C4: HoloPyramid

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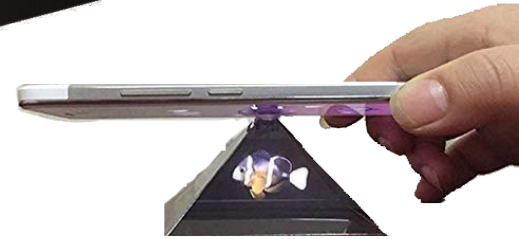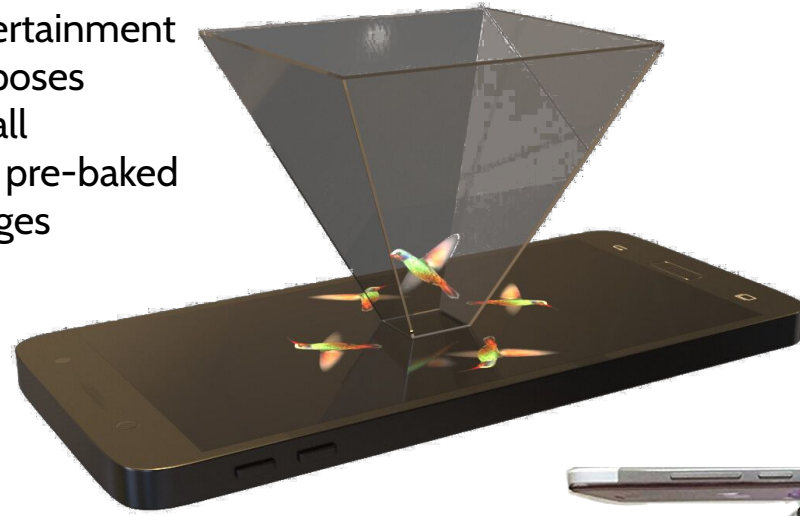
Use Case

Provide an immersive presentation tool to enlarge an object for easier viewing by a group of people
- Hardware
- Signal Processing

Existing Solutions

- Entertainment purposes
- Small
- Use pre-baked images

Requirements

1. **Enlargement:** Display 3-4" object with 5x enlargement
2. **Timing:** Stable real-time capture and display of video feeds of uniformly lit object
3. **Video Frame Quality:** Projection of four crisp videos on a 720p display
4. **Illusion:** Illusion of 3D projection of local object
   a. No background
   b. Visible in office lighting environments

Solution Approach

1. Live studio captures four simultaneous video feeds of a local object
2. FPGA filters and combines four video feeds into one
3. VGA monitor displays the combined video
4. Acrylic pyramid reflects images to create a holographic illusion

