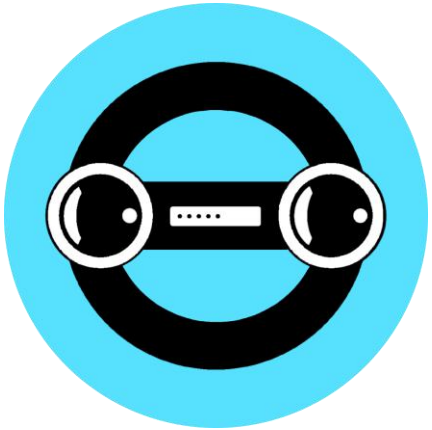


small · e

OUR TEAM

Ebony Warren

Reiley Batelaan

Roberto Garcia

Ryan Niu

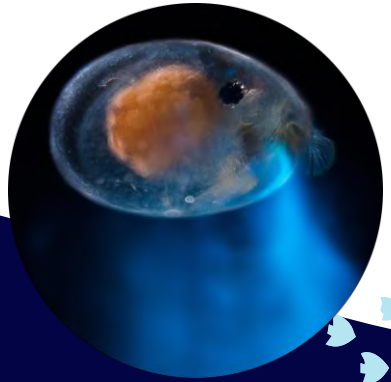
Sammy Umezawa

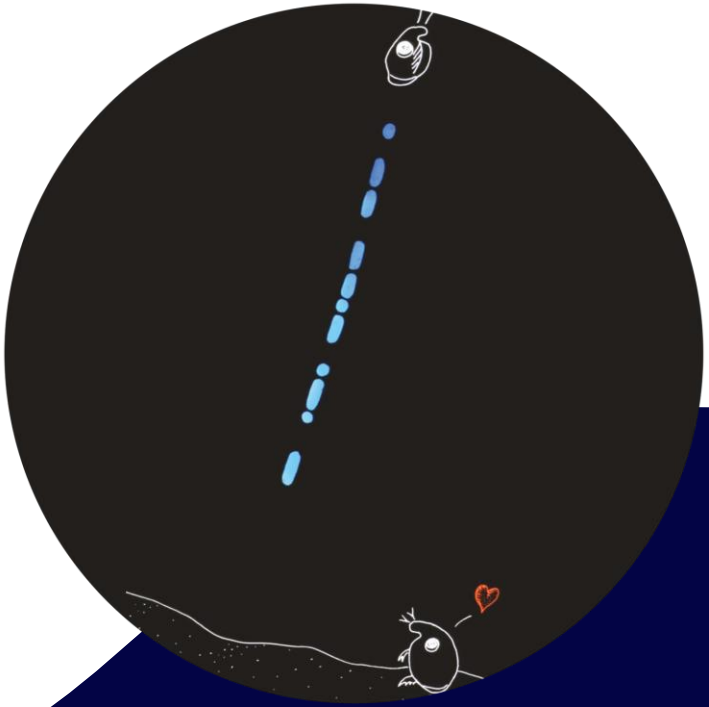
TABLE OF CONTENTS

1 INTRODUCTION

Background Information and our Goals

OSTRACOD BIOLUMINESCENCE COURTSHIP



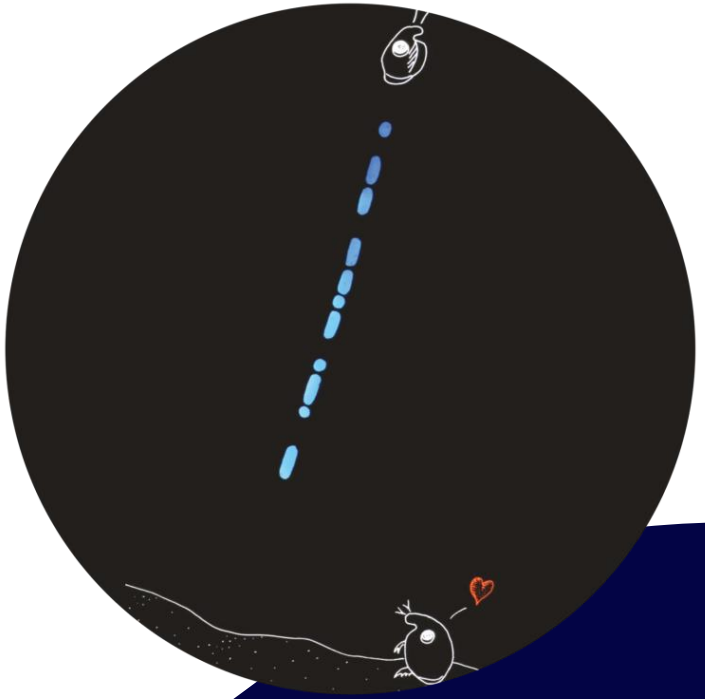


Source(left): Elliot Lowndes
Source(center): Trevor Rivers
Source(right): James Morin

