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# Image-based methods for real-time water level estimation

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Obtaining real-time water level estimations is crucial for effective monitoring and response during emergencies caused by heavy rainfall and rapid flooding. Typically, this type of monitoring can be a difficult task, requiring river reach preparations and specialized equipment. Moreover, in extreme flood events, standard observation methods may become ineffective. This is why the possibility of developing low-cost, automatic monitoring systems represents a significant advancement in our ability to monitor river courses and allow emergency teams to respond appropriately.

Image-based methods for water level estimation facilitate the development of a low-cost river monitoring strategy in a quick and remote approach. These techniques are faster and more convenient regarding the setup than traditional water stage monitoring methods, allowing us to efficiently monitor the river from different locations with a cost-effective approach. By increasing the density of the observation network, we can improve flood warning and management.

The approach presented involves placing cameras in secure locations to capture images of the river, for which we have previously modelled the terrain in 3D using Structure from Motion (SfM) algorithms supported by GNSS data. With the images obtained every 15 minutes, we perform a Convolutional Neural Network (CNN) segmentation based on artificial intelligence algorithms that allow us to automatically extract the contours of the water surface area. In this study, two different neural network approaches are presented to segment water in the images.

Using a photogrammetric strategy, we reproject the water line extracted by the AI on the 3D model of the scene. This reprojection is also supported by the use of a keypoint detection neural network that allows us to accurately identify the ground control points (GCPs) observed in the images captured by the surveillance camera. This approach allows us to automatically assign to each image the real coordinates of the GCPs and subsequently estimate the camera pose.

This AI segmentation and automatic reprojection into the 3D model has allowed us to generate a robust centimetre-accurate workflow, capable of estimating the water level in near-real time for daylight conditions. In addition, the automatic detection of the GCP has permitted to obtain automatic water level measurements over a longer period of time (one year). This approach

represents the basis for obtaining other river monitoring parameters, such as velocity or discharge, which allow a better understanding of river floods and represent key steps for the development of early warning systems for flood events.