Lightning Talks

Week 5: Design - Part 2

Team Information

- **Project ID:** ssddec24-proj006
- Senior Design Website
- **Team members:** Deniz Tazegul, Liam Janda, Taylor Johnson, Ritwesh Kumar
- **Client:** JR Spidell
- **Faculty Advisors:**
  - Dr. Mohammad Tayeb Al Qaseer
  - Dr. Phillip Jones

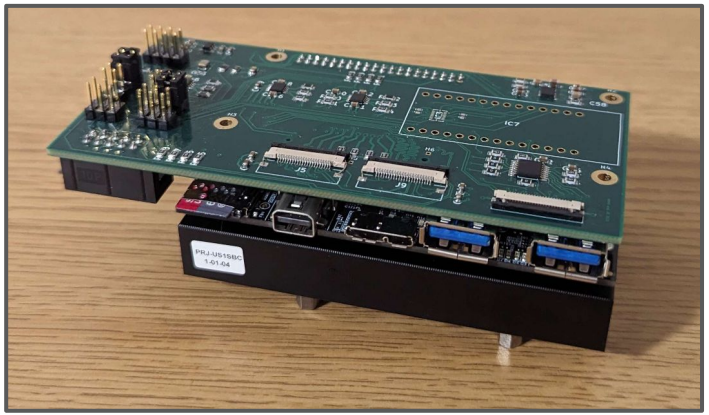
Project Overview

- We will be developing a video pipeline from a MIPI-connected COTS camera module to a video monitor
- The MIPI video data will be sent through a custom FPGA-based video pipeline
- The augmented video will be sent to a monitor connected via an active displayport cable
- The software will execute within a Linux operating system
- STRETCH GOAL: Video may be passed into a machine learning algorithm and the output of the ML algorithm will be used to augment the video sent to the monitor

IMX219 Image Sensor

Vocabulary

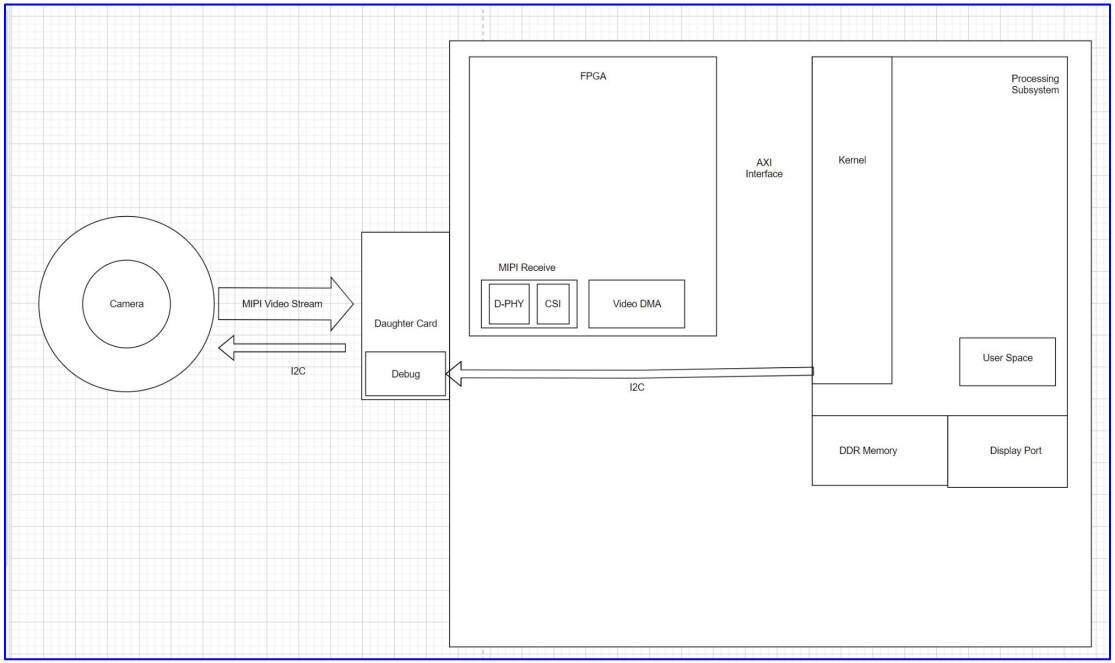
- **IMX219 image sensor:** camera
- **MIPI:** mobile industry processor interface
- **D-PHY:** physical communication layer
- **CSI:** camera serial interface
- **VDMA:** video direct memory access
- **DDR:** double data rate) memory



