Accelerating Augmented Reality Video Processing with FPGAs

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Background/Motivation

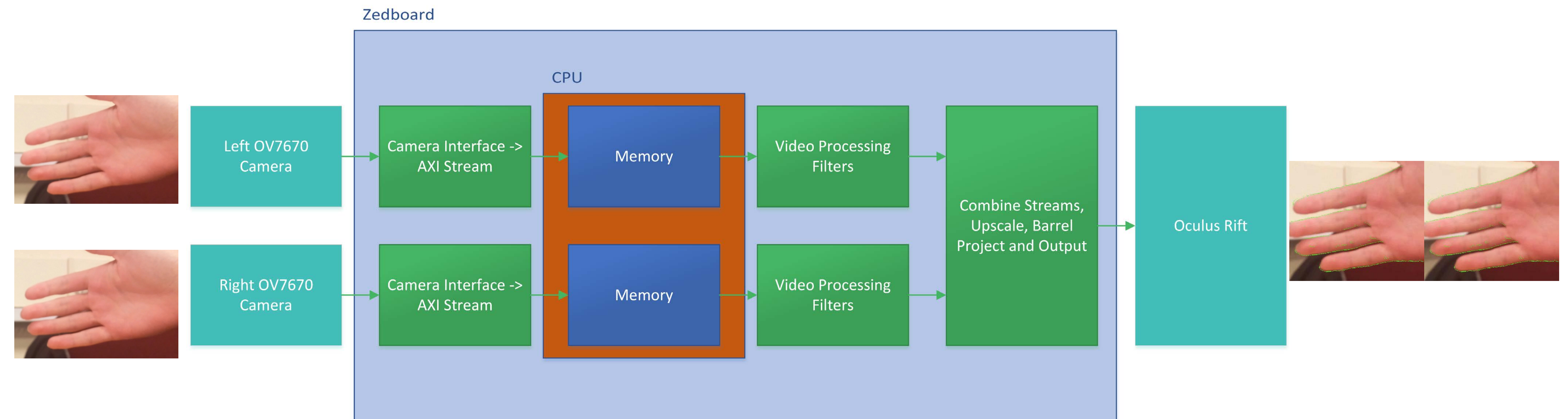Virtual Reality is a fast growing field with several new systems shipping this year

Currently $1000+ gaming PC is needed in addition to VR hardware

FPGAs allow for efficient parallel video processing, making them an ideal candidate for VR/AR systems
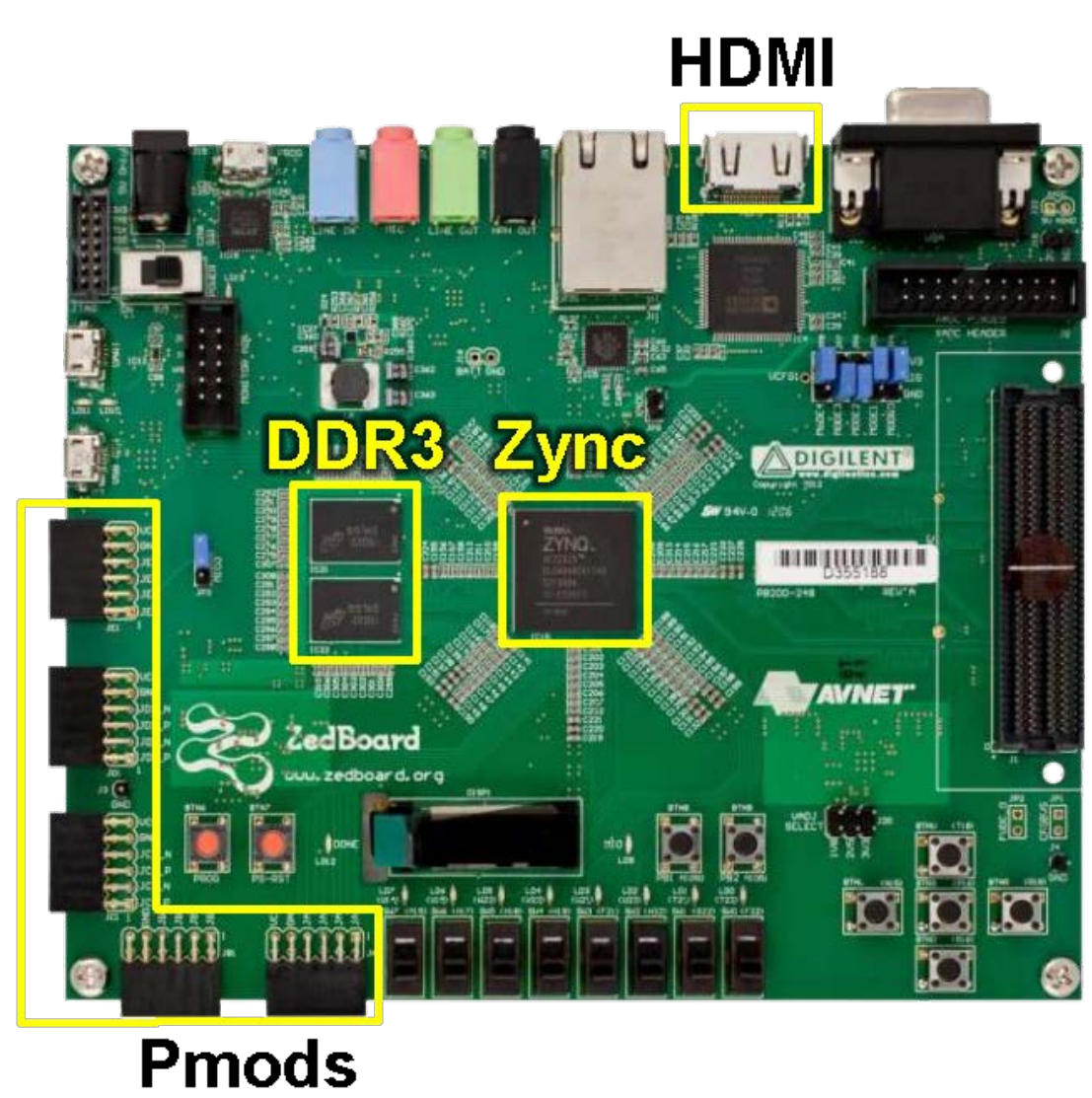
https://www.flickr.com/photos/collinmel/14802996132
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System Overview

