Advanced Editing with AV Foundation

Session 612
Scott G. Johnston
AV Foundation Engineer

These are confidential sessions—please refrain from streaming, blogging, or taking pictures
Agenda

• Custom video compositing
  ▪ Existing architecture
  ▪ New custom video compositing
  ▪ Choosing pixel formats
  ▪ Tweening
  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Agenda

• Custom video compositing
  • Existing architecture
  • New custom video compositing
  • Choosing pixel formats
  • Tweening
  • Performance

• Debugging compositions
  • Common pitfalls
Existing Architecture
AV Foundation editing today

- Available since iOS 4.0 and OS X Lion
- Used in video editing apps from Apple and in the store
- Video editing
  - Temporal composition
  - Video composition
  - Audio mixing
Possible Today
Wipes, Dissolves, Transforms,…
New Opportunities
OpenGL and Everything Else
Custom Video Compositor
What Is a Video Compositor?

• Unit of video mixing code
• Receives multiple source frames
• Blends or transforms pixels
• Delivers single output frame
• Part of the composition architecture
Composition Model
Composition Model

AVComposition

A

B
Composition Model

AVComposition

AVVideoComposition

A

B

A

B

A
Composition Model
Composition Model

AVComposition

AVVideoComposition

A B A B A

A B A B A
Composition Model

AVComposition

AVVideoComposition
Video Instructions

AVVideoComposition

A
B
A
B
A

Instruction
Inst.
Inst.
Inst.
Instruction
Video Instructions

AVVideoComposition

A

Instruction

B

Inst.

B

Inst.

A

Instruction
Video Instructions

AVVideoComposition

A

B

Instruction

Inst.

Inst.

Inst.

Instruction

Simple mix
1 source track
Video Instructions

Complex mix
>1 source tracks
Video Instructions

AVVideoComposition

Instruction

Inst.

Inst.

Inst.

Instruction

Compositor
Video Instructions

AVVideoComposition

Instruction

Inst.

Inst.

Inst.

Instruction

Compositor
Video Instructions

AVVideoComposition

A

Instruction

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Instruction

Compositor
Video Instructions

AVVideoComposition

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Instruction

Compositor
Video Instructions

AVVideoComposition

A

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Instruction

Compositor

Instruction

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Instruction
Video Instructions

AVVideoComposition

A

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Instruction

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Instruction

Compositor
Video Instructions

AVVideoComposition

A

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B

B

A

Instruction

Inst.

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Instruction

Compositor
Compositor
Compositor
Video Compositor

Compositor
Video Compositor

Instruction

Compositor

[Image of deer]
Video Compositor

Instruction

Compositor

[Images of deer and person]
Video Compositor

Instruction

Compositor
Video Compositor

Instruction
Opacity Ramp 1 to 0

Compositor
Agenda

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  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Instruction
Opacity Ramp 1 to 0

Built-In Compositor

Video Compositor
Video Compositor

Instruction
Opacity Ramp 1 to 0

Built-In Compositor
Video Compositor

Instruction
Opacity Ramp 1 to 0

Built-in Compositor
Custom Video Compositor

Instruction
Opacity Ramp 1 to 0

Your Code Here
Custom Video Compositor

Instruction
Opacity Ramp 1 to 0

Your Code Here
Custom Video Compositor

Instruction
Your Mixing Parameters

Your Code Here
Custom Video Compositor

Instruction
Your Mixing Parameters

Your Code Here

[Images of video compositor instructions and code samples]
Custom Video Compositor

Request

Instruction
Your Mixing Parameters

Your Code Here
Custom Video Compositor

Request

Instruction

Your Mixing Parameters

@protocol AVVideoCompositing

Your Code Here
Custom Video Compositor

AVAsynchronousVideoCompositionRequest

Instruction
Your Mixing Parameters

Your Code Here

@protocol AVVideoCompositing
Custom Video Compositor

AVAsynchronousVideoCompositionRequest

Instruction
Your Mixing Parameters

@protocol AVVideoCompositionInstruction

Your Code Here

@protocol AVVideoCompositing
Custom Video Compositor

Request

Instruction

Your Mixing Parameters

Your Code Here

Your Code Here
Custom Video Compositor

Instruction
Your Mixing Parameters

startVideoCompositionRequest:

Your Code Here
Custom Video Compositor

Request

Instruction
Your Mixing Parameters

Your Code Here

finishWithComposedVideoFrame:

startVideoCompositionRequest:
Custom Video Compositor

Request

Instruction

Your Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:
Custom Video Compositor

