EyeMatic

–

Eye Anatomy Recognition ECE Capstone

Winter 2024 Design Review

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Problem

- Cataract surgery is very common
    - ⅙ Americans develop cataracts by age 40
    - More than half of Americans develop cataracts by 80
- Patients' eyes usually rotate or move around when patients lie down during surgery
    - Makes surgery confusing and complicated at times
    - Surgeon’s attention primarily focused on camera display

What is EyeMatic? - The Solution

- EyeMatic is a camera system that utilizes machine learning in order to detect eye anatomy on a patient's eye.
- Differentiate different anatomy of eye anterior + detect eye rotation and movement → makes system smarter
  - Guide other surgical devices to do eye alignment + registration
- Allows surgeons to focus more on the surgery at hand
  - Rotation is important for surgeons to accurately perform cataract surgery

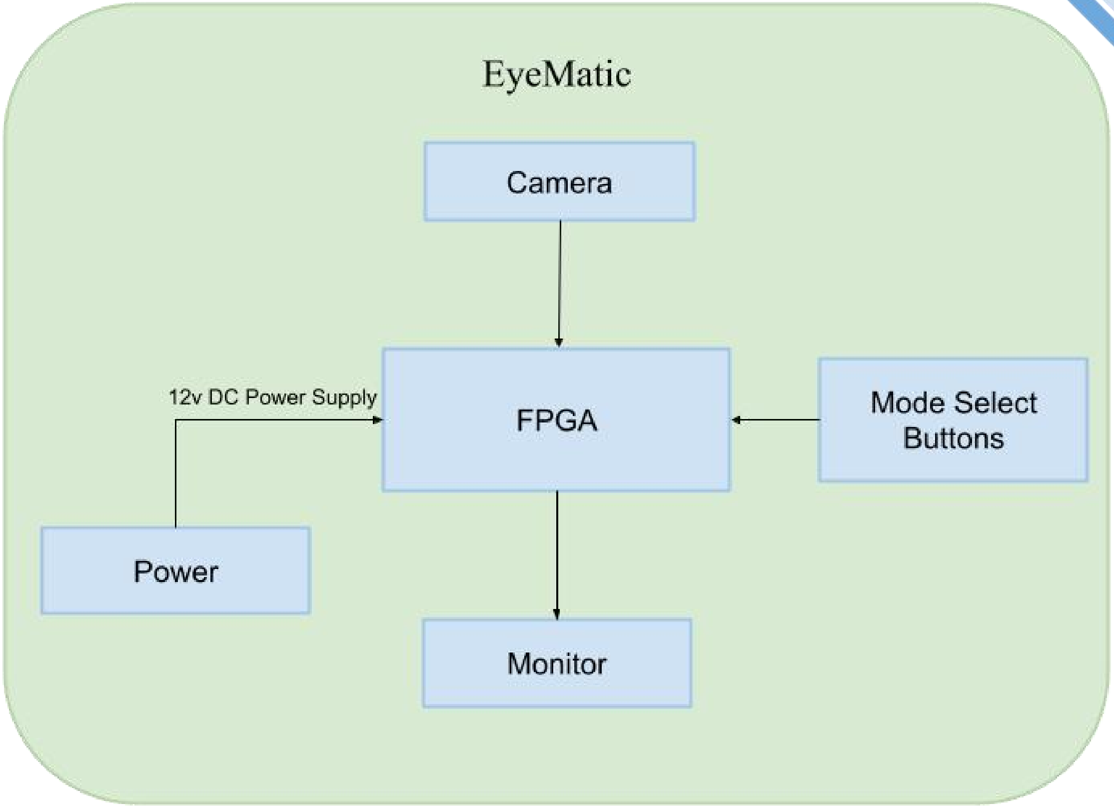
Team

- Kenya Aridomi: Model
- Andrew Chen: Training
- Michelle Ly: Project Lead, Presentation/Documentation, Training
- Ethan Nguyen: Training
- Marco Wong: Model

