Revolutionizing Veterinary Education: Canine Eye Simulation for Hands-On Learning

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Modeling Dog Eyes

The goal of this project is to develop a pair of canine eyes that implements a wide range of eye functions, including blinking, pupil dilation/constriction, and eye movement in response to sensor feedback. This embedded eye simulation system will be integrated with a larger canine system, allowing veterinary students to train with more realistic feedback when diagnosing medical cases of canine patients.

Project Breakdown

1. Eye Appearance: realistic canine eyes
2. Sensor Integration: 2 light sensors and 1 sound sensor
3. Packaging: 3D printed casing for eye displays and sensors
4. Communication Protocols: within subsystem and to the larger system

Eye Appearance

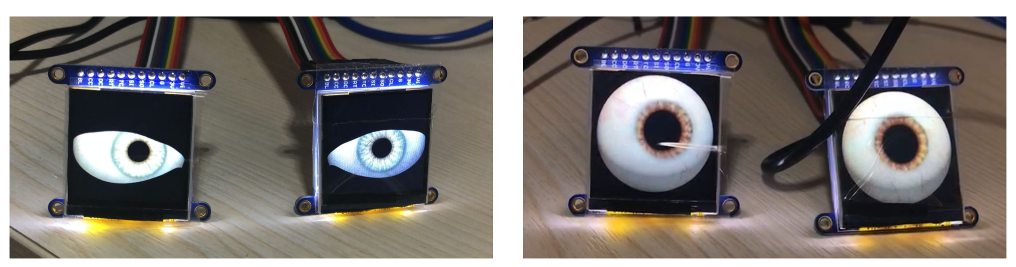

Figure 1: Monster Eyes Modified to Dog Eyes

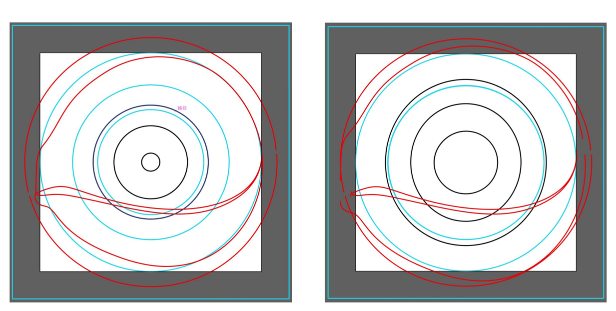

Figure 2:
Original vs Modified Eye Shape SVG File

Eye Shape

- smaller sclera (eyes white)
- higher pupil to sclera ratio
- rounded upper and lower eyelids

Pupil Size

- larger resting pupil size
- max pupil size for dilation
- min pupil size for constriction

