Introduction

In this project, we constructed a vision-based real time motion capture system to monitor daily locomotor rhythm of Plainfin Midshipman, a vocal fish. We used infrared cameras to collect input data and a GUI based Matlab program to display and analyze useful information.

We want to monitor midshipman's locomotion over 24-hour period of time, but it is almost impossible for human to manually record for such a long time, a reasonable approach is to design a vision-based self-recording system which is reliable and user-friendly. Also, infrared camera does not impose any physical restrictions on fish, which provides a natural way of measuring fish's daily activity.

In this system, every frame of the picture captured by camera is treated as input of our Matlab Program, with our program, we can find out the fish's location on every frame, these locations will be saved in a file, so we can analyze the data to master fish's activity rhythm.

Methods

Hardware equipment used to support the completion of project:

1. **An infrared camera** - used to monitor the 24-hour activity of fish
2. **TV-USB adaptor** - to transfer data from camera to computer
3. **Infrared LED backlight** - to provide infrared light for camera to capture the fish
4. **A laptop** - to process and save the data

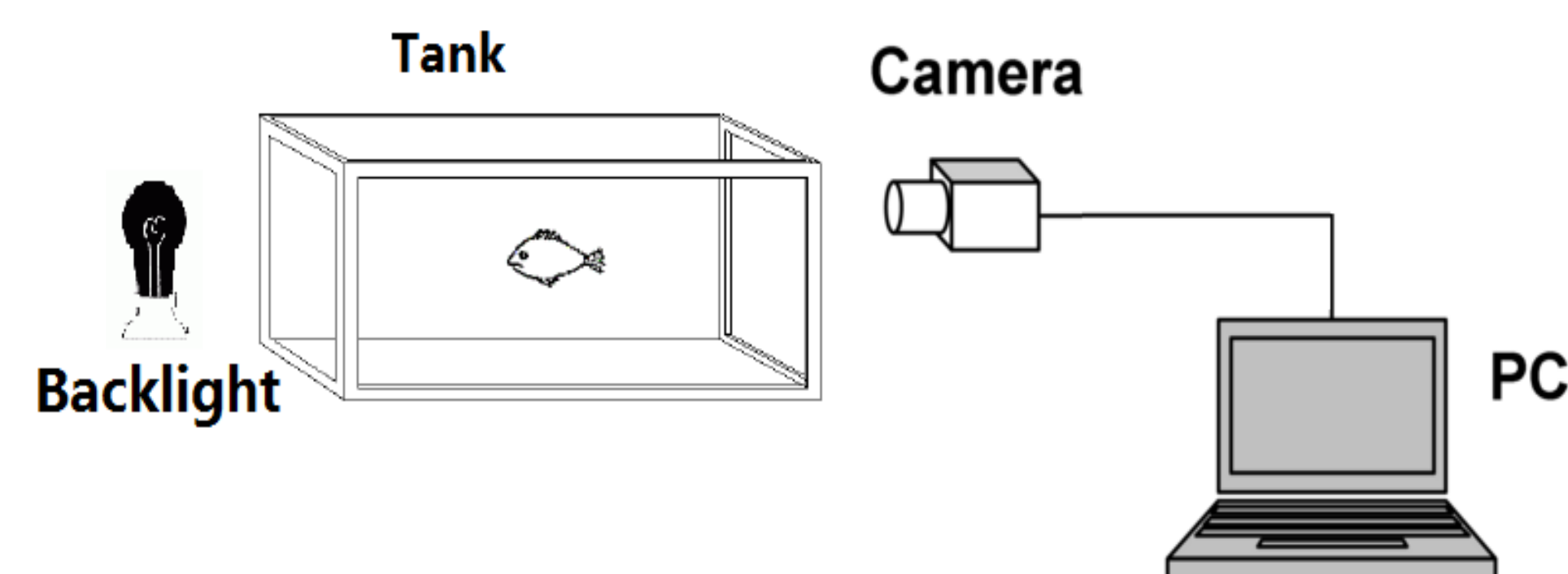**Demonstration of hardware setup:**

Figure 1.Hardware Setup

Tracking Algorithm

For the location of the fish, we will first find the fish in a frame obtained by subtracting the current frame $I[n]$ from an averaged background $I_B[n]$, resulted in a subtracted frame $I_\Delta[n]$, then we use Matlab functions to deal with $I_\Delta[n]$ to eliminate noises in recording, and find the pixel of maximum intensity in the subtracted frame, we will use Matlab to find out the centroid of the area with maximum intensity, thus to locate the fish.

