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Low-cost Particle Image Velocimetry as an additional tool for Fluid Dynamics Trainers

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Abstract

Fluid Dynamics is a core course within several engineering disciplines including Mechanical, Chemical and Civil Engineering. It is, however, a difficult course to teach as it involves concepts that can often be viewed as abstract by the students - concepts such as, for example, rotational versus irrotational flows. Teaching of Fluid Dynamics also involves the use of high level mathematics that is usually difficult to associate with physical flow situations. To aid in the breaking down of these conceptual barriers, simple experiments are often used to complement classroom teaching. While a number of such experiments already exist (eg wind tunnel experiments), this study proposes the use of low-cost particle image velocimetry (PIV) as an additional tool. PIV is an established non-intrusive velocity measurement technique that is mainly used within the research space as opposed to the educational space due to the associated high costs and need for high-level expertise. However, recent efforts have been geared towards making PIV more affordable and accessible. Such efforts have included, for example, replacing high-end cameras with mobile phone cameras, replacing high-end lasers with cheaper light sources and the development of open-source software for analysis (both computer-based and phone-based). Building on these efforts, this study seeks to illustrate how low-cost PIV can be easily incorporated into a typical undergraduate Fluid Dynamics laboratory. A simple flow set up was assembled using a beaker, a magnetic stirrer, water-glycerine mixture and a relatively inexpensive laser and optics system. The flow was recorded using a mobile phone camera and the subsequent analysis done using the open-source PIVlab software. Velocity data has been obtained and additional analysis done to illustrate concepts such vorticity within the flow. It is envisioned that this work will help to stir conversation and research around context-relevant or discipline-relevant uses of low-cost PIV as a tool to enhance the delivery of Fluid Dynamics.

Keywords: Particle image velocimetry, low-cost, Fluid Dynamics