

opto3D

The Team

- **Matthew Wong**
 - Nvidia Jetson configuration and camera interfacing
 - 3D modeling and printing
 - Video processing in Python
- **Sanil Baweja**
 - Video processing in Python/CUDA
 - GPIO buttons
- **Brian Lee**
 - Video processing in C++
 - Image correction
- **Thomas Stubbs**
 - Video processing in C++
 - GPIO buttons
- **Rami Dabit**
 - Video processing in Python/CUDA
 - 3D modes in Python



Project Description

- Alcon developed a stereo camera mounted on a microscope for eye surgery, displaying the image on a 3D monitor to provide the surgeon with better depth, flexible color adjustments, and ease of use
- **Problem:** Powerful host computer required to act as a middleman
- **Our Goal:** Bypass the the need for a host computer



How Does 3D Video Work?

A solid red rectangular box with a thin black border. In the center of the box is a large, bold, black capital letter 'L'.

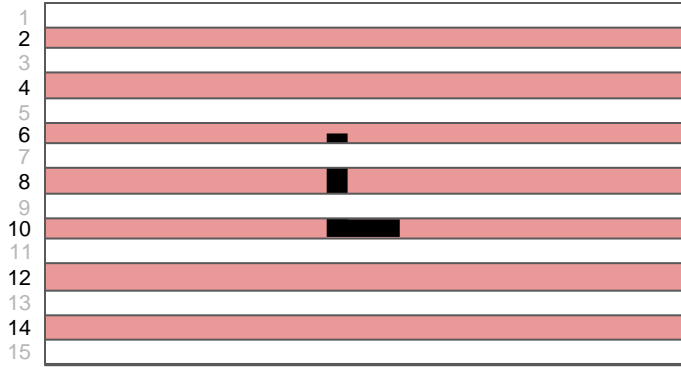
L

A solid blue rectangular box with a thin black border. In the center of the box is a large, bold, black capital letter 'R'.

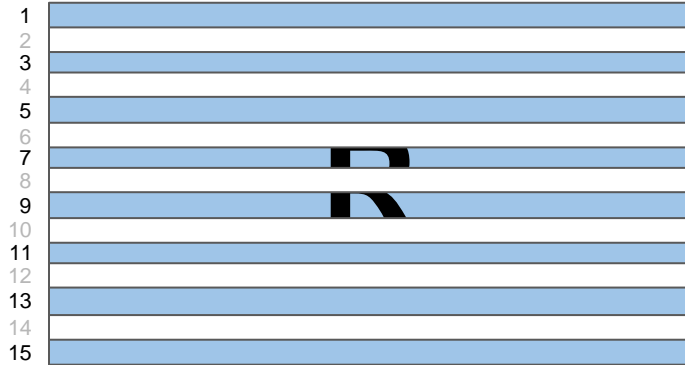
R

How Does 3D Video Work?

Even Rows Selected

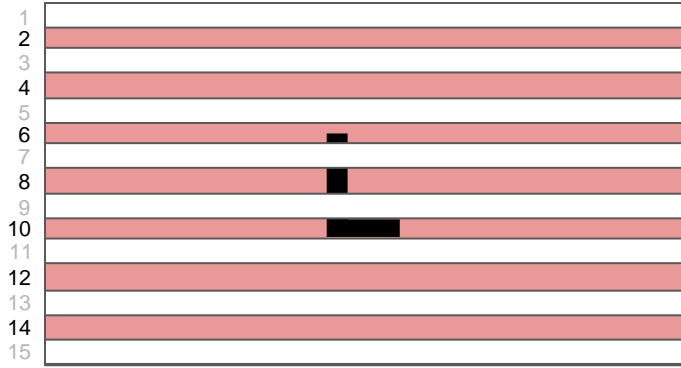


Odd Rows Selected

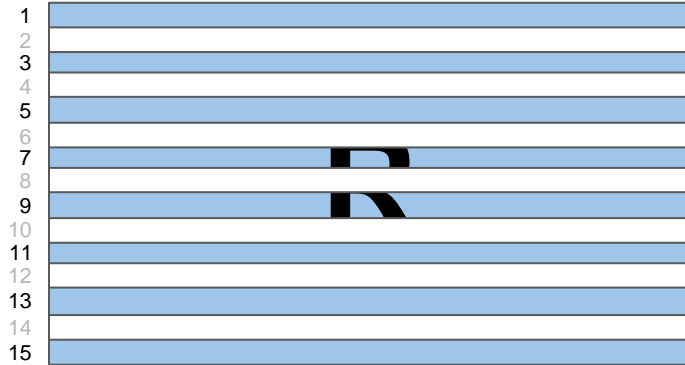


How Does 3D Video Work?

