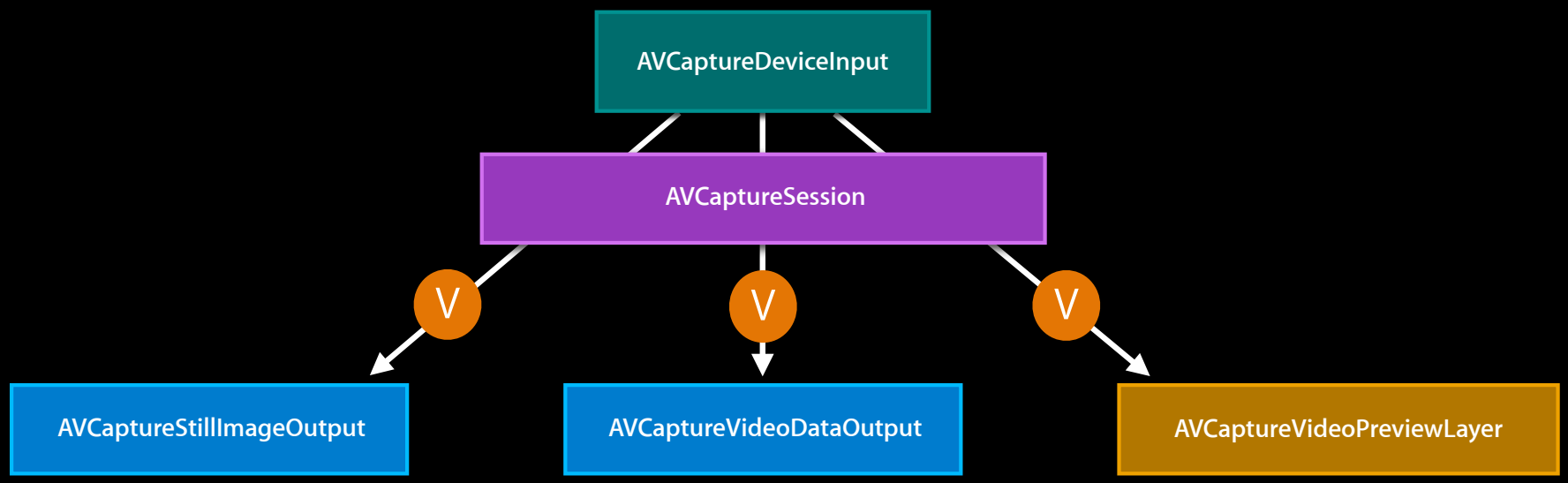

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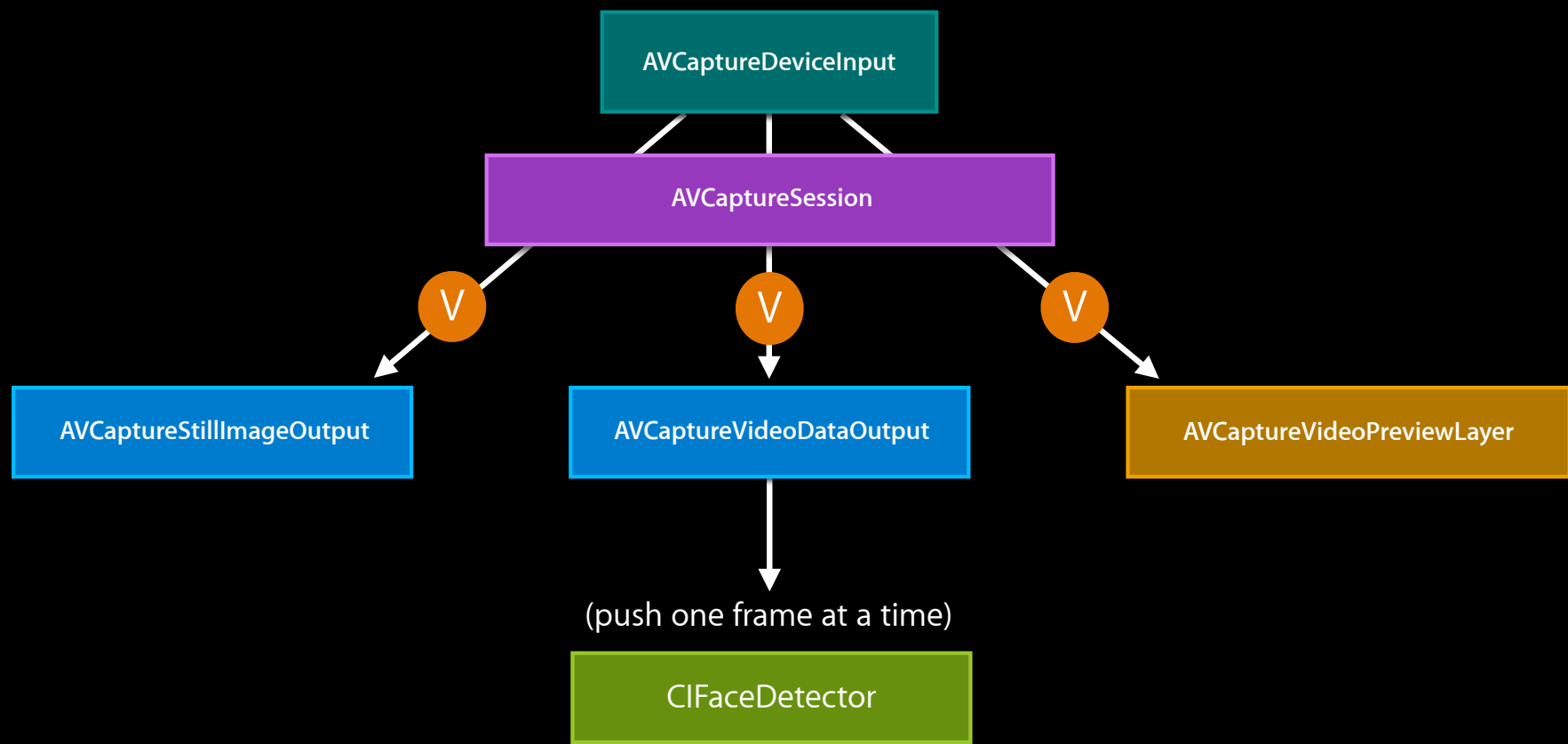

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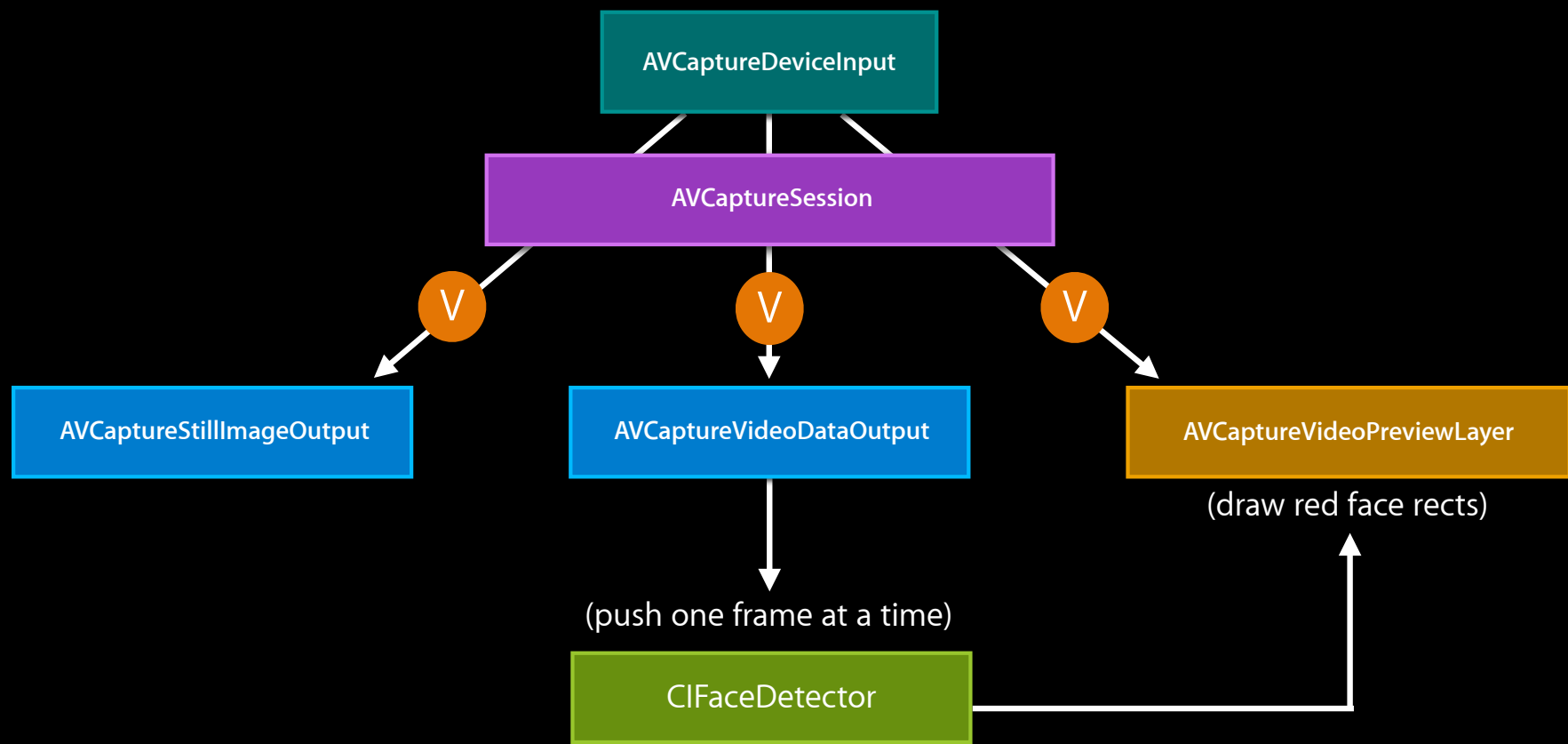

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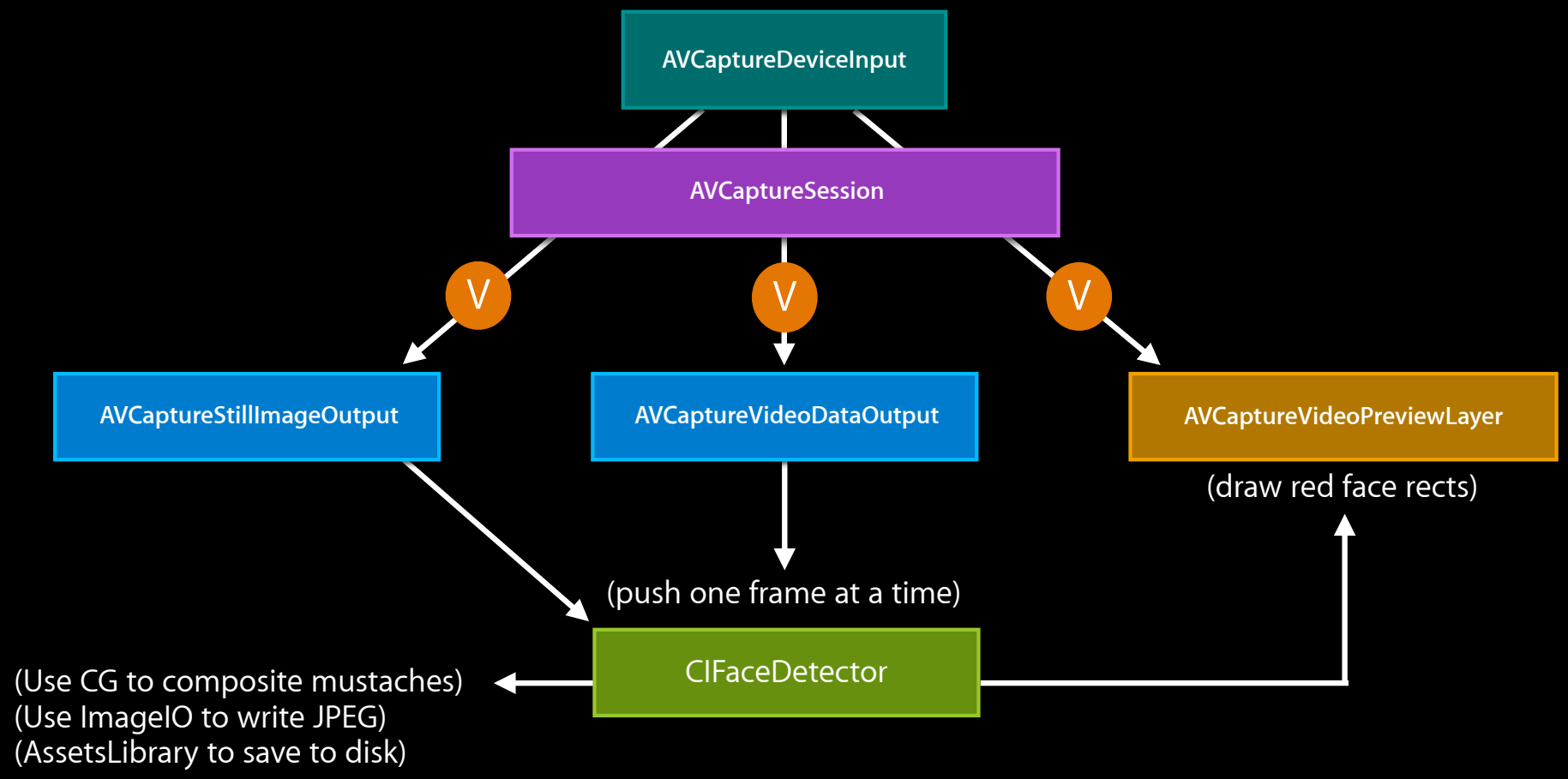

‘StacheCam 2 (real-time path)

