FishSense

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PROJECT OVERVIEW

SUMMARY

Fish are a vital part of our global ecosystem and in order to best protect and preserve them, we must be able to effectively learn about them. We need to not only learn about fish on an individual level, but on a global level too. This can prove difficult, however, as the ocean is their home, not ours! One method that has been used for millennia is to simply go fishing, and analyze characteristics of the fish you catch: species, length, weight, health, location, etc. This invasive method, while accurate, does not capture the full picture. You only are able to report on the fish you catch, and you do not see the interactions between fish, or between fish and their habitat.

Say then you dive underwater to view the fish in the wild. Now you have the opposite problem: fish are not keen on letting you grab them and measure them. Recent advancements in underwater imaging technology such as laser calipers and stereo camera rigs have made measurement a little easier, but they present additional problems. These include being too bulky for divers to efficiently operate, being unable to fully capture interactions between fish or the habitat, or being inaccurate, especially when fish are not lined up perfectly.

We present FishSense as a solution for capturing all characteristics of fish in their natural habitat. Our ergonomic diver operated handheld system brings cutting edge 3D imaging technology below the surface of the ocean. With this device we are able to directly measure geometric and volumetric information about the fish and their environment directly, without needing to perform expensive and specialized post-processing. The extra dimension in the data will also improve AI models for fish detection and classification, which will allow fisheries' research to scale up dramatically.

PROJECT APPROACH

GOALS

Fish sense is a long-term project that started several months ago. The group members have already achieved some great goals -- image capturing, data labeling, model building and bounding box detection. The work for us during this quarter, with all well labeled data fish images, we will mainly focus on one of the major functions -- length detection, and one of the major problems -- noise filtering.

Fish length detection

As the name, we are looking for methods to calculate the fish length inside the image. We need to firstly get familiar with data format, and write algorithms for basic frames of the easiest data. In specific steps, we need to translate bounding boxes in RGB images to depth data, determine how to choose adequate points within the box to measure depth, and write the code to triangulate length.

Noise filtering & calibration and motion

In this part we would introduce noisier data with motion. Indeed, noise filtering is a calibration problem. Therefore, different kinds of noise filtering algorithms will be implemented and tested through data with moderate noise taken in air. In specific steps, we need to determine how to remove the pixels with similar color, and how to take better use of data in both RGB and depth images.

DATA FORMAT

We will be working with multiple datasets in this project as described below. Each of the three datasets will include both RGB images (in .png format) and depth data (in .csv format). We plan to connect each RGB image with its corresponding depth data by timestamp. This way, we can draw bounding boxes on the RGB images and translate the bounding boxes onto the depth data in order to calculate length.

Images captured in the air with minimal noise

We will have a dataset for fish images captured in the air with minimal noise. The fish in these images is a fake fish that we know the length of. The images are captured in an office, and the images capture the fish in different poses and different distances from the camera. However, the images are clear and do not include patterns that are similar to the fish pattern.

Images captured in the air with moderate noise

We will have a dataset for fish images captured in the air with moderate noise. The fish in these images is a fake fish that we know the length of. Again, the images capture the fish in different poses and different distances from the camera. However, these images include blur. We will also introduce noise into these images such as patterns that are more similar to the fish pattern as well as other objects that may obstruct the image.

Images captured underwater

Eventually, we hope that our algorithm will correctly calculate the length of a fish when given images captured underwater. These images will also use a fake fish so that we can test our algorithm against a known length. However, these images will include the inevitable noise introduced by an underwater environment such as water movement and other objects which can potentially obstruct the images. Also, these images will be affected by the camera's calibration issue when taking underwater images, so that will be another challenge to the success of our algorithm on underwater images.

METHODS

Real sense SDK

The most important tool for this project is probably Intel's open source real sense SDK, since we are using the camera, Intel RealSense D455. With these SDKs and the datasheet from the official website, we should be able to get the parameters like calibration matrix, focus lengths, etc, and then get some results from calling the libraries.

Python libraries to help with image processing

We consider using some possible libraries from Python to deal with image processing and computer vision, e.g. openCV, scikit-image together with NumPy & SciPy, PIL, etc. Most of these libraries are open source, and many have convenient APIs that we can directly use.