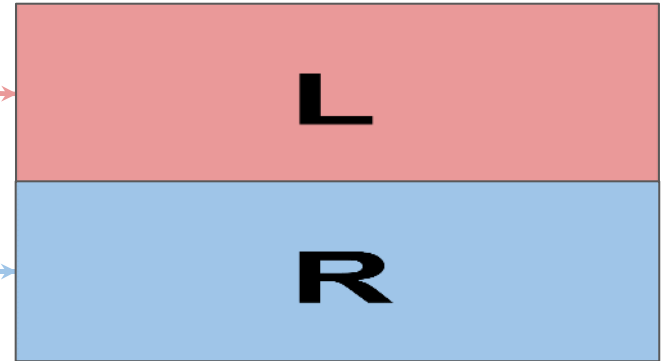
Even Rows Selected



Odd Rows Selected



Top-Bottom Configuration



How Does 3D Video Work?

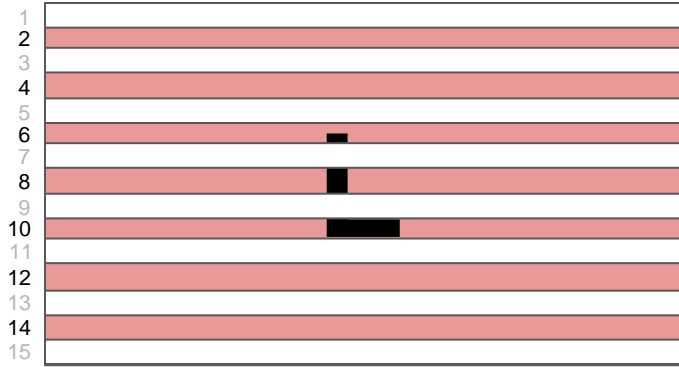


Top-Bottom Configuration

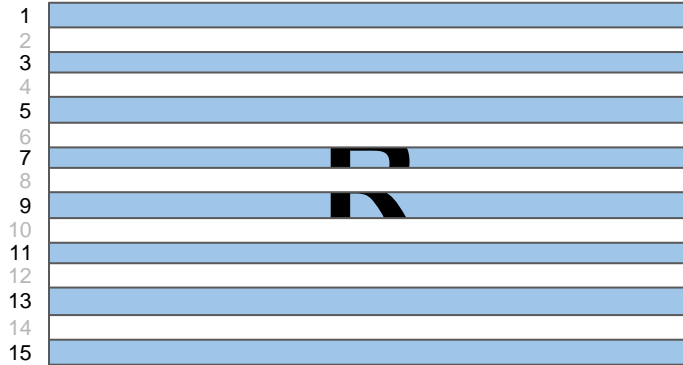


How Does 3D Video Work?

Even Rows Selected

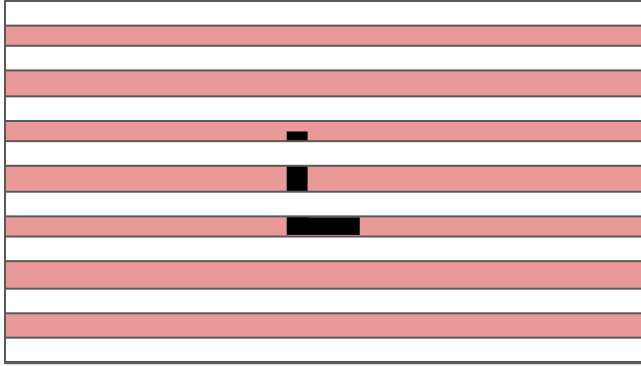


Odd Rows Selected

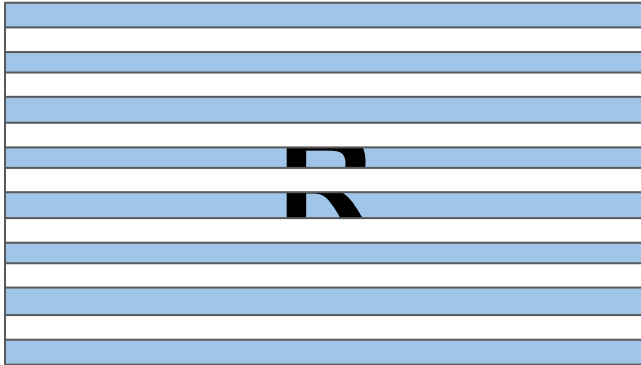


How Does 3D Video Work?