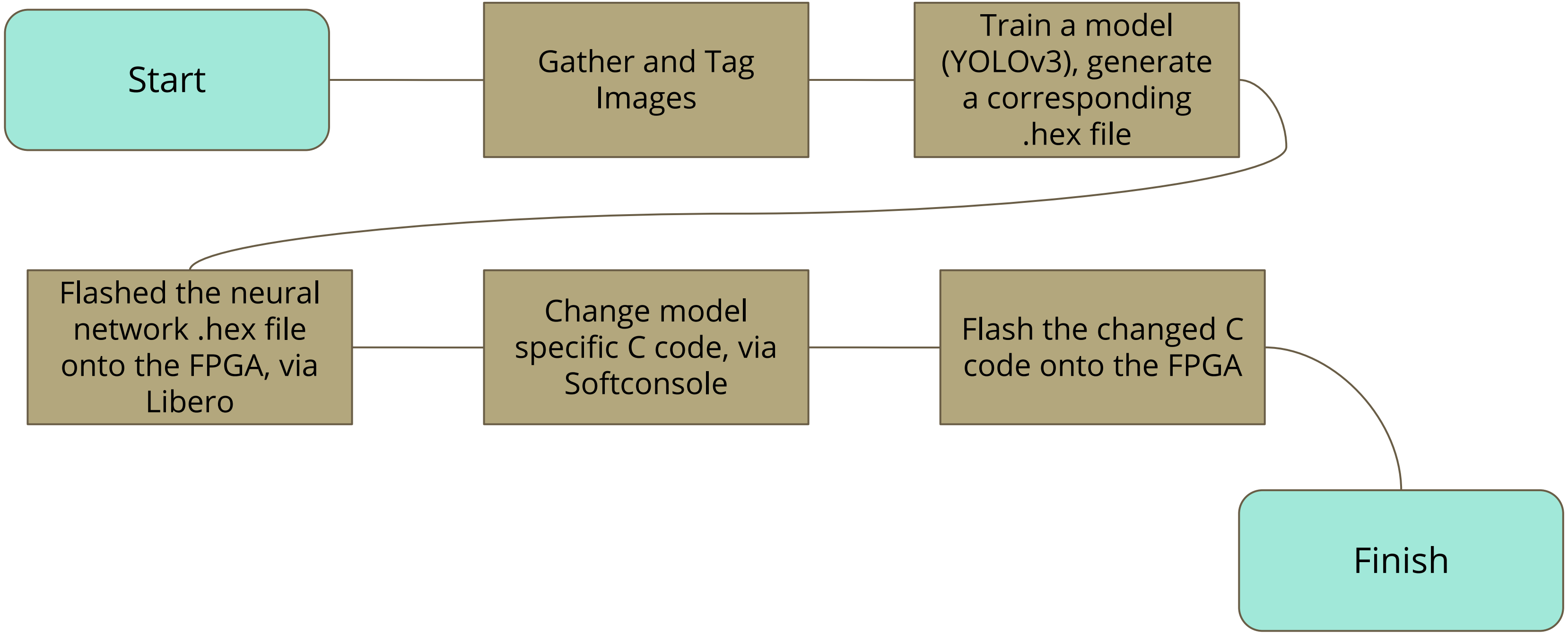




Block Diagram

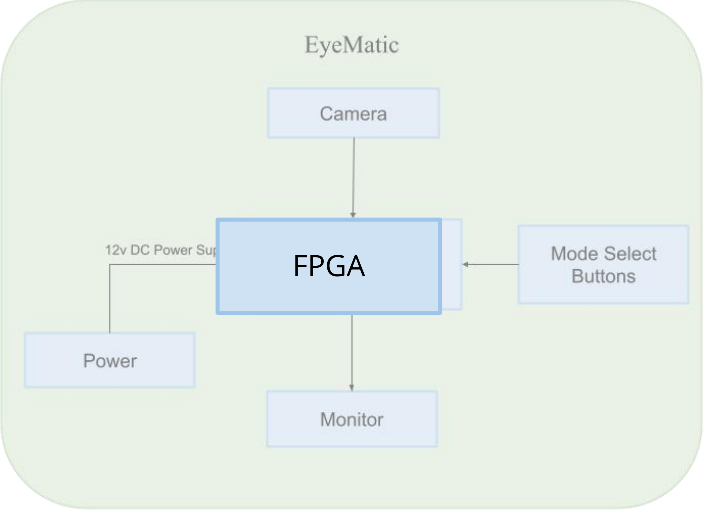


Workflow


Start
Gather and Tag Images
Train a model (YOLOv3), generate a corresponding .hex file
Flashed the neural network .hex file onto the FPGA, via Libero
Change model specific C code, via Softconsole
Flash the changed C code onto the FPGA
Finish