ROS (if needed)

ROS is for reading the complete records of .bag file generated by the real sense camera. For sure, there are also other ways to look into these record files from other tools in different format.

Geometry background

Considering using the camera, we cannot do this project without geometry transformations, e.g. the calibration algorithms, either in air (testing) or underwater (practical usage); pinhole camera model and point cloud; etc.

AI models

We may also use artificial intelligence, neural networks, and machine learning after we get enough images/videos in the dataset and well-label them.

MINIMUM VIABLE PRODUCT

MVP

The minimum viable product for this project will be the optimized length detection algorithm. The MVP is described by our first deliverable. The optimized length detection algorithm should produce a length measurement given raw fish imaging taken in the air with minimal noise.

ITERATION

We aim to complete our MVP quickly so that we can continue to iterate on it. As mentioned, the initial algorithm will aim to calculate the length of a fish given an image collected in the air with minimal noise. After we finish testing and are confident in the algorithm's success with low-noise air images, we plan to iterate on the algorithm using underwater noise filtering techniques such that the algorithm will successfully calculate the length of a fish in noisier air images. The reason that we will use underwater noise filtering is so that ultimately this algorithm can be adapted to calculate the length of fish from underwater images.

PROJECT OBJECTIVES FOR THE QUARTER

The specific objectives for this project in this quarter are as follows: develop an algorithm that successfully calculates the length of a fish given images of the fish taken in the air with minimal noise, appropriately filter noise from noisier air images of fish, and finally iterate on the original length detection algorithm such that it successfully calculates the length of a fish in noisier air images.

LONG TERM GOALS

Longer term goals of this project include making the noise filtering process more robust such that the program can successfully filter noise from underwater images, iterating on the length detection algorithm such that it successfully calculates the length of a fish given noisy underwater images, adapting the program to do real-time length calculations, and using the same type of noise filtering to develop algorithms for volumetric calculations from noisy underwater fish imaging.

CONSTRAINTS, RISK, AND FEASIBILITY

POTENTIAL STUMBLING BLOCKS

Some of the potential stumbling blocks for this quarter include the team's unfamiliarity with required libraries and the complication of length calculation given images where a fish is directly facing the camera.

RISKS

Potential risks for this project include mechanical and electrical failures with the hardware which could prevent us from getting good data, the asynchronous nature of the RGB images and depth data, and the calibration issues with the Intel camera D455 which affects underwater performance. We also might have to wait for data collection from E4E members since we do not have our own cameras to capture images of the fish. Additionally, we may run into issues with our length detection algorithm not working on more complicated datasets. We also might face compatibility issues between the hardware and the different software libraries that we plan to use.

FEASIBILITY

We believe that during the quarter we should be able to complete a functional length detection algorithm and noise filtering such that we can measure the length of fish in noisy images captured in air. While we hope that we can use the algorithm we develop to also measure the length of fish from underwater images, we recognize that underwater imaging introduces additional complications such as calibration issues with the camera when it is underwater. Thus, we are trying to manage the scope of the project so that we will be able to finish the measurements on air images by the end of the quarter. We find this to be a feasible goal given the resources such as software libraries that are available to use for noise filtering and length detection.

GROUP MANAGEMENT

MAJOR ROLES

We are all project participants under the guidance of the project lead and collaborate with other E4E group members.

DECISIONS

Decisions are made by all group members during the meetings. Everyone of us will share our thoughts and listen to each other. Then the final decision will be made by the agreement of all team members.

COMMUNICATION

We will communicate over email and our private Discord channel which includes our E4E project correspondent, Peter.

SCHEDULING

We will meet every week to check in with each other on technical progress and milestones, so we will know if we are not keeping up with the planned schedule. We will adjust for schedule slips by reevaluating our milestones and reconsidering the necessary time for each task. If we start to recognize that certain tasks are more time intensive than we anticipated, then we can reallocate people to different tasks.

RESPONSIBILITIES

All team members are responsible for the two major deliverables. For the detailed tasks under each deliverable, each of us is responsible for one specific milestone at each timeline. Please see the project schedule for more details on specific milestone responsibilities.

