VR for a Small Fish

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Invisible Fish

This project aims to assist Dr. Andrew Bass and his research group in their study of *Danionella dracula*,or "dracula fish". These fish are transparent, allowing their brains and nervous systems to be seen and mapped visually.

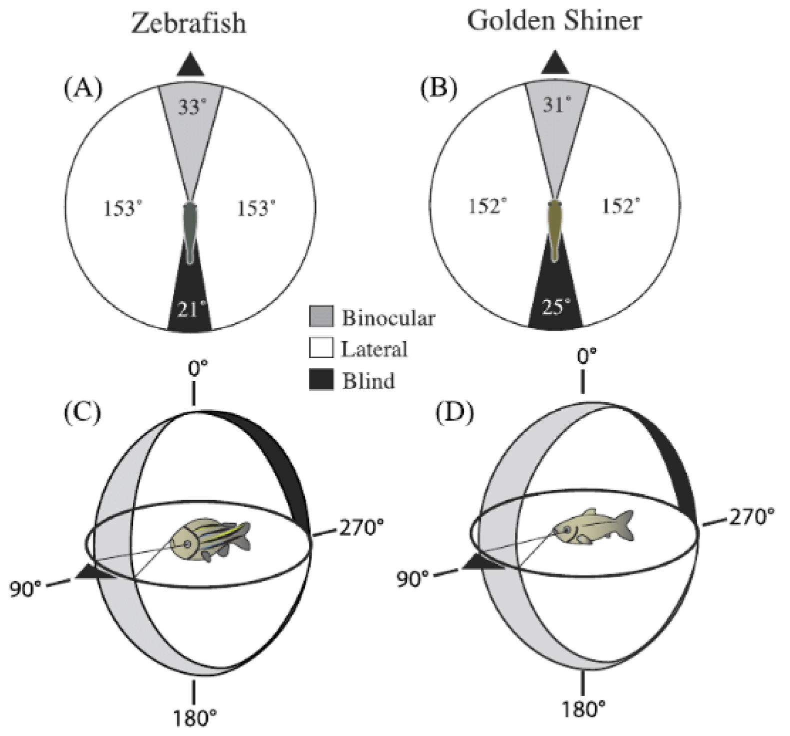
Virtual Reality for Fish

Dr. Bass and his team seek to study how the fish respond to various visual stimuli to get a baseline understanding of their visual systems. To begin these experiments, a virtual reality environment was created to display various visual stimuli. For example, some of the first experiments will perform a grating acuity test to determine how small/fast the fish can see moving objects.

To display the visuals to the fish, the setup to the right was used. The Raspberry Pi runs Python programs which use the Pygame library to display the desired visual stimuli. It is connected to a projector which displays the image onto the side of the tank. To avoid glare and create a softer image, a sheet of white paper is taped to the side of the tank for the image to bleed through to the inside of the tank.