SEA FIREFLIES

Crustaceans that emit bioluminescent courtship messages

- **Timing:** Occurs after nightfall in the absence of moonlight
- **Description:** Low light pulses with varying temporal and spatial patterns across species



OUR GOAL

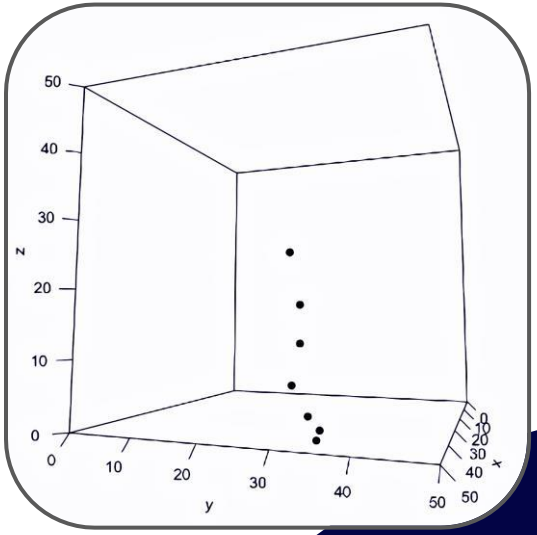
To **aid** the UCSB Oakley Evolution Lab's Research

- ➔ **Objective:** Investigating the evolutionary history of bioluminescence courtship signaling in ostracods

OUR SOLUTION

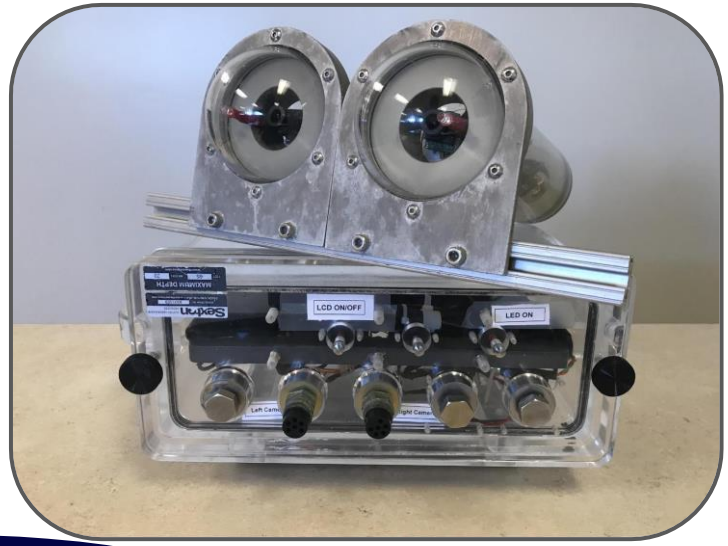
small • e will aid in the following

- ➔ **Approach:** Capturing pulses for mapping
- ➔ **Mapping:** 4D representations combining 3D space and time
- ➔ **Additional Focus:** Acquisition of environmental DNA



WHAT IS small · e ?

- **S**tereovideographic & **M**acromolecular **A**cquisition of **L**ow-**L**ight **E**mitters
- Submersible camera system
- Deployed on the ocean floor
- **Improved version of WALL-E (predecessor)**


LCD ON/OFF
LED ON

WHAT'S CHANGED?

12*

Hour Runtime

Compared to WALLE's estimated 3 hours

NEW

Auto Camera Sync

No more manual syncing

NEW

Light Intensity Measurement

Captures emission at the ostracod retinal perception rate (~ 200 Hz)

NEW

eDNA Collections

Ability to sample for three different time intervals

WHAT'S CHANGED?

IMPROVED

1080p Resolution

Improved from 480p

Compactness

For less buoyancy and safer deployments

Camera Fixation

One-time calibration for stereo vision

Cost and Scalability

Plans to have multiple iterations!

