Proof of Concept: Designing a Particle Image Velocimetry Chamber for Fluid Motion Visualization

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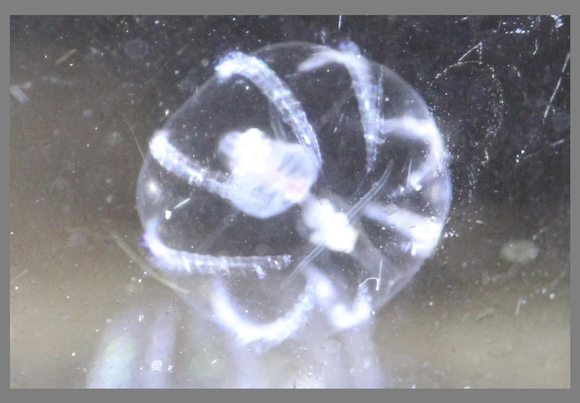
INTRODUCTION & RATIONALE

The Dual View microscope developed by Niamh Burke, Amy Hassett and Dr. Mark Pickering allows for both lower-magnification and high-magnification views of a sample organism to be simultaneously captured. The higher-magnification camera is able to translate in two dimensions at the manual click of a mouse, although there is progress being made in the direction of autonomous tracking. An experimental chamber would be designed which, when attached to the microscope assembly, would then allow for particle image velocimetry (PIV) to be conducted from a laser light sheet.

P. pileus (fig 1), otherwise known as “sea gooseberries,” are simple model organisms native to the Irish coast that can help us understand the nervous systems of more complex animals. If this method is proven successful, the aim is to begin imaging the fluid motion surrounding P. pileus as it interacts with its environment.



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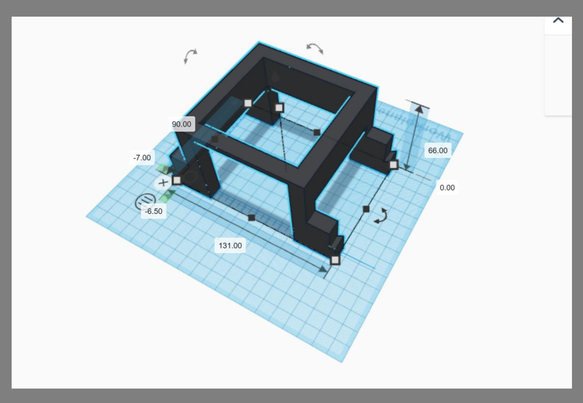

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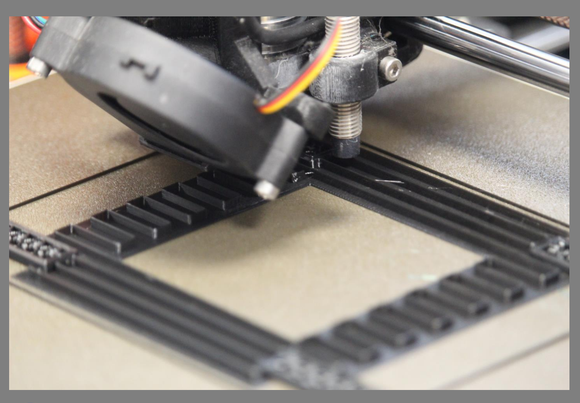

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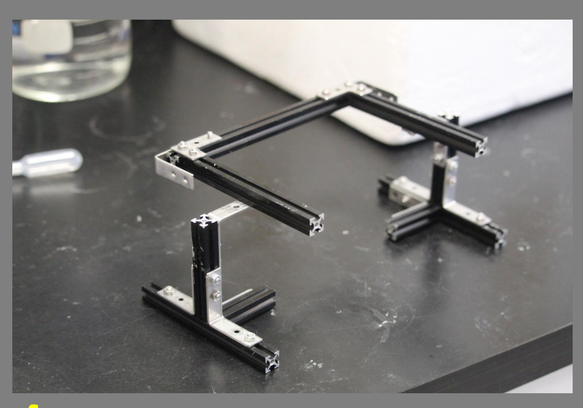

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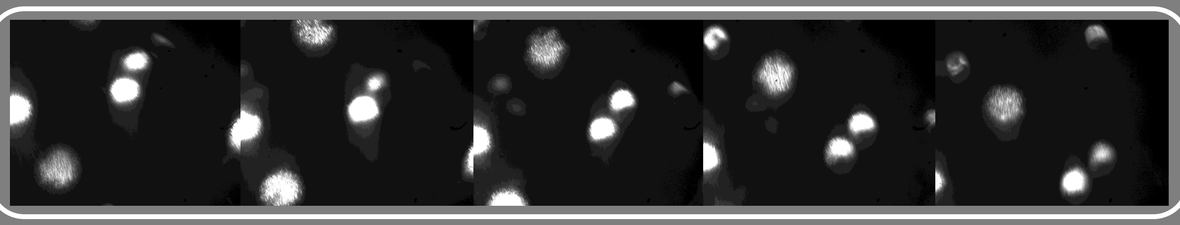