Pyramid

FPGA
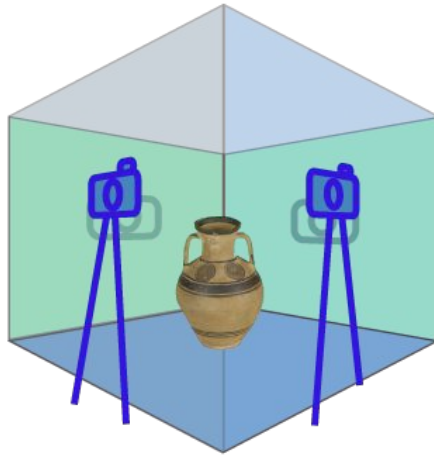
TV display

Studio
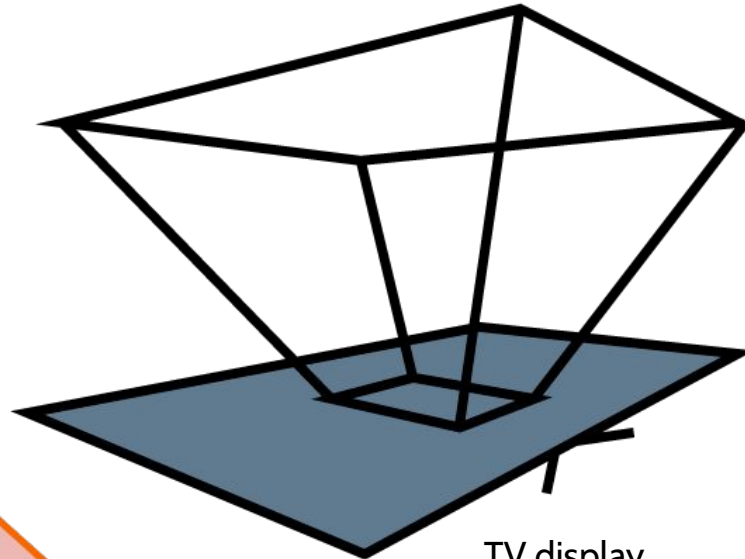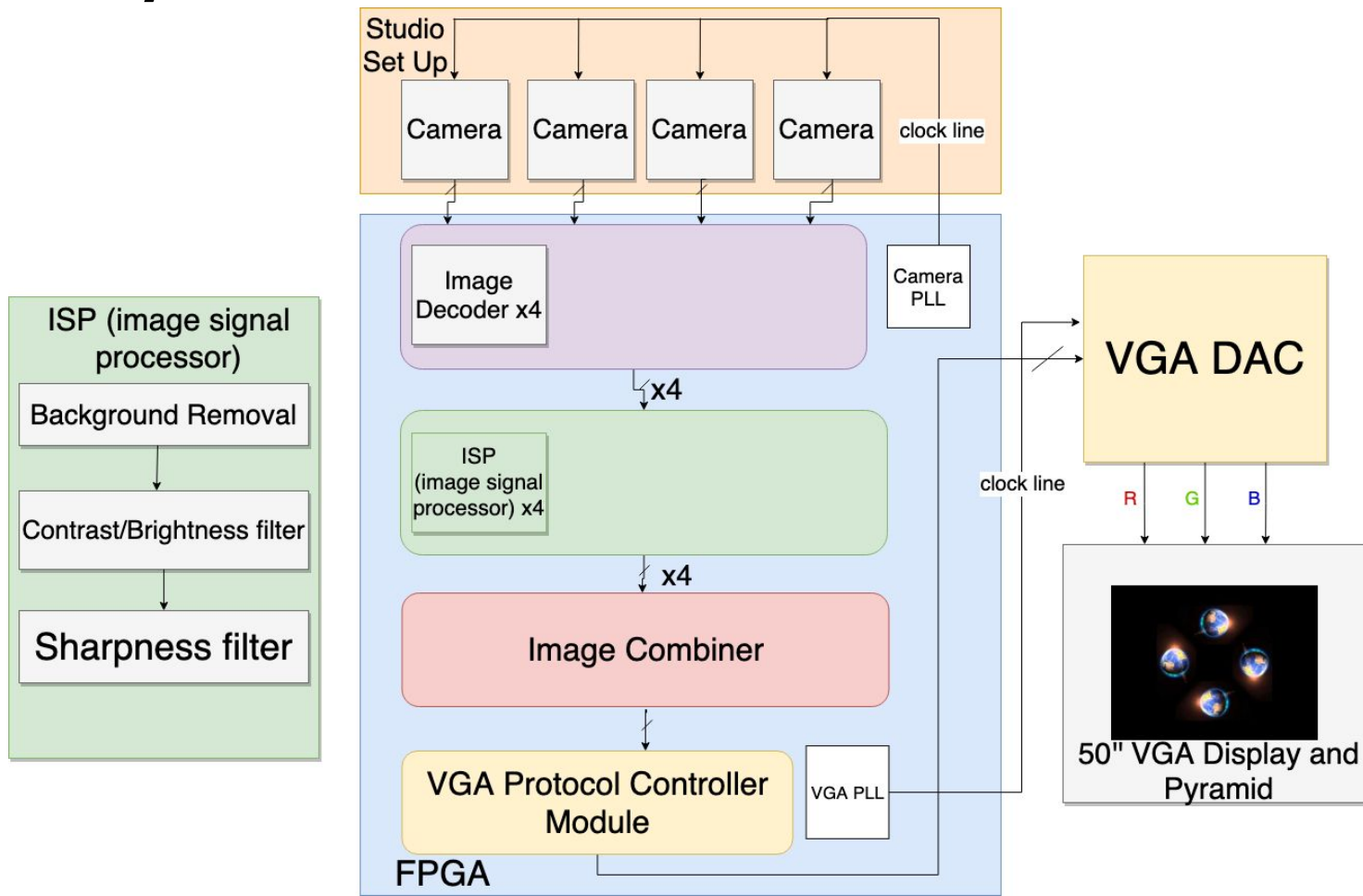
System Overview

Technical Challenges

- Time constraint of < 17 ms through three image filters, further processing, and VGA protocol
- PLL usage to increase image resolution
- Synchronization of four camera feeds
- Construction of pyramid
  a.   Trade-off between reflection quality and scale
- Risk mitigation: fallback plan of scaling back and reducing image resolution and pyramid size

Testing

1. Enlargement
   - Measure physical object and projection on hologram
2. Timing
   - Latency (whole system)
     - Flash a light in the studio and measure the delay to the projection on the hologram using a high speed camera
   - Stable frame rate (FPGA)
     - Measure differences in frame lengths
     - Check cycle count

Testing (continued)

3. Video Frame Quality
- Image sharpness
  - Compare MTF score of holographic pyramid with high-quality camera at 720p resolution

