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Towards a comprehensive optical workflow for monitoring and estimation of water levels and discharge in watercourses

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Coping with natural disasters such as floods places special demands on the emergency units. From the point of view of command-and-control operators, observations of watercourses are desirable in the event of flooding in order to obtain an accurate picture of the situation. Optical measurement methods using cameras offer thereby advantages as they do not require water contact and hence can be used safely. Therefore, the project "KIWA: Artificial Intelligence (AI) for Flood Warning" (http://kiwa.hydro.tu-dresden.de/) is developing AI-based tools for the robust quantification of water levels, flow velocities and flow rates from surveillance cameras.

In this article, we present the workflow for an exclusive optical measurement of time series of water level and discharge from single images and short video sequences. The basis is a high-precision (i.e., at centimetre level), georeferenced 3D terrain model of the measurement site including the riverbed. The terrain model is created using the structure-from-motion (SfM) technique and georeferenced via ground control points (GCPs) measured with a multiband GNSS receiver. To determine the water level, the water area in the single images is automatically segmented using AI based on convolutional neural networks (CNNs) and then intersected with the terrain model. Changes of the camera geometry influence the measurement accuracy during long-term observations. Therefore, the GCPs are automatically detected in the individual images with an adapted AI-based keypoint detector to frequently update the estimated camera orientation. To estimate the discharge, the water surface flow velocity is determined using short video sequences and applying the particle tracking (PTV) method, whereby the segmented water area narrows down the search area for the particle detection. Afterwards, the "OptiQ" modelling approach is used to derive the discharge times series based on the PTV measurements. Thereby, data filtering and error correction methods are used to achieve continuous time series.

The methods were developed at three different measuring gauges, whose cameras record single images and videos every 15 minutes over several months. The accuracy of the water level measurement is in the centimetre range, even at night with the support of infrared emitters. Depending on the water level, there are deviations in the flow rate, which average less than 10%.