2 COMPONENTS

Breakdown of essential components and block diagram

KEY COMPONENTS

Jetson Nano

Decodes and encodes captures

Auto-synchronizes cameras

Controls DNA collection

WAT-933 IP Cameras

Captures low light 1080p video at 30 FPS

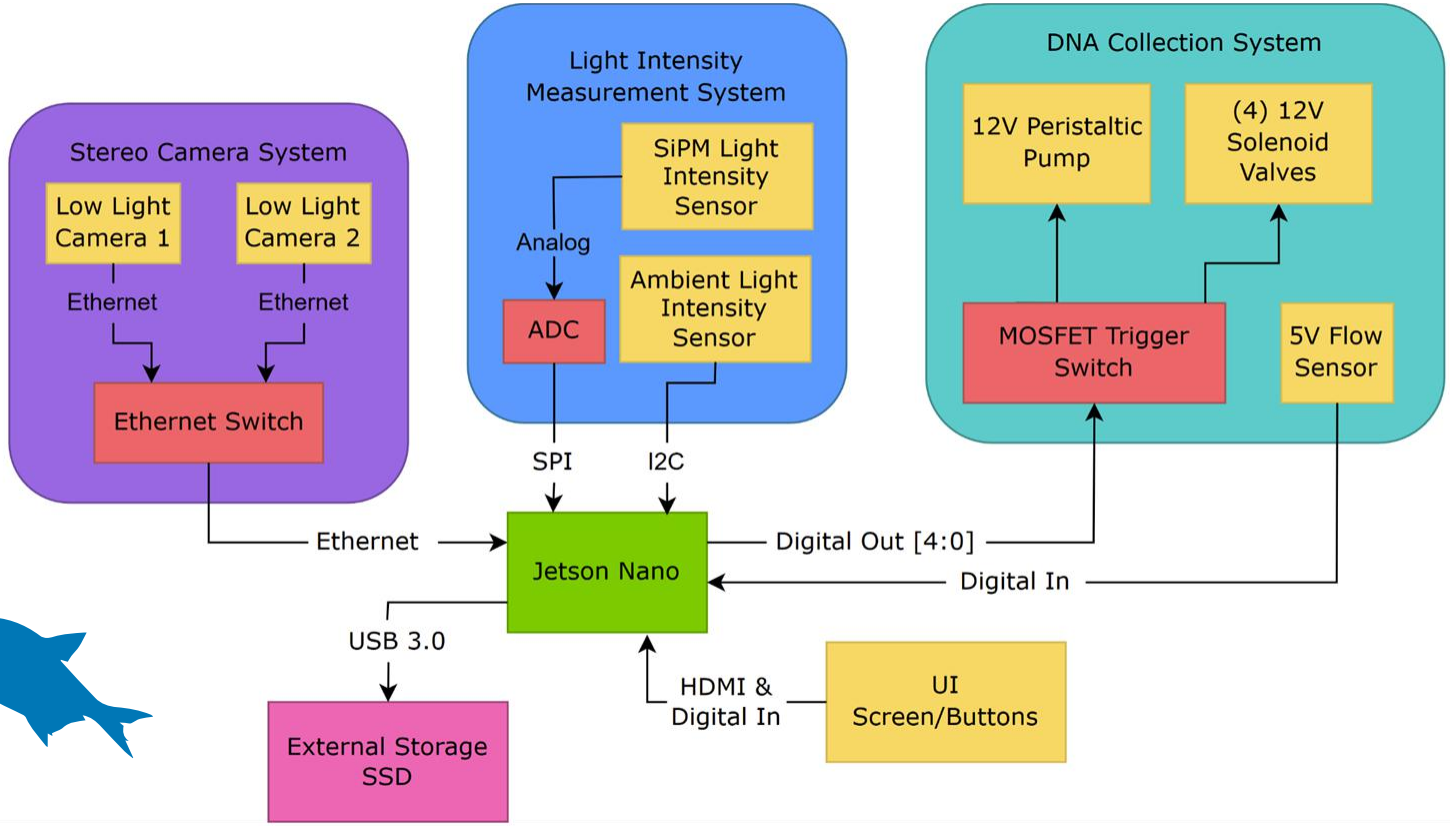
SiPM Module

Silicon photomultiplier captures light intensity of pulses sampled by an ADC at 200Hz