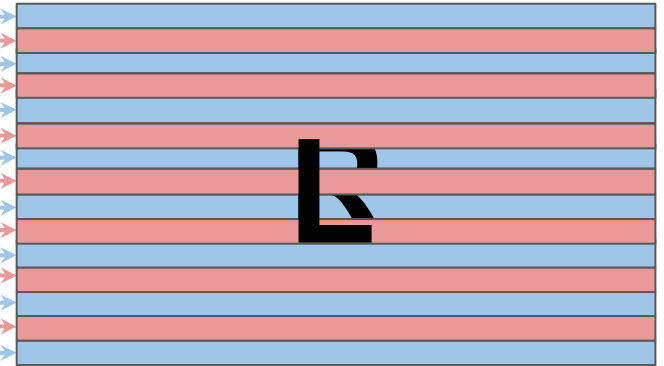
Even Rows Selected



Odd Rows Selected



Row-Interleaved



How Does 3D Video Work?



Row-Interleaved Configuration

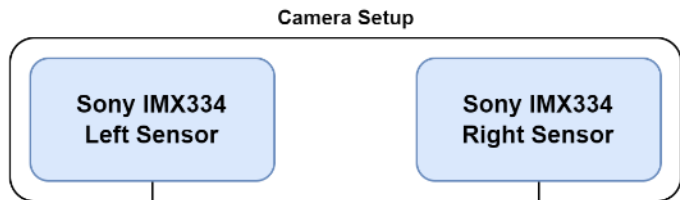


Why is this so challenging?

- The final product must run in real time, or else safety is a concern
 - Regular (CPU Processed) NumPy → NumPy on CUDA (GPU Processed)
- CUDA and GPU processing
 - Complex and dense APIs and corresponding documentation
 - Reduce memory copy from CPU to GPU as much as possible
- Components come from different manufacturers
 - SOC and development boards from Nvidia
 - TX1 is EOL and losing support
 - Camera sensor made by Sony
 - Module, adapter board, and drivers from Leopard Imaging
 - Results in many dependency and driver challenges

Hardware

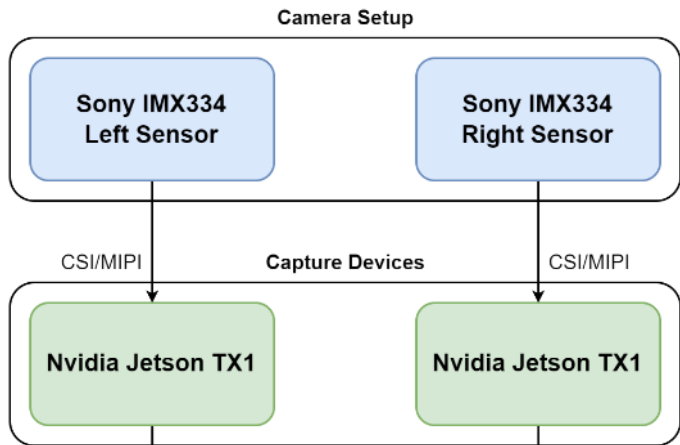
Hardware Block Diagram



Sony IMX334 Sensor

- ES0522F.IR Lens Setup
- Assembled by Leopard Imaging
 - Interfaced with MIPI CSI-2
- Two sensors used to simulate the left and right eyes

