An On-Line Closed-Loop Behavioral Control System Setup for Fish Experiments

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Introduction

Our project focuses on the **design and implementation** of a real-time data collection system for behavioral control experiments with fish.

- ❖ Our system allows stimulation of visual and mechanosensory systems of the fish while swimming under laminar flow.
- ❖ We observe fish's response via image processing techniques
- ❖ The entire data collection system works in real time

Specifications and Design Requirements

Design Requirements:

- ❖ Real-time data collection at 20Hz,
- ❖ Laminar flow in the swim tunnel,
- ❖ Capturing fish position under milimeter resolution
- ❖ Fast image processing (less than 5ms)

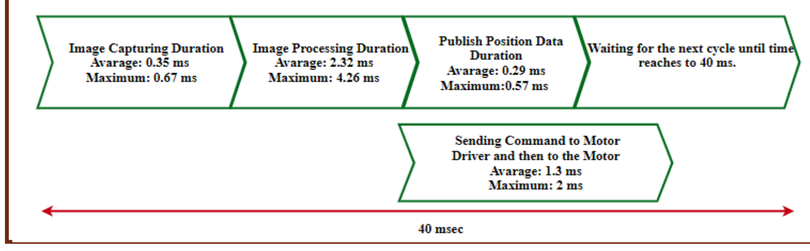


Figure: Time flow of a cycle on the average

Hardware Solutions

- ❖ Major tasks performed:
  - Tracking the movements of the fish
  - Use image processing to detect the position of the fish
  - Driving a stimulating actuator

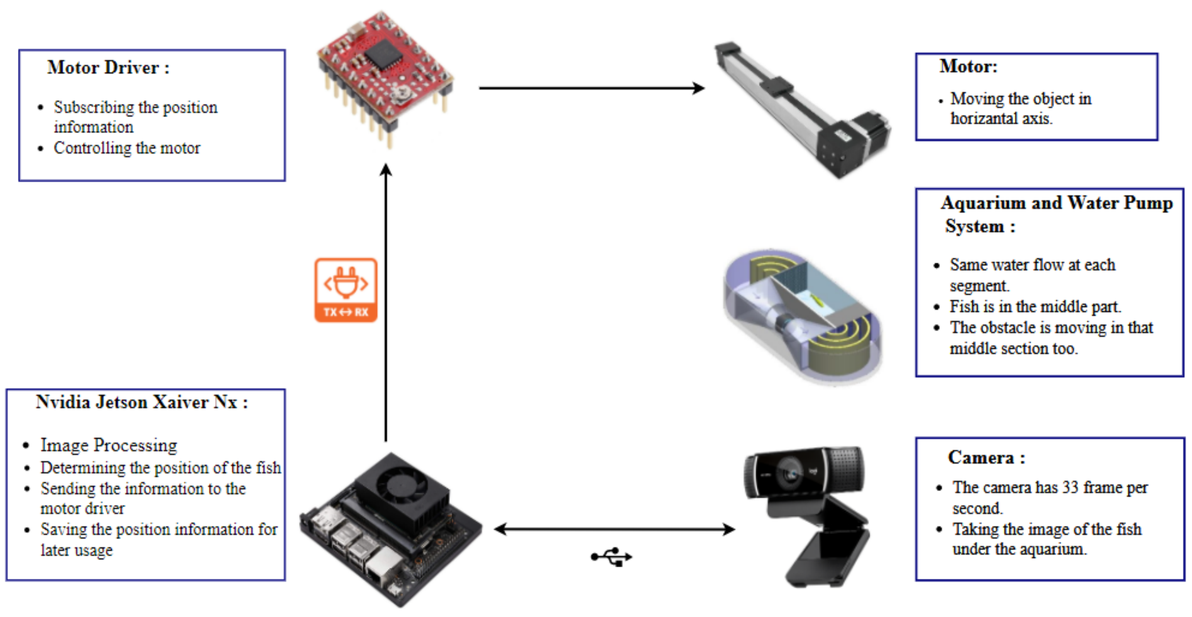


Figure: Electronic Architecture of the system

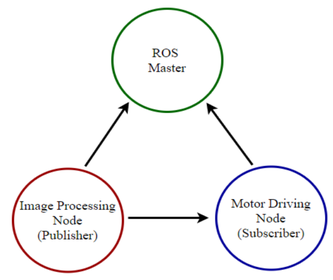
- ❖ We used an SD card inside the processor to record the data.
- ❖ We used NVIDIA Jetson Xavier NX as the main computational device in our project.
- ❖ CPU: 6-core NVIDIA Carmel ARMv8.2 64-bit CPU(It is necessary to install an operating system on it)
- ❖ I/O interfaces like USB, HDMI, GPIO, I2C, etc.
- ❖ Besides, it has network connectivity via ethernet or wi-fi.
- ❖ Installing an operating system enables using many application programs and programming languages.

Software Solutions

To have strict control over the system and create a robotics standard, we decided to use ROS (robot operating system).

This framework provides:

- ❖ Easier thread system
- ❖ Stable and fast communication
- ❖ Modularity: even if one element crashes, the system still works without it
- ❖ We used threads to quickly capture frames from the camera
- ❖ Basically, we made a pipeline for frames
- ❖ We triggered the pipeline at every 0.37ms with thread in the main function.



With this solution, we reduced capture time to a minimal value. And for the image processing part we used the MOSSE Tracking algorithm. MOSSE creates correlation filters that significantly outperform simple templates and map input images to their ideal outputs.

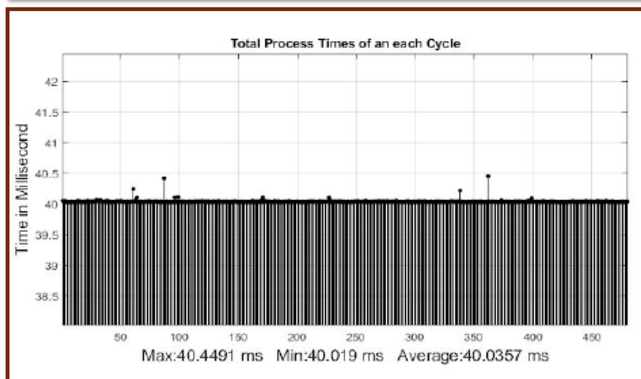
- ❖ Reduced interference with the background and achieves better performance.
- ❖ Robust to changes in lighting, scale, pose and shape of an object
- ❖ Stable and fast results

Application Areas

If observing and real-time events and reacting according to these events are required in a real-time system as we have constructed in this project:

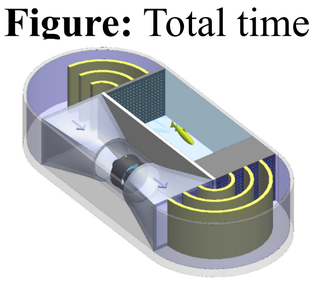
- ❖ The synchronization and scheduling between tasks
- ❖ The hardware solutions that we used in this project can be used in any real-time system that requires interaction with natural events.

Results and Discussion



- ❖ One cycle time:40 msec
- ❖ Time constraints are satisfied with the help of the Mosse algorithm used in the software.

Figure: Total time of one cycle measured with experiment



Also, the fish tank that was designed and produced straightens the water flow.

Figure : The aquarium used in the project

Possible further work:

- ❖ Using this system to study multisensory integration in zebrafish by independently stimulating the sensory structures of the animal.

Conclusion

We have successfully constructed a real-time system that examines zebrafish's natural behavior.We learned about:

- ❖ Real-time systems and image processing
- ❖ Threads and computer architecture
- ❖ Electrical motors

References

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