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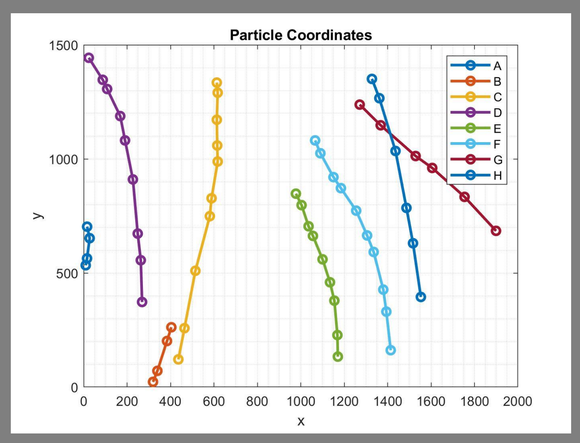
METHODS

1. The dimensions of the chamber were dictated by the geometry of the dual view microscope itself, including the distance between its horizontal support beams and the range of the low-magnification camera view. The final chamber frame design was created using Tinkercad once the design was completed on paper (fig 2).
2. PETG was selected for its durability as the print material (fig 3). Poly(methyl methacrylate) (perspex) was hand-cut to desired dimensions for the transparent bottom face, allowing the high-mag lens to image directly through the chamber. A microscope slide was used for the laser window, and silicone glue was added last as sealant during final assembly.
3. The completed chamber with all its components had to be watertight in order to protect the high-mag lens. To test for leakage an elevated rack, which suspended the new assembly over a dry paper towel, was designed using MakerBeam (fig 4).
4. Additional challenges arrived in the form of aligning the laser light sheet to a static focal plane for the high-mag lens. This required the laser mount to be adjustable in terms of both pitch and roll. Saltwater was used during the process to account for differences such as density and turbidity. The high-mag lens was then adjusted accordingly once an even plane had been achieved by the light sheet.
5. “Particles” were added to the mounted chamber in the form of brine shrimp *(Artemia)* eggs. P. pileus was later added to test the feasibility of the immediate design on imaging and tracking larger, moving animals.
6. Series of high-magnification images were captured over the span of a few seconds (fig 5). Data collection of the positions of individual particles over time were then completed using ImageJ.



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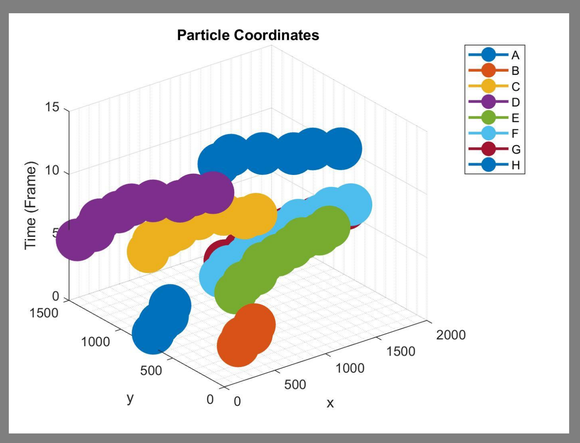

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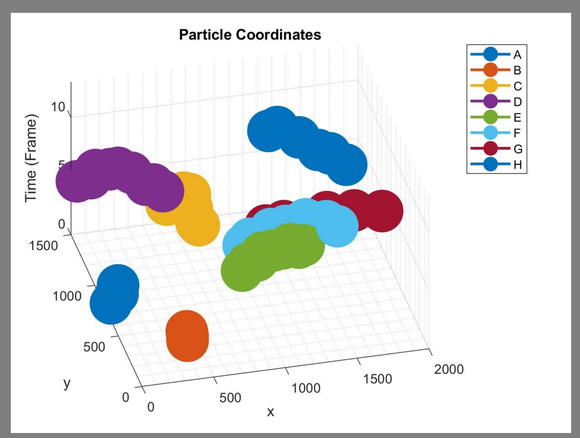

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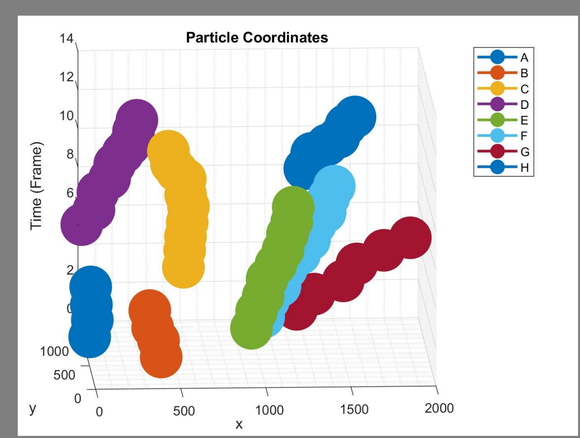

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OUTCOMES

The tests showed that the experimental chamber in conjunction with the microscope was indeed capable of capturing multiple particles across the light sheet, simulating fluid movement. We were able to visualize the data using a variety of programs and methods; access to particle coordinate data over time allowed the creation of three-dimensional graphical analyses (figs 6a-6d). The experiment in all its stages of development were likewise a testament to research design around modular components, which allows for ease of implementation and greater reproducibility.

ACKNOWLEDGEMENTS

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