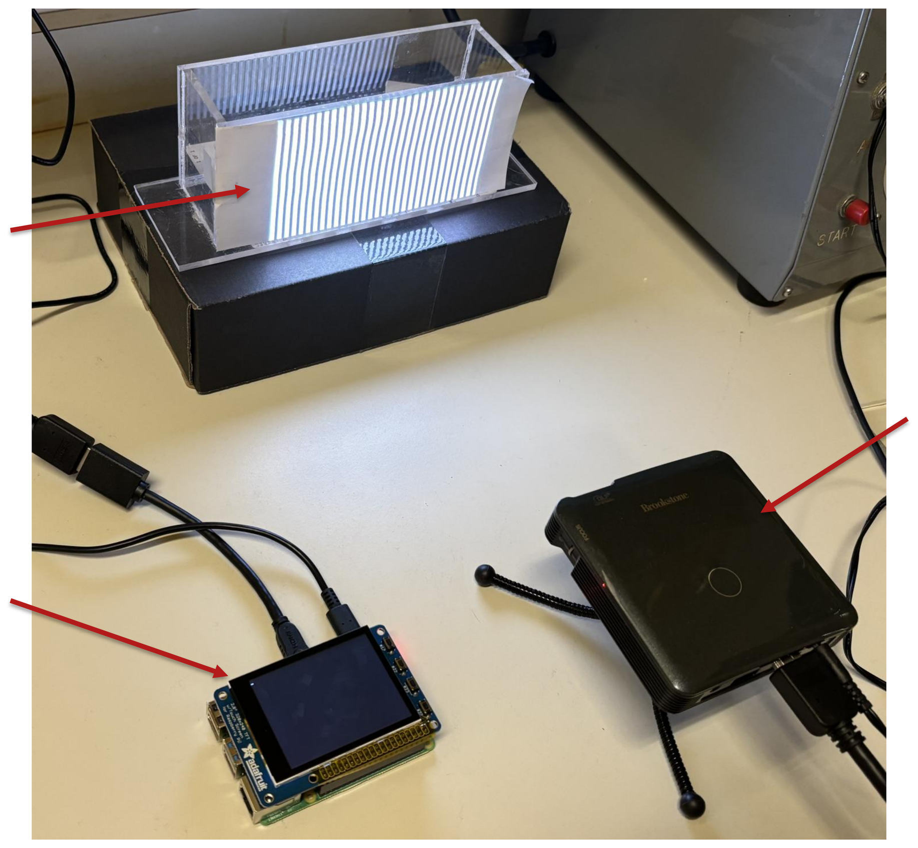
Fish Can't Wear VR Goggles

How is this virtual reality when it only displays a 2D image to the side of the tank? Unlike humans, who have forward-facing eyes and rely heavily on binocular vision for depth perception, Dracula fish and many other fish species possess eyes positioned on the sides of their heads. This grants them a very wide field of view, often approaching 360°, but results in a limited binocular overlap and thus a reduced perception of depth. Instead, their vision is largely two-dimensional. Because of this, presenting moving or patterned stimuli on a 2D screen on the side of the tank can effectively simulate environmental changes or motion, enabling researchers to probe visual responses without the need for more complex 3D setups. This setup serves as a kind of "virtual reality" tailored to the perceptual world of fish.

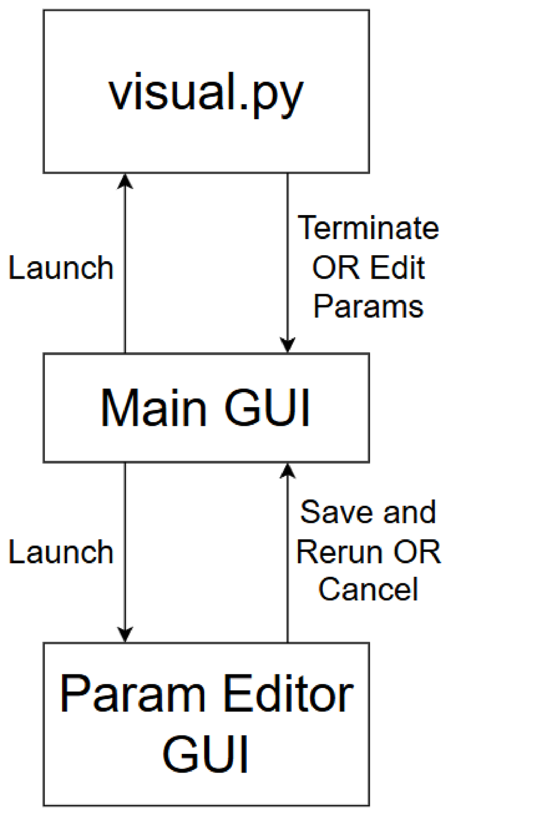


Visual fields of zebrafish and golden shiner [4]