The background can be acquired first by averaging the first 20 frames and then update the background through running average, which means, we will combine the current background with current frame to get new background, the equation can be expressed as below:

$$I_B[n+1] = \alpha I_B[n] + (1-\alpha) I[n]$$

Where $0.9 \leq \alpha \leq 1$, then a subset image I_{sub} around the location of fish is extracted and replaced with the pixels in the original background, this process can prevent the fish been included into background.
Then use $I_B[n]$ to calculate $I_\Delta[n]$ with following equation:

$$I_\Delta[n] = (I[n] - I_B[n])^2$$

Finally, to determine the location of the fish, the pixel of maximum intensity is found in each frame, and a subset image $I_{\Delta sub}$ around this pixel is extracted. The center of intensity of the subset image is calculated and used to calculate the object's *x* and *y* locations.

$$x[n] = \frac{\sum_{j=1}^{L_x} j I_{\Delta sub}[n]}{\sum_{j,i}^{L_x, L_y} I_{\Delta sub}[n]} + (I_\Delta^{max}[n])_x - L_x$$

$$y[n] = \frac{\sum_{i=1}^{L_y} i I_{\Delta sub}[n]}{\sum_{j,i}^{L_x, L_y} I_{\Delta sub}[n]} + (I_\Delta^{max}[n])_y - L_y$$

Here *i* and *j* correspond to row and column indices respectively; L_x and L_y are the dimensions of the subset image; and I_Δ^{max} is the pixel of maximum intensity in the subset image.
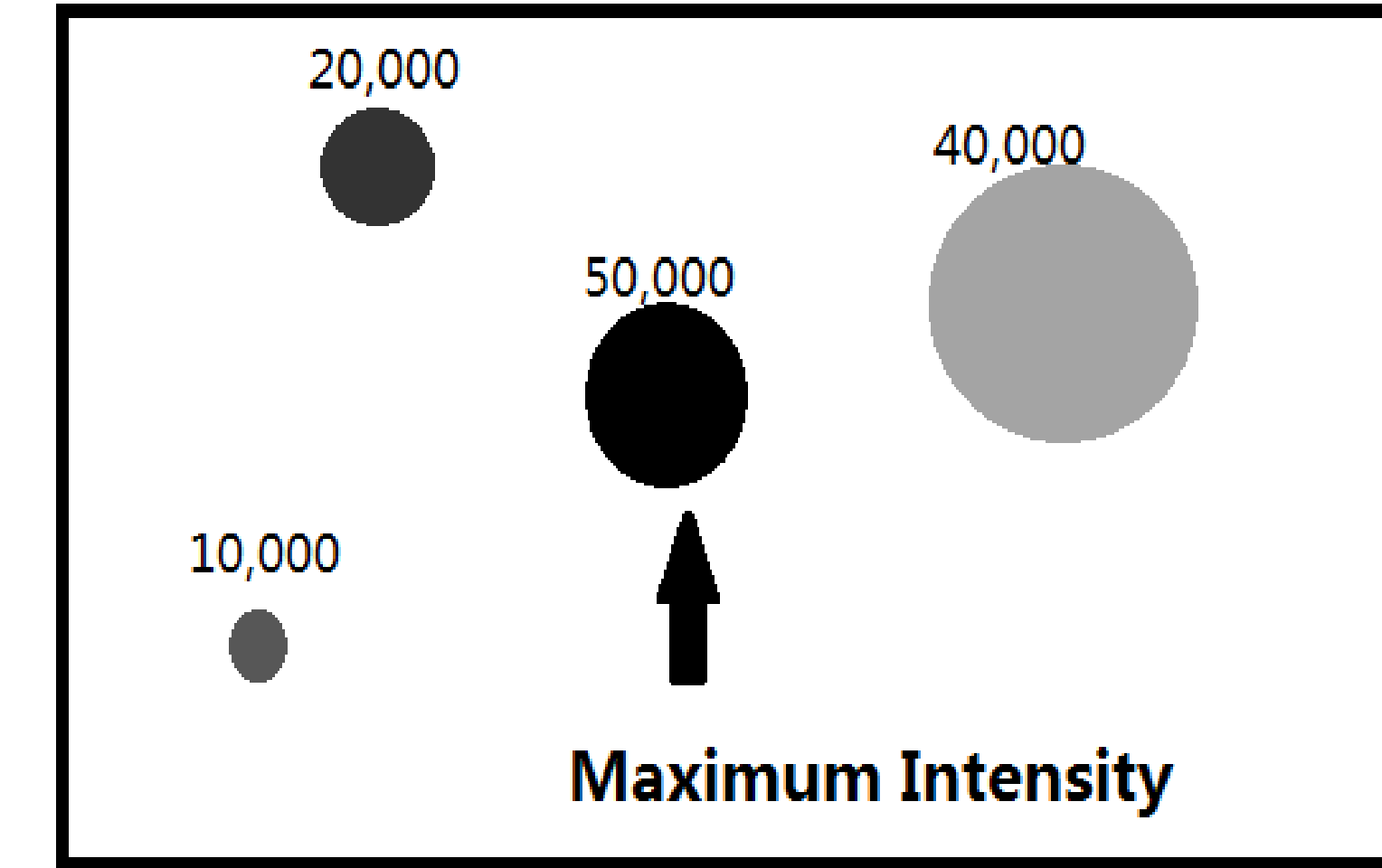