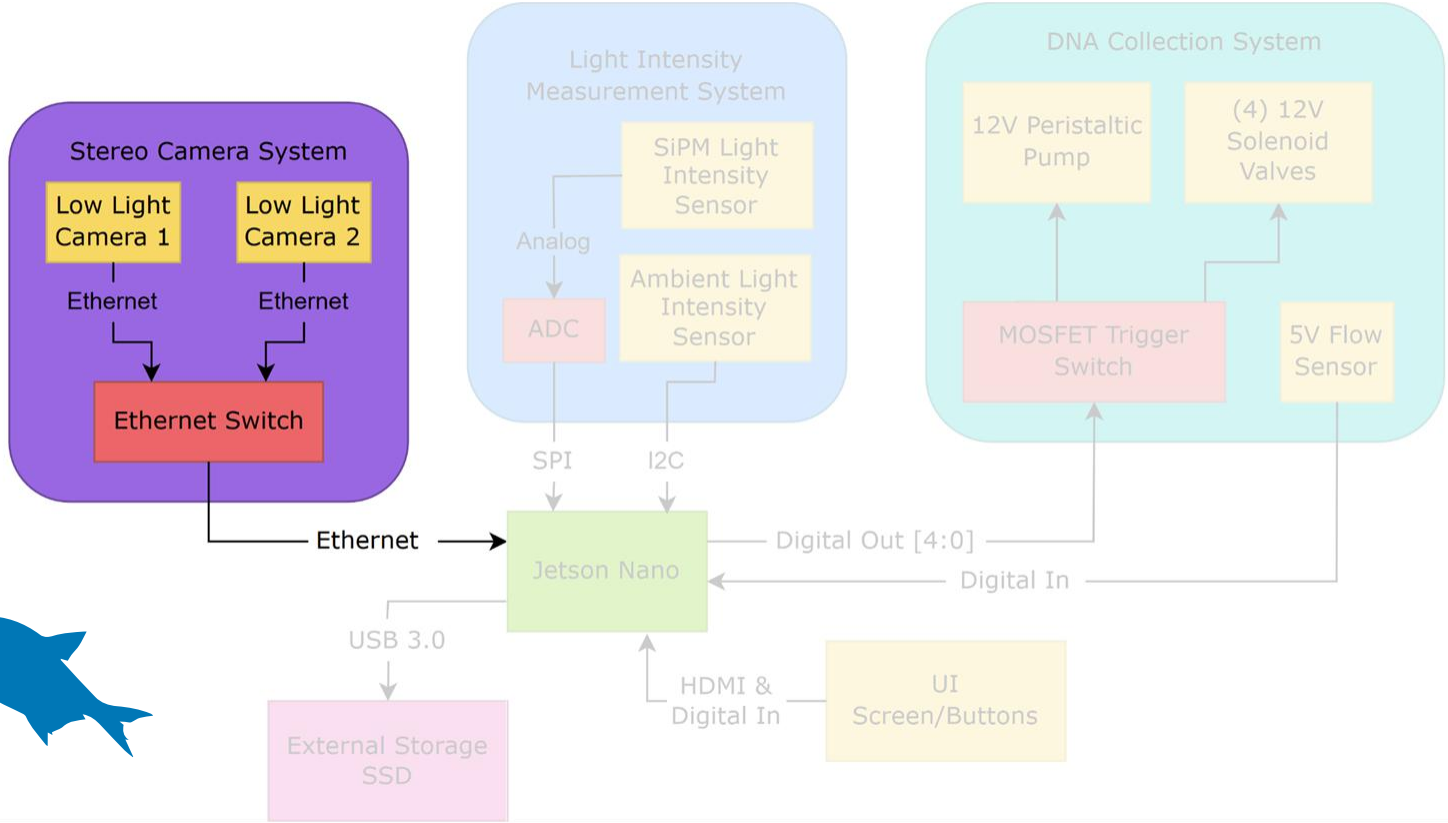
Sterivex Filter

Filter membrane retains eDNA given enough concentration

BLOCK DIAGRAM



STEREO CAMERAS



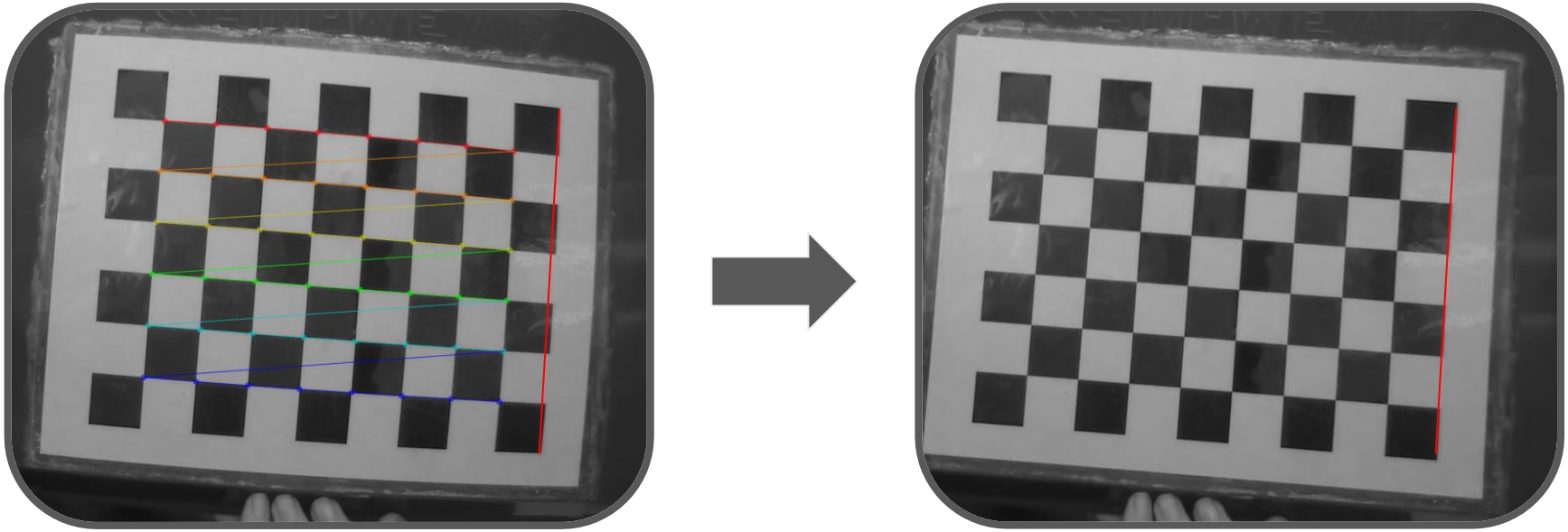
CAMERA SYNCHRONIZATION

- ➔ Used GStreamer pipeline software with **simple sync option**
- ➔ **Video/Audio pipelining**