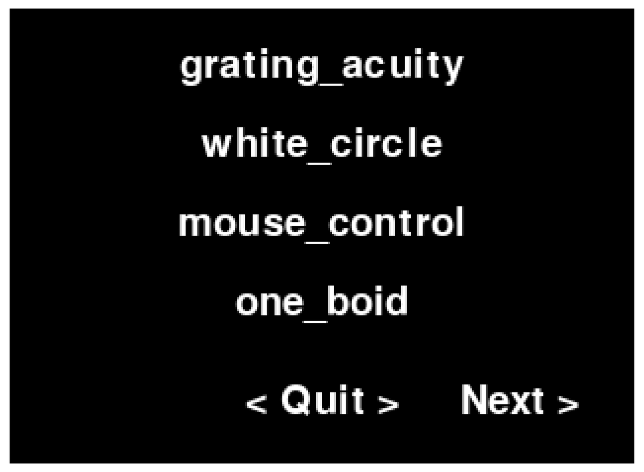
Bringing VR to the Tank



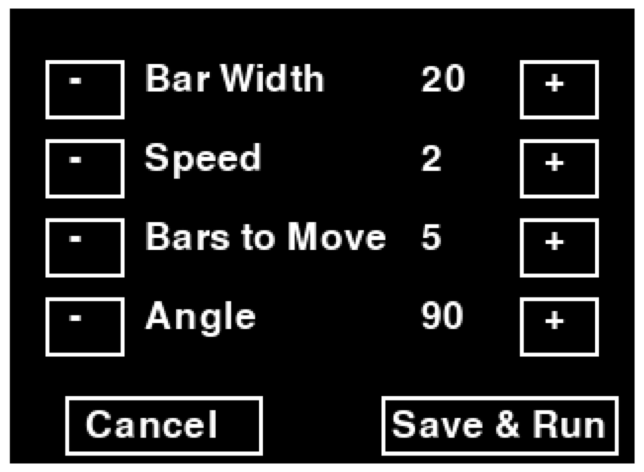
Scientist-Oriented Interface



To make the system more convenient to use for the researchers' purposes, a simple graphical user interface (GUI) was designed. The main GUI launches automatically when the Raspberry Pi boots up, and the GUI is navigated using a PiTFT touchscreen, avoiding the need to plug in a mouse and keyboard to the Raspberry Pi. Programs can be launched from the main GUI by pressing the corresponding button on the screen. While a program is running, the user can use the physical buttons on the PiTFT to either exit the program back to the main GUI or launch a separate GUI for editing parameters. This flow is illustrated in the software diagram to the left. Example screens of the main GUI and parameter-editor GUI are shown below.



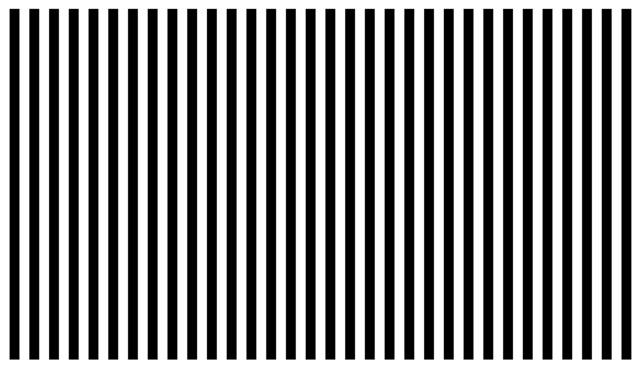
Example screen of the main GUI.



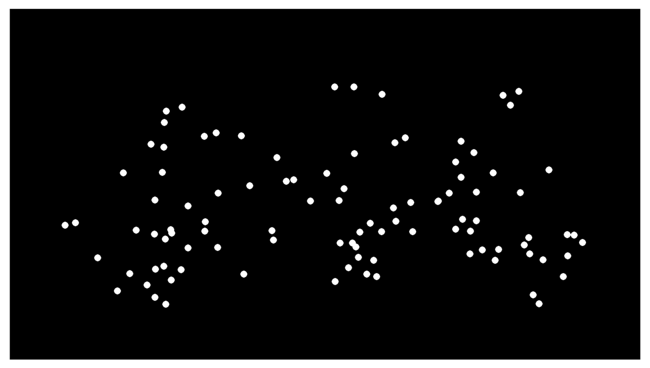
Example screen of the param editor GUI.

Results

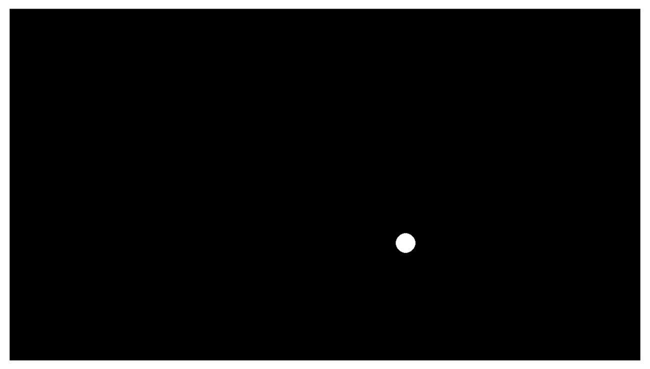
The system is working as intended, providing a useful tool for presenting visual stimuli for experiments with the fish. Below are some example outputs that are displayed by the projector to the side of the tank.



Grating Acuity Test



Boids Algorithm



Trace Path

Image of Dracula Fish

Future Work

With the system complete, Dr. Bass and his team will begin the first experiments with this setup. As they proceed with experiments, programs will likely be added/modified depending on results for future experiments. They may also wish to add quality-of-life features to the GUI. For these reasons, the code has been written to be extensible. The programs are all modular and well-documented, allowing them to be modified easily in the future.

References

[1] Pygame Documentation. https://www.pygame.org/docs/
[2] Python Software Foundation. *Python subprocess module documentation.* https://docs.python.org/3/library/subprocess.html
[3] Cornell University. *ECE 5725 Embedded Operating Systems Laboratory Materials*, Fall 2024.
[4] Pita, Diana & Moore, Bret & Tyrrell, Luke & Fernández-Juricic, Esteban. (2015). Vision in two cyprinid fish: Implications for collective behavior. PeerJ. 3. e1113. 10.7717/peerj.1113.

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About Bass Lab

This project was done in collaboration with Bass Lab. Dr. Andrew Bass and his team investigate the neural basis of vocal communication and behavior in fishes, using model organisms like *Danionella dracula* to study brain function, social behavior, and sensory systems.

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