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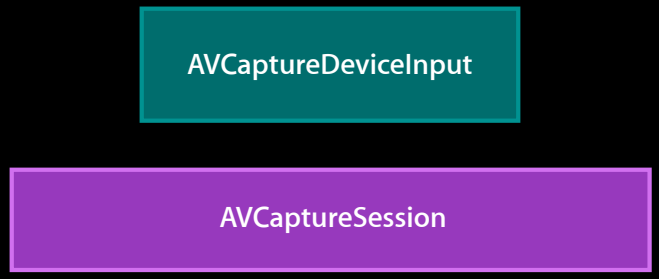

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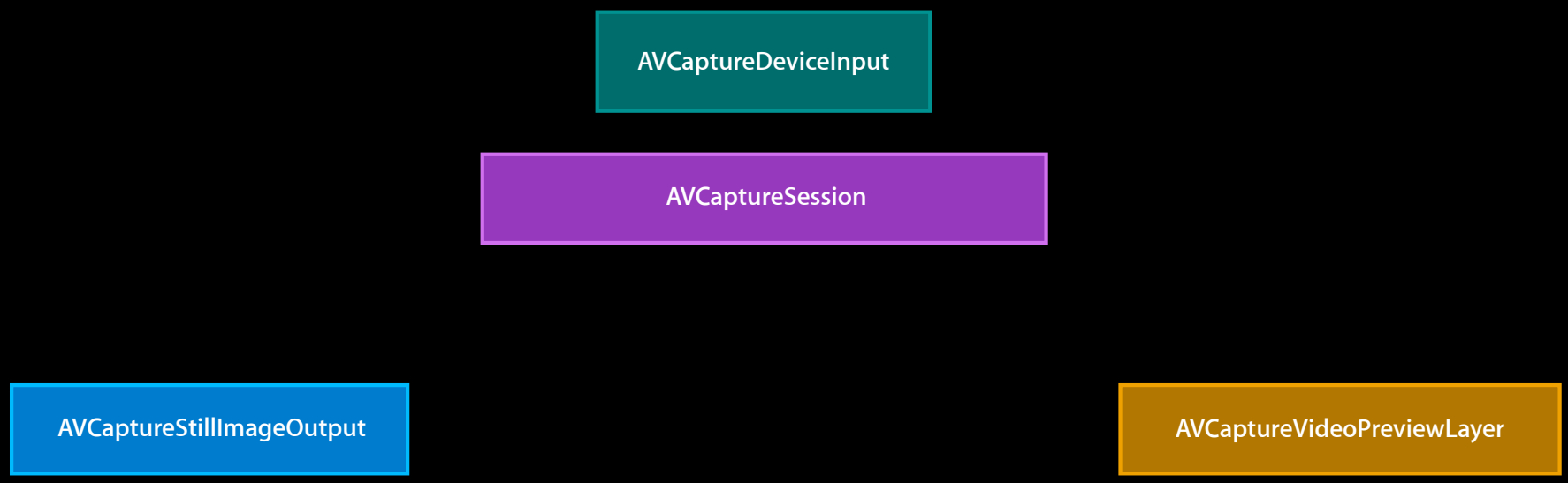

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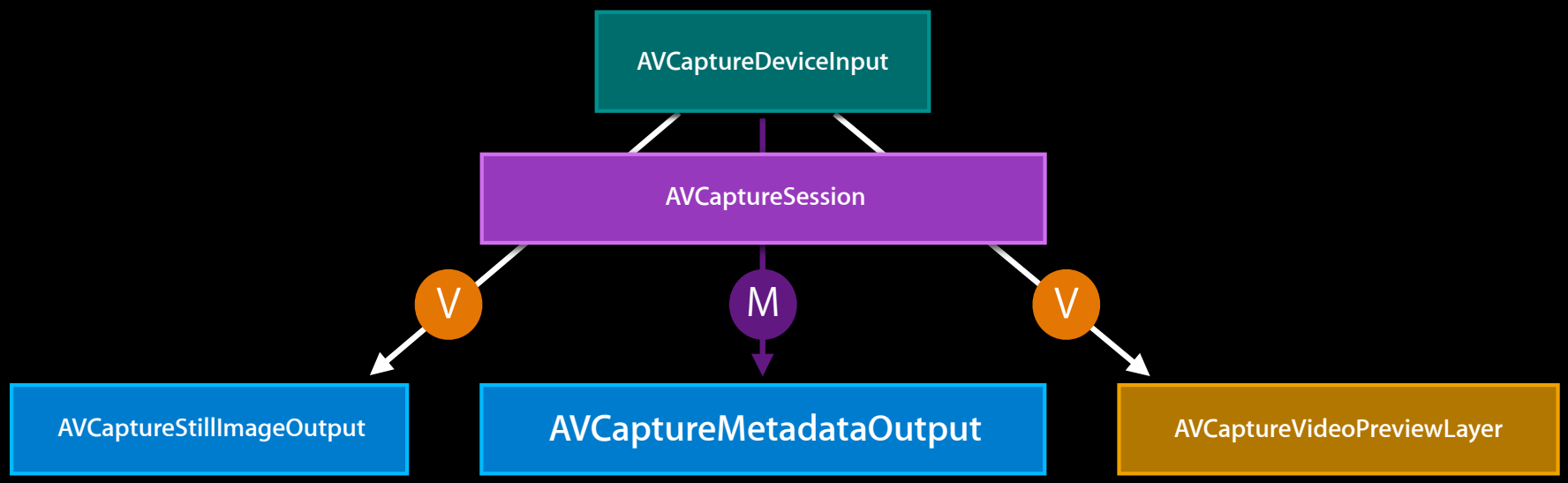

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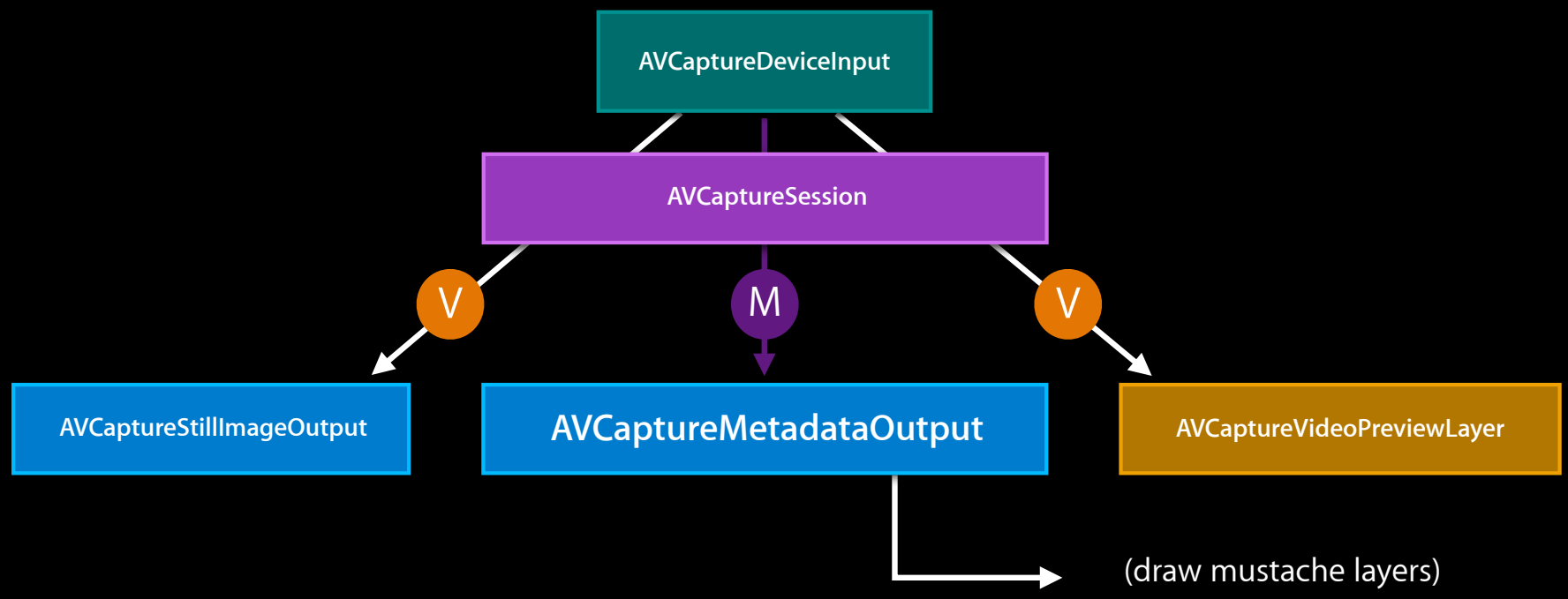

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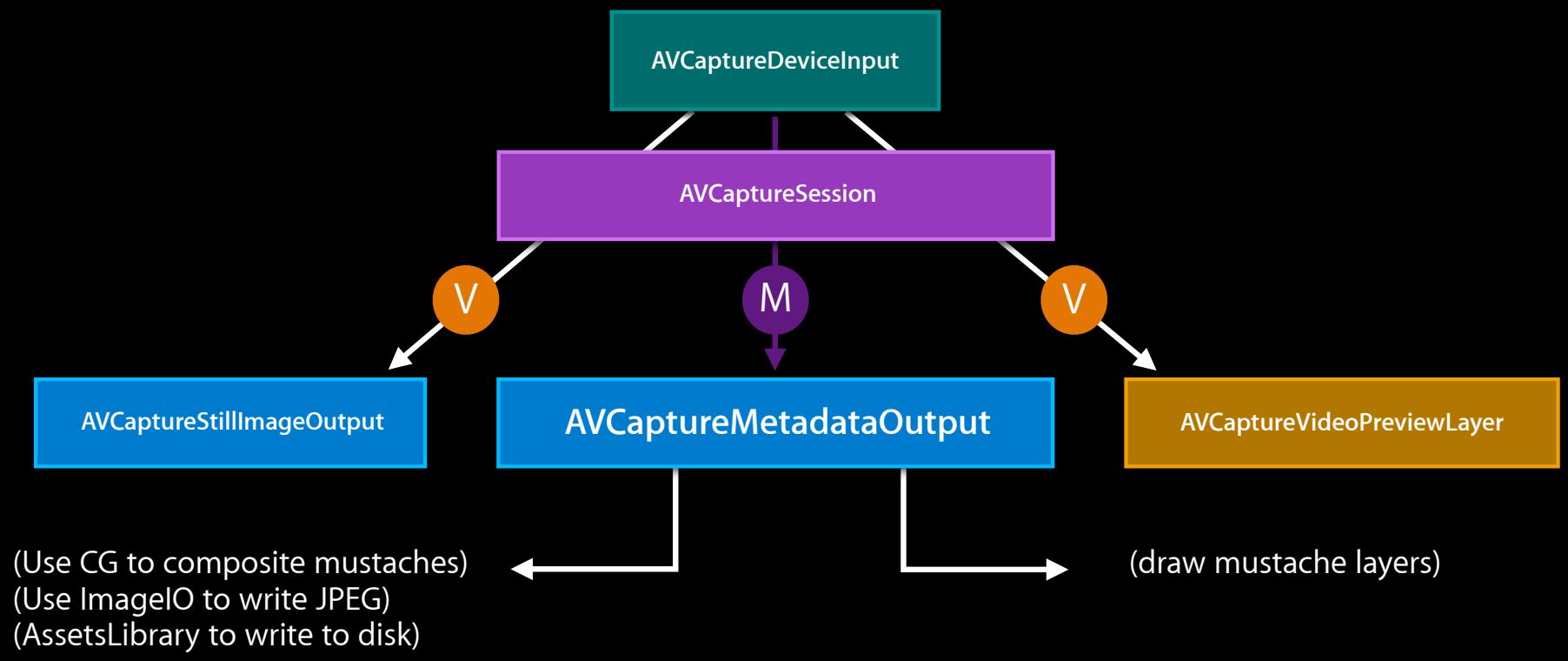

Face Detection

Programming model

Face Detection

Programming model

- AVCaptureDeviceInput exposes an input port of AVMediaTypeMetadata

Face Detection

Programming model

- AVCaptureDeviceInput exposes an input port of AVMediaTypeMetadata
- New AVCaptureOutput subclass AVCaptureMetadataOutput

Face Detection

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  - Patterned after AVCaptureVideoDataOutput

Face Detection

Programming model

- AVCaptureDeviceInput exposes an input port of AVMediaTypeMetadata
- New AVCaptureOutput subclass AVCaptureMetadataOutput
  - Patterned after AVCaptureVideoDataOutput
  - Outputs an NSArray of AVMetadataObjects to a delegate

Face Detection

Programming model

- AVCaptureDeviceInput exposes an input port of AVMediaTypeMetadata
- New AVCaptureOutput subclass AVCaptureMetadataOutput
  - Patterned after AVCaptureVideoDataOutput
  - Outputs an NSArray of AVMetadataObjects to a delegate
  - Allows discovery of `-availableMetadataObjectTypes`

Face Detection

Programming model

- AVCaptureDeviceInput exposes an input port of AVMediaTypeMetadata
- New AVCaptureOutput subclass AVCaptureMetadataOutput
  - Patterned after AVCaptureVideoDataOutput
  - Outputs an NSArray of AVMetadataObjects to a delegate
  - Allows discovery of `-availableMetadataObjectTypes`
  - Lets you request a subset of available metadata

```
NSArray *faceMetadata = [NSArray arrayWithObject:AVMetadataObjectTypeFace];
[metadataOutput setMetadataObjectTypes:faceMetadata];
```

Face Detection

What's in a face?

```
 - (void)captureOutput:(AVCaptureOutput *)captureOutput
         didOutputMetadataObjects:(NSArray *)metadataObjects
         fromConnection:(AVCaptureConnection *)c
{
   for ( AVMetadataObject *object in metadataObjects ) {

     if ( [[object type] isEqual:AVMetadataObjectTypeFace] ) {

      CMTime timestamp = [face time];
      CGRect faceRectangle = [face bounds];
      NSInteger faceID = [face faceID];
      CGFloat rollAngle = [face rollAngle];
      CGFloat yawAngle = [face yawAngle];

      // Do interesting things with this face
     }
   }
}
```