Ultra-96 FPGA Board

Video Pipeline Block Diagram

- IMX219 image sensor to MIPI Receive (D-PHY and CSI)
- MIPI Receive to VDMA
- VDMA to DDR memory
- DDR memory to DisplayPort monitor

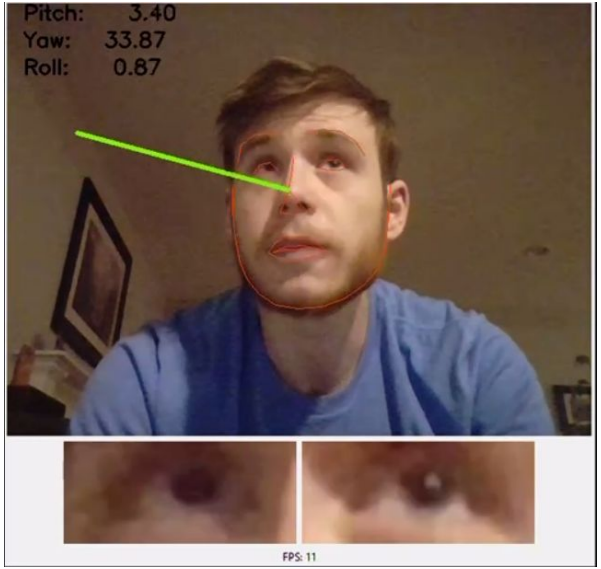


Video Pipeline Block Diagram

Functionality

- **Disabled users** can utilize the product to track their eye movements in real-time for seizure detection and communication and navigation assistance

- **Programmers** can utilize this product to implement Machine Learning algorithms for different tasks
  - Facial recognition
  - Object detection and avoidance for self-driving vehicles
  - Surveillance for traffic control or intelligence applications



Eye-Tracking Algorithm by a previous SD Team

Technology Considerations

- We will utilize Sony IMX219 and OmniVision Technologies OV5647 image sensors
- A programmable Ultra-96 FPGA will be used
- **Advantages:**
  - Commonly available off-the-shelf hardware components and image sensors
  - Cost-effective
  - Documentation available from previous Senior Design teams and datasheets online
  - Programmable exposure time, gain control, black level adjustment, defect correction, etc. possible for image sensors to function in a variety of lighting conditions
- **Disadvantages:**
  - FPGA hardware design and software development technical expertise needed

Areas of Concern and Development

- Work with the Ultra-96 is in progress
- Block diagrams for video pipeline and component subsystems are complete or almost done
- Learning how to program in a PYNQ versus a non-PYNQ environment is the current challenge
- Based on the current design, the team is confident that the project is achievable and can be done on schedule

Conclusions

This product implements a video pipeline for a computer vision system in C and Python code working on a Linux image. The hardware is off-the-shelf, commonly available components and sensors designed to aid disabled or injured users. Our product is accessible for programmers interested in Machine Learning (ML) for many real-world tasks such as facial recognition, object detection and avoidance for self-driving vehicles, and surveillance for traffic control or intelligence applications.

To help visualize the workflow, we created a system-level block diagram to show the input and output signal relationships between different subsystems. Next, we defined the technology components (FPGA board and image sensors) our product will utilize to function as desired. We compared the advantages and disadvantages of these components and potential promising solutions. Lastly, we discussed different areas of concern and development the team is working on currently and our outlook for the future.