Using Graphics Rendering Contexts to Enhance the Real-Time Video Coding for Mobile Cloud Gaming

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What is Cloud Gaming?
What is Cloud Gaming?

What is Cloud Gaming?

What is Cloud Gaming?

Broadband Internet
What is Cloud Gaming?

Broadband Internet

PC

Mac

TV
What is Cloud Gaming?

Broadband Internet

Mobile Cloud Gaming
Mobile Cloud Gaming

- 3D Game Scene Data
- Rendering Server
  - Rendering Viewpoint
  - Rendering Results
  - Wireless Networks
  - Control Updates
- Mobile Client
  - User Interaction
  - Display

Tuesday, November 29, 11
Mobile Cloud Gaming
Mobile Cloud Gaming

• Research Prototype
  • Remote Rendering Games for iPhone
  • BZFlag: an open source 3D tank shooting game
Mobile Cloud Gaming

- Research Prototype
  - Remote Rendering Games for iPhone
    - BZFlag: an open source 3D tank shooting game

- Demo Video
Join Game
Options
Save Settings
Help
Leave Game
Quit
Benefits

✔ No Need of Powerful Graphics Hardware
✔ Same Game Console 3D Experience
✔ Cross-Platform Solution
✔ Easy Distribution
✔ Prevent Pirating

... ...
Challenges

? Interaction Latency
Challenges

? Interaction Latency

3D Game Scene Data

Rendering Server

Rendering Viewpoint

Rendering Results

Wireless Networks

Control Updates

Mobile Client

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Challenges

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Challenges

• Interaction Latency


? Network Bandwidth
# Network Bandwidth Usage

<table>
<thead>
<tr>
<th>Mobile Devices</th>
<th>Video Requirements</th>
<th>Raw Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Mobile Device 1" /></td>
<td>320x240 @ 30fps</td>
<td>26.4 Mbps</td>
</tr>
<tr>
<td><img src="image2.png" alt="Mobile Device 2" /></td>
<td>640x480 @ 30fps</td>
<td>105 Mbps</td>
</tr>
<tr>
<td><img src="image3.png" alt="Mobile Device 3" /></td>
<td>1280x720 @ 30fps</td>
<td>316 Mbps</td>
</tr>
</tbody>
</table>
Real-Time Video Coding
Real-Time Video Coding

- Low Coding Efficiency
  - No bi-directional prediction
  - Strict encoding deadline
  - One-pass rate control
  - Low buffer occupancy
  - Intra refresh coding
  - ... ...
Real-Time Video Coding

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- How bad is it?
Real-Time Video Coding
Real-Time Video Coding

OnLive Video Bandwidth Usage

![Graph showing OnLive Video Bandwidth Usage]

- Bit Rate (Mbps)
- Time (s)
- Downlink
- Mean

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Real-Time Video Coding

OnLive Video Bandwidth Usage
Real-Time Video Coding

OnLive Video Bandwidth Usage

- Bit Rate (Mbps)
- Time (s)

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- Mean

x264 Encoding Performance

- Quality in PSNR (dB)
- Bit Rate (Mbps)

40dB: Excellent Quality
Real-Time Video Coding

OnLive Video Bandwidth Usage

x264 Encoding Performance

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Real-Time Video Coding

OnLive Video Bandwidth Usage

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x264 Encoding Performance

- Quality in PSNR (dB)
- Bit Rate (Mbps)
- 40dB: Excellent Quality

6 - 7 times worse!
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  - ... ...
Video Coding Basics
Real-Time Video Coding
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Real-Time Video Coding

... ...
Real-Time Video Coding

- No B Frame!!!
Real-Time Video Coding
Real-Time Video Coding

I B B B P B B B P ... ...
Real-Time Video Coding

I P B B B P B B B ...

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Auxiliary Frame Generation

I P B B B P B B B ...

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Auxiliary Frame Generation
Auxiliary Frame Generation
Auxiliary Frame Generation
Auxiliary Frame Generation
Auxiliary Frame Generation

I

P

B

I AUX₁ 2 3

AUX₁

I
Auxiliary Frame Generation

I P B B
I AUX₁ 2 3 4
Auxiliary Frame Generation

I  P  B  B  B
I  AUX₁ 2  3  4  5
Auxiliary Frame Generation
Auxiliary Frame Generation
Auxiliary Frame Generation
Auxiliary Frame Generation

I  P  B  B  B  B  P  B
I  AUX₁ 2  3  4  5 AUX₂ 6  7
Auxiliary Frame Generation

I P B B B B P B B

I AUX$_1$ 2 3 4 5 AUX$_2$ 6 7 8 .......
Auxiliary Frame Generation

I P B B B B P B B B
Auxiliary Frame Generation

| I | P | B | B | B | B | B | P | B | B | B | B |

AUX

AUX
Basics of Video Coding

• Motion Estimation

http://www.cmlab.csie.ntu.edu.tw/cml/dsp/training/coding/motion/me1.html
Basics of Video Coding

- Search Method and Range

http://www.cs.cmu.edu/~yvchen/projects.html
3D Image Warping
3D Image Warping

- **Input:**
  - Image: $I_1$
  - Depth: $D_1$
  - Viewpoints:
    - $v_1$
    - $v_2$
3D Image Warping

- Input:
  - Image: $I_1$
  - Depth: $D_1$
  - Viewpoints:
    - $v_1$
    - $v_2$

- Output:
  - Image: $I_2$
Double Warping
Double Warping
Double Warping
Double Warping
Double Warping
Warping Based Real-Time Video Coding

AUX_1

I P B B B B B P B B B B B ...

AUX_2
Warping Based Real-Time Video Coding
Warping Based Real-Time Video Coding
Warping Based Real-Time Video Coding
Warping Based Real-Time Video Coding

AUX₁

AUX₂

R R W W W W W R W W W W W W W W

......
Results

- Original x264 Encoding with only I/P frames
- Proposed warping based encoding method using auxiliary frames

A short sequence of 315 frames

A long sequence of 4072 frames
Discussion
Discussion

• Interaction Latency Reduction
Discussion

- Interaction Latency Reduction
- Limitations
  - Only applicable to cloud gaming or other remote rendering applications
  - Mostly useful for first person perspective games
  - Can’t handle graphical effects well
Discussion

• Interaction Latency Reduction

• Limitations
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• Optimizations
  • Integration with x264
Conclusion

- Reduce video bandwidth for real-time coding in cloud gaming
  - Generate auxiliary frames based on camera motion to enable B frame encoding
  - Replace search based motion estimation with efficient 3D image warping using depth maps and camera vectors
- Think differently for different applications
Thank you!

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• Questions?