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Towards automatic real-time water level estimation using surveillance cameras

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The handling of natural disasters, especially heavy rainfall and corresponding floods, requires special demands on emergency services. The need to obtain a quick, efficient and real-time estimation of the water level is critical for monitoring a flood event. This is a challenging task and usually requires specially prepared river sections. In addition, in heavy flood events, some classical observation methods may be compromised.

With the technological advances derived from image-based observation methods and segmentation algorithms based on neural networks (NN), it is possible to generate real-time, low-cost monitoring systems. This new approach makes it possible to densify the observation network, improving flood warning and management. In addition, images can be obtained by remotely positioned cameras, preventing data loss during a major event.

The workflow we have developed for real-time monitoring consists of the integration of 3 different techniques. The first step consists of a topographic survey using Structure from Motion (SfM) strategies. In this stage, images of the area of interest are obtained using both terrestrial cameras and UAV images. The survey is completed by obtaining ground control point coordinates with multi-band GNSS equipment. The result is a 3D SfM model georeferenced to centimetre accuracy that allows us to reconstruct not only the river environment but also the riverbed.

The second step consists of segmenting the images obtained with a surveillance camera installed ad hoc to monitor the river. This segmentation is achieved with the use of convolutional neural networks (CNN). The aim is to automatically segment the time-lapse images obtained every 15 minutes. We have carried out this research by testing different CNN to choose the most suitable structure for river segmentation, adapted to each study area and at each time of the day (day and night).

The third step is based on the integration between the automatically segmented images and the 3D model acquired. The CNN-segmented river boundary is projected into the 3D SfM model to obtain a metric result of the water level based on the point of the 3D model closest to the image ray.

The possibility of automating the segmentation and reprojection in the 3D model will allow the generation of a robust centimetre-accurate workflow, capable of estimating the water level in near real time both day and night. This strategy represents the basis for a better understanding of river flooding and for the development of early warning systems.