Instruction

Your Mixing Parameters

Your Code Here

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Mixing Parameters

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Mixing Parameters

Request

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Instruction

Mixing Parameters

Request

startVideoCompositionRequest:

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:
Choosing Pixel Formats

Instruction

Mixing Parameters

startVideoCompositionRequest:

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:
Choosing Pixel Formats

Source Pixel Format
- YUV 8-bit 4:2:0
- YUV 8-bit 4:4:4
- YUV 10-bit 4:2:2
- YUV 10-bit 4:4:4
- RGB 24-bit
- BGRA 32-bit
- BGR 24-bit
- ARGB 32-bit
- ABGR 32-bit
Choosing Pixel Formats

Instruction

Source Pixel Format
YUV 8-bit 4:2:0

Your Code Here

Request

startVideoCompositionRequest:

Your Code Here

finishWithComposedVideoFrame:

finishWithError:

finishCancelledRequest:
Choosing Pixel Formats

Your Mixing Parameters

Source Pixel Format
YUV 8-bit 4:2:0

(NSDictionary *) sourcePixelBufferAttributes
Choosing Pixel Formats

Source Pixel Format
YUV 8-bit 4:2:0

(NSDictionary *) sourcePixelBufferAttributes
kCVPixelFormatType_32BGRA,...
Choosing Pixel Formats

Source Pixel Format

kCVPixelFormatType_32BGRA,...

(NSDictionary *) sourcePixelBufferAttributes

Your Code Here
Choosing Pixel Formats

Source Pixel Format

Instruction

Mixing Parameters

StartVideoCompositionRequest:

Your Code Here

FinishWithError:

FinishCancelledRequest:

FinishWithComposedVideoFrame:
Choosing Pixel Formats

**Source Pixel Format**
BGRA 32-bit

**Instruction**

- startVideoCompositionRequest:
- Source Pixel Format: BGRA 32-bit

**Request**

- finishWithError: 
- finishCancelledRequest: 
- finishWithComposedVideoFrame: 

Your Code Here
Choosing Pixel Formats

Source Pixel Format
BGRA 32-bit

Your Code Here
Choosing Pixel Formats

Request

Instruction

Mixing Parameters

Your Code Here

startVideoCompositionRequest:

Source Pixel Format
BGRA 32-bit

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:
Choosing Pixel Formats

Source Pixel Format: BGRA 32-bit

Output Pixel Format

Your Code Here

startVideoCompositionRequest:

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:
Choosing Pixel Formats

Instruction
Mixing Parameters

StartVideoCompositionRequest:

(nsDictionary *) requiredPixelBufferAttributesForRenderContext

FinishWithComposedVideoFrame:

FinishWithError:

FinishCancelledRequest:

Output Pixel Format

Your Code Here
Choosing Pixel Formats

Instruction

Mixing Parameters

Request

(startVideoCompositionRequest):

Your Code Here

(outputPixelFormat)

(finishWithError):

finishCancelledRequest:

finishWithComposedVideoFrame:

(NSDictionary *) requiredPixelBufferAttributesForRenderContext

kCVPixelFormatType_32BGRA,...
Choosing Pixel Formats

Instruction

Mixing Parameters

Your Mixing Parameters

Request

startVideoCompositionRequest:

Your Code Here

finishWithComposedVideoFrame:

finishCancelledRequest:

finishWithError:

Output Pixel Format

kCVPixelFormatType_32BGRA,...

NSDictionary * requiredPixelBufferAttributesForRenderContext

Your Code Here
Choosing Pixel Formats

Instruction

Your Mixing Parameters

Request

startVideoCompositionRequest:

Your Code Here

finishCancelledRequest:

finishWithError:

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Output Pixel Format
Choosing Pixel Formats

Instruction
Mixing Parameters

Request

startVideoCompositionRequest:

Your Code Here

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:

Output Pixel Format
BGRA 32-bit
Choosing Pixel Formats

Instruction
Mixing Parameters

[request.renderContext newPixelBuffer]

Your Code Here

startVideoCompositionRequest:
finishWithComposedVideoFrame:

Finish Cancelled Request:
finishWithError:

Output Pixel Format
BGRA 32-bit
Choosing Pixel Formats

Instruction
Mixing Parameters

startVideoCompositionRequest:

Your Code Here

Output Pixel Format
BGRA 32-bit

[request.renderContext newPixelBuffer]
Choosing Pixel Formats

Instruction

Mixing Parameters

startVideoCompositionRequest:

[request.renderContext newPixelBuffer]

Your Code Here

Output Pixel Format
BGRA 32-bit

finishWithError:
finishCancelledRequest:
finishWithComposedVideoFrame:
Choosing Pixel Formats

