VOLUMETRIC VELOCITY MEASUREMENTS ON TURNING BEHAVIOR IN JELLYFISH

APPLICATION NOTE V3V-9000-CS-001 (A4)

Jellyfish (*Aurelia aurita*)

Maneuverability is critical to the success of many species. Understanding animal control of fluids for maneuvering has both biological and engineering applications. Within inertial fluid regimes, propulsion involves the formation and interaction of vortices to generate thrust. The V3V technique was used to quantify how jellyfish (*Aurelia aurita*) modulate vortex rings during turning behavior.

V3V-9000-CS System

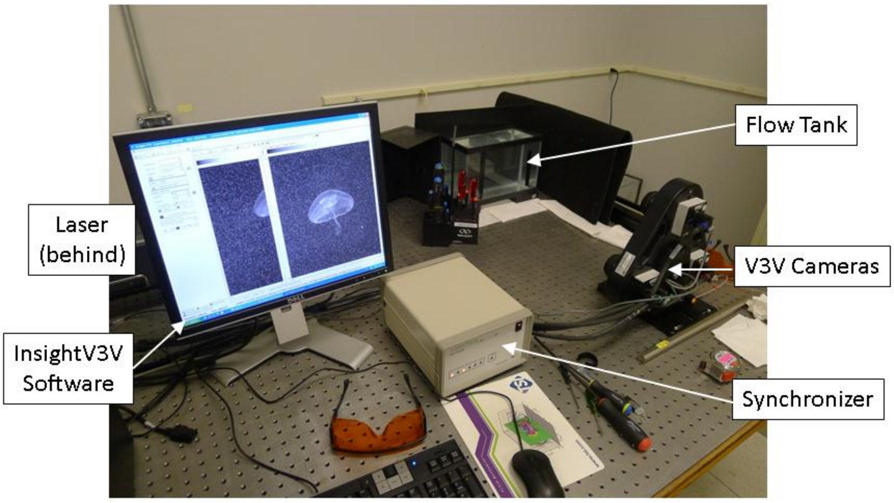

Fig. 1. The experimental setup showing the positioning of the V3V system components

The V3V-9000-CS system was used in taking the volumetric velocity measurements (fig. 1). The V3V camera mount, with three 4MP cameras captured three-dimensional snapshots of the wake structure produced by the jellyfish *Aurelia aurita*. The volume of interest (14×14×10 cm) was illuminated by a 120 mJ dual-head pulsed Nd:YAG laser (532 nm). Groups of image pairs (one pair per camera—3 pairs in total) were captured at 7.25 Hz with a time of 3.5 ms in between each image pair, at 12-bit resolution. The imaging aquarium was seeded with 55 um diameter polyamide particles. Particle positions and displacements were calculated between laser pulses using the INSIGHT V3V 4G™ software as detailed in Troolin & Longmire [1] and Pereira et al. [2]. The three lenses and charge-coupled device (CCD) arrays (2048 × 2048) were calibrated by traversing a target with known dot-spacing across the transverse (Z) plane of the flow tank where the target animals swam. Tecplot® software was used to visualize the results.

Results

Volumetric analysis of the vortex wake shed by *Aurelia aurita* reveals a sequence of vortex rings left in the path. In Fig. 2, the trajectory of the animal is downward and to the left. The blue isosurface was calculated based upon the local particle density, and is a unique feature of INSIGHT V3V 4G software, easily identifying objects within the flow, where no 3D particles are triangulated. The yellow isosurfaces show locations of Q-criterion, an indicator of vortex cores. Three distinct vortex rings can be seen in the wake of the animal, as well as two more interconnected rings near the center of the plot. These interconnected rings exhibit a location where the jellyfish was engaged in turning behavior. The unique footprint of 3D wake structures in this region provide clues into the body deformations performed in order to re-orient the body.

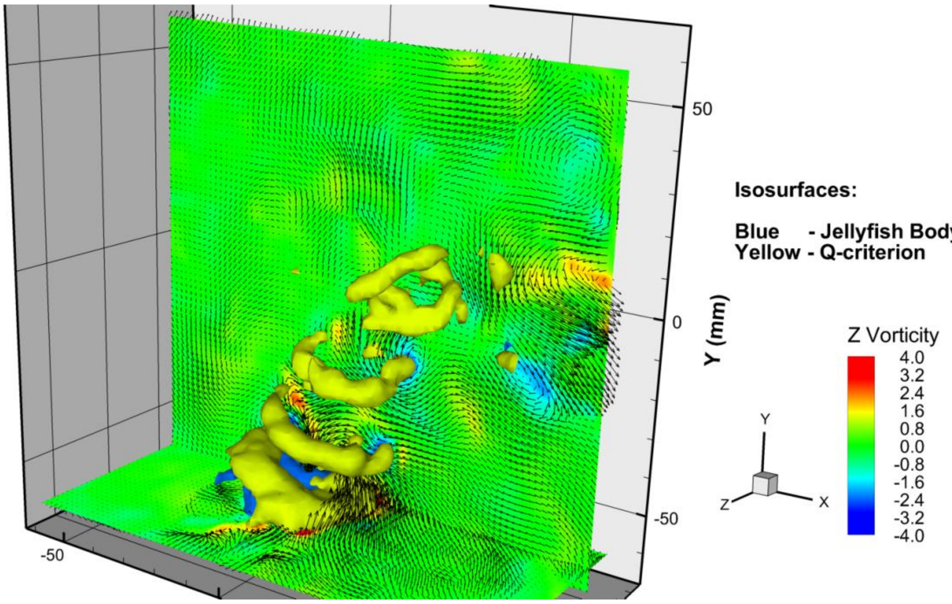

Fig. 2. Single, instantaneous velocity field of the jellyfish wake. The body of the jellyfish is seen in the blue isosurface. Q-criterion, representing vortex cores, is visualized in yellow isocontours. The color of the planes represents vorticity.

For more details on this experiment, the full paper can be found here:

Gemmell BJ, Troolin DR, Costello JH, Colin, SP, Satterlie RA (2015) Control of Vortex Rings for Maneuvrability, *J. R. Soc. Interface, 20150389.* http://dx.doi.org/10.1098/rsif.2015.0389

Reference

[1] Troolin D.R., Longmire E.K. 2010 Volumetric velocity measurements of vortex rings from inclined exits. *Experiments in Fluids* **48**(3), 409-420.

[2] Pereira F., Stuer H., Graff E.C., Gharib M. 2006 Two-frame 3D particle tracking. *Measurement science and technology* **17**(7), 1680.

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