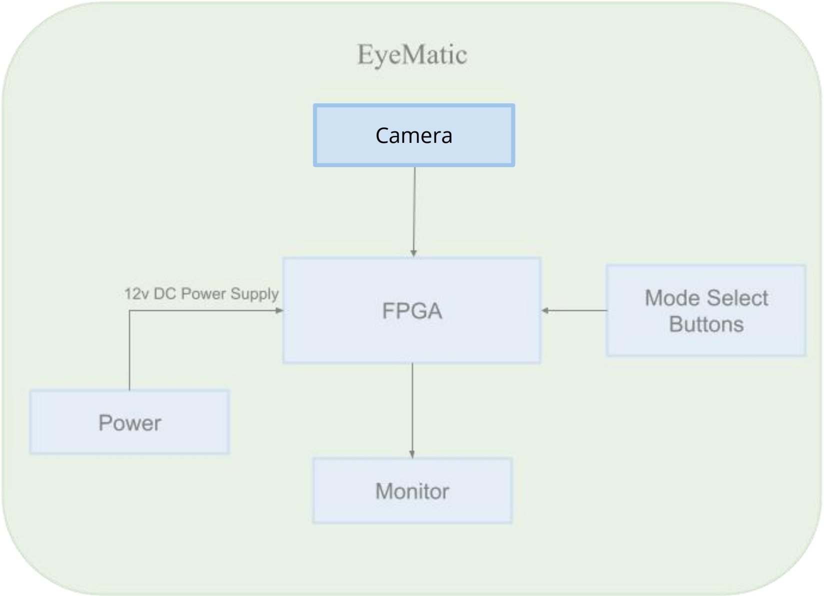
Components - FPGA

- PolarFire FPGA MPF300-VIDEO-KIT - manufactured by Microchip Technology
- 4GB DDR4 x32 RAM
- Embedded programming and debugging using SPI and JTAG
- 300K Logic Elements
- 1x 1Gb SPI Flash Memory
- USB to UART interface
- HDMI 2.0 RX and TX
- HDMI 1.4 TX



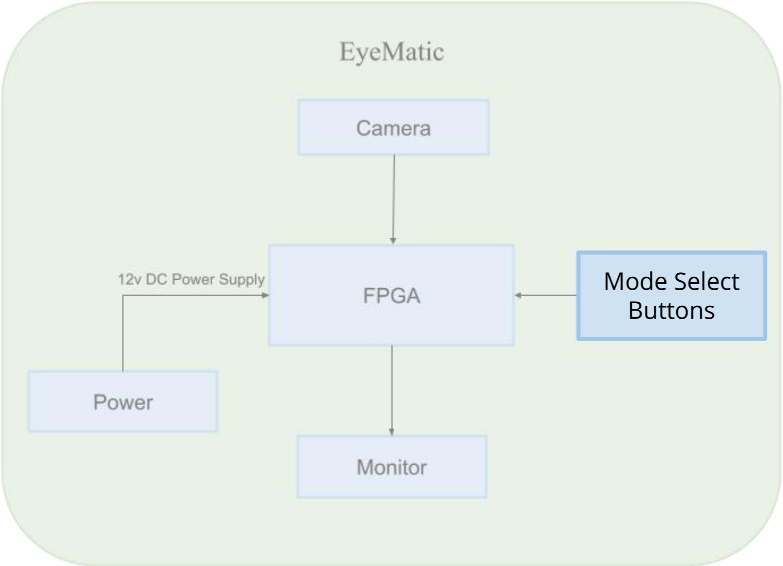
Components - Camera

- Sony Dual Camera Sensor (IMX334) over Amphenol FCI connector (CSI-2 RX)
- 60FPS RGB
- 8.42M pixels resolution