Instruction

Mixing Parameters

Request

startVideoCompositionRequest:

Your Code Here

finishWithComposedVideoFrame:

finishWithError:

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Output Pixel Format

BGRA 32-bit
Choosing Pixel Formats

Instruction

Mixing Parameters

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Output Pixel Format
BGRA 32-bit

finishWithError:
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startVideoCompositionRequest:

Output Pixel Format

BGRA 32-bit
Choosing Pixel Formats

Instruction

Mixing Parameters

startVideoCompositionRequest:

Your Code Here

finishWithError:

finishCancelledRequest:

finishWithComposedVideoFrame:
Demo

CPU and GPU custom compositors
Agenda

• Custom video compositing
  ▪ Existing architecture
  ▪ New custom video compositing
  ▪ Choosing pixel formats
  ▪ Tweening
  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Tweening

AVVideoComposition

A
B
B
A

Instruction
Instruction
Instruction
Instruction
Instruction

Compositor
Tweening
Tweening
Tweening

AVVideoComposition

A
B

Instruction

Compositor
Tweening

AVVideoComposition

A

B

Compositor
Tweening

AVVideoComposition

Opacity Ramp 100% to 0%

Compositor
Tweening

A

B

Opacity Ramp 100% to 0%

MyInstruction.timeRange = { start 5, duration 10/30 secs }
MyInstruction.opacityRamp = { 100% to 0% }
Tweening

elapsed = 0 secs

AVVideoComposition

A

B

Opacity Ramp 100% to 0%

Compositor
Tweening

elapsed = 0 secs

AVVideoComposition

Opacity Ramp 100% to 0%

opacity = 100%

Compositor
Tweeving

elapsed = 0 secs

AVVideoComposition

Opacity Ramp 100% to 0%

tween = elapsed / duration = 0.0

Compositor
Tweening

\[
\text{elapsed} = \frac{1}{30} \text{ secs}
\]

\[
\text{opacity} = 90\%
\]

\[
\text{tween} = \frac{\text{elapsed}}{\text{duration}} = \frac{1}{30} / \text{duration} = 0.1
\]

Calculate how far through the animation we are; Subtract the start time, divide by the duration.
Tweening

\[
\text{elapsed} = \dots \text{ secs}
\]

\[
\text{opacity} = \dots \%
\]

\[
\text{tween} = \frac{\text{elapsed}}{\text{duration}} = \dots
\]
## Tweening

**AVVideoComposition**

![Layer Stack](image)

- **Opacity Ramp 100% to 0%**

**Compositor**

- **tween = elapsed / duration**

- **elapsed = .. secs**

- **opacity = ..%**
Tweening

AVVideoComposition

Opacity Ramp 100% to 0%

Compositor

tween = elapsed / duration = 1.0

elapsed = 10/30 secs

opacity = 0%
Agenda

• Custom video compositing
  ▪ Existing architecture
  ▪ New custom video compositing
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  ▪ Tweening
    ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
## iOS Apps

<table>
<thead>
<tr>
<th>Foreground</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>CPU</td>
</tr>
<tr>
<td><img src="Images/Opengl.png" alt="OpenGL ES" /></td>
<td>—</td>
</tr>
</tbody>
</table>
Performance

Instruction properties

@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}

Performance

Instruction properties

@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}

Performance

passthroughTrackID
Performance

passthroughTrackID

passthroughTrackID = A; // bypass compositor
passthroughTrackID = A; // bypass compositor
Performance

Instruction properties

@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}

Performance

requiredSourceTrackIDs

requiredSourceTrackIDs = @[ A ];
Performance

requiredSourceTrackIDs = @[ A ];
Performance

requiredSourceTrackIDs = nil
Performance

requiredSourceTrackIDs

AVVideoComposition

A

B

Instruction

Instruction

Instruction

Instruction

Instruction

requiredSourceTrackIDs = nil

Deliver Frames from ALL Tracks
Performance
Instruction properties

@protocol AVVideoCompositionInstruction<NSObject>
{
    @property CMPersistentTrackID passthroughTrackID;
    @property NSArray *requiredSourceTrackIDs;
    @property BOOL containsTweening;
}

Performance contains Tweening

Moving picture-in-picture, same source frames every time
containsTweening = YES;

Moving picture-in-picture, same source frames every time
Performance

containsTweening

containsTweening = YES;
Performance
containsTweening

containsTweening = YES;

Static picture-in-picture,
same source frames every time
containsTweening = YES;

Frame #0

Custom Compositor

Static picture-in-picture, same source frames every time
Performance
containsTweening

containsTweening = YES;