- ➔ Provides **hardware-accelerated encoding/decoding** plugins
- ➔ No need for complicated code for synchronization

CAMERA PREVIEW

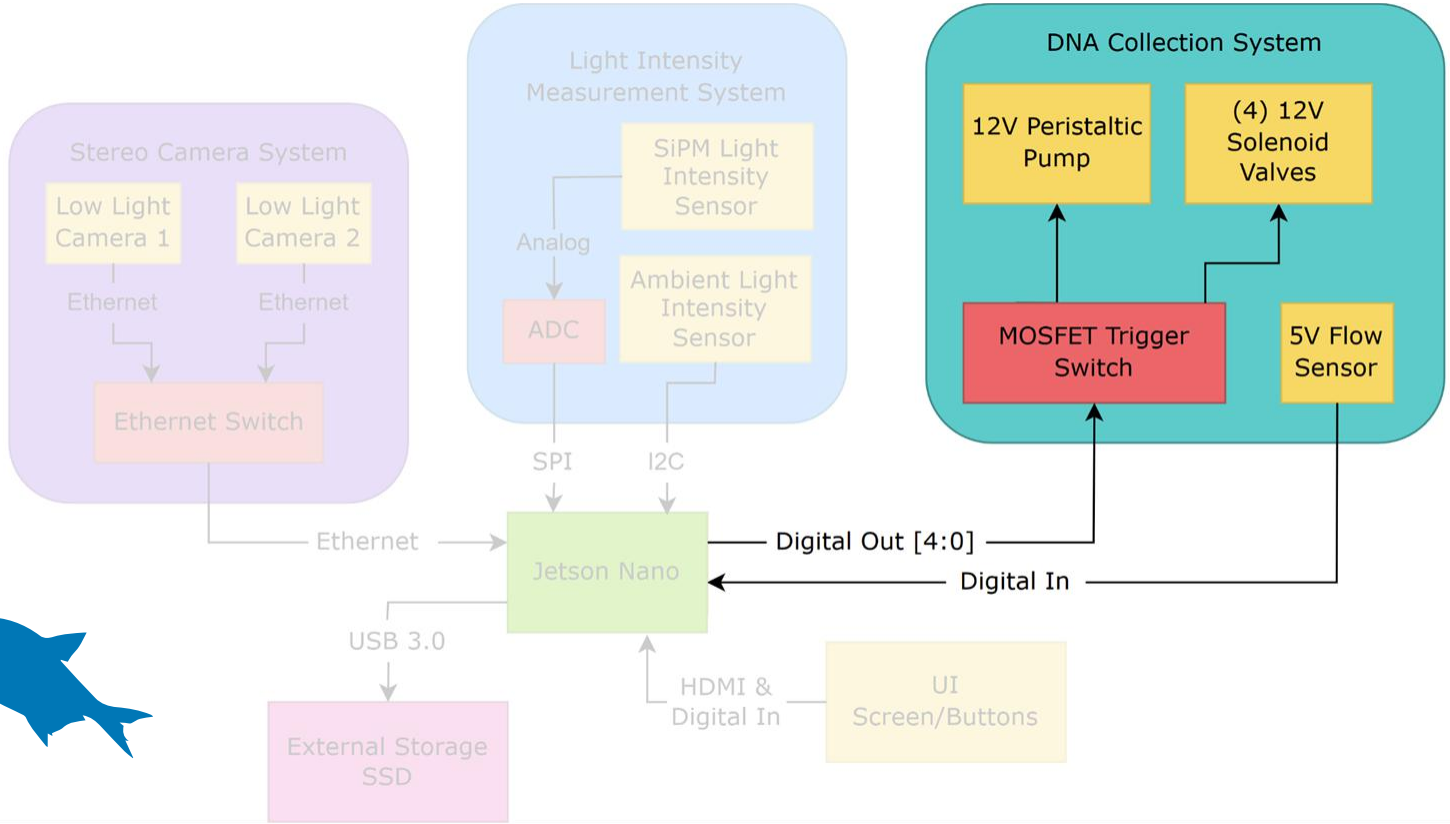
- Redirect the video pipeline sink from **filesink** to **ximagesink**
- Displays synchronized footage directly onto the display with 2 second delay