Face Detection

What's in a face?

```
 - (void)captureOutput:(AVCaptureOutput *)captureOutput
         didOutputMetadataObjects:(NSArray *)metadataObjects
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   for ( AVMetadataObject *object in metadataObjects ) {

     if ( [[object type] isEqual:AVMetadataObjectTypeFace] ) {

       CMTime timestamp = [face time];
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       // Do interesting things with this face
     }
   }
}
```

Face Detection

AVFaceMetadataObject

Face Detection

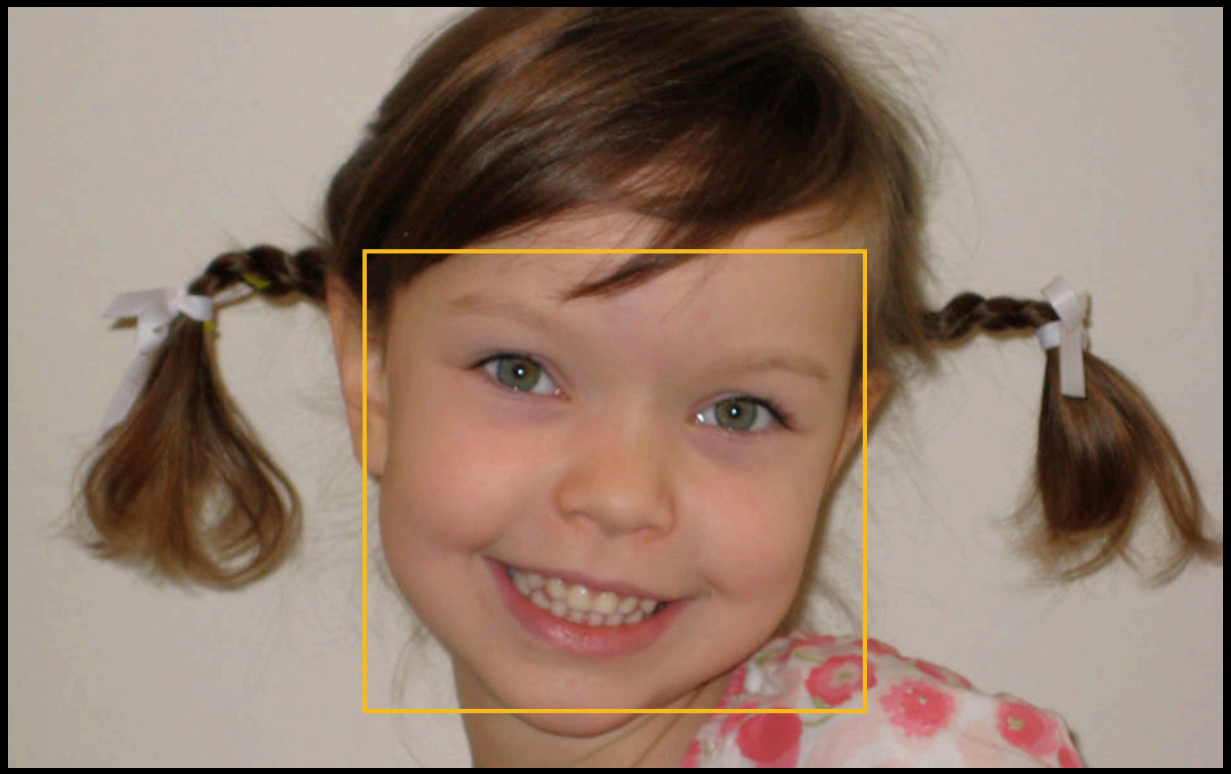
AVFaceMetadataObject

- Face bounds extend from above the eye brows to below the lips

Face Detection

AVFaceMetadataObject

- Face bounds extend from above the eye brows to below the lips



Face Detection

AVFaceMetadataObject

- Face bounds extend from above the eye brows to below the lips
- CGRect coordinates are scalar values from 0 to 1

Face Detection

AVFaceMetadataObject

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- Face bounds extend from above the eye brows to below the lips
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- CGRect coordinates refer to an untransformed source picture

Face Detection

AVFaceMetadataObject

- Face bounds extend from above the eye brows to below the lips
- CGRect coordinates are scalar values from 0 to 1
- CGRect origin is top-left
- CGRect coordinates refer to an untransformed source picture
- CIFaceDetector and AVCaptureMetadataOutput rectangles are comparable in size and origin

Face Detection

Still image support

Face Detection

Still image support

- When using AVCaptureMetadataOutput + AVCaptureStillImageOutput, face rectangles are included with the still image Exif metadata

Face Detection

Still image support

- When using AVCaptureMetadataOutput + AVCaptureStillImageOutput, face rectangles are included with the still image Exif metadata
- Still image output's `-jpegStillImageNSDataRepresentation:` preserves face metadata in XMP Regions

```
[stillImageOutput captureStillImageAsynchronouslyFromConnection:connection
                                                completionHandler:
     ^(CMSampleBufferRef imageSampleBuffer, NSError *error) {
        if ( ! error ) {
           NSData *jpegData = [AVCaptureStillImageOutput
                 jpegStillImageNSDataRepresentation:imageSampleBuffer];

           // Write to disk or AssetsLibrary
     }
```

Face Detection

Still image support

- When using AVCaptureMetadataOutput + AVCaptureStillImageOutput, face rectangles are included with the still image Exif metadata
- Still image output's `-jpegStillImageNSDataRepresentation:` preserves face metadata in XMP Regions

```
[stillImageOutput captureStillImageAsynchronouslyFromConnection:connection
                                                completionHandler:
     ^(CMSampleBufferRef imageSampleBuffer, NSError *error) {
        if ( ! error ) {
           NSData *jpegData = [AVCaptureStillImageOutput
                 jpegStillImageNSDataRepresentation:imageSampleBuffer];

           // Write to disk or AssetsLibrary
     }
```

Face Detection

Supported platforms

iPhone 4S	✓
iPad 2	✓
The new iPad	✓

New in iOS 6

- Video stabilization
- Real-time face detection
- AVCaptureVideoPreviewLayer enhancements

AVCaptureVideoPreviewLayer enhancements

- Conversion methods for focus and exposure points of interest

AVCaptureVideoPreviewLayer enhancements

- Conversion methods for focus and exposure points of interest

ID: 10118665

Title: [API] AVFoundation: Setting focus and exposure points of interest is ridiculously hard

AVCaptureVideoPreviewLayer enhancements

- Conversion methods for focus and exposure points of interest

ID: 10118665

Title: [API] AVFoundation: Setting focus and exposure points of interest is ridiculously hard

"Setting an AVCaptureDevice's focusPointOfInterest and exposurePointOfInterest requires a CGPoint between {0,0} and {1,1}, in a totally arbitrary space, regardless of device orientation. This makes using said API extremely difficult."

AVCaptureVideoPreviewLayer Enhancements

AVCaptureDevice pointOfInterest review

AVCaptureVideoPreviewLayer Enhancements

AVCaptureDevice pointOfInterest review

- `focusPointOfInterest` is a CGPoint from {0, 0} to {1, 1}

AVCaptureVideoPreviewLayer Enhancements

AVCaptureDevice pointOfInterest review

- `focusPointOfInterest` is a CGPoint from {0, 0} to {1, 1}
- Top-left is {0,0}, bottom-right is {1,1}

AVCaptureVideoPreviewLayer Enhancements

AVCaptureDevice pointOfInterest review

- `focusPointOfInterest` is a CGPoint from {0, 0} to {1, 1}
- Top-left is {0,0}, bottom-right is {1,1}
- Camera sensor native (unrotated) orientation is landscape

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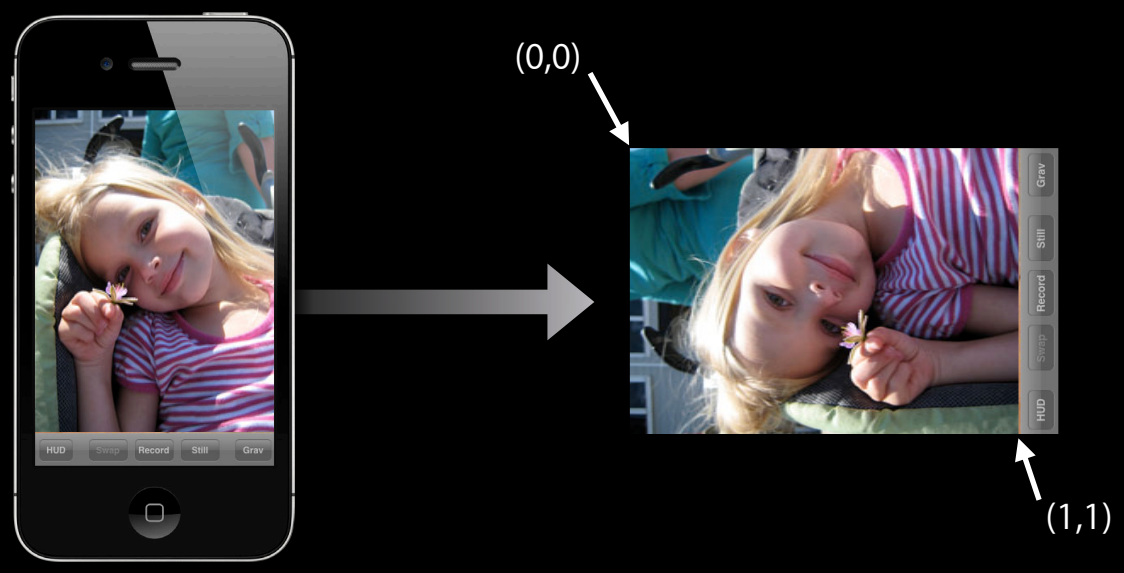

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

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What makes coordinate conversion so hard?

- Preview may be rotated (videoOrientation)

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- Preview may be rotated (videoOrientation)
- Preview may be mirrored (videoMirrored)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- Preview may be rotated (videoOrientation)
- Preview may be mirrored (videoMirrored)
- Preview bounds rect may not have the same aspect ratio as the sensor video buffers (bounds)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- Preview may be rotated (videoOrientation)
- Preview may be mirrored (videoMirrored)
- Preview bounds rect may not have the same aspect ratio as the sensor video buffers (bounds)
- Preview may stretch, shrink, crop, or letterbox the source content (videoGravity)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- AVLayerVideoGravityResizeAspect
- “Letterbox mode"

AVCaptureVideoPreviewLayer Enhancements

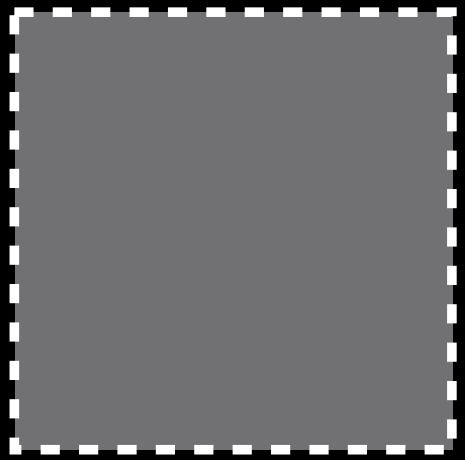
What makes coordinate conversion so hard?

- AVLayerVideoGravityResizeAspect
- “Letterbox mode"

1280 x 720 Source Image

+

640 x 640 Settings



AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- AVLayerVideoGravityResizeAspect
- “Letterbox mode"

1280 x 720 Source Image

+

640 x 640 Settings

=

640 x 640 (with black bars)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- AVLayerVideoGravityResizeAspectFill
- “Crop mode"

1280 x 720 Source Image

AVCaptureVideoPreviewLayer Enhancements

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- AVLayerVideoGravityResizeAspectFill
- “Crop mode"

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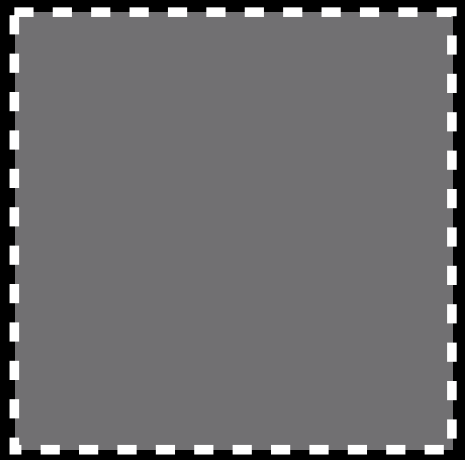
=



640 x 640 (cropped)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- AVLayerVideoGravityResizeAspectFill
- “Crop mode"

1280 x 720 Source Image

+

640 x 640 Settings

=

640 x 640 (cropped)

AVCaptureVideoPreviewLayer Enhancements

What makes coordinate conversion so hard?