4. Illusion
- Background Removal Effectiveness (Chroma Keying)
  - Measure % removal of background and object
- (Lack of) Distortion
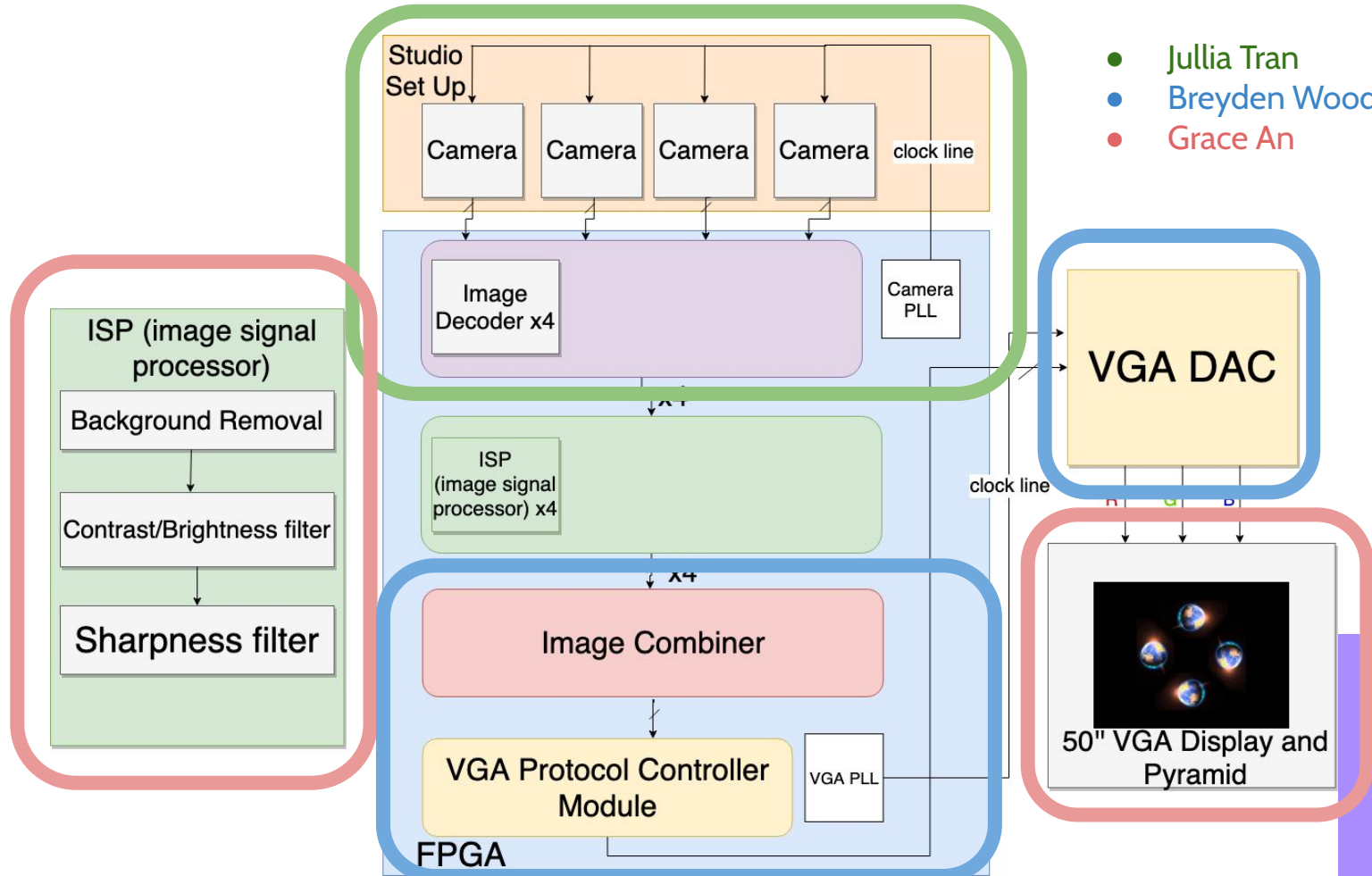 - Project lines on the pyramid and measure perspective distortion

Task List

- Breyden Wood
  - Image combiner
  - VGA PLL
  - Test image quality and latency
- Jullia Tran
  - Camera interface with FPGA
  - Image decoder
- Grace An
  - Pyramid and studio
  - Image filters

Division of Labor

- Jullia Tran
- Breyden Wood
- Grace An

Studio Set Up

Camera | Camera | Camera | Camera | clock line

Image Decoder x4

Camera PLL

ISP (image signal processor)

Background Removal

Contrast/Brightness filter

Sharpness filter

ISP (image signal processor) x4

x4

Image Combiner

x4

VGA Protocol Controller Module

VGA PLL

FPGA

VGA DAC

clock line

R G B

50" VGA Display and Pyramid

Schedule

Task list / Start week for task	2/22/2021	3/1/2021	3/8/2021	3/15/2021	3/22/2021	3/29/2021	4/5/2021	4/12/2021	4/19/2021	4/26/2021	5/3/2021
Logstics											
Proposal presentation	■										
Design review presentation			■								
Final presentation											■
Order camera		■									
Order pyramid materials					■	■					
Research											
VGA protocol		■									
PLL		■									
Image filters and pyramid design		■									
Implementation											
Image decoder											
Implement PLL With Camera Interface			■								
Implement Image Decoder				■							
Test, Debug, Synthesize				■	■	■					
VGA protocol controller											
Implement PLL with VGA			■								
Implement VGA protocol controller				■							
Test, debug, synthesize				■	■	■					
Image Filters											
Chroma-keying filter			■								
Brightness filter				■							
Sharpness filter					■						
Test, debug, synthesize					■	■					
Integration/Testing											
Construction of pyramid and live studio						■	■				
Image combiner and Integration of FPGA						■	■		■		
Testing							■		■		