CAMERA DISPARITIES

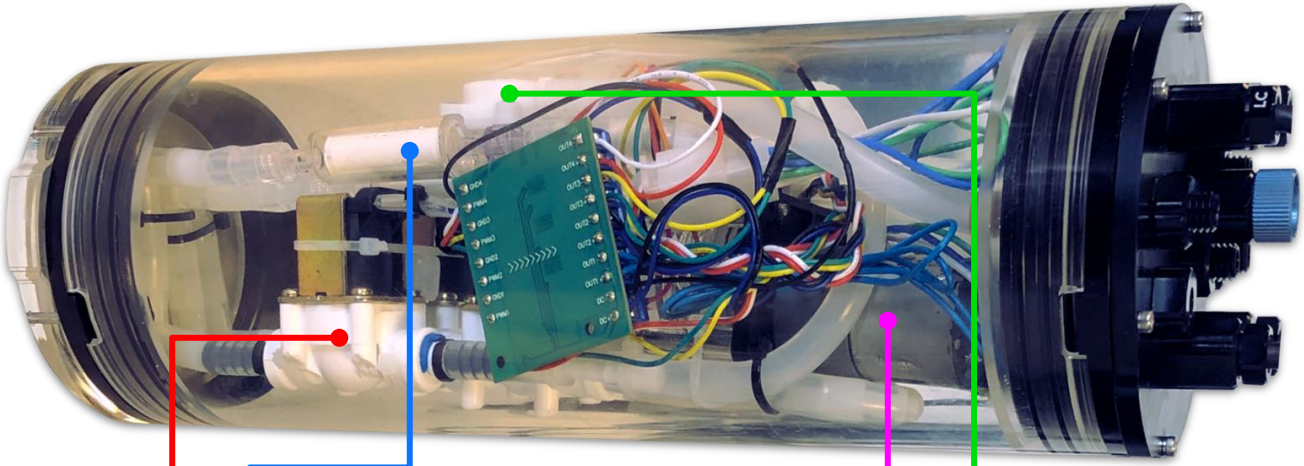


- Cameras, their position, and their lens usually introduce disparities to the image
- Removing these irregularities will allow for more efficient and accurate depth estimation.

PUMP SYSTEM


Stereo Camera System
Low Light Camera 1
Low Light Camera 2
Ethernet
Ethernet
Ethernet Switch
Light Intensity Measurement System
SiPM Light Intensity Sensor
Analog
ADC
Ambient Light Intensity Sensor
SPI
I2C
DNA Collection System
12V Peristaltic Pump
(4) 12V Solenoid Valves
MOSFET Trigger Switch
5V Flow Sensor
Ethernet
Jetson Nano
Digital Out [4:0]
Digital In
USB 3.0
External Storage SSD
HDMI & Digital In
UI Screen/Buttons

PUMP SYSTEM



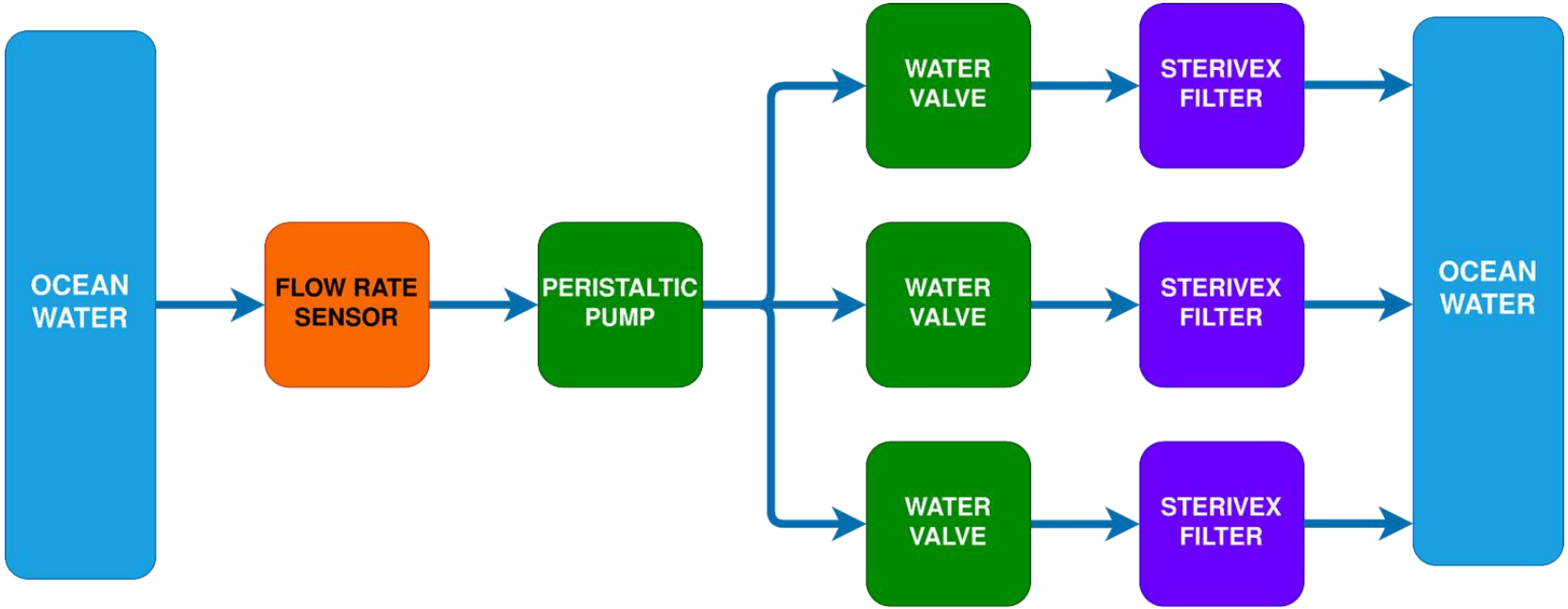
Electric valve solenoid functions to select singular filter when sampling