- AVLayerVideoGravityResize
- “Funhouse mode"

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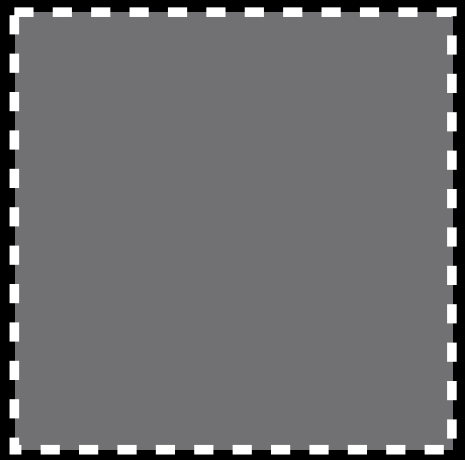

AVCaptureVideoPreviewLayer Enhancements

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- AVLayerVideoGravityResize
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640 x 640 Settings

=

640 x 640

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

- Convert from a touch point to an AVCaptureDevice point of interest

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

- Convert from a touch point to an AVCaptureDevice point of interest

```
// Set point of interest
CGPoint tapPoint = [gestureRecognizer locationInView:previewView];
CGPoint convertedPoint =
  [videoPreviewLayer captureDevicePointOfInterestForPoint:tapPoint]
[captureDevice setFocusPointOfInterest:convertedPoint];
```

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

- Convert from a touch point to an AVCaptureDevice point of interest

```
// Set point of interest
CGPoint tapPoint = [gestureRecognizer locationInView:previewView];
CGPoint convertedPoint =
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[captureDevice setFocusPointOfInterest:convertedPoint];
```

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

- Convert from an AVCaptureDevice point of interest to a touch point

```
// Get the current point of interest to draw on preview layer
CGPoint poi = [device focusPointOfInterest];
CGPoint layerPoint =
  [videoPreviewLayer pointForCaptureDevicePointOfInterest:poi];

// Draw something at layerPoint
```

AVCaptureVideoPreviewLayer Enhancements

Conversion methods to the rescue

- Convert from an AVCaptureDevice point of interest to a touch point

```
// Get the current point of interest to draw on preview layer
CGPoint poi = [device focusPointOfInterest];
CGPoint layerPoint =
  [videoPreviewLayer pointForCaptureDevicePointOfInterest:poi];

// Draw something at layerPoint
```

AVMetadataObject Conversion For Preview

AVMetadataObject Conversion For Preview

- Convert face metadata for video preview layer drawing

```
for ( AVMetadataFaceObject *face in metadataObjects ) {
  AVMetadataFaceObject *transformedFace =
    [previewLayer transformedMetadataObjectForMetadataObject:face];
  CGRect transformedFaceRect = [transformedFace bounds];

  // Draw a funny mustache on the face
}
```

AVMetadataObject Conversion For Preview

- Convert face metadata for video preview layer drawing

```
for ( AVMetadataFaceObject *face in metadataObjects ) {
  AVMetadataFaceObject *transformedFace =
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AVMetadataObject Conversion for Output

AVMetadataObject Conversion for Output

- Convert face metadata for AVCaptureOutput drawing

AVMetadataObject Conversion for Output

- Convert face metadata for AVCaptureOutput drawing
- Align faces with physically rotated video data output

```
for ( AVMetadataFaceObject *face in metadataObjects ) {
  AVCaptureConnection *c = [vdo connectionWithMediaType:AVMediaTypeVideo];
  AVMetadataFaceObject *transformedFace =
    [vdo transformedMetadataObjectForMetadataObject:face connection:c];
  CGRect transformedFaceRect = [transformedFace bounds];

  // Draw a funny mustache on the face
}
```

AVMetadataObject Conversion for Output

- Convert face metadata for AVCaptureOutput drawing
- Align faces with physically rotated video data output

```
for ( AVMetadataFaceObject *face in metadataObjects ) {
  AVCaptureConnection *c = [vdo connectionWithMediaType:AVMediaTypeVideo];
  AVMetadataFaceObject *transformedFace =
    [vdo transformedMetadataObjectForMetadataObject:face connection:c];
  CGRect transformedFaceRect = [transformedFace bounds];

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}
```

AVCaptureVideoPreviewLayer Enhancements

Pause and resume video preview

- AVCaptureVideoPreviewLayer exposes an AVCaptureConnection

AVCaptureVideoPreviewLayer Enhancements

Pause and resume video preview

- AVCaptureVideoPreviewLayer exposes an AVCaptureConnection
- All connection properties are available to the layer

AVCaptureVideoPreviewLayer Enhancements

Pause and resume video preview

- AVCaptureVideoPreviewLayer exposes an AVCaptureConnection
- All connection properties are available to the layer
- To pause video preview, disable the connection

AVCaptureVideoPreviewLayer Enhancements

Pause and resume video preview

- AVCaptureVideoPreviewLayer exposes an AVCaptureConnection
- All connection properties are available to the layer
- To pause video preview, disable the connection
- Causes no glitch in any of the outputs

```
AVCaptureConnection *previewConnection = [videoPreviewLayer connection];

// pause preview
[previewConnection setEnabled:NO];
```

AVCaptureVideoPreviewLayer Enhancements

Pause and resume video preview

- AVCaptureVideoPreviewLayer exposes an AVCaptureConnection
- All connection properties are available to the layer
- To pause video preview, disable the connection
- Causes no glitch in any of the outputs

```
AVCaptureConnection *previewConnection = [videoPreviewLayer connection];

// pause preview
[previewConnection setEnabled:NO];
```

AVCaptureVideoPreviewLayer

Deprecations

AVCaptureVideoPreviewLayer

Deprecations

- Preview layer's `-connection` property makes some methods redundant

AVCaptureVideoPreviewLayer

Deprecations

- Preview layer's `-connection` property makes some methods redundant
- See AVCaptureVideoPreviewLayer.h

AVCaptureVideoPreviewLayer

Deprecations

- Preview layer's `-connection` property makes some methods redundant
- See AVCaptureVideoPreviewLayer.h

Deprecated	Instead Use
	`conn = [layer connection];`
`layer.isOrientationSupported`	`conn.isVideoOrientationSupported`
`layer.orientation`	`conn.videoOrientation`
`layer.isMirroringSupported`	`conn.isVideoMirroringSupported`
`layer.automaticallyAdjustsMirroring`	`conn.automaticallyAdjustsVideoMirroring`
`layer.isMirrored`	`conn.isVideoMirrored`

Miscellaneous API Enhancements

- AVCaptureDevice's `-torchActive` property
- AVCaptureDevice's `-setTorchModeOnWithLevel:error:` method
- AVCaptureStillImageOutput's support for AVVideoQualityKey

What You Will Learn

- Performance improvements in Mac OS X 10.8
- Camera ecosystem
- New AV Foundation capture features in iOS 6
- Solutions for performance problems in your capture app
- Synchronizing motion data with video

Solutions for Performance Problems

Solving Performance Problems

Common performance problems

Solving Performance Problems

Common performance problems

- My app is dropping frames during video capture

Solving Performance Problems

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- My app is dropping frames during video capture
  - Is it my fault?

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- My app is dropping frames during video capture
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  - What can I do to recover?

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Solving Performance Problems

Common performance problems

- My app is dropping frames during video capture
  - Is it my fault?
  - What can I do to recover?
- My AVAssetWriter recorded movies have frame drops at the beginning
- My AVAssetWriter recorded movies have garbage (I use OpenGL)

Solving Performance Problems

Common performance problems

- My app is dropping frames during video capture
  - Is it my fault?
  - What can I do to recover?
- My AVAssetWriter recorded movies have frame drops at the beginning
- My AVAssetWriter recorded movies have garbage (I use OpenGL)
- My DIY preview is slow

Solving Performance Problems

Common performance problems

- My app is dropping frames during video capture
  - Is it my fault?
  - What can I do to recover?
- My AVAssetWriter recorded movies have frame drops at the beginning
- My AVAssetWriter recorded movies have garbage (I use OpenGL)
- My DIY preview is slow
  - How do I speed it up?

Solving Performance Problems

Handling frame drops

Solving Performance Problems

Handling frame drops

- Set AVCaptureVideoDataOutput's `-alwaysDiscardsLateVideoFrames` to YES

Solving Performance Problems

Handling frame drops

- Set AVCaptureVideoDataOutput's `-alwaysDiscardsLateVideoFrames` to YES
  - Unless you are recording

Solving Performance Problems

Handling frame drops

- Set AVCaptureVideoDataOutput's `-alwaysDiscardsLateVideoFrames` to YES
  - Unless you are recording
  - Enforces a buffer queue size of 1 at the end of video data output's processing pipeline

Solving Performance Problems

Handling frame drops

- Set AVCaptureVideoDataOutput's `-alwaysDiscardsLateVideoFrames` to YES
  - Unless you are recording
  - Enforces a buffer queue size of 1 at the end of video data output's processing pipeline
  - Saves you from periodically slow processing

Solving Performance Problems

Handling frame drops

- Set AVCaptureVideoDataOutput's `-alwaysDiscardsLateVideoFrames` to YES
  - Unless you are recording
  - Enforces a buffer queue size of 1 at the end of video data output's processing pipeline
  - Saves you from periodically slow processing
  - Does not save you from chronically slow processing

Solving Performance Problems

Handling frame drops

Solving Performance Problems

Handling frame drops

- New in iOS 6, AVCaptureVideoDataOutput can report frame drops

```
// New optional AVCaptureVideoDataOutputDelegate method
- (void)captureOutput:(AVCaptureOutput *)captureOutput
    didDropSampleBuffer:(CMSampleBufferRef)sampleBuffer
         fromConnection:(AVCaptureConnection *)connection
{
    // We just dropped a frame!

}
```

Solving Performance Problems

Handling frame drops

- New in iOS 6, AVCaptureVideoDataOutput can report frame drops

```
// New optional AVCaptureVideoDataOutputDelegate method
- (void)captureOutput:(AVCaptureOutput *)captureOutput
    didDropSampleBuffer:(CMSampleBufferRef)sampleBuffer
         fromConnection:(AVCaptureConnection *)connection
{
    // We just dropped a frame!

}
```

Solving Performance Problems

Handling frame drops

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data
- Does contain timing information and format description

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data
- Does contain timing information and format description
- Does contain `kCMSampleBufferAttachmentKey_DroppedFrameReason`

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data
- Does contain timing information and format description
- Does contain `kCMSampleBufferAttachmentKey_DroppedFrameReason`
  - `kCMSampleBufferDroppedFrameReason_FrameWasLate`

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data
- Does contain timing information and format description
- Does contain `kCMSampleBufferAttachmentKey_DroppedFrameReason`
  - `kCMSampleBufferDroppedFrameReason_FrameWasLate`
  - `kCMSampleBufferDroppedFrameReason_OutOfBuffers`

Solving Performance Problems

Handling frame drops

- The didDropSampleBuffer contains no image data
- Does contain timing information and format description
- Does contain `kCMSampleBufferAttachmentKey_DroppedFrameReason`
  - `kCMSampleBufferDroppedFrameReason_FrameWasLate`
  - `kCMSampleBufferDroppedFrameReason_OutOfBuffers`
  - `kCMSampleBufferDroppedFrameReason_Discontinuity`

Solving Performance Problems

Handling frame drops

Solving Performance Problems

Handling frame drops

- Frame drops can be mitigated by lowering the frame rate

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Handling frame drops

- Frame drops can be mitigated by lowering the frame rate
- As of iOS 5, the video data output frame rate can be altered dynamically
- No glitch in preview or output

```
// Lower the min and max frame rate to recover from slow processing
AVCaptureConnection *c = [dataOutput connectionWithMediaType:AVMediaTypeVideo];

// min duration is 1 / max frame rate
int32_t newFrameRate = currentRate - 1;
[c setVideoMinFrameDuration:CMTimeMake( 1, newFrameRate )];
[c setVideoMaxFrameDuration:CMTimeMake( 1, newFrameRate )];
```

Solving Performance Problems

Handling frame drops

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Solving Performance Problems

Solving AVAssetWriter frame drops

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Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput

Solving Performance Problems

Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput
  - Optimized for real-time file writing

Solving Performance Problems

Solving AVAssetWriter frame drops

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  - Optimized for real-time file writing
  - Preallocates buffers for glitch free movie writing

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- AVAssetWriter

Solving Performance Problems

Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput
  - Optimized for real-time file writing
  - Preallocates buffers for glitch free movie writing
- AVAssetWriter
  - Does not know the source format

Solving Performance Problems

Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput
  - Optimized for real-time file writing
  - Preallocates buffers for glitch free movie writing
- AVAssetWriter
  - Does not know the source format
  - Cannot prime the render pipeline

Solving Performance Problems

Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput
  - Optimized for real-time file writing
  - Preallocates buffers for glitch free movie writing
- AVAssetWriter
  - Does not know the source format
  - Cannot prime the render pipeline
  - Sets things up on the first `-appendSampleBuffer:`

Solving Performance Problems

Solving AVAssetWriter frame drops

- AVCaptureMovieFileOutput
  - Optimized for real-time file writing
  - Preallocates buffers for glitch free movie writing
- AVAssetWriter
  - Does not know the source format
  - Cannot prime the render pipeline
  - Sets things up on the first `-appendSampleBuffer:`
  - Result: dropped frames at the very beginning

Solving Performance Problems

Solving AVAssetWriter frame drops

Solving Performance Problems

Solving AVAssetWriter frame drops

- Set AVAssetWriterInput's `-expectsMediaDataInRealTime` flag to YES

Solving Performance Problems

Solving AVAssetWriter frame drops

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- New in iOS 6, AVAssetWriterInput allows you to hint the source format up front

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Solving AVAssetWriter frame drops

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```
+ (AVAssetWriterInput *)assetWriterInputWithMediaType:(NSString *)mediaType
```

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Solving AVAssetWriter frame drops

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```
+ (AVAssetWriterInput *)assetWriterInputWithMediaType:(NSString *)mediaType
     outputSettings:(NSDictionary *)outputSettings
```

Solving Performance Problems

Solving AVAssetWriter frame drops

- Set AVAssetWriterInput's `-expectsMediaDataInRealTime` flag to YES
- New in iOS 6, AVAssetWriterInput allows you to hint the source format up front

```
+ (AVAssetWriterInput *)assetWriterInputWithMediaType:(NSString *)mediaType
     outputSettings:(NSDictionary *)outputSettings
     sourceFormatHint:(CMFormatDescriptionRef)sourceFormatHint;
```

Solving Performance Problems

Solving AVAssetWriter frame drops

- Set AVAssetWriterInput's `-expectsMediaDataInRealTime` flag to YES
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```

- Start up costs move to [AVAssetWriter startWriting]

Solving Performance Problems

Solving AVAssetWriter frame drops

- Set AVAssetWriterInput's `-expectsMediaDataInRealTime` flag to YES
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      outputSettings:(NSDictionary *)outputSettings
      sourceFormatHint:(CMFormatDescriptionRef)sourceFormatHint;
```