Hardware Block Diagram

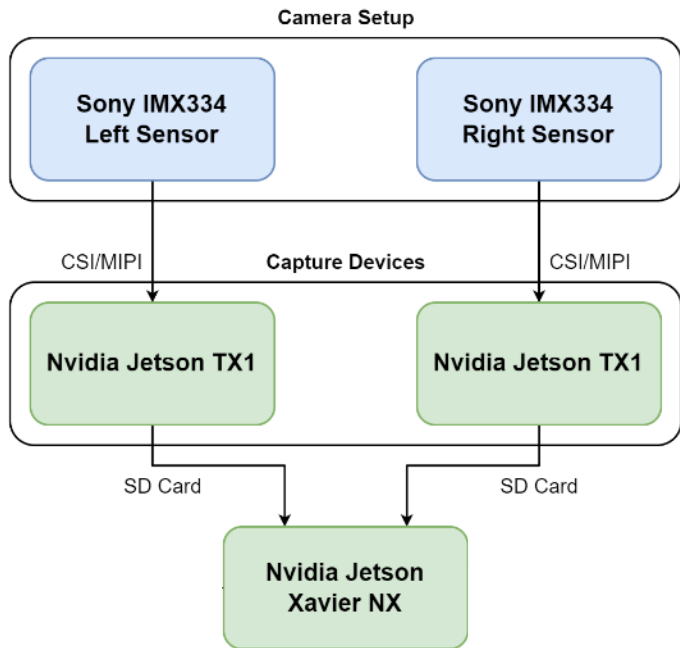


Nvidia Jetson TX1

- Designed for visual computing
 - Runs Linux with JetPack SDK
- Quad-core ARM Cortex-A57 Microcontroller
- Maxwell GPU w/ 256 CUDA cores



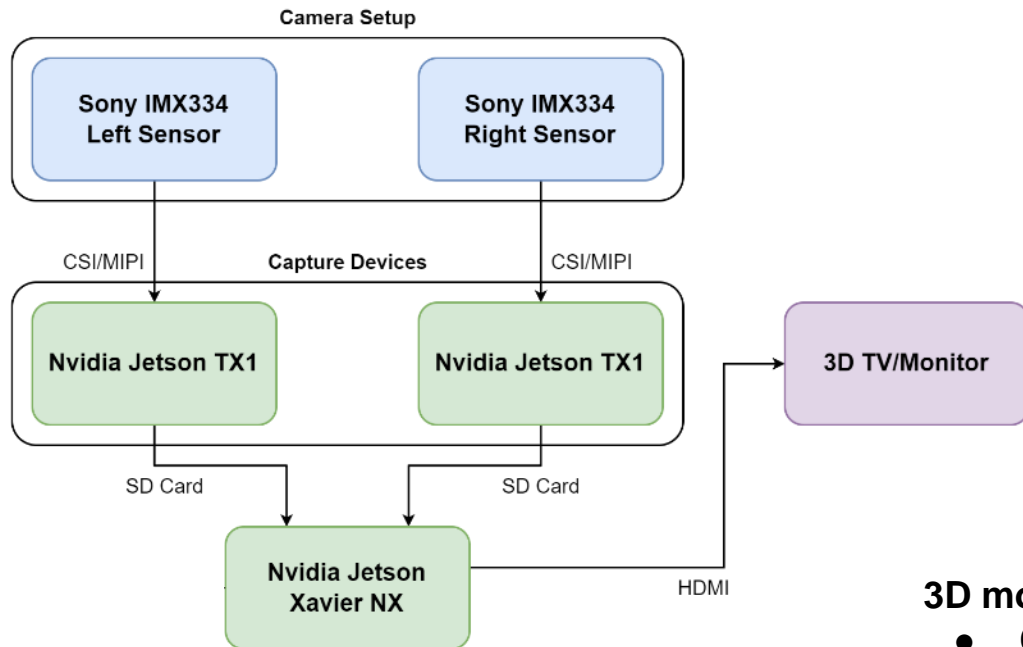
Hardware Block Diagram



Nvidia Jetson Xavier NX

- Designed for visual computing
 - Runs Linux with JetPack SDK
 - Output either HDMI or DisplayPort
- 6-Core Nvidia Carmel CPU
- Volta GPU w/ 384 CUDA cores