Filter collects DNA sample after enough concentration

Pump pushes water throughout system

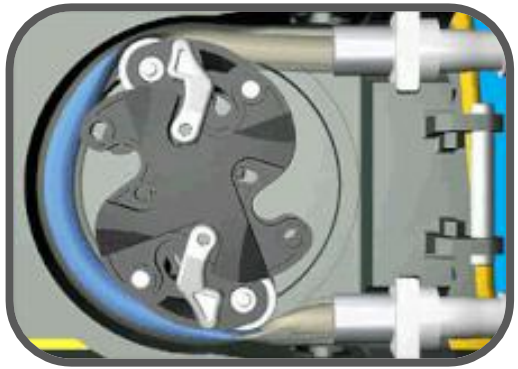
Flow Sensor verifies amount sampled (2L for concentrated filter)

WATER PIPELINE

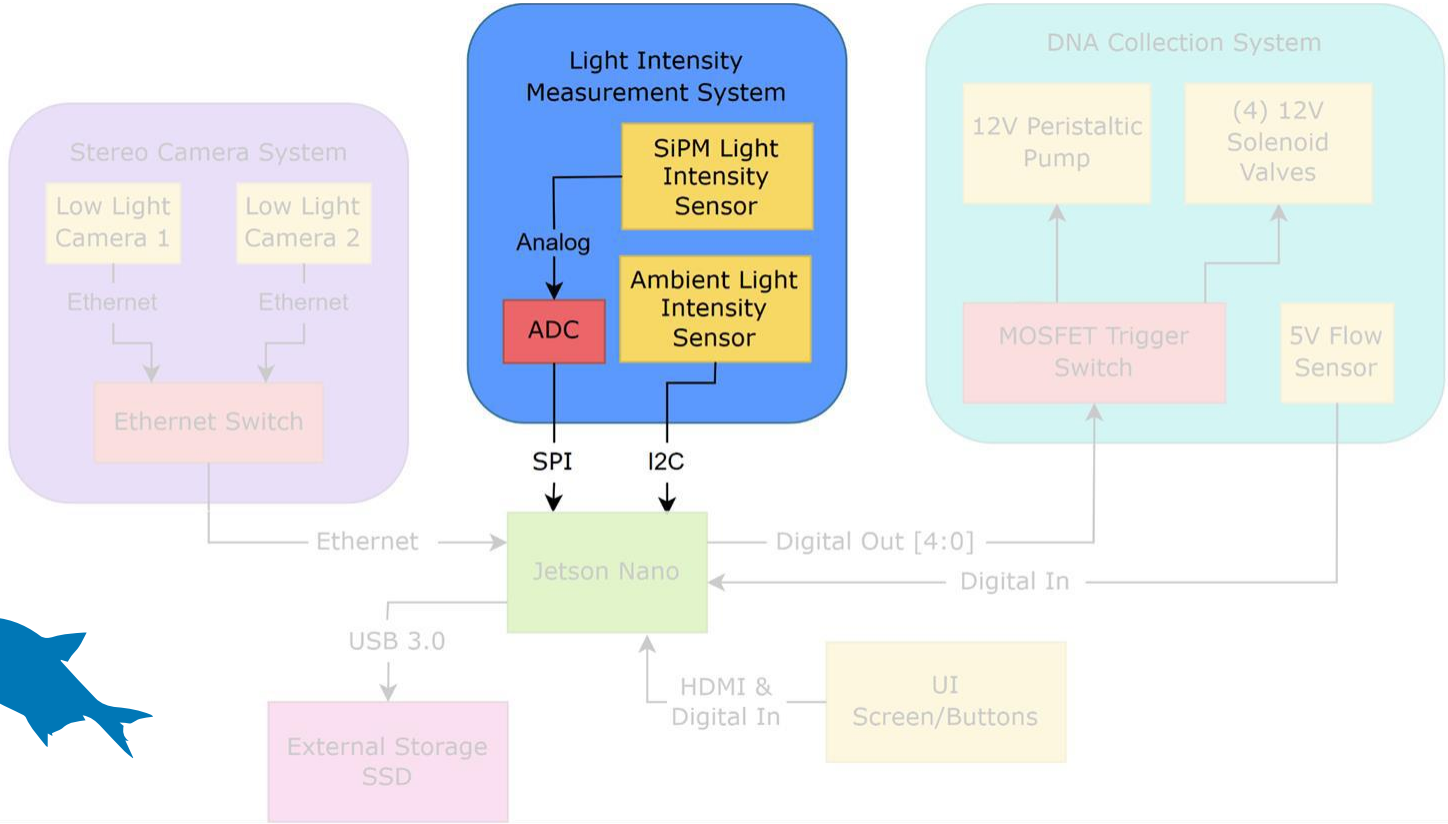


eDNA ACQUISITION SPECS

- 12V pump rated 400 mL/min
  - **~200 mL/min** with sampling filter
  - **~10 mins** to collect a **2L** concentrated sample
- Software is configured to **collect 3 samples** at set time intervals
- Replaceable tubing for easier sterilization



SIPM LIGHT SENSOR

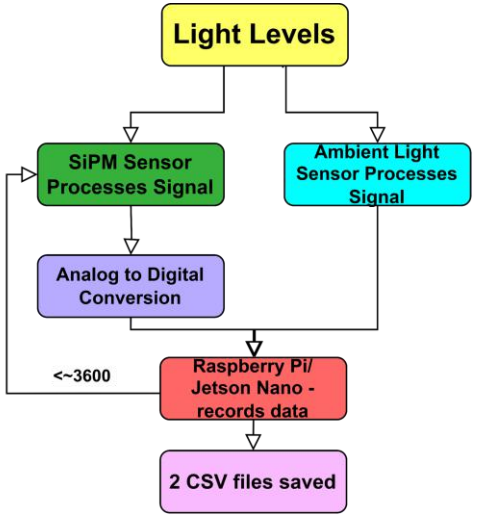


SiPM CASE DESIGN

Ambient light sensor dimensions: **27mm * 25mm**
SiPM light sensor dimensions: **36mm * 22mm**

SiPM DATA FLOW

- ➔ Ambient light sensor triggers SiPM sensor to record at suitable light levels
- ➔ **Samples** are saved to csv files with timestamps.
- ➔ Time-resolved intensity measurements are compared with video footage.