Figure 2. subtracted frame $I_\Delta[n]$ with area of interest

Noise Elimination

Since Matlab needs to transform analog signal from camera to digital signal, there exists noises in the frame acquired, we need to eliminate the noises:

Take the subtracted frame $I_\Delta[n]$, since we need to find the area of maximum intensity to determine the fish's location, we will set a threshold value T, if the maximum intensity is below T, we will regard the detected signal as noise and the don't change the fish's location, if the maximum intensity is above T, we will only take the signal as that caused by fish.
Also, if the area of maximum intensity is too small, we will take that as noise.

Results

Finally we end up with three recording modules which could monitor three tanks simultaneously.
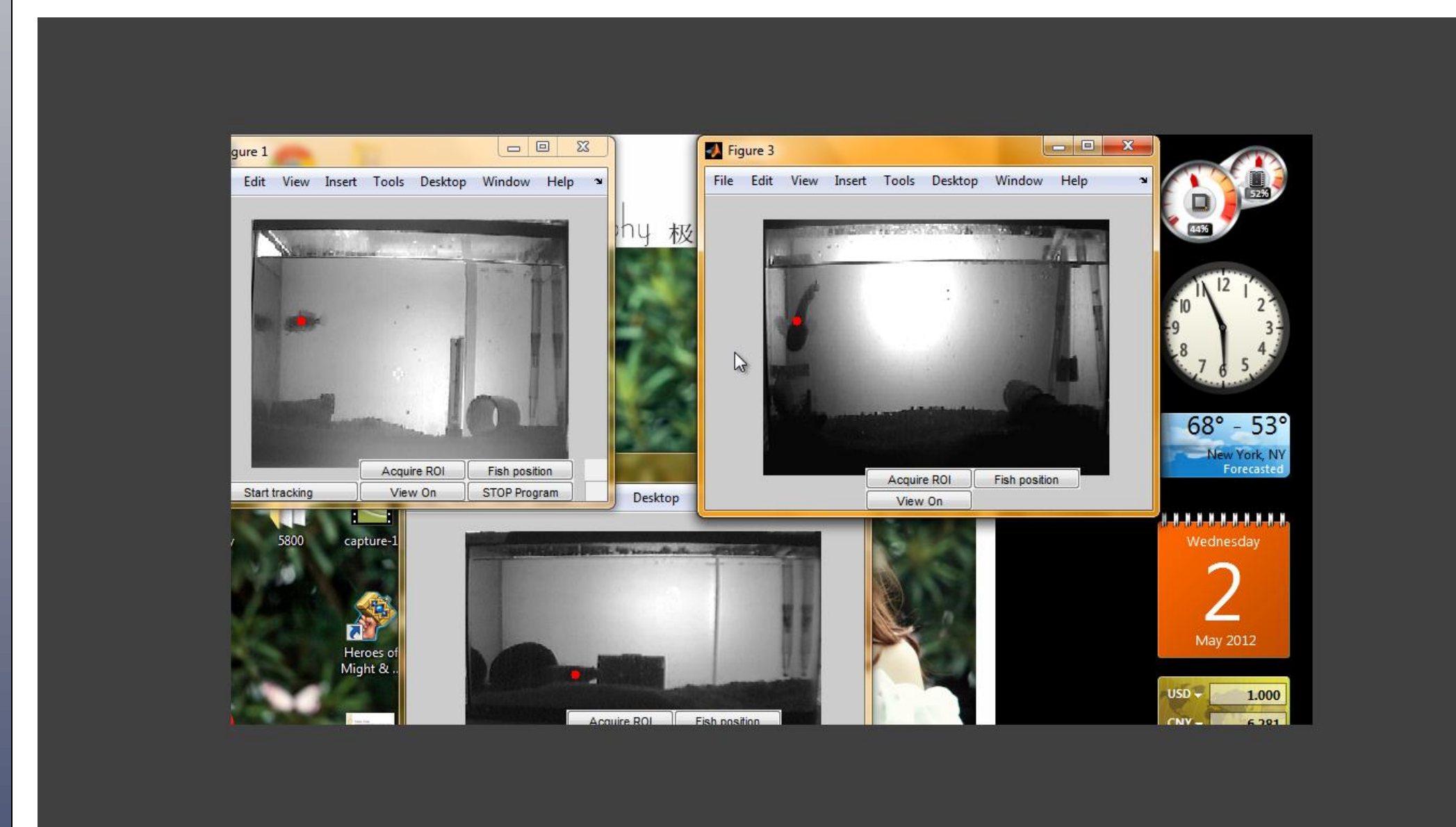

Figure 3. Recording 3 fish with red dots on fish

The red dot represents the location of the fish recorded by the program. The fish location of each frame and the time associated with it were stored in files. Besides, files were stored in hard drive every minute.