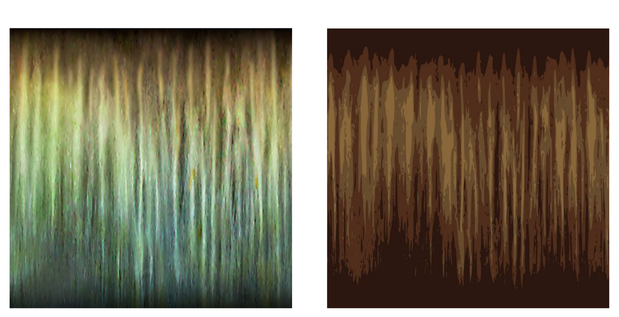

Figure 3:
Original vs Modified Iris Color PNG File

Iris Color

- brown, orange
- warm, neutral tones
- customizable

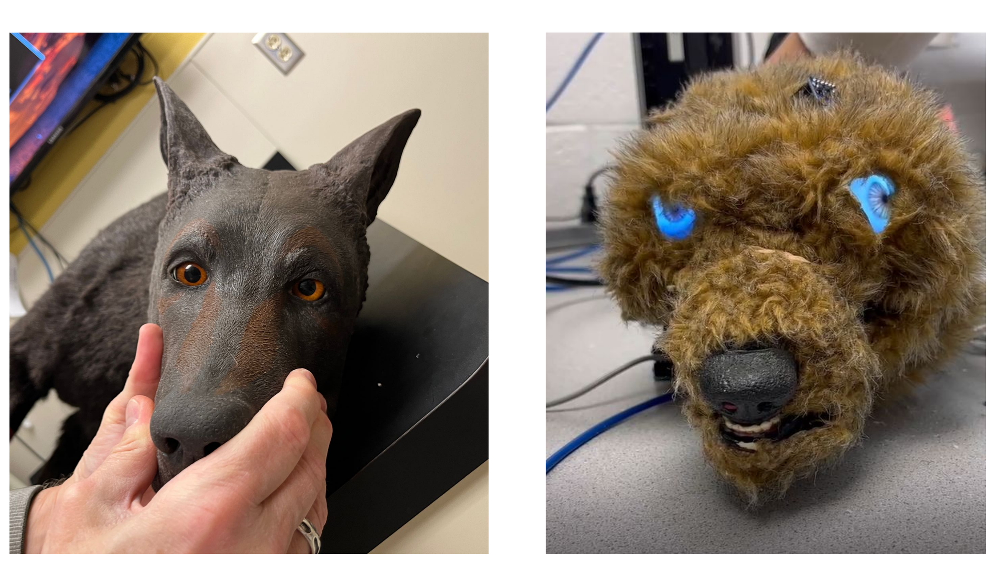

Figure 4: Model's Glass Eyes vs Prototype's LED Eyes

Hardware Breakdown

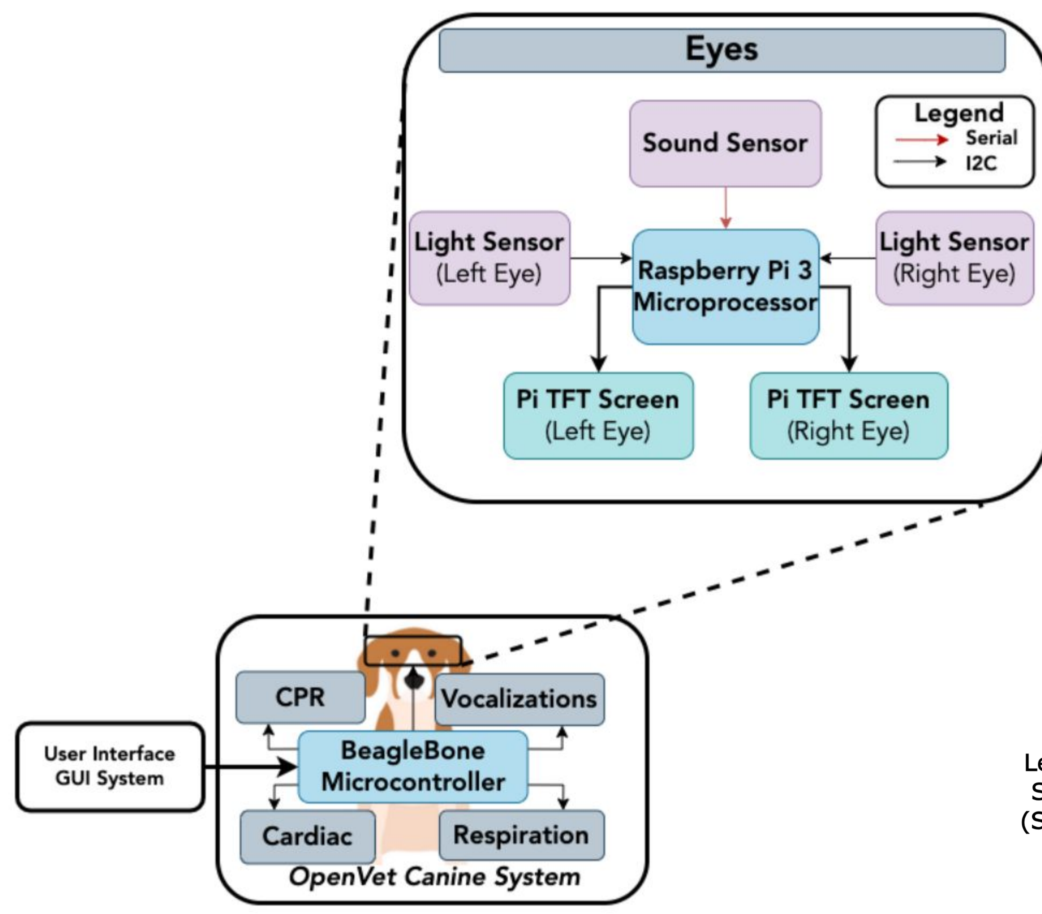

Figure 5: Eye Subsystem with OpenVet Canine System

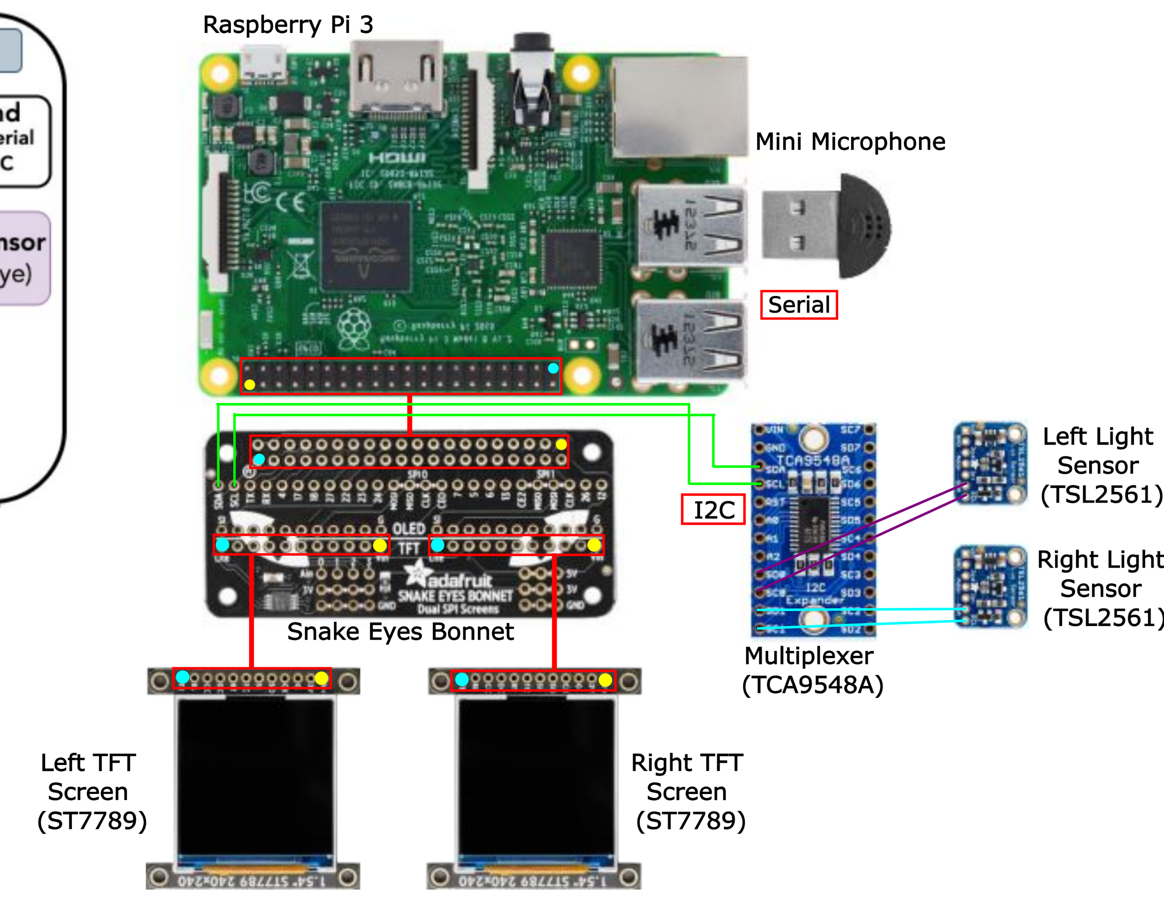

Figure 6: Hardware & Wiring of the Embedded Eye Simulation System

Raspberry Pi 3 (RPi 3)

- has high processing power/RAM and graphics capabilities
- runs the eye simulation software which responds to environmental stimuli
- processes lux measurements per program-defined thresholds ranges
  - [0,100], [100,1000], [1000, infinity] to change pupil sizes
- processes volume measurements per program-defined threshold value
  - ~70dB (hand clap) to change eye movement

Snake Eyes Bonnet

- passes data from RPi3 to two 240x240 TFT displays

Inter-integrated Circuit (I2C) Multiplexer

- passes data between 2 light sensors sharing the same address via a single bus

Thin Film Transistor (TFT) Screen

- displays movement and pupil responses for each eye
- has high resolution and pixel density, accurate color reproduction, and high durability

