TEAM 14

FRUIT FLY FEEDER

Salk Institute for Biological Studies

STUDENTS

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MENTORS

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CUSTOMER BACKGROUND

Salk Institute's research suggests that controlling the feeding and sleeping cycle can improve the overall fitness of fruit fly. An automated system to monitor the activity and simultaneously the food consumption of flies can greatly help to advance this research. Hopefully, our device can accurately record the movement of flies and their food intake. The data from flies modeling human diseases will aid to investigate the underlying mechanism involved in those conditions.

SCOPE OF WORK

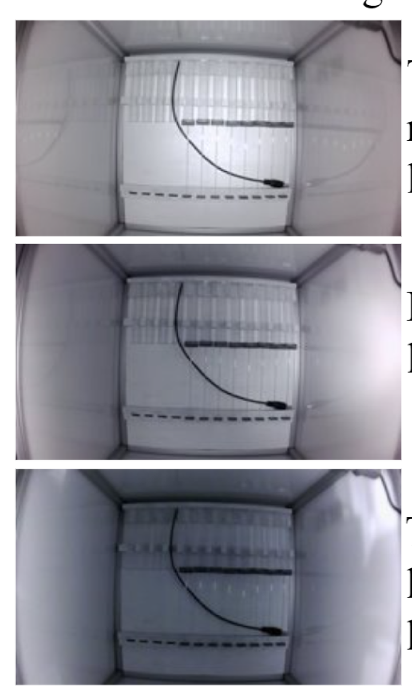
- Create a system that can monitor and control fruit fly feeding cycles.
- Create documentation to assist in repairs and trouble shooting.
- To create and test a new fruit fly enclosure that uses our new mechanical and software ideas, such as different cameras and lighting.

REQUIREMENTS MATRIX

Req. #	Design Requirement	Design Targets	Validation
1	Camera Selection	Locate fruit fly positions and read the meniscus in calipers of food solution	Test camera in various positions of our design to pick up data
2	Camera - Stats	The camera must have an FOV and focal length that matches the height of our final design, without sacrificing the final image of the data	Research camera lenses and test the range of coverage before the fisheye effect kicks in
3	Camera - Mounting	The camera mount must be able to move in the horizontal direction, as well as be able to be taken off the enclosure	Design a mounting system that works with 80-20 bracket material that meets these requirements
4	Camera - Lighting	The lighting system must be able to light up the enclosure while not giving a glare to throw off data	Test various lighting placements with LED designs
5	Feeder System - Assembly	The feeder assembly should be able to open and close to allow the fruit flies to consume their food solution	Design an adjustable system and test the open/closing feature with the fruit fly enclosures
6	Feeder System - measurement	The design should be able to clearly show the capillaries used to feed the fruit flies	Capillaries need to be refilled/replaced, but can also have the meniscus of the food solution showing from the camera
7	Enclosure - Size	The enclosure must be within the 400x500x600mm dimensions	Measure the final enclosure's dimensions
8	Program - Software Code	Code needs to read and report data with the camera given	Previous code working with the camera reading positions
9	Program - Software Testing	The code must outline the proper dimensions and amount of fruit fly enclosures along with the positions of the capillaries	Test the final camera's position with the final amount of fly enclosures.
10	Fly Enclosure - Design	The fly enclosures must fit with the feeder system and be positioned to be read by the camera's final position	Design an enclosure/fly holder that fits with the rest of the design
11	Enclosure - Positioning	The entire enclosure must be able to support itself and internal parts must not be moving when rotated	Make sure all design elements are rigid, as well as add handles to outer design to allow for easy rotation