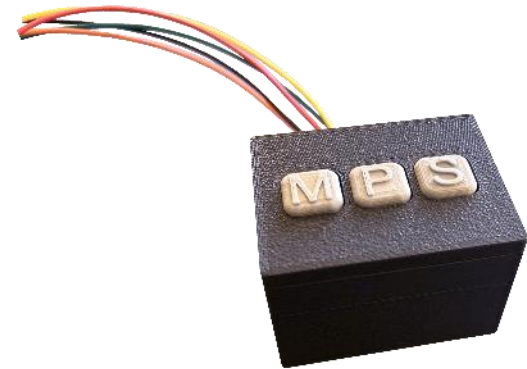
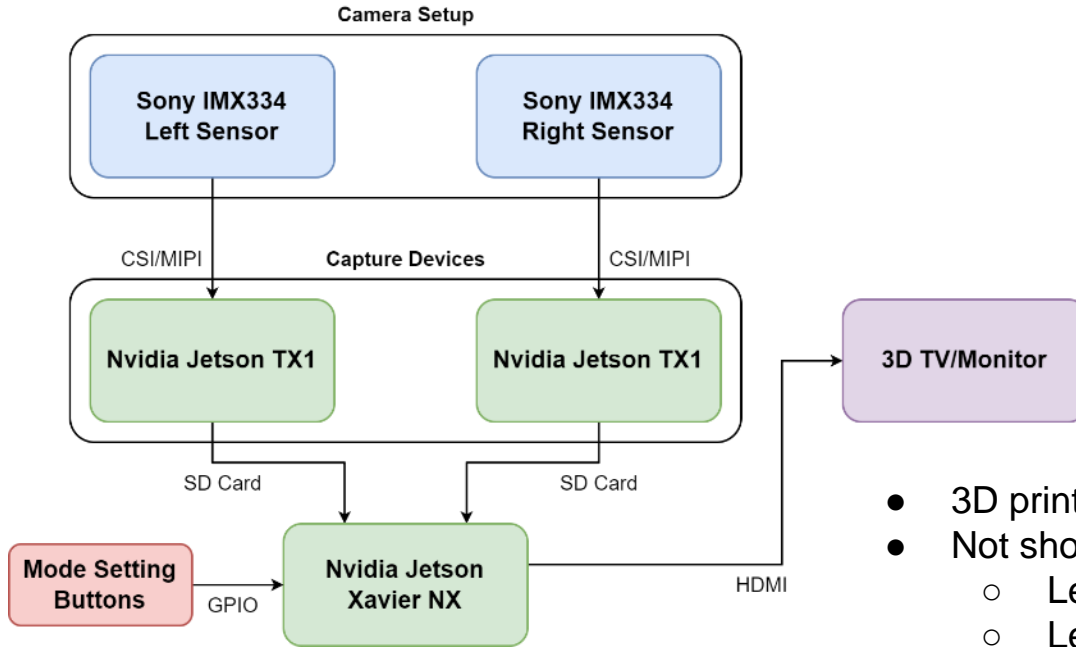
Hardware Block Diagram



