Particle Tracking Velocimetry Employing Aerial Thermography[1]

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Abstract: The present study demonstrates a proof-of-concept particle tracking velocimetry (PTV) system based on aerial thermography taken from a small, unmanned aircraft system (sUAS). In this work, both visible light and thermal video is collected by sUAS, allowing observation of tracers appropriate to each data source. While visible light tracers were brightly colored plastic spheres that had to be recovered after use, the thermal tracers were ice cubes: discrete, rigid, and thermally visible tracers. To locate these cubes and mitigate the effect of vehicle motion, large quantities of ice located at fixed points along the stream were also used as ground references. The present work demonstrates a video analysis program to analyze this imagery and derive quantitative flow information that compares well with flow measurements taken with traditional instruments. The program uses OpenCV for image pre-processing, along with open-source software OpenPTV for particle tracking and velocity estimation. The pre-processor, developed in this work, is employed to account for incidental vehicle motion during data collection by automatically detecting and referencing ground references in each frame. In addition, OpenPTV and a postprocessing script are employed to produce continuous velocity fields. In its current state, when implemented on a straight, gravel-lined channel, the surface velocities estimated by this system differ from handheld acoustic-doppler velocimeters by approximately 15%. While further testing and development is needed, the program shows significant promise to enable a low-impact, ad-hoc flow measurement system ideal for evaluating flow structures in abandoned mine drainage (AMD) treatment systems.

Additional Key Words: Unmanned aircraft system, Python, OpenCV, OpenPTV, abandoned mine drainage

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