EXPERIMENTATION

IR Camera Testing

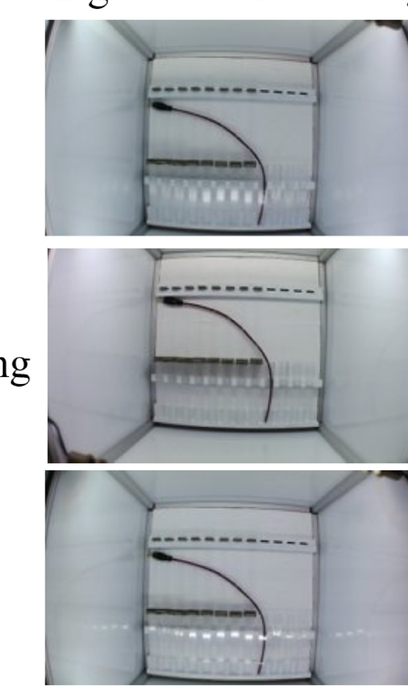


Too much light

Best lighting

Too little light

Light Camera Testing



Too much glare

No glare

Too much glare

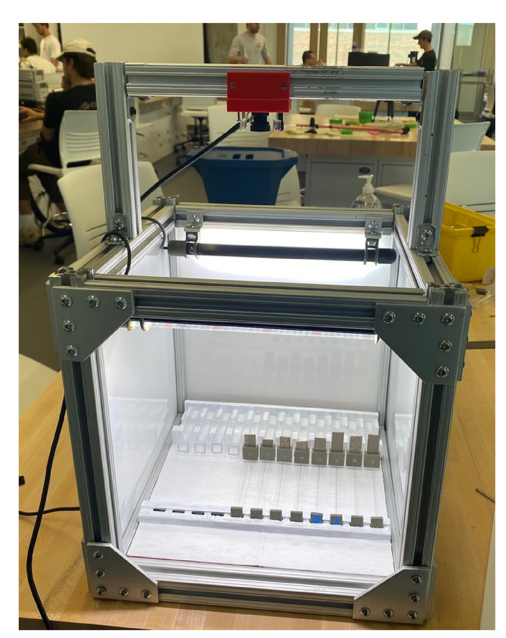
Lens Camera Testing

Too much fish-eye

Best Fish-eye effect

Too little fish-eye

FINAL DESIGN

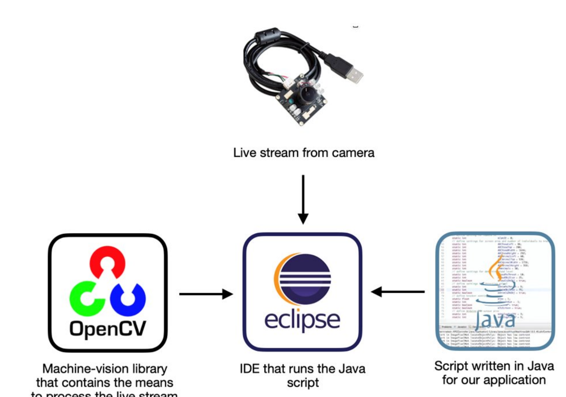


Camera

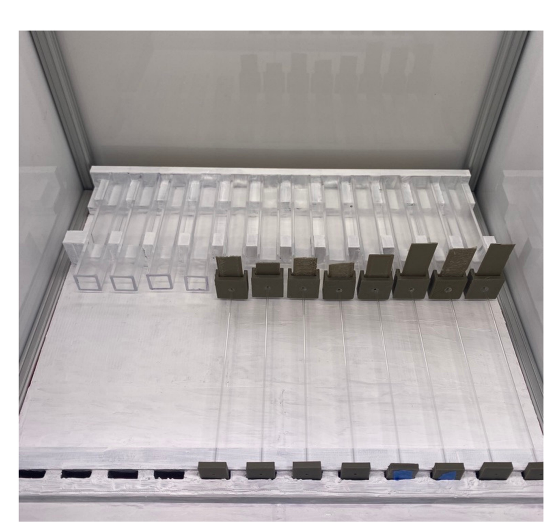
LED Lights

Fly Tubes

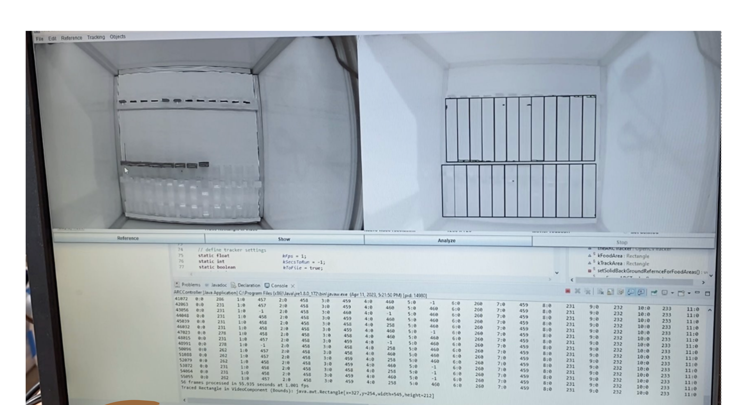
Capillaries



Software Overview



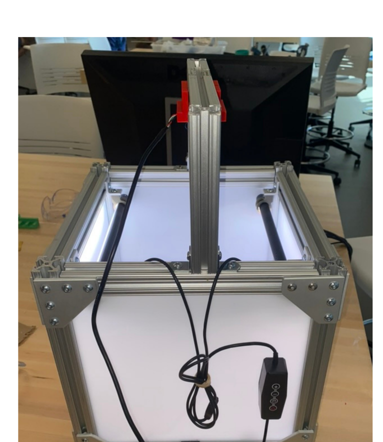
Capillary Setup



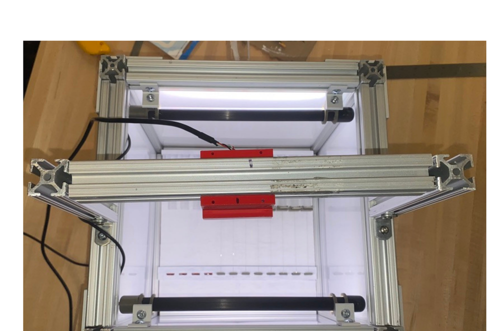
Software Snapshot

```
10016   153   151   150   150
11008   153   151   150   150
12000   153   151   150   150
12992   153   151   151   152
14080   153   151   150   150
15072   153   151   150   150
16064   153   151   151   150
17056   153   151   151   150
18048   153   151   150   150
19040   153   151   150   150
20032   153   151   150   150
21024   153   151   150   150
22016   153   151   151   150
23008   153   151   150   150
24000   153   151   150   150
24992   154   151   151   152
26080   153   151   151   152
```