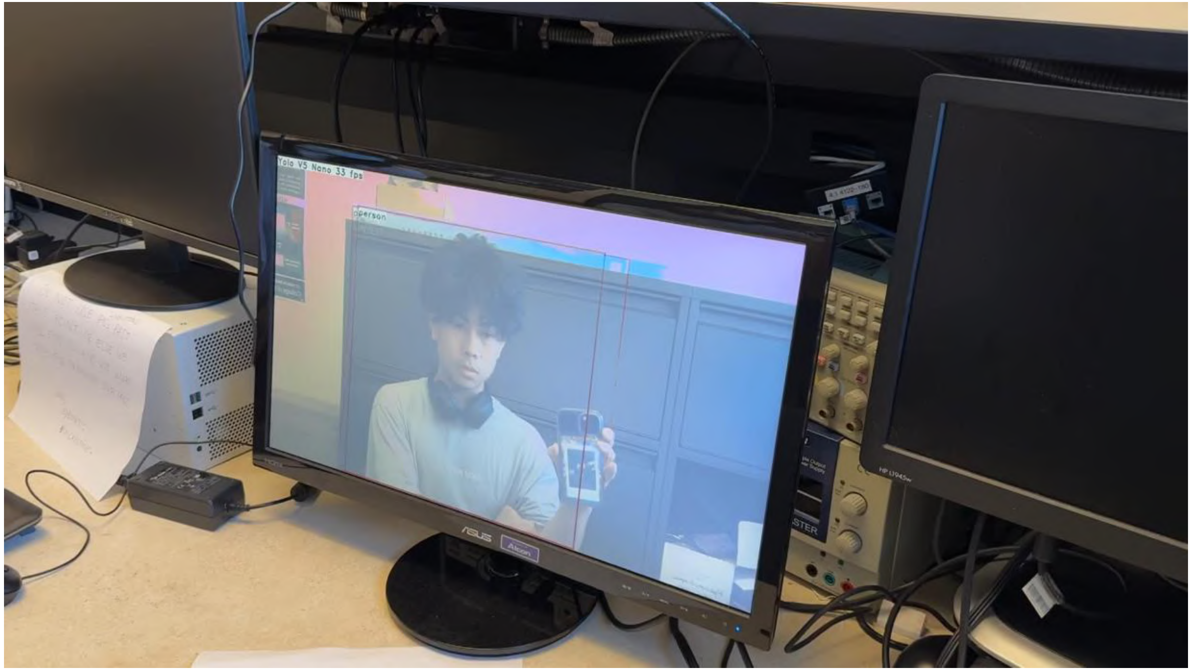


Components - Mode Select Buttons

- Allows user to pick and choose from a list of programmed models
  - Flashed and stored in SPI memory

