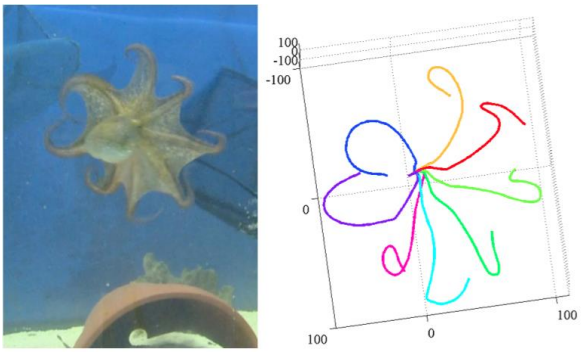
3D reconstruction of octopus arm swimming motion

Asimina Kazakidi[1], Stefanos Stefanou[1], Xenophon Zabulis[1], Michael Kuba[2], John A. Ekaterinaris[1,3], Tamar Flash[4], Binyamin Hochner[2], Dimitris P. Tsakiris[1,*]

[1] Foundation for Research & Technology - Hellas, Greece; [2] The Hebrew University of Jerusalem, Israel; [3] University of Patras, Greece; [4] Weizmann Institute of Science, Israel

Arm swimming in the octopus is a mode of locomotion that is used by the animal primarily for hunting, defence, or escape. The motion, in general, is characterized by a fast closing of the arms and a slow opening of the arms, resulting in a considerable propulsive power. The movement has previously been discussed, however the detailed kinematics is still unknown. For that, we investigated in detail the arm swimming movement in the benthic common octopus, by means of image segmentation and motion reconstruction of video data acquired by the authors. The 3D trajectories of all eight arms were tracked in three sequences of octopus arm swimming, revealing a synchronous, albeit complex, pattern of motion. Video acquisition by three high-definition cameras was used on adult octopuses, kept in the aquarium (*Octopus vulgaris*, 200-400gr of weight). The image sequences were a posteriori deinterlaced, synchronized, and compensated for radial and tangential lens distortion. Using a checkerboard pattern, the intrinsic and extrinsic calibration of each camera was performed, with a strong estimation of the camera parameters. To reconstruct an individual arm in 3D, the 2D arm contour was manually segmented from each camera frame, and its medial axis was extracted, thereafter, automatically [Yekutieli, 2007]. Employing epipolar geometry constraints and least-square approximation, between each camera view, the reconstruction of each, corresponding, medial axis in 3D was obtained. A back-projection process, from 3D to 2D, allowed evaluation and verification of the resulting 3D trajectories, via a manually iterative procedure. The 3D trajectories of the medial axes of octopus arms during arm swimming motion were, therefore, robustly extracted from three video sequences of live octopuses. This is the first demonstration of the complete 3D octopus swimming motion involving all arms. The data obtained from the sequences provide new kinematic information about this, relatively unknown, propulsive motion.



Reference

Yekutieli, Y., Mitelman, R., Hochner, B. and Flash, T. 2007. Analyzing Octopus Movements Using Three-Dimensional Reconstruction. J Neurophysiol 98:1775-1790.