Behavioral analysis of a "swimming neuron" with deep learning

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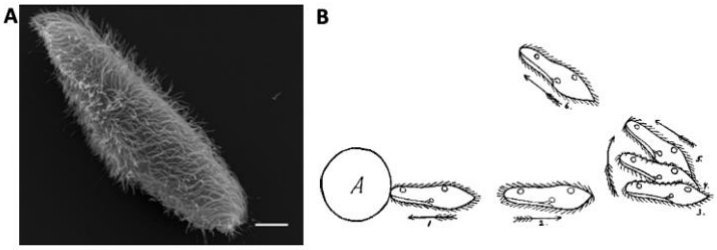
More details: http://romainbrette.fr/neuroscience-of-a-swimming-neuron/

Paramecium is a unicellular organism that swims in fresh water by beating thousands of cilia. When it is stimulated (mechanically, chemically, optically, thermally…), it often swims backward then turns and swims forward again. This "avoiding reaction" is triggered by a calcium-based action potential. For this reason, some authors have called *Paramecium* a "swimming neuron" (Brette, 2021; Elices et al., 2022). *Paramecium* can adapt to changing environments and learn.



A, Scanning electron microscopy image of Paramecium tetraurelia (scale bar: 10 µm) (Valentine et al., 2012). B, Avoiding reaction against an obstacle, as illustrated by Jennings (Jennings, 1906).

This project belongs to a broader project aiming at developing integrative models of *Paramecium*, bridging physiology and behavior. To this end, we perform detailed observations of behavior in various conditions. This means extracting precise individual trajectories from microscopy movies, despite collisions between individuals or with obstacles. We also want to extract 3D position as well as 3D orientations.

Preliminary work in the lab has shown that it is possible to localize and track paramecia using YOLO, as well as predicting the vertical position (z) from the image, presumably based on the diffraction pattern, but this requires further work and validation.

We would like to go further and estimate the 3D orientation of the cell from an image. To this end, the idea is to train a network to predict the cell position in the next frame from the current frame. Given that the motion vector correlates with orientation, this should give the orientation vector. The more difficult parameter to estimate is the cell's angle relative to its longitudinal axis (it spins around its main axis). The idea is to use the fact that *Paramecium* tends to swim in helicoidal paths, with the oral groove facing the spiral axis. By training a network to predict the cell's angle relative to the spiral, the network will be able to estimate the position of the oral groove.

The project can be adapted to the duration of the internship and to the profile and interests of the student.

Brette R (2021) Integrative Neuroscience of Paramecium, a “Swimming Neuron.” eNeuro 8:ENEURO.0018-21.2021.

Elices I, Kulkarni A, Escoubet N, Pontani L-L, Prevost AM, Brette R (2022) An electrophysiological and behavioral model of Paramecium, the “swimming neuron.”

Jennings HS (1906) Behavior of the lower organisms. New York, The Columbia university press, The Macmillan company, agents; [etc., etc.].