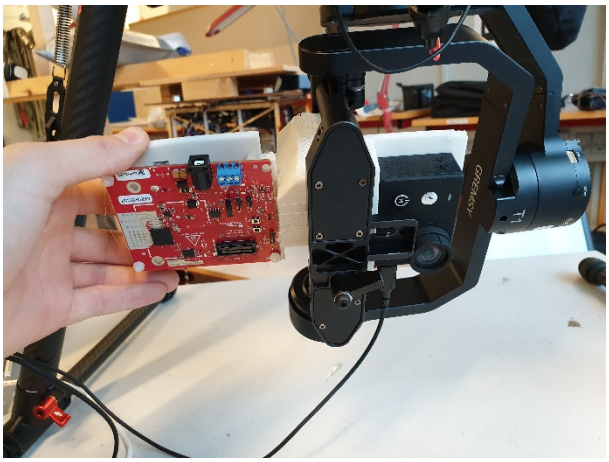
UAS water surface velocity (WSV) and discharge observations

A New Tool for Water Resources Engineering

Summary:
We have developed a new drone-borne camera solution, which can measure Water Surface Velocity (WSV) at high accuracy in rivers, streams, and wetlands. The payload can also estimate discharge where uniform flow occurs.



The surface water velocity drone payload

The payload:

The payload consists of the differential global navigation satellite system (GNSS) unit, the WSE radar and an RGB camera. The GNSS records the exact position of the UAV platform, while the camera retrieves video of the water surface. WSV can be estimated by determining the displacements of tracer particles (e.g. leaves, foam, or artificial particles such as woodchips) between two subsequent frames. Image analysis cross-correlation techniques, such as Particular Image Velocimetry (PIV), can be used to estimate the surface velocity field. The conversion of the velocity field from pixels into meters is performed by informing a camera pinhole model with the distance to the water surface, measured by the WSE radar. Conversion from WSV into discharge requires i) water depth ii) full vertical velocity profile. For approximately uniform flow occurs, the vertical profiles follow a logarithmic law, which is a function of Manning number. Uniform flow generally occurs where i) the watercourse is straight over a distance of 5 times the channel width upstream and twice the width downstream, ii) there are no significant changes of watercourse width in this stretch. If uniform flow occurs, water depth, the WSV and WSE slope can be used to jointly estimate Manning number and discharge.

Accuracy of surface velocity measurements	Ca. ±7%
Accuracy of discharge measurements	Ca. ±15%.
Locations suitable for discharge measurements	Uniform flow conditions
Recommended flight speed	Hovering
Hover time to estimate a surface velocity field	Ca. 30 seconds
Survey time for a cross section	ca. 2-3 min
Processing time for a cross section	ca. 1 hour

UAV-borne WSV and discharge surveys: Technical specifications

Applications:

The drone payload can be used to efficiently measure WSV and discharge in rivers, streams and over wetlands. Applications include:

- River monitoring - WSV is important to estimate dead zones and mixing processes, while discharge is essential to mitigate flood risk, estimate the optimum levels of water use for sustainable water management, etc.
- River maintenance - Manning number and discharge are important to estimate river conveyance and target river maintenance.
- Hydrodynamic modelling - discharge is a primary input at the boundary of hydrodynamic models. UAV-borne discharge observations can be used to obtain detailed information about the discharge sources and sinks in a watercourse
- Risk assessment in contaminated sites and river ecosystems: discharge is essential to estimate dilution of pollutants in watercourses. Discharge is a primary variable affecting water quality and ecosystem health.

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Technical reference: A contactless airborne method to jointly estimate discharge and Manning's roughness in rivers and streams Bandini, F., Luethi, B.., Borst. C., Liu, J., Karagkiolidou, S., Bjerg, P. & Bauer-Gottwein, P. (2019). In preparation