Frame #0
- Custom Compositor

Frame #1
- Custom Compositor

Static picture-in-picture, same source frames every time
Performance
containsTweening

containsTweening = YES;

Frame #0
Custom Compositor

Frame #1
Custom Compositor

Frame #2
Custom Compositor

Static picture-in-picture,
same source frames every time
Performance
containsTweening

containsTweening = YES;

Frame #0
Custom Compositor

Frame #1
Custom Compositor

Frame #2
Custom Compositor

Static picture-in-picture,
same source frames every time
Performance
containsTweening

`containsTweening = YES;`

Static picture-in-picture,
same source frames every time
Performance
contains Tweening

Static picture-in-picture, same source frames every time
Performance
containsTweening

containsTweening = NO;

Frame #0
Custom Compositor

Frame #1
Custom Compositor

Frame #2
Custom Compositor

Static picture-in-picture,
same source frames every time

I’m not animating
Performance
containsTweening

containsTweening = NO;

Static picture-in-picture,
same source frames every time
Performance

containsTweening

containsTweening = NO;

Custom Compositor

Frame #0

Static picture-in-picture,
same source frames every time
Performance containsTweening

containsTweening = NO;

Frame #0

Custom Compositor

Frame #1

Static picture-in-picture, same source frames every time
Performance
containsTweening

containsTweening = NO;

Custom Compositor

Static picture-in-picture,
same source frames every time
Performance

containsTweening

containsTweening = NO;

Reusable identical output

Static picture-in-picture, same source frames every time
Performance

Pixel buffer formats

• Performance hit converting sources
  ▪ H.264 decodes to YUV 4:2:0
  ▪ Best performance, work in YUV 4:2:0

• Output format less critical
  ▪ BGRA or YUV 4:2:0 out
Performance

Pixel buffer formats

• Performance hit converting sources
  • H.264 decodes to YUV 4:2:0
  • Best performance, work in YUV 4:2:0

• Output format less critical
  • BGRA or YUV 4:2:0 out
Sample Code

Custom compositor

• AVCustomEdit
• GPU compositor
Agenda

• Custom video compositing
  ▪ Existing architecture
  ▪ New Custom video compositing
  ▪ Choosing pixel formats
  ▪ Tweening
  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Debugging Compositions
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms
Debugging Compositions

Common pitfalls

- Gaps between segments
- Misaligned track segments
- Misaligned layer instructions
- Misaligned opacity/audio ramps
- Bogus layer transforms

So close :-(

Whale.m4v
Otters.m4v
Sea.m4v
Waves.m4v
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms

Not the alignment we’re looking for!
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms

Overshoot!
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms
Debugging Compositions

Common pitfalls

• Gaps between segments
• Misaligned track segments
• Misaligned layer instructions
• Misaligned opacity/audio ramps
• Bogus layer transforms
Demo
AVCompositionDebugViewer
Sample Code

Debugging compositions

• AVCompositionDebugViewer
Debugging Compositions

• Drop AVCompositionDebugView into your own app
• Extend it to draw your own video instructions
• Spot overlaps and gaps; tracks, video instructions, and audio mix
• Don’t forget the composition validation API
  • @protocol AVVideoCompositionValidationHandling
Summary

• Custom video compositing
  ▪ Existing architecture
  ▪ New custom video compositing
  ▪ Choosing pixel formats
  ▪ Tweening
  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Summary

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  ▪ Performance

• Debugging compositions
  ▪ Common pitfalls
Custom Compositors
Effects, Transitions, Generators
Custom Compositors
Effects, Transitions, Generators
More Information

John Geleynse
Director, Technology Evangelist
geleynse@apple.com

Documentation
AVFoundation

Apple Developer Forums
http://devforums.apple.com
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<th>Session</th>
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<tbody>
<tr>
<td>Moving to AV Kit and AV Foundation</td>
<td>Pacific Heights</td>
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<tr>
<td>Preparing and Presenting Media for Accessibility</td>
<td>Nob Hill</td>
<td>Wednesday 10:15AM</td>
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<tr>
<td>What's New in Camera Capture</td>
<td>Nob Hill</td>
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<td>Labs</td>
<td>Time/Location</td>
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<tr>
<td>OS X and iOS Capture Lab</td>
<td>Media Lab B Thursday 9:00AM</td>
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<td>AV Foundation Lab</td>
<td>Media Lab B Thursday 2:00PM</td>
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<tr>
<td>AV Foundation Lab</td>
<td>Media Lab B Friday 9:00AM</td>
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