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A novel sensor platform for the rapid hydraulic characterisation of freshwater ecosystems

Thomas Kriechbaumer (1), Kim Blackburn (1), Toby Breckon (2), Andrew Gill (1), Nick Everard (3), Ros Wright (4), and Monica Rivas Casado (1)

(1) Department of Environmental Science and Technology, Cranfield University, Cranfield, United Kingdom (m.rivas-casado@cranfield.ac.uk), (2) School of Engineering and Computing Sciences, Durham University, Durham, United Kingdom, (3) Environment Agency, Hydrometry and Telemetry, Wallingford, United Kingdom, (4) Environment Agency, Fisheries and Biodiversity, Feering, United Kingdom

The spatially explicit quantification of hydraulic features provides valuable information for the physical habitat assessment of freshwater ecosystems. Collection of data on water velocities and depths using in-situ current meters or acoustic sensors on tethered boats is time-consuming and requires good site accessibility. Moreover, on smaller rivers precise spatial data referencing can be challenging, as river bank vegetation can block sky view to navigation satellites over a considerable proportion of the water surface. This paper describes the development and testing of a new small sized remote control sensor platform and a novel approach to spatial data referencing based on computer vision to enable the rapid hydraulic characterisation of habitats in small rivers. It highlights the manifold opportunities that recent achievements in the disciplines of computer science and electronics can create for the environmental sciences. The platform carries an acoustic Doppler current profiler (ADCP) to rapidly collect large amounts of data on water velocities and river depths, from which the spatial and temporal water velocity distributions can be derived. The 1.30m long and 0.60m wide platform hull has been designed to enable single person deployment. Platform pitch and roll magnitudes and periods are quantified at a frequency of 512Hz through a low-cost inertial measurement unit on board, allowing the quantification of the errors that these platform motions can cause in the ADCP data. Jet propulsion and a tail thruster ensure high manoeuvrability, minimum draught operation and greater safety than propellers. An on-board Raspberry Pi computer enables time-synchronised logging of data from a GPS unit, the ADCP and further sensors that may be added to the platform. Real-time serial communication between the Raspberry Pi and the embedded propulsion system control (an Arduino Uno microcontroller) builds the basis for future platform autonomy. This can enable the autonomous implementation of pre-defined data collection strategies. Through field experiments, a set of technologies to position the platform in the river environment has been evaluated. Simultaneous localisation and mapping (SLAM) based on frames from a stereo camera has been identified as a promising alternative to satellite-based platform positioning. In terrestrial environments, SLAM has recently achieved high position accuracies, comparable with those of differential GPS. Software that implements SLAM for the river environment is currently developed. This constitutes the first application of visual SLAM on water and, to the authors' knowledge, its first application in the context of environmental research. Furthermore, platform tracking with a motorised Total Station has been found to be a highly accurate (cm-level) positioning technique despite fast platform movements, as long as line of sight to the tracked object is given. In the near future, the platform will be used to characterise the hydraulic conditions downstream of fish passes in order to rapidly assess the attractivity of these facilities to migrating fish species. Several of the applied technologies (e.g. Raspberry Pi, Arduino) are cheap and easily accessible. They provide a multitude of opportunities to facilitate data collection and prototype development in the environmental sciences.