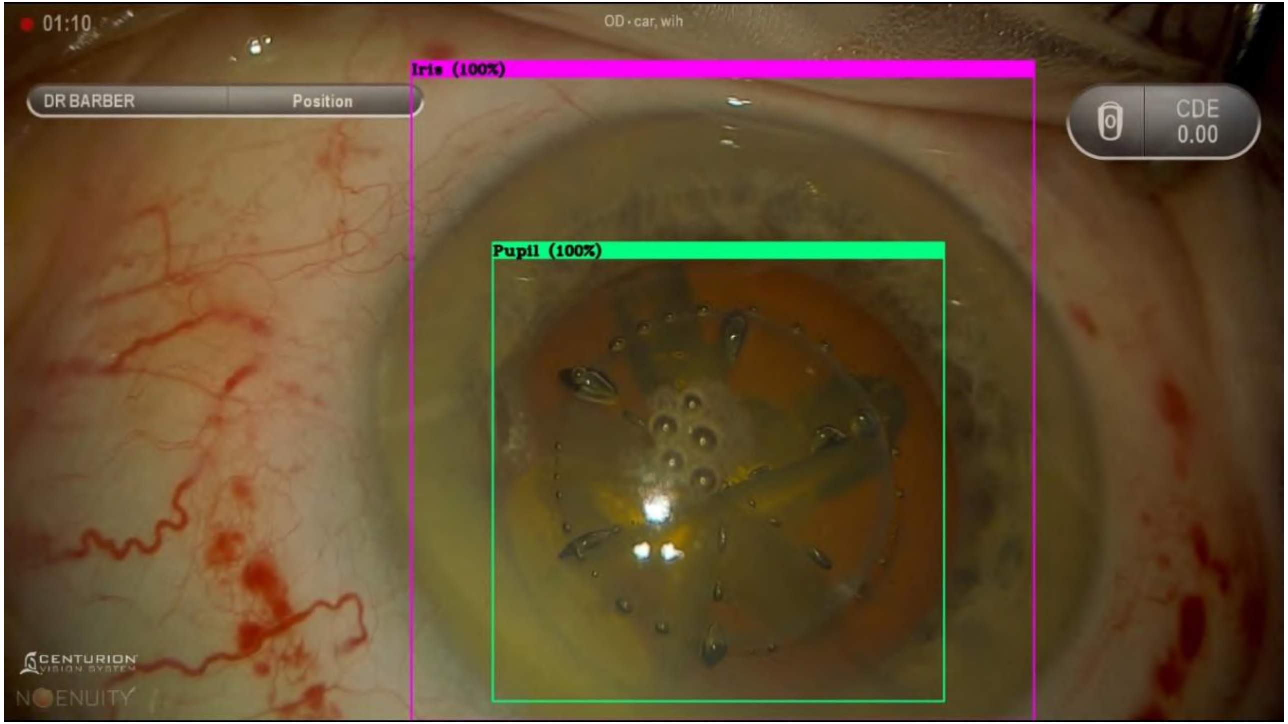


Demo Video (Flashed Models)



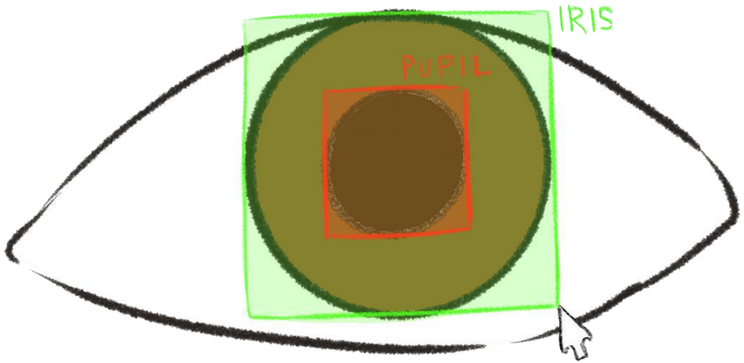
VIEWER DISCRETION ADVISED:
CLOSE UP OF EYES, SHARP OBJECTS

Demo Video (Our Trained Model)



Machine Learning

- Training YOLOV3
  - Training models
    - Eye anatomy - classification
    - Eye rotation - regression
- Tagged ~5000 images
  - Need to ensure that there's variation in data

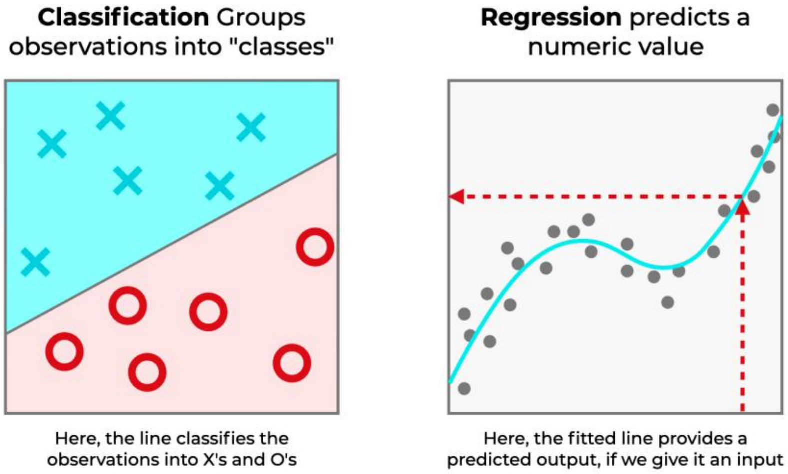


What We've Done

- Finished tagging images
- Found more images for more accurate training
- Close to finishing model training
- Uploaded model
- Began looking into creating model for eye rotation

Eye Rotation Model (Possible Approach)

- Brute Force Method Approach
- Augment and Tag images manually for each degree
- Train YOLOv3 model as a regression task compared to a classification task



