Accelerating Augmented Reality Video Processing With FPGAs

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Background

• What is Virtual Reality (VR)?
• What is Augmented Reality (AR)?
• Current AR/VR is based on Desktop Computer
• FPGAs offer
  ▪ Improved Portability, Latency, Performance, Bandwidth
  ▪ Excellent Platform for Video Processing
  ▪ Lower cost, ~$500 versus ~$1000
  ▪ Lower Power, ~10 Watts
Scope

- Proof of Concept of Augmented Reality on an FPGA
- Highlight moving objects in front of user
Hardware

• 2 Cameras (OV7670)
• Avnet Zedboard
  – Xilinx Zynq 7020
• Oculus Rift Development Kit 2
Xilinx Zynq Product Family

- Fusion between FPGA and an embedded system
  - Dual Core ARM Processor
  - 7 Series FPGA
- Unique benefits for augmented reality
  - CPU Centric IO
  - High Speed RAM
  - Configurable AR coprocessors
Solution Overview

Video In → Frame Buffer

1

2
Video Processing

Input

Delta

Threshold

Median

Sobel Edge
Solution Overview

1. Video In
2. Frame Buffer
3. Delta
4. Threshold
5. Median
6. Sobel
7. Overlay

Diagram showing the processing steps from Video In to Overlay.
Barrel Projection

Barrel Distortion (In-Engine)

Pin-cushion Distortion (From Rift Lenses)

No Distortion (Final Observed Image)
Barrel Projection
Solution Overview

1. Video In
2. Frame Buffer
3. Delta
4. Threshold
5. Median
6. Sobel
7. Overlay
8. Barrel Projection
9. Stereo Combine

10. Overlay on Barrel Projection
11. Stereo Combine
12. Final Image
Methods

- Write modules from ground up (Verilog)
- Design with Xilinx High Level Synthesis (HLS)
- Leverage Xilinx IP Cores
- Use the ARM cores on Zync Platform (C/C++)
- Testing and Simulating in MATLAB
- Simulating in XSIM (Verilog for Test)
- Testing with Hardware and Lab Equipment
- PCB Design (Altium)
Challenges

• Learning Curve
• Scripting the Xilinx Tools to add Source Control
• Synthesis/Timing Requirements
  — Barrel Projection
  — Project Overall
• Hardware is difficult to test

Post Synthesis Timing Test of Barrel Projection
Results and Conclusions

- Project implements a working end-to-end Video Pipeline  
  - Displays video and highlights moving objects
- FPGAs are viable platforms for developing Augmented Reality
- A couple video processes are working standalone, waiting to be merged in
- Much improved cost factors  
  - $500 for FPGA/Camera Hardware
  - $1000+ for a AR/VR capable PC
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Questions

Thank You for Your Attention