The maximum (known) temporal sampling rate of crustacean retinas is 160 Hz, (Kingston et al., *Bio. Letters*, 2020) therefore **200 Hz**.

3

DEMO VIDEO

How to use smalle and stereo calibration footage

Switches

4 CHALLENGES

No project comes without its challenges!

CHALLENGES

Camera Sync

Trouble finding low light sensitive, hardware synced cameras

GStreamer was used to software sync

Light Sensor Sensitivity

SiPM malfunctions when there is too much light

Separate ambient light sensor used to activate SiPM

Water Pathway

No pre-built solutions to bring water into the enclosure through the end caps

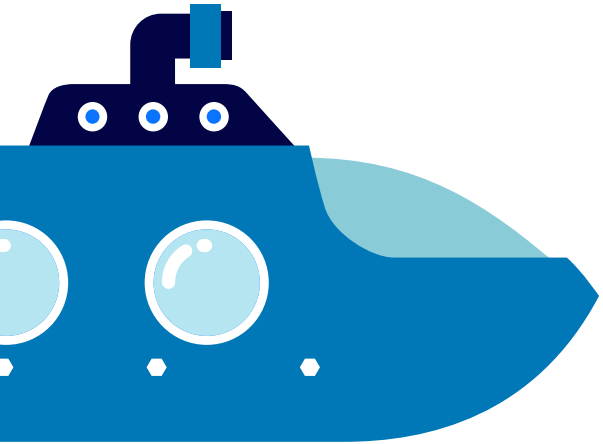
Used vacuum plug and marine sealant

Overheating

The Jetson and the power supply system generates a lot of heat

Used fans and forced convection to dissipate heat

Thank You!



OAKLEY
EVOLUTION LABORATORY
UC SANTA BARBARA

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