3D monitor provided by Alcon

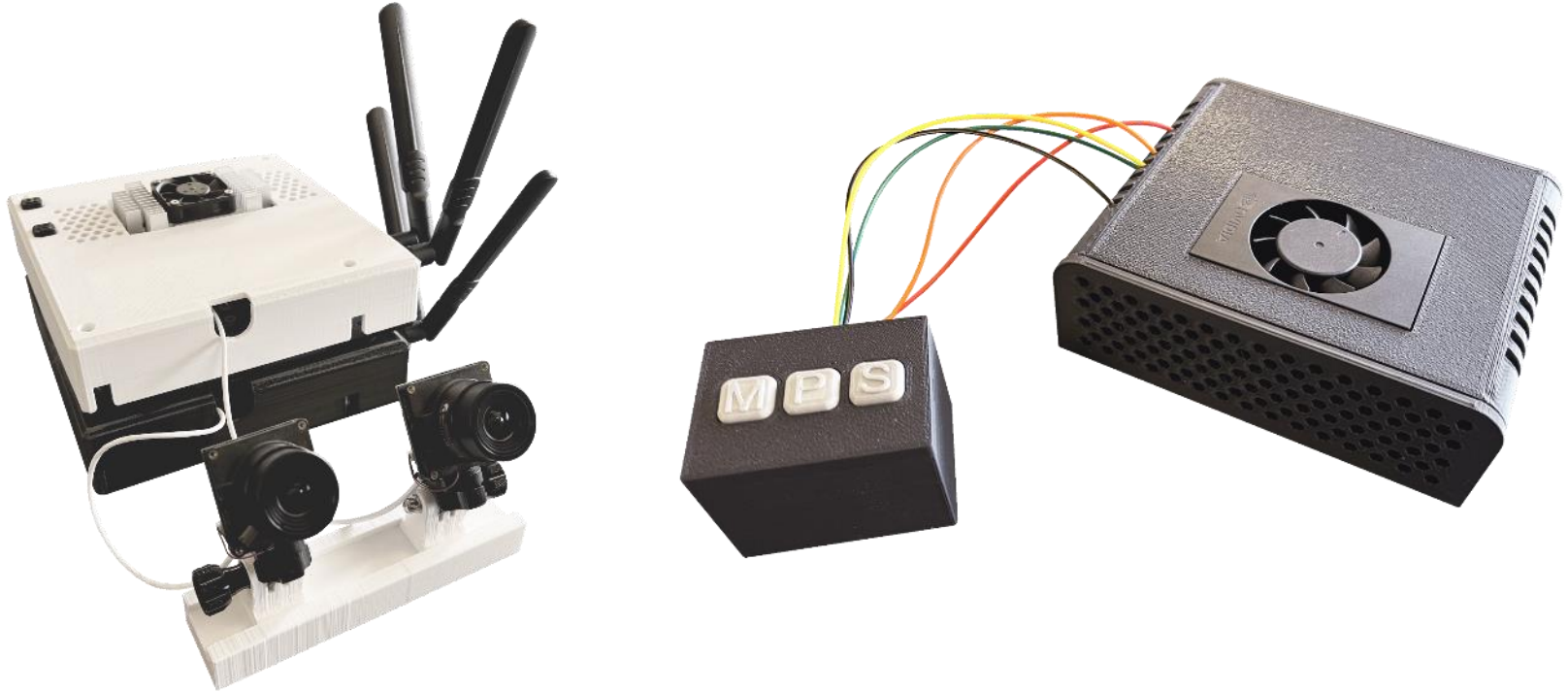
- Capable of monoscopic, side-by-side, top-bottom, and row-interleaved 3D modes

Hardware Block Diagram



- 3D printed casing and buttons
- Not shown — Miscellaneous parts:
 - Leopard Imaging Micro Coax I-PEX cable
 - Leopard Imaging camera adapter board
 - Connects TX1 to IMX334