Zedboard

CPU

Left OV7670 Camera → Camera Interface -> AXI Stream → Memory → Video Processing Filters → Combine Streams, Upscale, Barrel Project and Output → Oculus Rift

Right OV7670 Camera → Camera Interface -> AXI Stream → Memory → Video Processing Filters

Zedboard

HDMI

DDR3   Zync

Pmods

Zync chip contains both an ARM Cortex A9 and a FPGA

512 MB of DDR3 memory

5 PMOD expansion ports

Video Hardware

Oculus Rift DK2
- 1080 x 1920 resolution
- Interfaces over USB and HDMI

OV7670 camera
- Programmed with an I^2C type serial port

Custom PCB to map ports
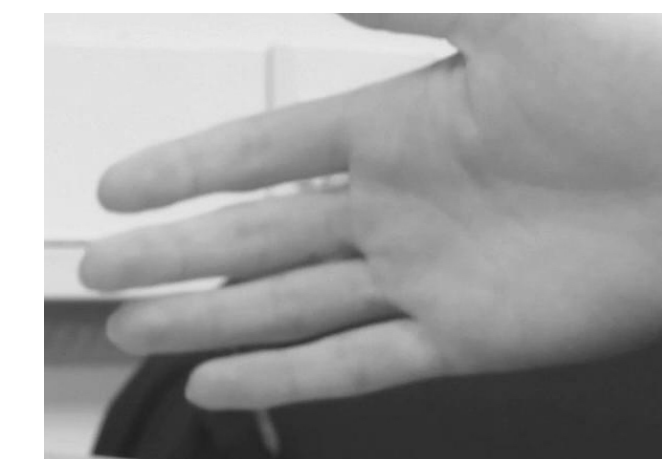
Video Filters

Original Image
- Comes in as a grayscale image for easier processing

Delta Frame Filter
- Processes what has changed between two frames by taking the absolute difference

Thresholding
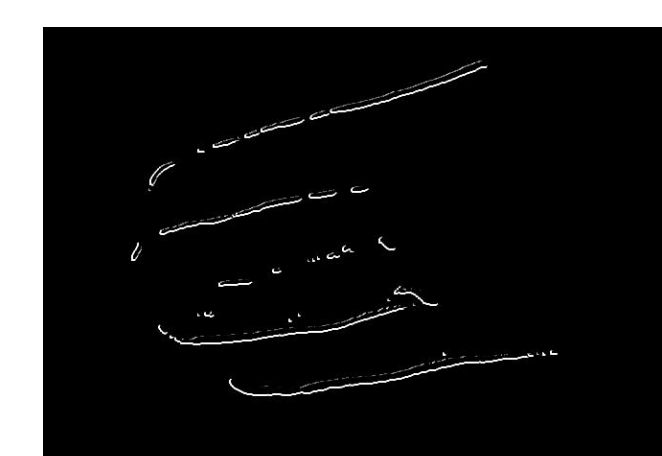- Removes any values below a threshold and sets the rest at maximum white

Median Filter
- Takes the median of each pixel to reduce noise

Sobel Filter
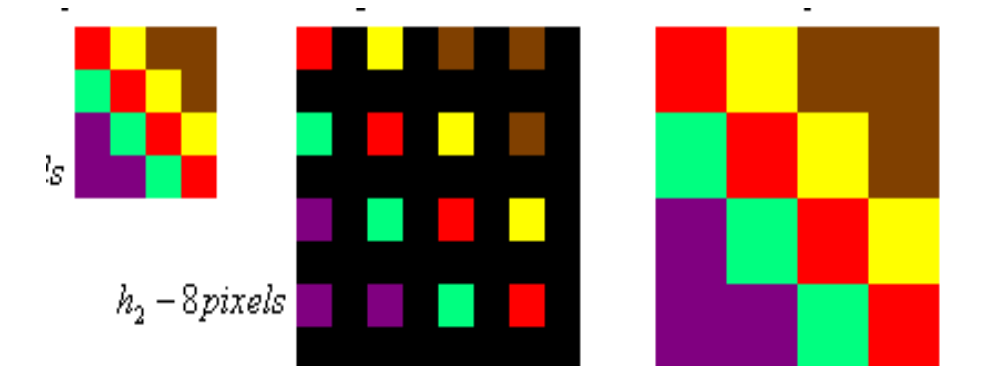- Detects final edges on the objects found in the image

