Electrical localization of weakly electric fish using neural networks

Greg Kiar[1], Yasin Mamatjan[1], James Jun[2], Len Maler[2], Andy Adler[1]
[1]Department on Systems and Computer Engineering, Carleton University, Canada
1125 Colonel By Drive, Ottawa, ON K1S 5B6
[2]Faculty of Medicine, University of Ottawa, Canada
550 Cumberland Street, Ottawa, ON K1N 6N5
gkiar@sce.carleton.ca

Weakly Electric Fish (WEF) emit an Electric Organ Discharge (EOD), which travels through the surrounding water and enables WEF to locate nearby objects or to communicate between individuals.

Benefits: From studying the temporal patterns of EOD, potential exists to both understand the brain function, and track the location and movement of WEF, which could allow us to understand the sensory-motor brain function of vertebrates.

Previous study: Previous tracking of WEF has been conducted using infrared (IR) cameras and subsequent image processing. The limitation of visual tracking is their relatively low frame-rate, and lack of reliability when visually obstructed. Thus, there is a need for reliable monitoring of WEF location and its behavior.

Objective: The objective of this study is to provide an alternative and non-invasive means of tracking WEF in real-time using Neural Networks (NN).

Methods: Our study was carried out in three stages. First stage was to recreate voltage distributions by simulating the WEF using EIDORS and finite element method (FEM) modeling. Second stage was to validate the model against our phantom data acquired from and Electrical Impedance Tomography (EIT) based system including a phantom fish and tank. In the third stage, the measurement data was acquired using a restrained WEF within a tank (1.5 m in diameter) surrounded by 8 graphite electrodes and filled with water (17.5 cm in depth). We trained the NN based on the voltage distributions for different locations of the WEF. With networks trained on the acquired data, we tracked new locations of the WEF and observed the movement patterns in a quantified way.

Results: The NN was trained on a real WEF data set containing 299 data points, which was interpolated to be 15210 datasets. We observed that the NN located the WEF within 1 cm for 94.3% of all cases in one dimensional tracking. The mean squared error (MSE) of the network was 0.02 mm for the WEF which is approximately 23 cm in length in the tank. The network average time if 4.7 ms per trial with a frequency of 213 Hz, while the frame rate of the IR camera is approximately 20 Hz.

Conclusion: The results showed a strong correlation between expected and calculated values of WEF position in 1D, yielding a high spatial resolution within 1 cm and more than 10 times higher temporal resolution than IR cameras. Thus, the developed approach could be used as a practical method to monitor the WEF in real-time and non-invasively.