- Start up costs move to [AVAssetWriter startWriting]
- Set up your AVAssetWriter outside of `-captureOutput:didOutputSampleBuffer:fromConnection:`

Solving Performance Problems

Rendering with OpenGL, writing to AVAssetWriter

Solving Performance Problems

Rendering with OpenGL, writing to AVAssetWriter

- When rendering to a texture using CVOpenGLESTextureCache, ensure GL has finished rendering before passing to AVAssetWriter

Solving Performance Problems

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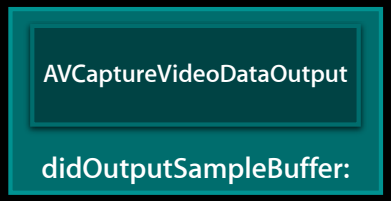
- When rendering to a texture using CVOpenGLESTextureCache, ensure GL has finished rendering before passing to AVAssetWriter
- `glFinish()` is safe but may block

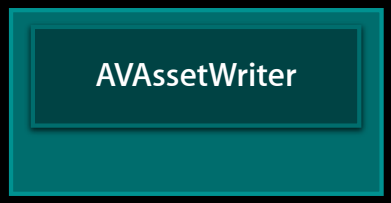
Solving Performance Problems

Rendering with OpenGL, writing to AVAssetWriter

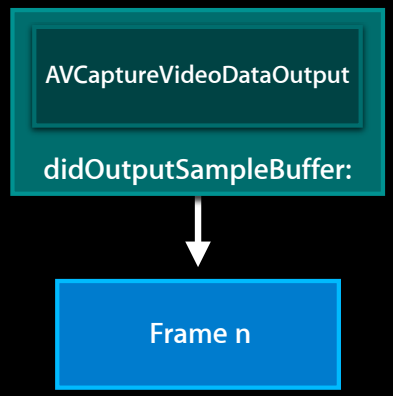
- When rendering to a texture using CVOpenGLESTextureCache, ensure GL has finished rendering before passing to AVAssetWriter
- `glFinish()` is safe but may block
- `glFlush()` + delayed `glFinish()` keeps both GPU and CPU busy

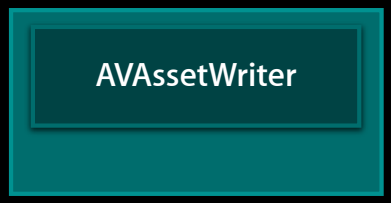
Solving Performance Problems



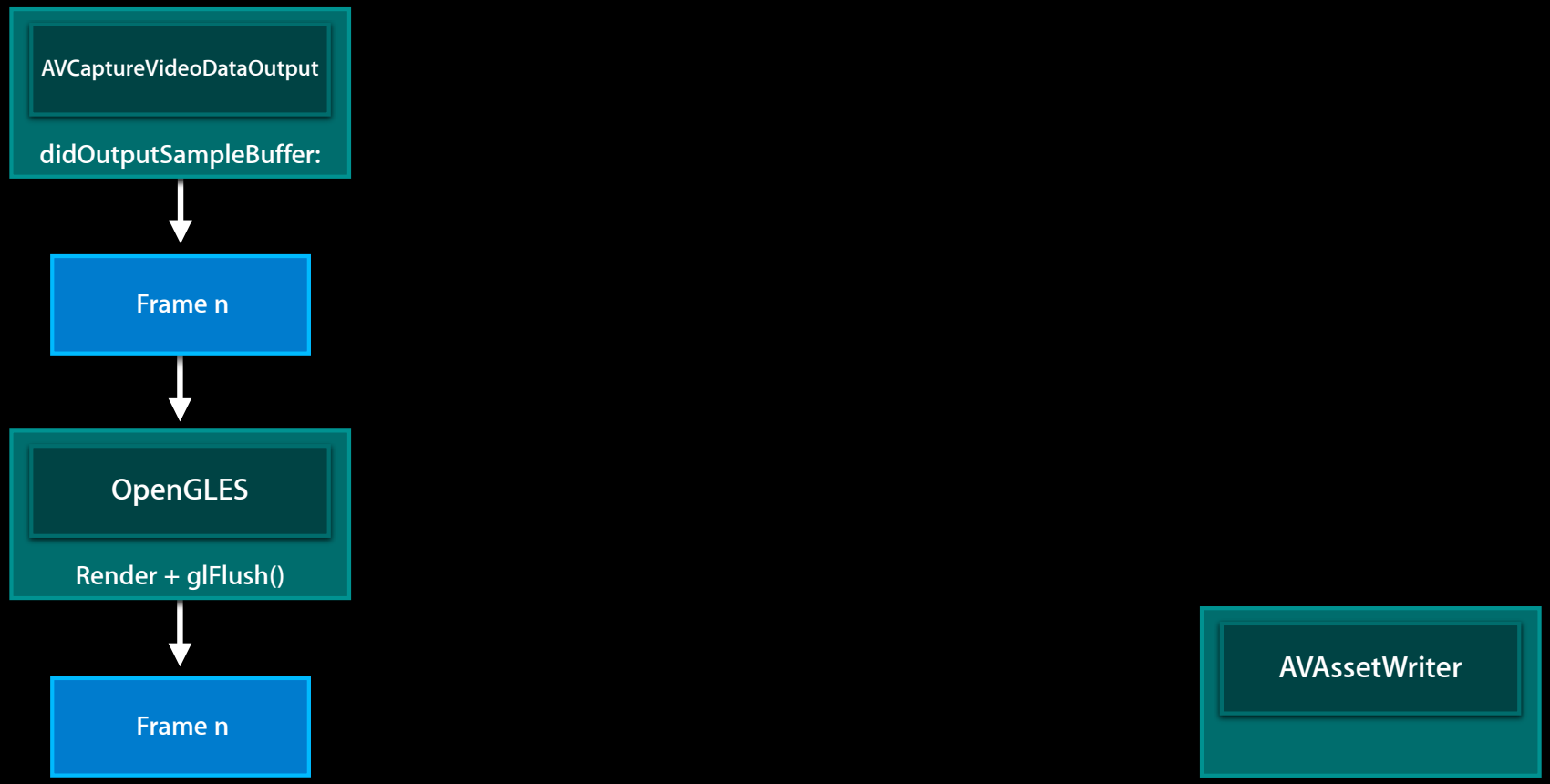


Solving Performance Problems

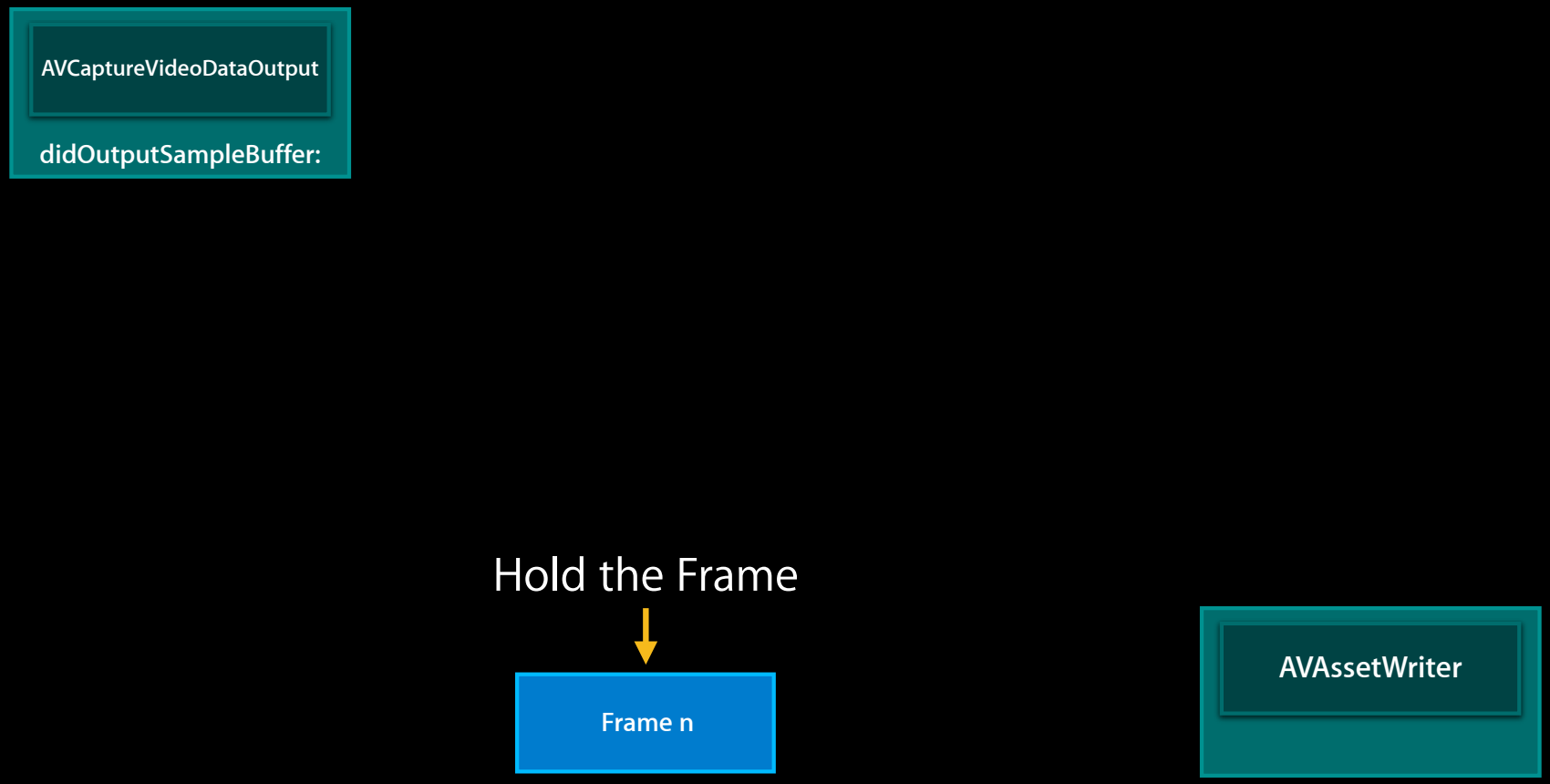




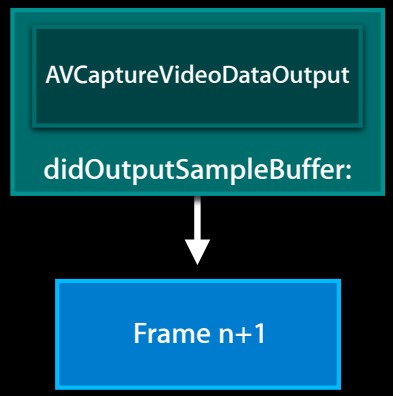
Solving Performance Problems

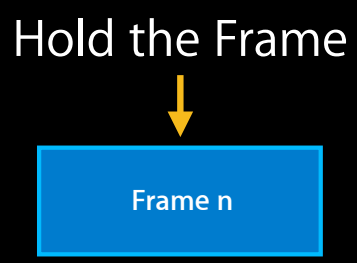


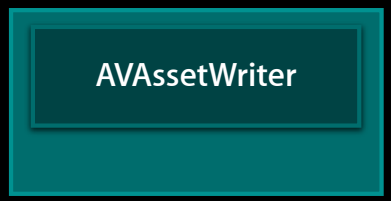
Solving Performance Problems



Solving Performance Problems







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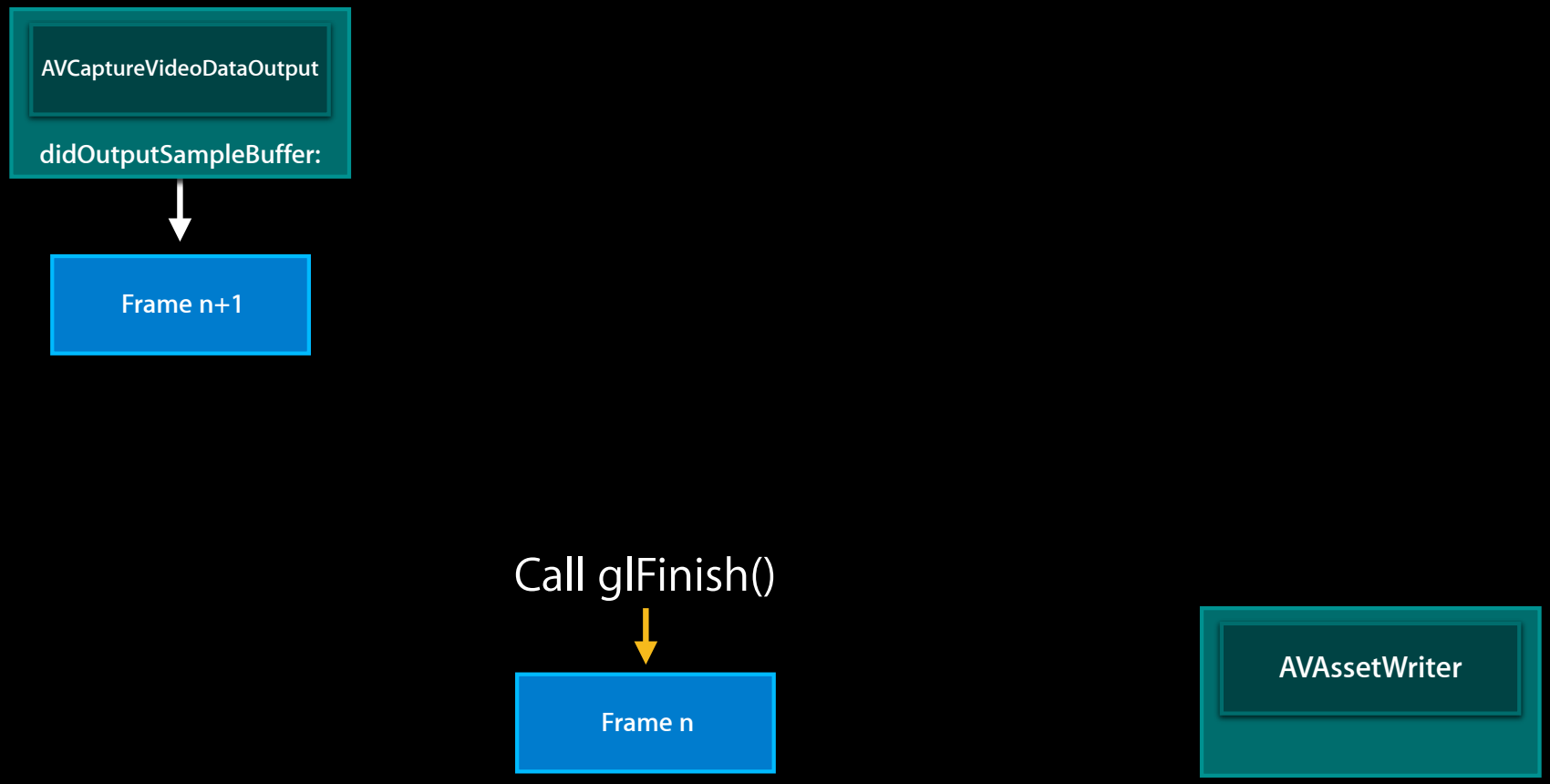