Overlay
- Takes the information from the Sobel filter and writes it on top of the original image

## Barrel Projection and Scaling

Scaling
- Scales from 640x480 to 1080x960 for Oculus
- Uses nearest neighbor horizontally
- Duplicates each line

http://tech-algorithm.com/uploads/nneighbor01.png

l_2 $h_2 - 8 pixels$

Barrel Distortion (In-Engine)   Pin-cushion Distortion (From Rift Lenses)

No Distortion (Final Observed Image)

Barrel Projection
- Correct for Oculus lens distortion
- Maps radius of coordinates in polar space
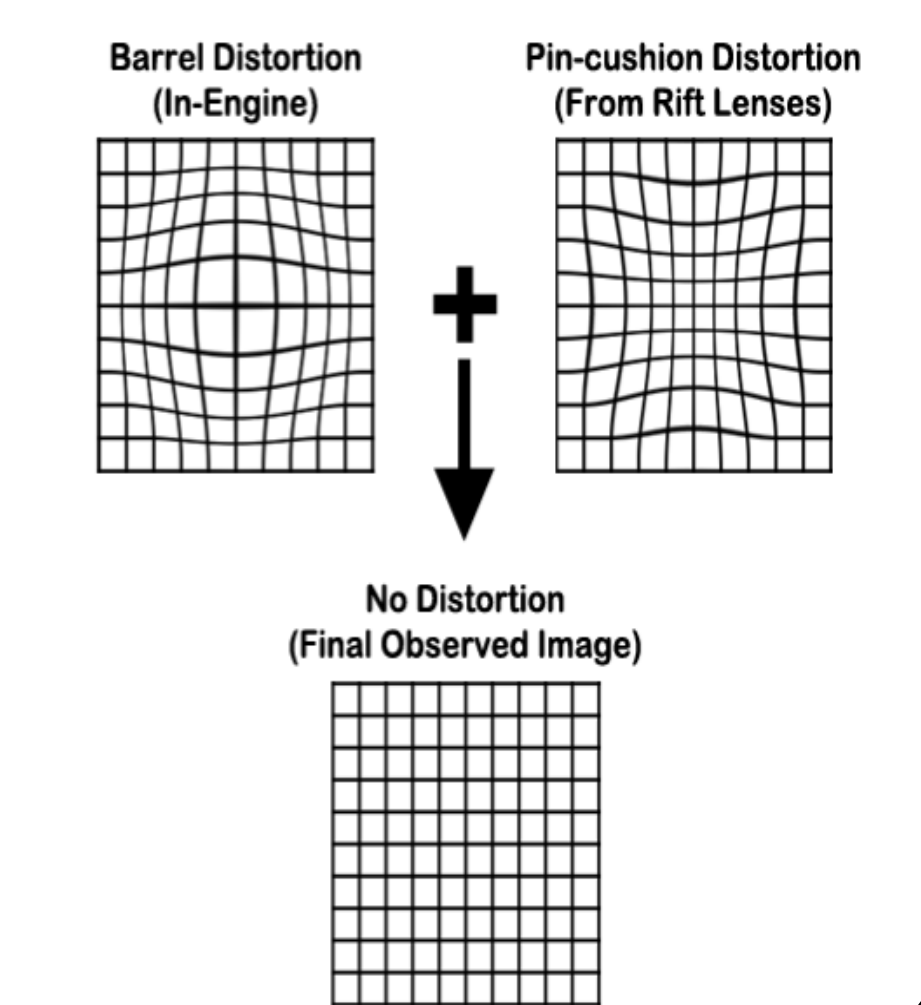
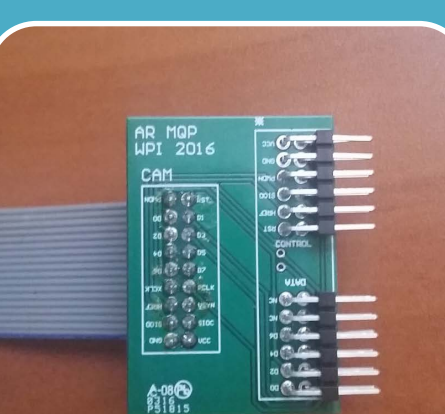http://www.gamasutra.com/db_area/images/blog/194007/Distortion.png

Accomplishments & Conclusions

Created working end-to-end system

Developed filters for highlighting differences

Costs about half as much as a typical VR capable computer

Reduced size, weight, and power consumption compared to a desktop PC