We test this program for 4 times, and no fatal error was found.(the longest test was 72 hours)

Furthermore, we wrote a program for data analysis based on the requirements from our sponsor, which calculates the distance fish traveled from time to time.
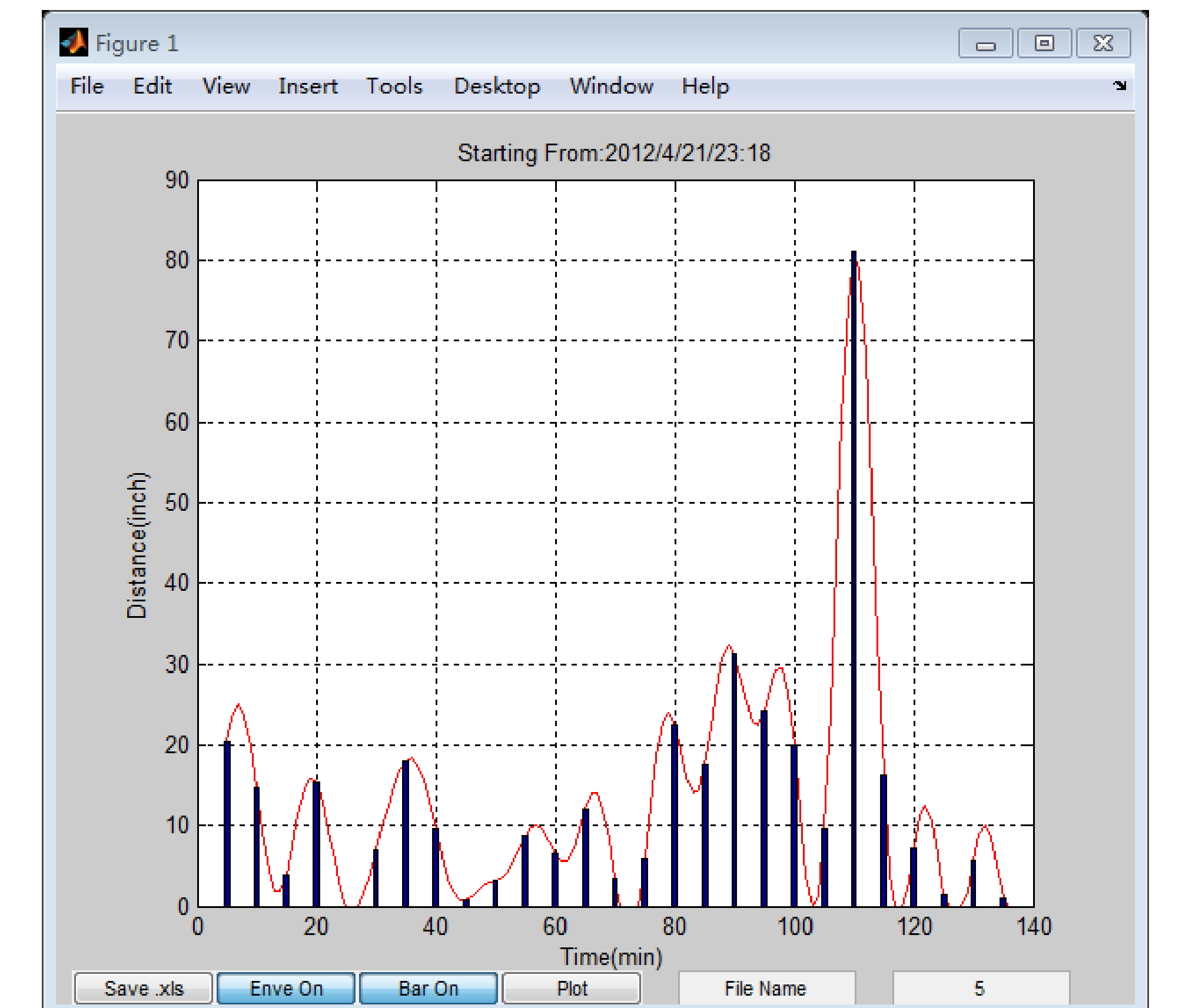

Figure 4. Data analysis for fish distance every 5 minutes

Acknowledgement

1. We would like to acknowledge the advice and guidance of our ECE advisor, Bruce Land and outside ECE advisor Jenny Feng.

2. We also want to thank Dawnis Chow from Department of Neurobiology and Behavior for sharing information and material with us for this project.