Text file Output



Side View



Top View

FAILURE MODE EFFECT ANALYSIS

FMEA - Failure Modes and Effective Analysis								
Key Process Step	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN
Outer Cage Feeding System								
Panels for cage wall	Panels are not secured to the cage.	Panels allow light into the cage.	4	Panel was measured incorrectly	2	Panels have been ordered to work with 80/20 panels	1	3
80/20 beams	80x20 Beam Breaks	Cage is unstable and tips over during experimentation.	3	Inadaqute cross section.	3	Measuring the beams before placement and checking for weak points.	2	4
Roof of Cage	Roof is not secured to the cage	Roof cannot connect to each other and the cage.	3	Wrong measurement.	2	Roof has 3 piece which can be put together.	4	3
Platform for Inside Cage								
Test Tubes	Test tubes are not securely placed in the platform.	Test tubes break.	3	Platform was printed incorrectly.	2	Tightly secured platform to prevent movement.	3	5
Floor of Cage	The platform does not secure any materials.	The test tubes, capillaries, or the platform fall out of the cage.	7	Platform was printed incorrectly or it was not properly supported to the bottom of the cage.	3	Sand the platform to make sure that it can fit into the cage.	3	2
Capillary Tubes	Break during the cage being rotated.	Capliaries break.	6	Break during the replacement of the feeding material.	4	Keep the tubes secured in a box before implementing into the system and	2	5
Test Tube Holder	Test Tubes move out of position upon rotation.	Test tubes and capillaries break and the flies escape.	4	The holder was 3D printed incorrectly, or the super glue did not secure it properly.	3	Painted white to reduce glare and reduce gap between sections. Used Gorrilla glue.	4	3
Camera System								
Power Source	Power source dies early.	Power source fully dies and cannot be recharged.	3	Was not fully charged	2	Have a rechargeable battery or power system.	4	5
LED Lights	Lights break or do not function properly.	Lights do not function properly.	3	LED lights break.	3	Keep the lights in a secure position using a force fit.	3	4
Camera	Camera lens is broken	Camera is not able to keep track of the fruit flies.	7	There was an issue when rotating the cage.	4	Check the bolts, if they are being used.	5	8
Camera Mount	Camera frame is not secured to the top of the cage.	Camera falls from the top of the cage.	2	Bar was not properly screwed into the cage when adjusting the camera.	2	Make sure there are levels for the team to adjust the camera to and Double check the supports.	3	3
Lighting System								
Power Source	Lights do not turn on.	Power supply ran out.	2	wiring was frayed and could not power the lights.	2	Contoller has a timer to allow set periods of time for lights to be on.	3	2
Lights	The cage does not have a source of light.	Lights do not function properly.	5	Bulbs are broken, or lights were soldered incorrectly.	2	Lights have been secured with a mold and bracket. Have been rewired to work with the powersource and soldered into place.	4	3

TESTING

Steps	Test	Details	Outcome
Electronic Testing			
1	Camera's Capabilities	Out of two cameras, the Infrared lights built into the camera needed to be tested for the night cycle, as well as how far and well the camera can pick up footage.	Confirmed which camera met the requirements for the project.
2	Lens Testing	The camera that was chosen came with 8 different lens with different lens angles. Each lens had varying effects of a fish-eye and focused at different heights.	Chose the lens that provided the least amount of fish-eye effect and was closest to the top of the chamber. This also determined the height of the camera.
3	Software	The software was tested and adjusted to track each individual fly tube and capillary.	This confirms the placement of the camera as well as the integrity of the code's ability to collect data. The software locates the flies and meniscus by pixle location.
4	Lighting Placement	The LED spectrum lights and the Infrared LEDs were adjusted to find the best angle to direct the LEDs within the chamber, which was to reduce the amount of glare on the fly's tubes and capillaries. Glare prevents the camera from picking up data.	With pointing only one LED spectrum light at the chamber wall and bending the Infrared LEDs at a 45° angle created the minimum amount of glare.
Mechanical Testing			
5	Chamber Rotation	One requirement from Salk is the chamber needs to be able to function when rotated at a 90° angle.	Rotating the chamber reveals any loose features that were not thought of beforehand. Loose features were found were fixed.
6	Eating Cycle	To control the eating cycles, a door is moved so the flys can access their food. They are inserted into the tube's 3D printed caps, and there needs to be enough friction so they stay in place during the eating and fasting cycles and when the chamber is rotated.	To make sure every fly's door works to design requirements, we made each one identical and tested each one. This provides uniformity in functionality.
7	Food	The flies get their food, which is essentially sugar water, from the capillaries. For the camera and software to be able to track the meniscus of the food, the liquid food is dyed blue with food coloring.	This test confirmed the tracking software's capabilities and the need for painting the baseplate white to provide contrast.
8	Live Flies	A test was ran with the food coloring in the capillaries and a live flies were put into their tubes.	This test confirmed the tracking software's capabilities and the need for painting the baseplate white to provide contrast.