Light Sensor

- receives light input and transmits illumination (lux) value

Microphone Sensor

- transforms audio input to real-time decibel value

Eye Configurations for Different Scenarios

Figure 7:
Constricted Pupil

10% Pupil
Lux > 1000

Figure 8:
Normal Pupil

10% - 90% Pupil
100 < Lux < 1000

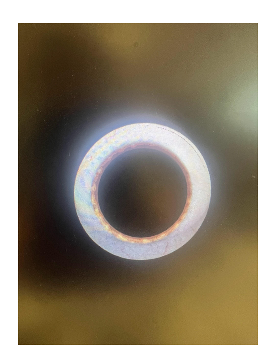

Figure 9:
Dilated Pupil

90% Pupil
Lux < 100

Figure 10: Individual Pupil Responses

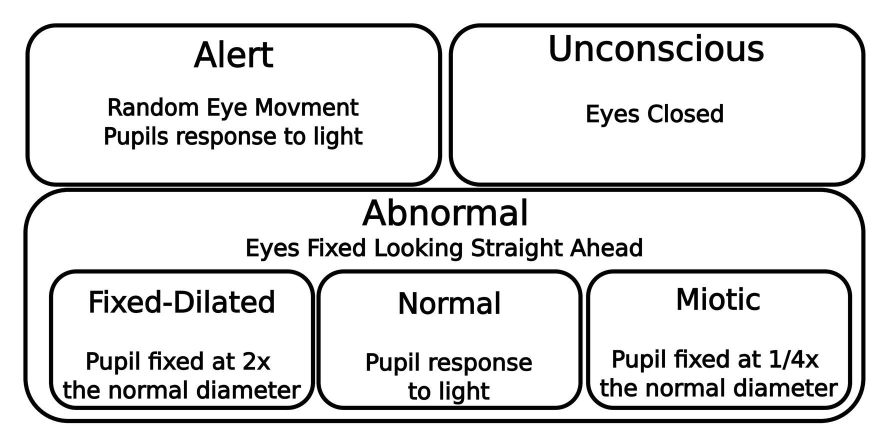

Figure 11: Different Mode of Operations for Eyes

Clinical Scenarios

- different combinations of diseases and medication affect bodily responses, including pupil behavior
- the proctor can choose between three abnormal states for each eye
- each eye has its own light sensor