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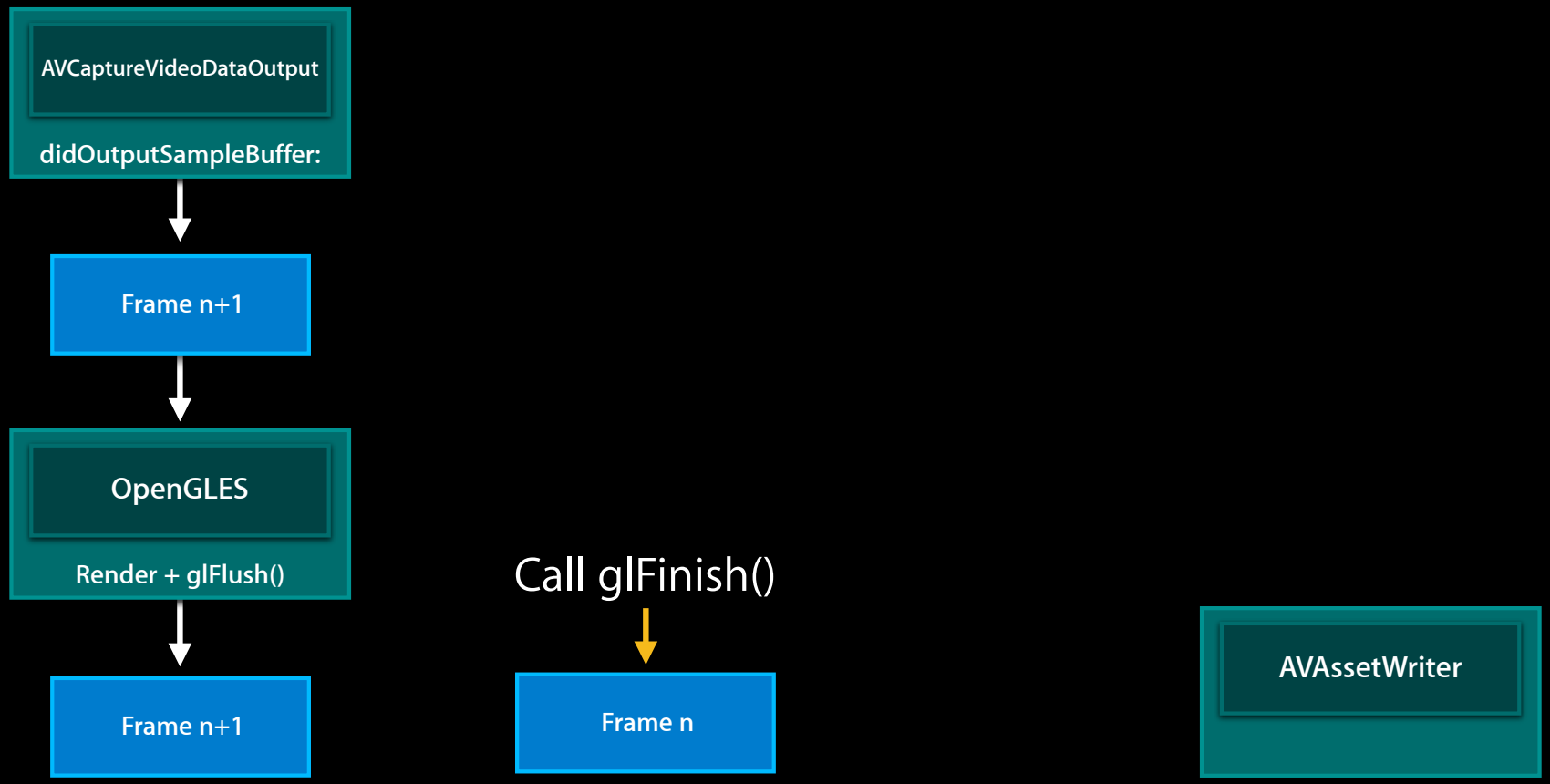

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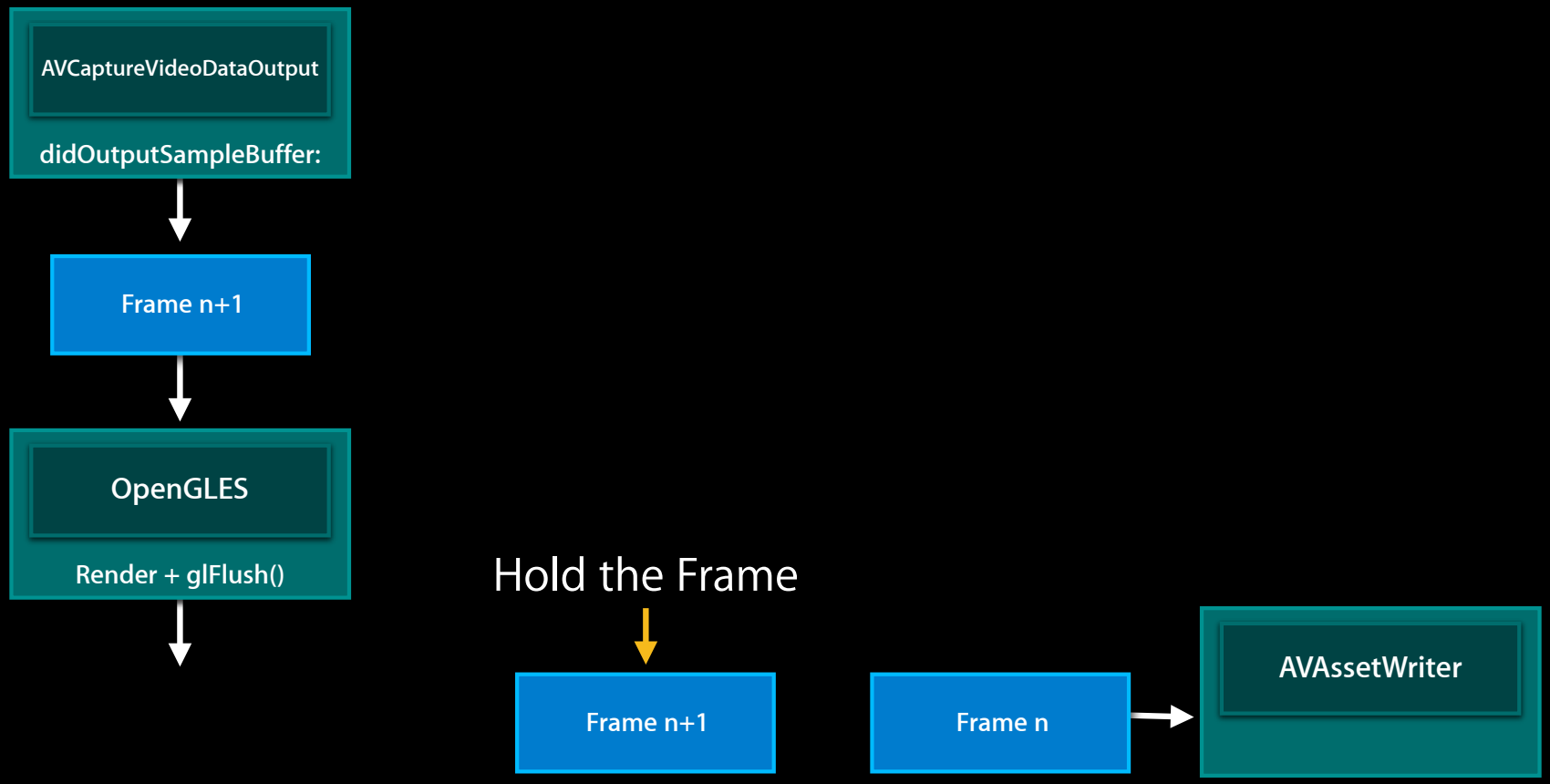

Solving Performance Problems

Rendering with OpenGL, writing to AVAssetWriter

Solving Performance Problems

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- `glFlush()` is not necessary if you present the render buffer for preview

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- In iOS 6, `glFinish()` is not necessary

Solving Performance Problems

Rendering with OpenGL, writing to AVAssetWriter

- `glFlush()` is not necessary if you present the render buffer for preview
- In iOS 6, `glFinish()` is not necessary
- AVAssetWriter ensures the GPU rendering is complete before writing

Solving Performance Problems

How to draw my own preview (fast!)

Solving Performance Problems

How to draw my own preview (fast!)

- Use AVCaptureVideoPreviewLayer + your own CALayers for simple overlays

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- Review GLCameraRipple sample code
  - Operates in '420v'
- Review RosyWriter sample code
  - Operates in 'BGRA'

What You Will Learn

- Performance improvements in Mac OS X 10.8
- Camera ecosystem
- New AV Foundation capture features in iOS 6
- Solutions for performance problems in your capture app
- Synchronizing motion data with video