Complete Hardware Setup



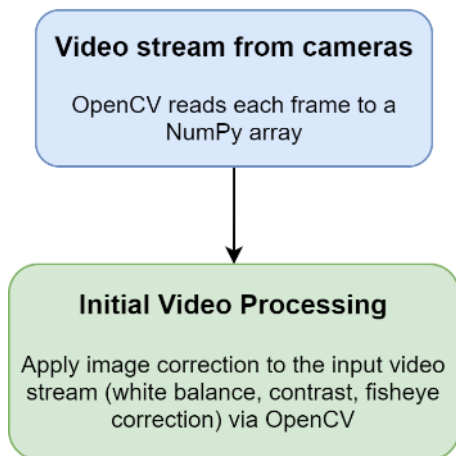
Software

Software Flow

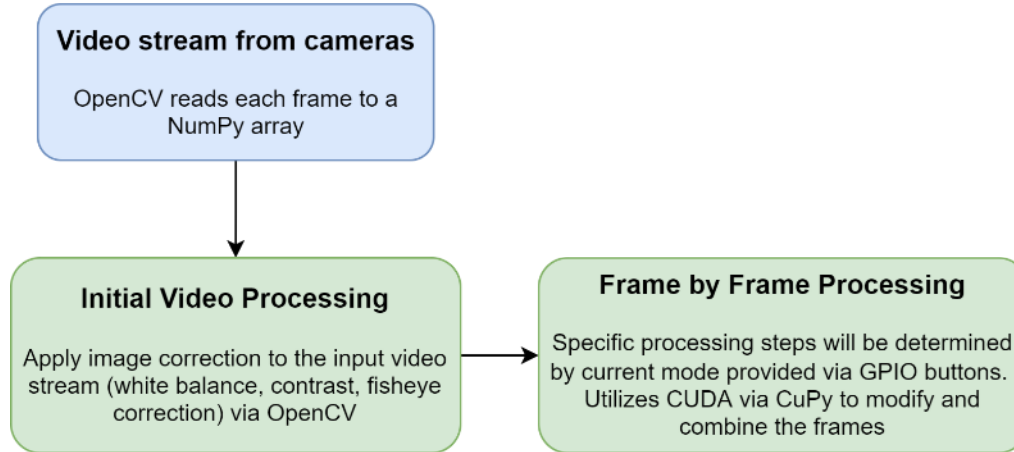
Video stream from cameras

OpenCV reads each frame to a
NumPy array

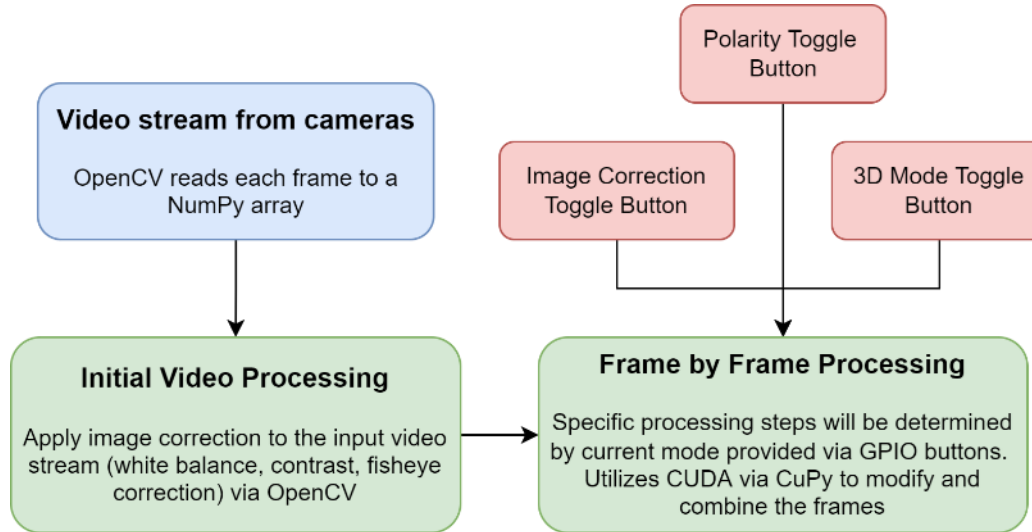
Software Flow



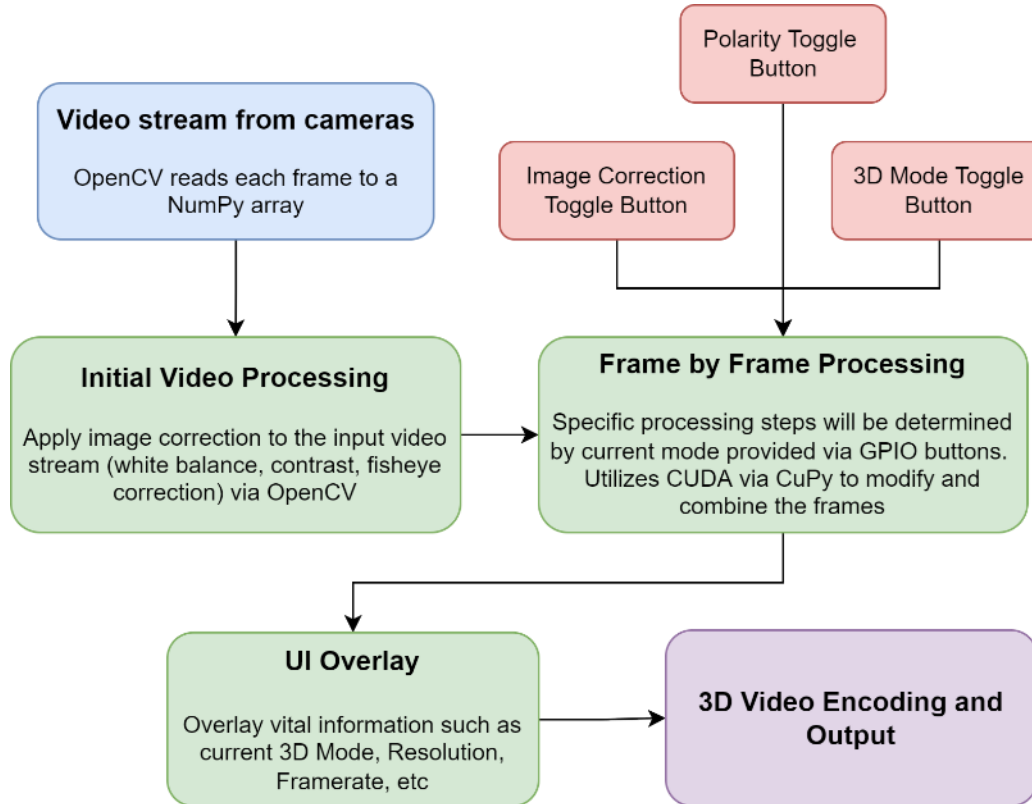
Software Flow



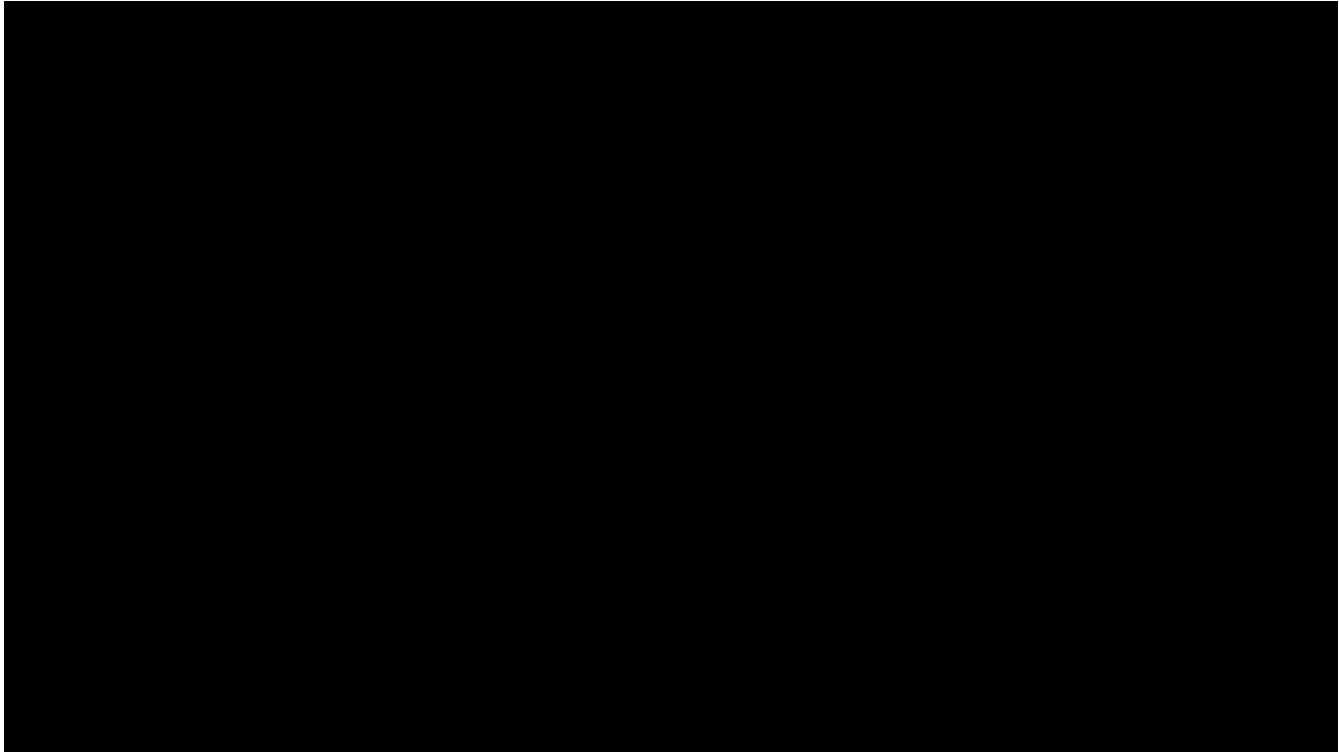
Software Flow



Software Flow



Demo Video



Thanks to our Support Team!

Alcon Point of Contact

- Yuepei Hu
 - Embedded Systems Manager at Alcon

UCSB Teaching Staff

- Professor Yogananda Isukapalli
- TA Brycen Westgarth
- TA Christopher Cheney

CACI

Lead sponsor of CE Program

Alcon

Alcon is the global leader in eye care, dedicated to helping people see brilliantly.

In Goleta, formerly TrueVision Systems (est. 2003), acquired by Alcon in 2018

UC SANTA BARBARA
College of Engineering

Thanks for listening!
Any questions?

Opto3D.org