PROJECT DEVELOPMENT

DEVELOPMENT ROLES

All team members collaborate to finish this project under the guidance of the project lead and the help of other E4E team members. We all help write the programs, read papers, and develop algorithms.

REQUIRED HARDWARE/SOFTWARE

We will be using the following hardware: Intel RealSense Depth Cameras D455. The required cameras are available to E4E members who we will work with for data collection. The following required software is freely available to us: image processing libraries such as openCV and a Python environment.

TESTING

We will be performing post-processing, meaning that we will be testing on already gathered data. We plan to use images collected by E4E of a fake fish that we know the length of. That way, we can measure the length of the fish at different points in time with different poses. As mentioned above, we will initially test our length detection algorithm on images with minimal noise by comparing our calculated length to the real known length of the fake fish. We will move on to our second dataset with moderate noise and use that dataset to test our noise filtration. Again, we will test the accuracy of our length detection algorithm on images with moderate noise by comparing our calculated length to the actual known length of the fake fish.

DOCUMENTATION

We will use Github/google drive as a version control tool as well as to hold our documentation. We will refer to the project specification document for milestone checks.

PROJECT MILESTONES AND SCHEDULE

DELIVERABLES

There will be two major deliverables in this quarter. At first, we will focus on the algorithms of calculating the fish length using both RGB and depth image with low noise taken in air. Then we will implement the code and write tests with the corresponding data. Therefore, our first deliverable will take around two weeks to accomplish, which will be delivered in week 6, with the fish length detection accuracy and error matrices.

After that, we will try to get better results from medium noise data taken in air, heavy noise data taken in air, and finally the data taken in actual situations -- water. Different methods of noise filtering will be taken into consideration and we will make the decision based on their performance on the data taken in air. This will be our second deliverable, which will take a relatively long time for implementation and testing. For the data taken in air, we will give the comparison for images without noise filtering and images with noise filtering in week 9. And hopefully our methods can be directly applied to the data taken in water so that we can have another deliverable before the end of the quarter.

WEEKLY MILESTONES

SCHEDULE		
Week	**MILESTONE DUE**	**PARTY RESPONSIBLE**
4	Searching for length detection algorithm and transfer the bounding box	Xilin Gao, Zixiang Zhou, Emily Ferguson
5	Implement the algorithm to measure the length of a fake fish in air with low noise from RGB images and Depth images	Xilin Gao
5	Perform the selected algorithm with some sample data	Zixiang Zhou
5	Testing the length detection algorithm on images taken in air with minimal noise	Emily Ferguson
6	Research on some papers about underwater noise filtering and calibration	Xilin Gao
6	Complete implementation of length detection algorithm. Perform testing and generate results.	Zixiang Zhou
6	Search for noise filtering algorithm to use on images with moderate noise	Emily Ferguson
6	**Deliverable**: Length detection algorithm succeeds on air images with minimal noise	Xilin Gao, Zixiang Zhou, Emily Ferguson
7	Testing the algorithms for length detection and underwater noise filtering	Xilin Gao
7	Search for different noise filtering algorithms and perform tests.	Zixiang Zhou
7	Test the noise filtration on noisier images	Emily Ferguson
8	Implement the length detection algorithm with underwater scenarios (more noise)	Xilin Gao
8	Combine the noise filtering with the length detection algorithm. Perform more training and testing.	Zixiang Zhou
8	Test the length detection algorithm on noisier images given the noise filtration	Emily Ferguson
9	Combine noise filtering with length detection to get better results	Xilin Gao
9	Generate the final result of length detection after noise filtering on moderate images in air.	Zixiang Zhou
9	Clean up the final algorithm and try the noise filtration and length detection on images with a lot of noise and underwater images if time allows	Emily Ferguson
9	**Deliverable**: Length detection algorithm succeeds on air images with moderate noise	Xilin Gao, Zixiang Zhou, Emily Ferguson
10	Maintain the data structure and code cleaness. Prepare the final report and final presentation	Xilin Gao, Zixiang Zhou, Emily Ferguson