Synchronizing Motion Data with Video

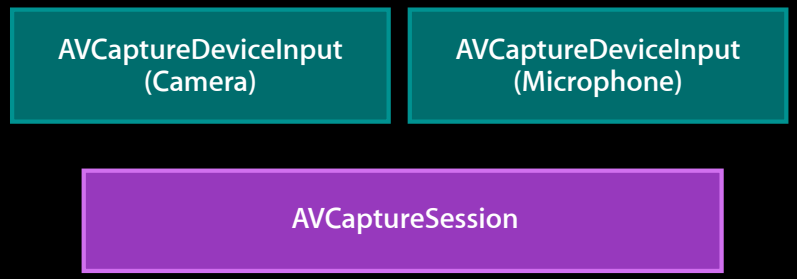
Demo

VideoSnake

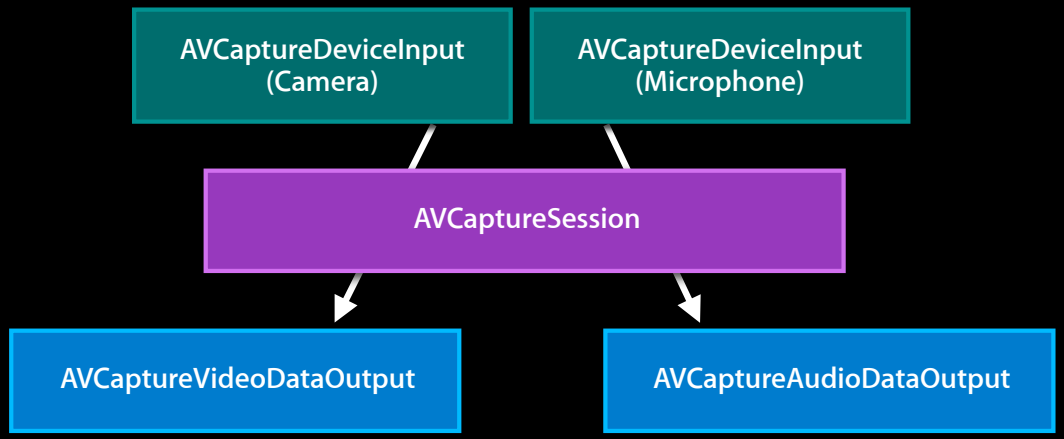
Walker Eagleston
Core Media Engineering

VideoSnake

VideoSnake


AVCaptureDeviceInput
(Camera)
AVCaptureDeviceInput
(Microphone)
AVCaptureSession

VideoSnake


AVCaptureDeviceInput
(Camera)
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AVCaptureVideoDataOutput
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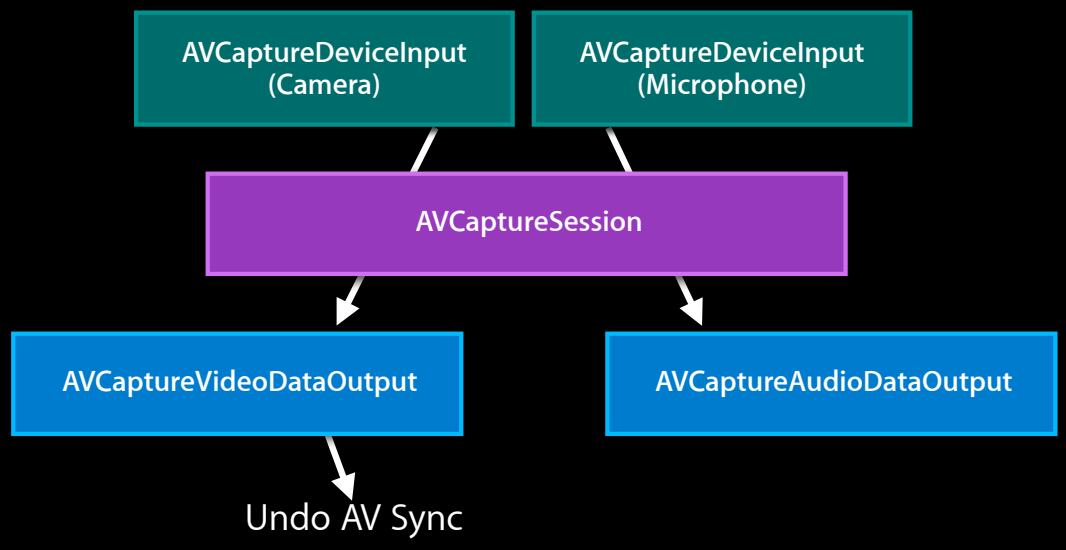
AVCaptureDeviceInput
(Camera)
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AVCaptureSession
AVCaptureVideoDataOutput
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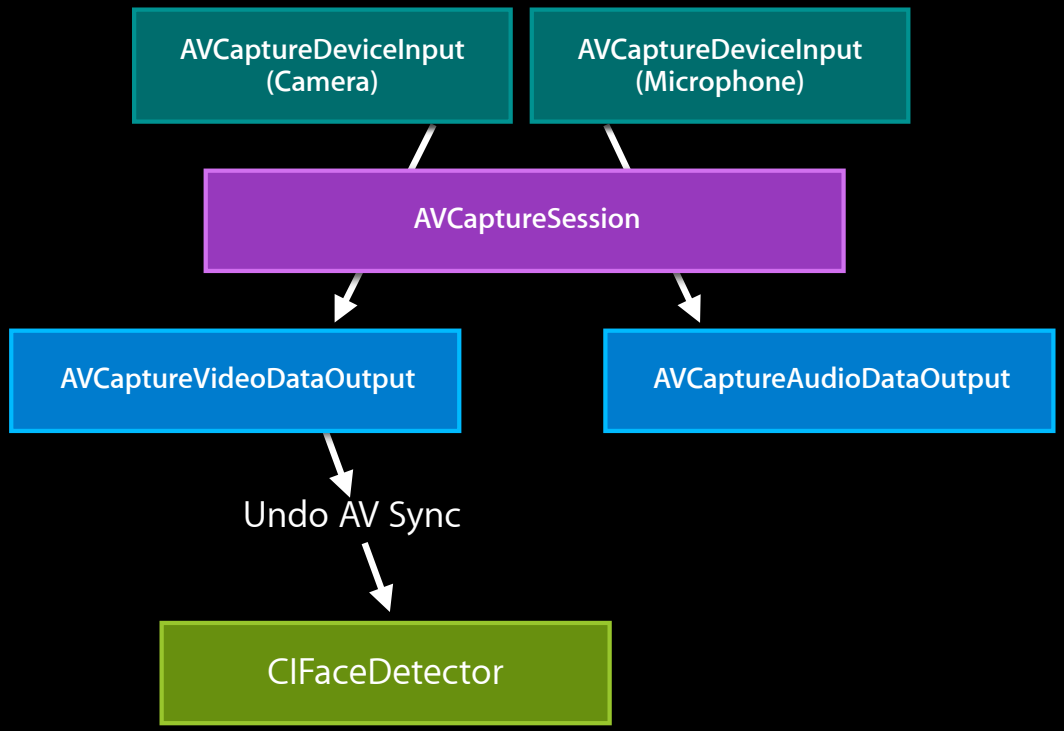
Undo AV Sync

VideoSnake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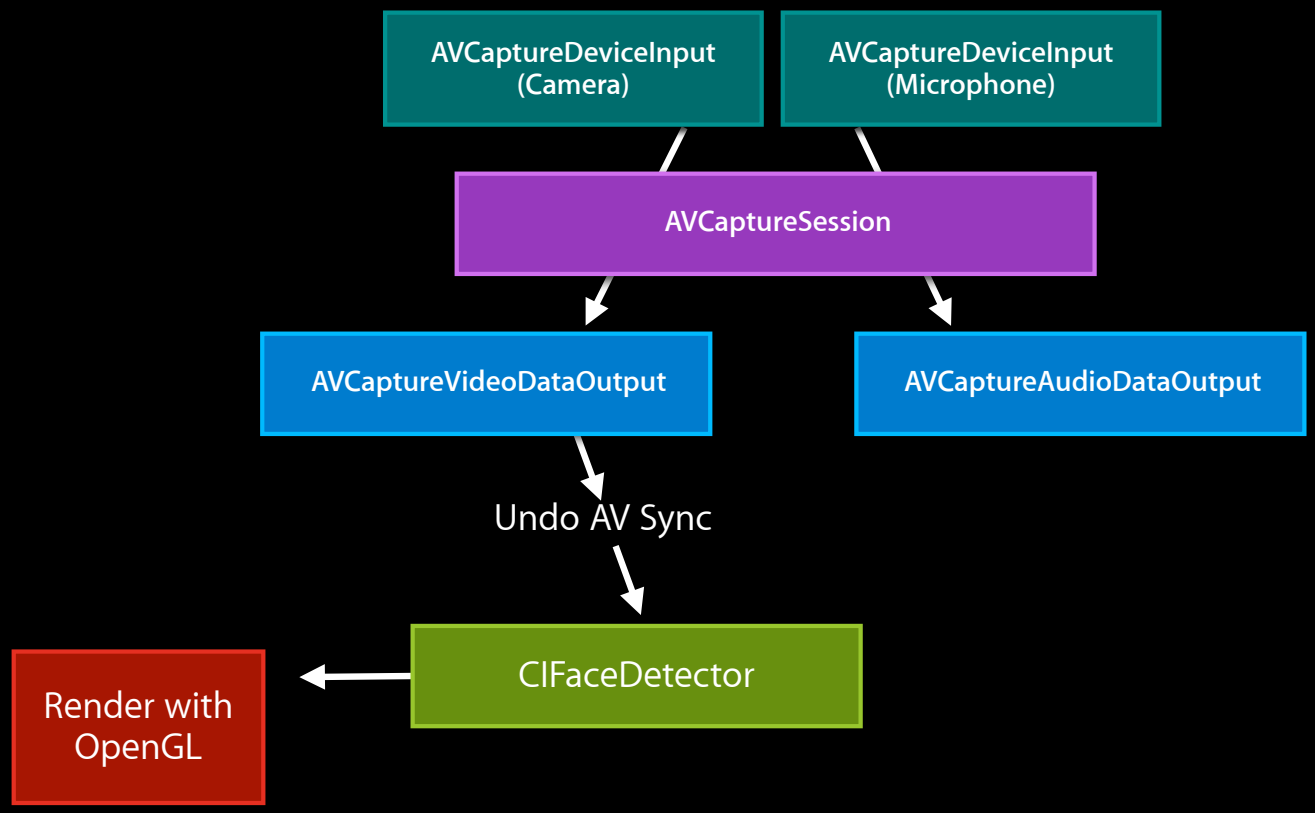
Undo AV Sync
CIFaceDetector

VideoSnake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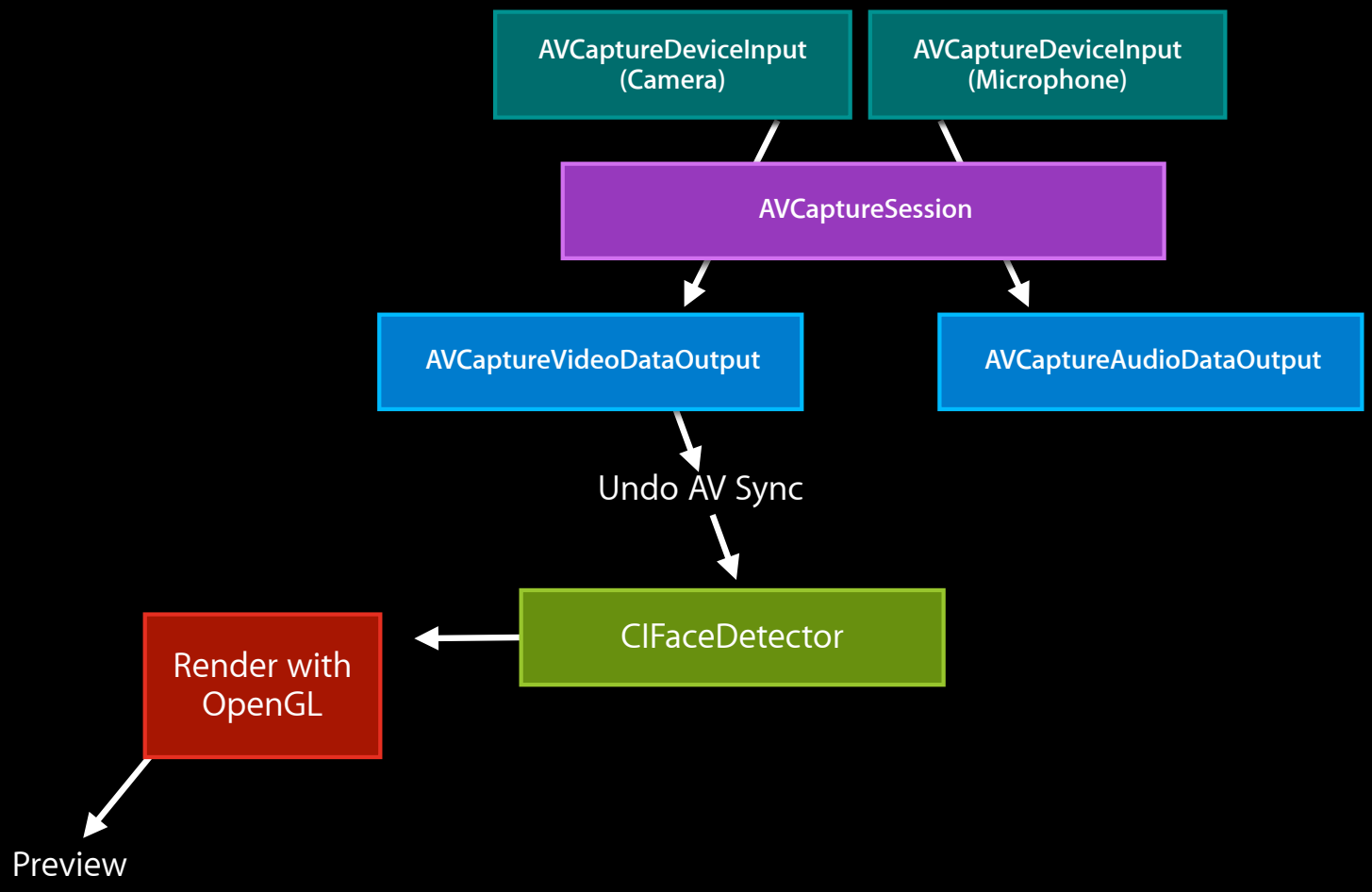
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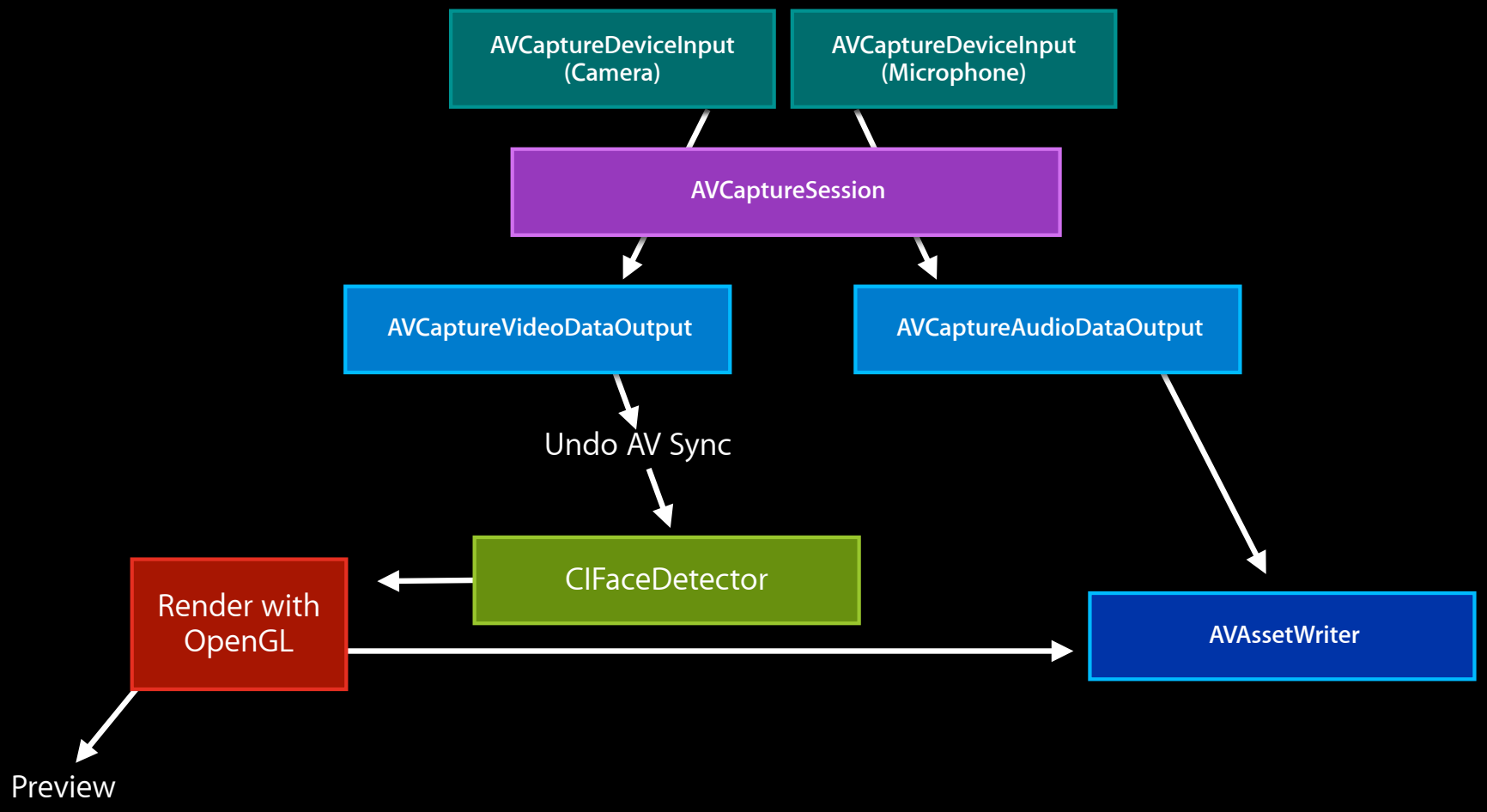
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AVCaptureAudioDataOutput
Undo AV Sync
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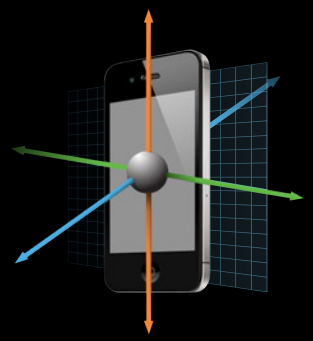
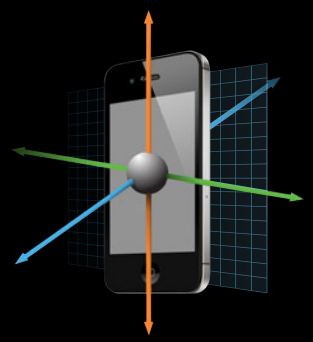
Render with
OpenGL
AVAssetWriter
Preview