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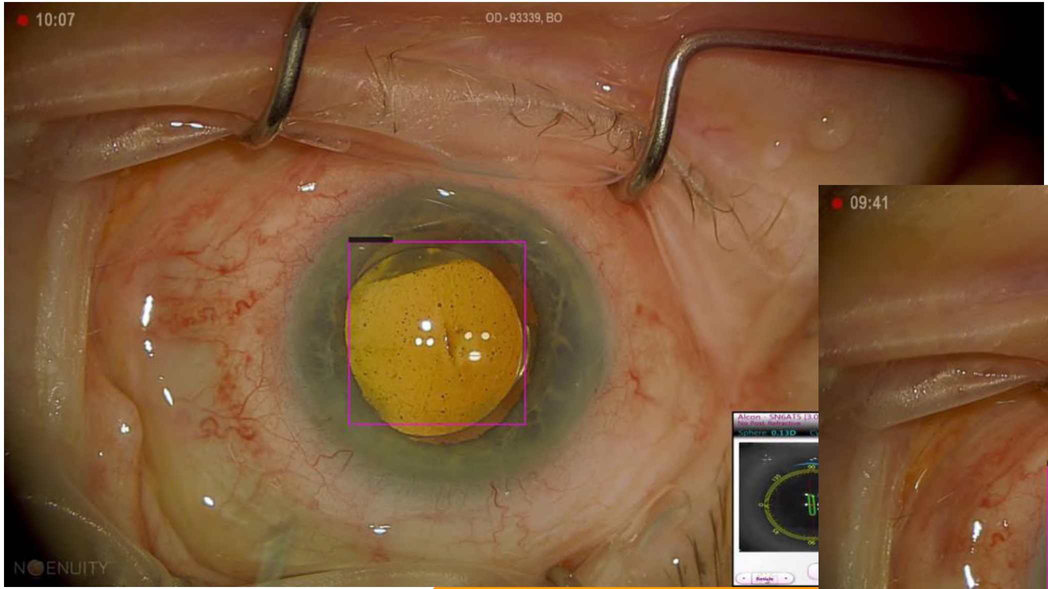
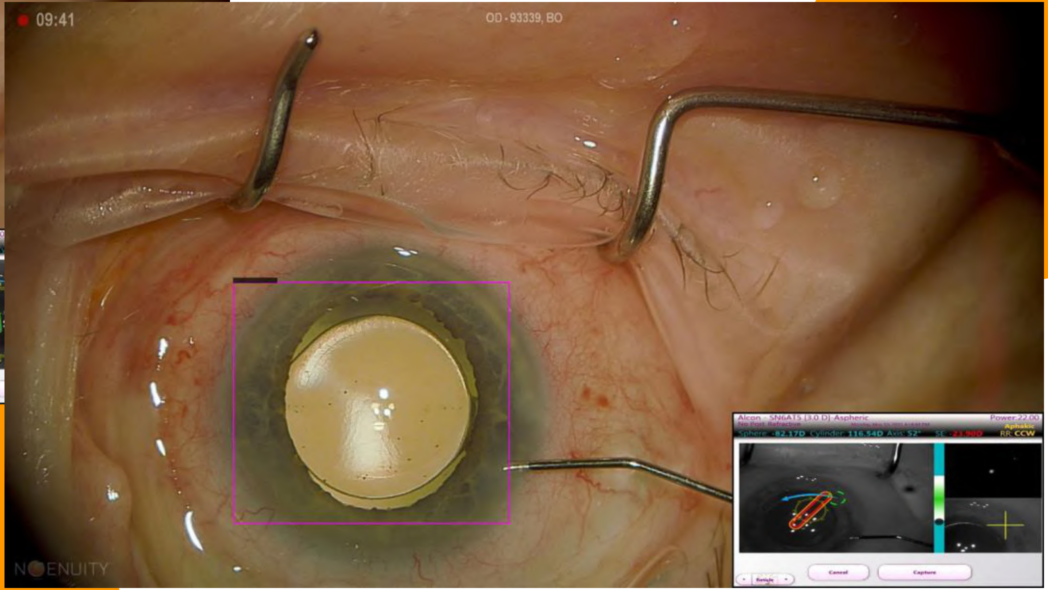
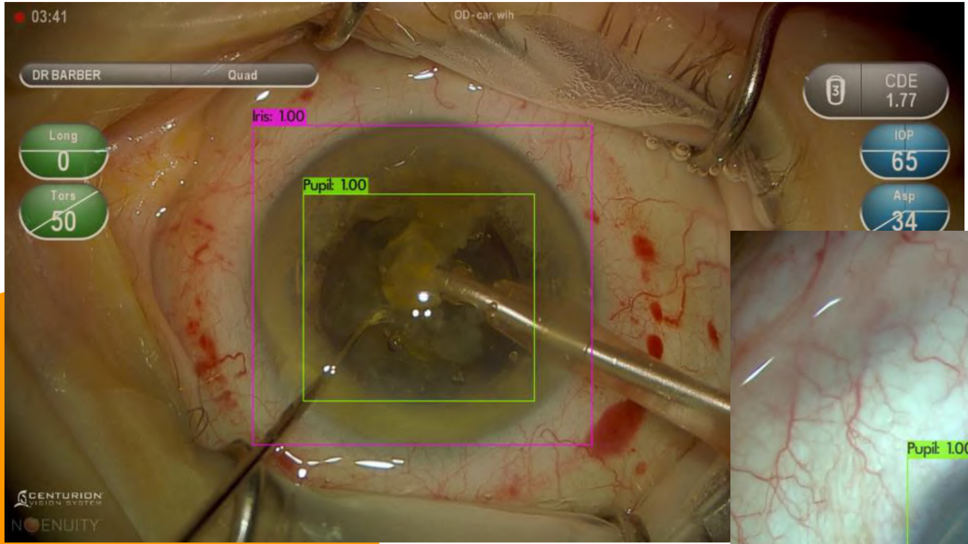
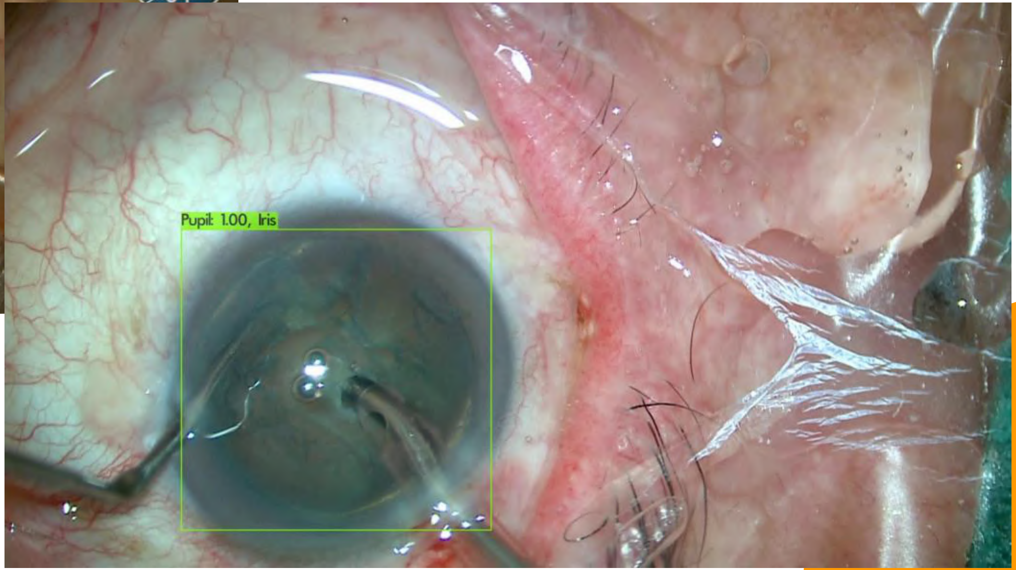
Model Progress (FALL)





Model Progress (WINTER)





Timeline

Winter
Continue tagging,
labelling, training model(s),
flash model(s) on FPGA

Spring
Train model(s),
have a working model on
FPGA
(Stretch Goal: Finding the
rotation of the eye)

Risk Analysis

- Deploying own model on the FPGA
  - Most time consuming task at the moment, the only step left before finishing the primary goal of the project
  - Meetings had with both Alcon and Microchip to debug and resolve issues
- Accuracy with model, some images where the pupil and iris look too similar have issues
  - Increased data diversity by finding more
  - Train using more tagged images, being cautious with overfitting

Acknowledgements

- Dr. Yogananda Isukapalli (Capstone Lead)
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Thank you!

Questions?