Electronics Packaging

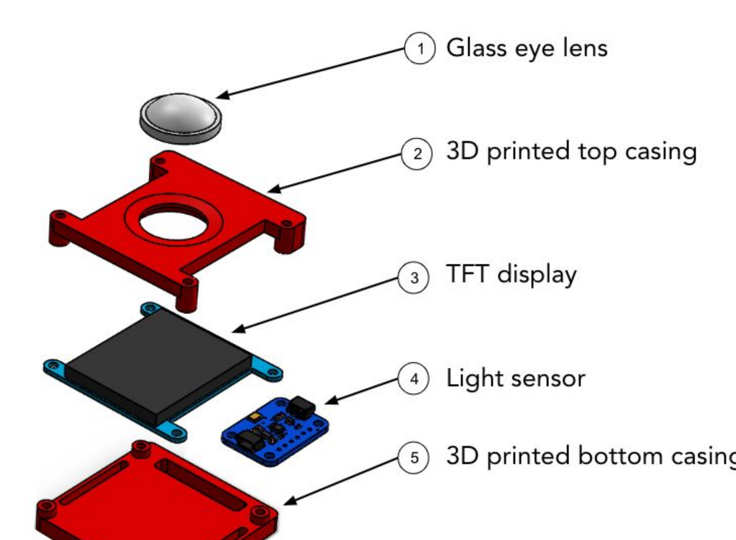

Figure 13: CAD Assembly

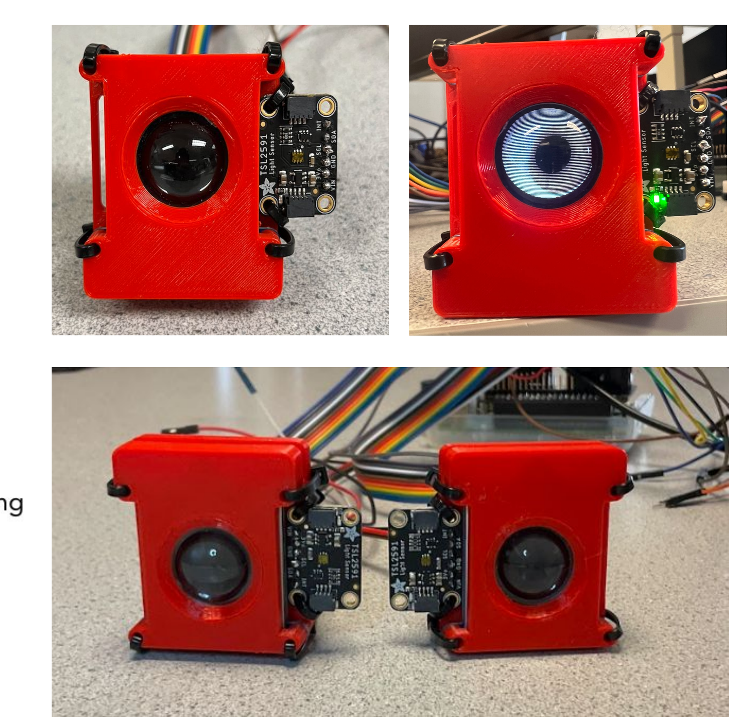

Figure 14: 3D Printed Sensor Casings (PETG Material)

Communication

System Integration

- Beaglebone to RPi3 with I2C
- RPi3 to light sensors with I2C
- RPi3 to microphone sensor with serial
- command line interface for preconfigured mode testing
  - switch cases for program flow alterations
  - Python argparse library utilized for passing terminal arguments

```
Usage: eyes.py [-h] [--leftpupil {on, off}]
                    [--rightpupil {on, off}]
                    [--alert] [--unconscious]
                    [--abnormal {fixed-dilated, normal, miotic}]

Control eye and sound movements

optional arguments:
-h, --help              Show this help message and exit
--leftpupil {on, off}   Turn left pupil on or off
--rightpupil {on, off}  Turn right pupil on or off

--alert                 Trigger alert mode
--unconscious           Trigger unconscious mode
--abnormal {fixed-dilated, normal, miotic}
                        Trigger abnormal mode
```

Figure 12: Communication Protocol Interface

Successful Simulation of Eyes

We were able to display and animate the canine eyes utilizing our hardware and packaging design. By adding light and sound sensors to the system, we were able to provide sensor feedback to alter eye movement and pupillary response with great success.

Future Considerations

1. Integrate the embedded eye system into the Open-Vet Canine System at Cornell University College of Veterinary Medicine (CUCVM)
   - Enhance existing control/customizations with a completed Application Programming Interface (API)
   - Configure relevant eye features for different medical conditions
2. Expand audio capabilities with sound localization (developed but not added per updated CUCVM requirements)
3. Switch to OLED displays to reduce reflective blue light
4. Improve cable extension and harnessing

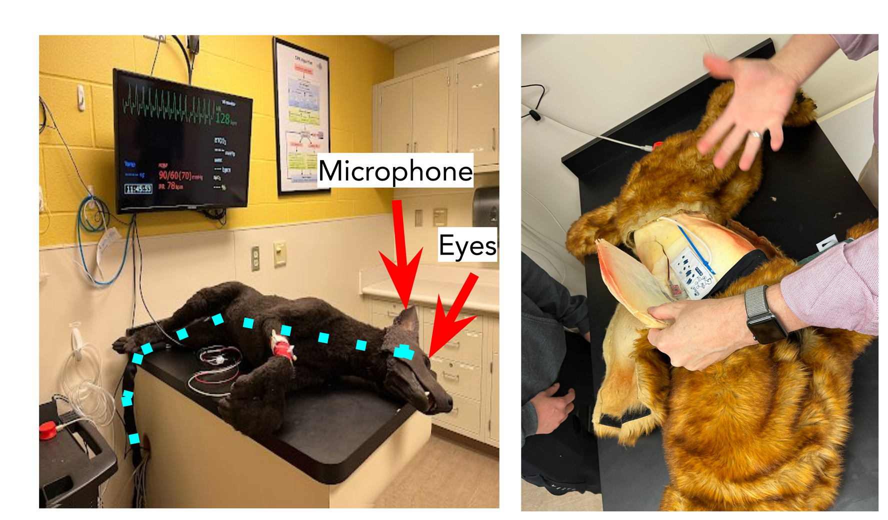

Figure 15 : Integration Plan

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