UAV-based PIV for quantifying water-flow processes in large-scale natural environments

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HIGHLIGHTS

- A novel large-scale flow measurement technique that couples UAV technology with image-based velocimetry is presented.
- An image rectification protocol based upon scale invariant feature transform methods has been developed to correct for UAV drift.
- Application of PIV algorithms allow for the complex two-dimensional flow fields of the water surface to be accurately resolved.
- These data are key to informing and calibrating predictive tools that can reconstruct potential emergency scenarios.

ABSTRACT

A novel large-scale flow measurement technique that couples UAV technology with image-based velocimetry has been developed for river applications. The system aims to remotely, safely and cost-effectively gain high-resolution and time-resolved images of the water surface. The images are interrogated using standard 2D cross-correlation analysis to resolve instantaneous surface velocity fields. A system based on commercial equipment has been devised and demonstrated herein whereby a quadcopter and high resolution camera have been successfully used to collect aerial images of a river flow. A test was conducted on the Saint Joseph River (Indiana, USA) that produced a series of high-resolution instantaneous velocity maps of flow downstream of a weir that demonstrate the vast potential of this remote-sensing method. This study has particularly shown that UAV drifting introduces severe bias that must be corrected prior to implementing image interrogation methods, otherwise erroneous velocity magnitude and directions will be produced. An image rectification protocol based upon scale invariant feature transform (SIFT) methods has been provided herein. The protocol was tested and its accuracy was qualitatively assessed.

Systems such as that described herein can theoretically be deployed for long periods of time for collecting data samples that are statistically significant, or for continuous monitoring during highly transient events. Such monitoring is key to informing and calibrating large-scale CFD models that can accurately predict potential emergency scenarios during flooding events. In addition, during extreme natural events, data can be collected with no risk to human operators.