Synchronizing Motion Data with Video

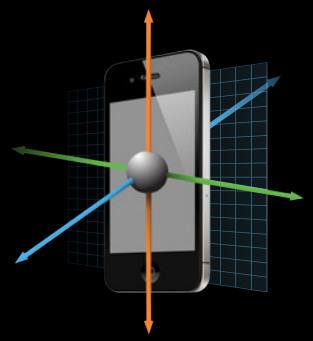
Synchronizing Motion Data with Video



Synchronizing Motion Data with Video



Synchronizing Motion Data with Video



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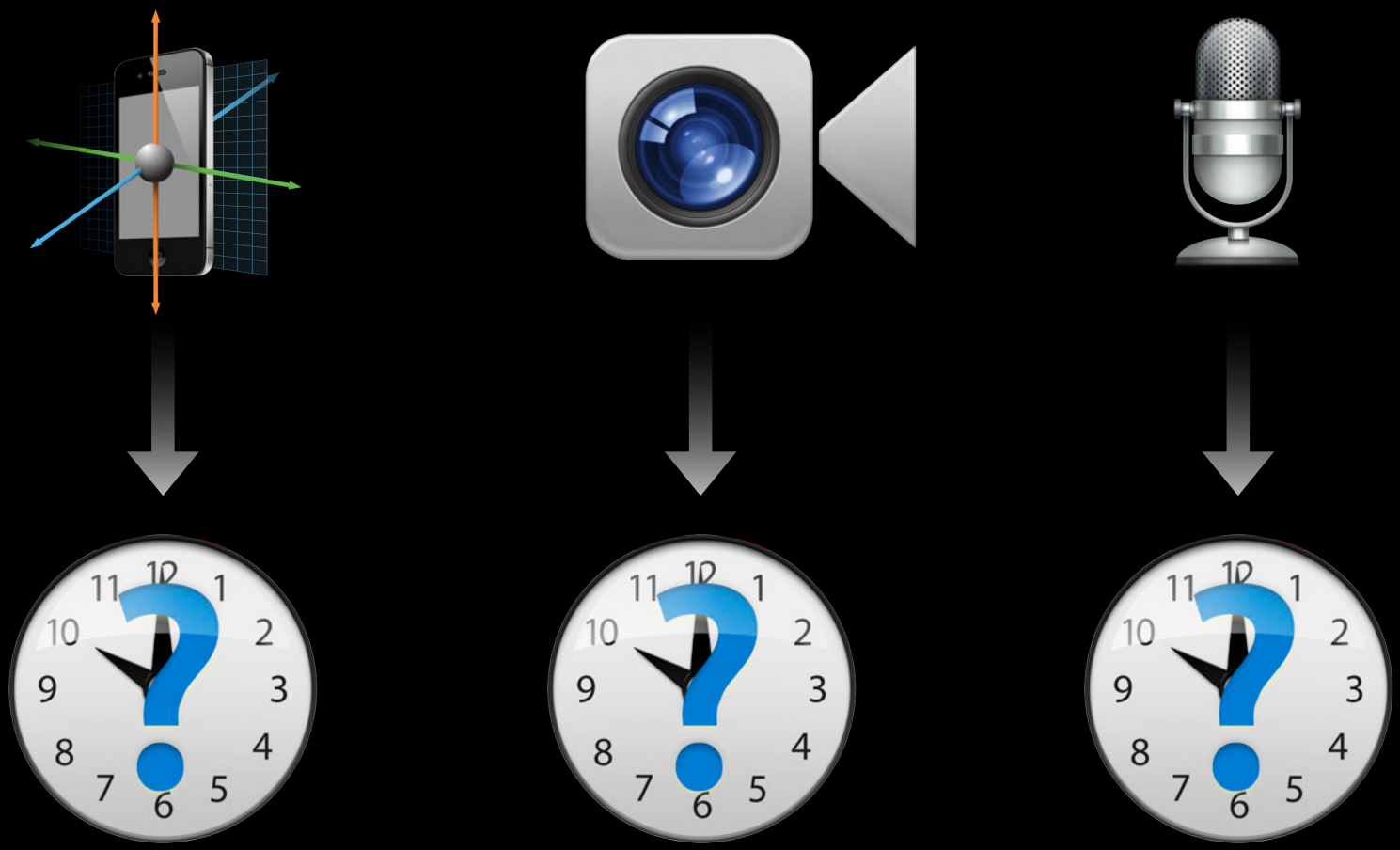

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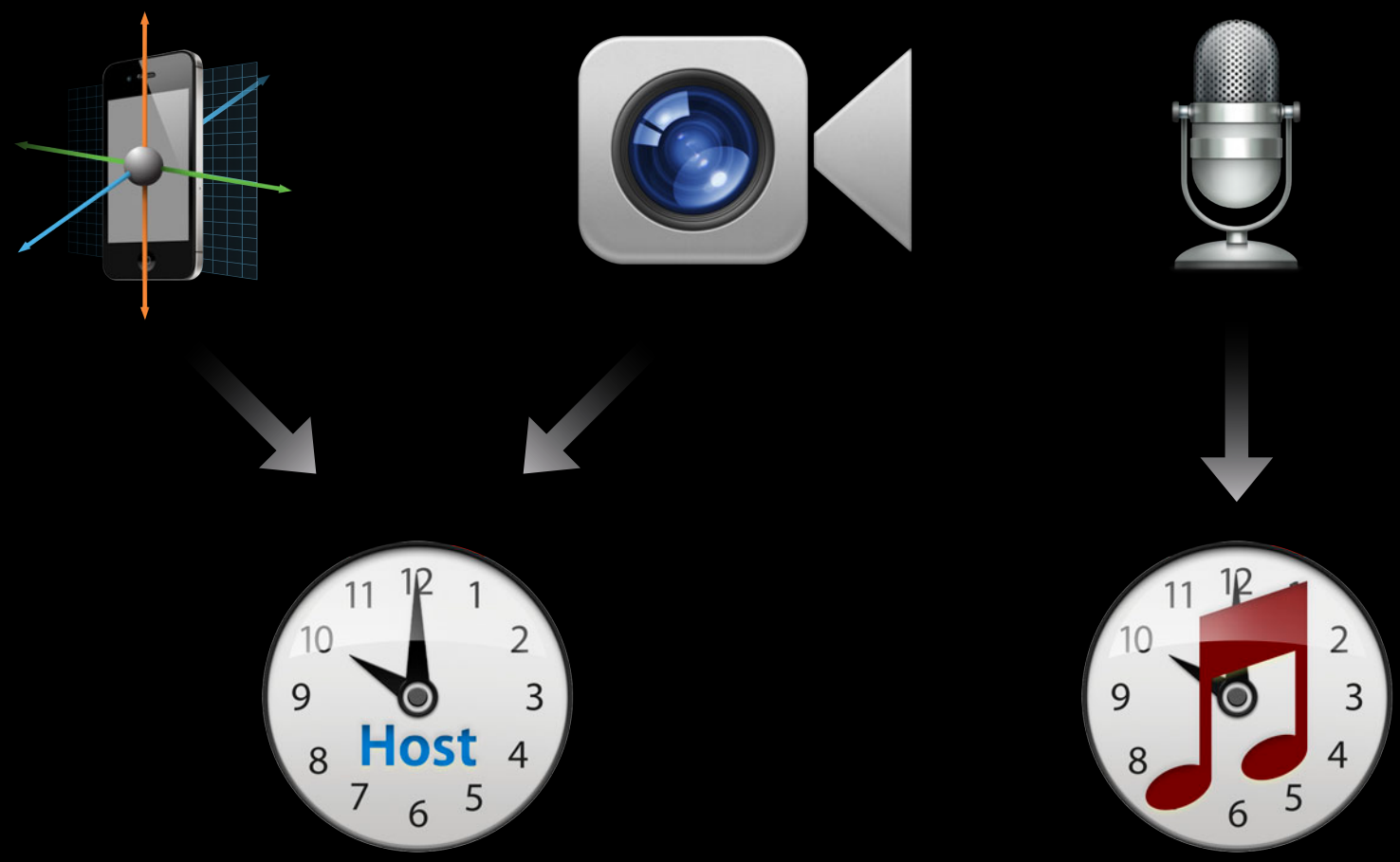

Synchronizing Motion Data with Video

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- CoreMotion samples contain a timestamp

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- CoreMotion uses the host time clock

Synchronizing Motion Data with Video

- CoreMotion samples contain a timestamp

```
NSTimeInterval motionTimestamp = [(CMDeviceMotion *)motion timestamp];
```

- Timestamp is the mach_absolute_time() of the motion
- CoreMotion uses the host time clock
- CoreMotion sampling rate should be at least 2x your video frame rate

Synchronizing Motion Data with Video

Video timestamps

Synchronizing Motion Data with Video

Video timestamps

- Sample buffers contain a timestamp

Synchronizing Motion Data with Video

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```
CMTime pts = CMSampleBufferGetPresentationTime(sampleBuffer);
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Synchronizing Motion Data with Video

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Synchronizing Motion Data with Video

Video timestamps

- Sample buffers contain a timestamp

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```

- Presentation time is the mach_absolute_time() of the frame
- Front and Back Camera AVCaptureDevices use the host time clock

Synchronizing Motion Data with Video

Audio timestamps

Synchronizing Motion Data with Video

Audio timestamps

- Audio sample buffers contain n samples (frames) of audio

Synchronizing Motion Data with Video

Audio timestamps

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Synchronizing Motion Data with Video

Audio timestamps

- Audio sample buffers contain n samples (frames) of audio
- Presentation time is the time at which the first sample in the buffer was picked up by the microphone
- The audio AVCaptureDevice uses the audio clock

Synchronizing Motion Data with Video

A/V Sync

Synchronizing Motion Data with Video

A/V Sync

- Audio clock != video clock

Synchronizing Motion Data with Video

A/V Sync

- Audio clock != video clock
- Audio and video might drift

Synchronizing Motion Data with Video

A/V Sync

- Audio clock != video clock
- Audio and video might drift
- When recording audio, the video sample buffers are synced to the audio (master) clock

Synchronizing Motion Data with Video

A/V Sync

- Audio clock != video clock
- Audio and video might drift
- When recording audio, the video sample buffers are synced to the audio (master) clock
- Re-clocking alters the video timestamps

Synchronizing Motion Data with Video

“Undoing” A/V Sync

Synchronizing Motion Data with Video

“Undoing” A/V Sync

```
CMClockRef audioClock = NULL, videoClock = NULL;
OSStatus err = CMAudioClockCreate( NULL, &audioClock );
videoClock = CMClockGetHostTimeClock();
CMTime pts = CMSampleBufferGetPresentationTime(videoBuffer);
CMTime convertedPTS = CMSyncConvertTime(pts, audioClock, videoClock);
// now match convertedPTS with CoreMotion timestamps
```

Synchronizing Motion Data with Video

“Undoing” A/V Sync

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Summary

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- What's new in camera capture

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  - Mac OS X 10.8 performance improvements

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  - iOS camera ecosystem

Summary

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  - New iOS 6 AV Foundation capture features

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  - Solving performance problems in your capture app
  - Synchronizing motion data with video

More Information

Eryk Vershen
Media Technologies Evangelist
evershen@apple.com

Documentation
AV Foundation Programming Guide
http://developer.apple.com/library/ios/#documentation/AudioVideo/Conceptual/AVFoundationPG/

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

Related Sessions

Audio Session and Multiroute Audio in iOS	Pacific Heights Tuesday 2:00PM
Audio and Video for Media and Games	Presidio Thursday 9:00AM
Understanding Core Motion	Pacific Heights Friday 10:15AM

Labs

OS X Capture Lab	GMG Lab A Tuesday 9:00AM - 1:30PM
AV Foundation Lab	GMG Lab A Tuesday 2:00PM - 6:00 PM
AVAudioSession Lab	GMG Lab D Wednesday 4:30PM - 6:00 PM
iOS Camera Capture Lab	GMG Lab D Thursday 2:00PM - 6:00 PM
AV Foundation Lab	GMG Lab C Thursday 2:00PM - 6:00 PM
iOS Camera Capture Lab	GMG Lab D Friday 9:00AM - 11:15 AM

WWDC2012