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Estimation of Open Channel Surface Velocity with Faster Region-Convolutional Neural Networks

Chih Yi Sung (1) and Hao Che Ho (2)

(1) Department of Civil Engineering, National Taiwan University, Taipei, Taiwan (r06521318@ntu.edu.tw), (2) Department of Civil Engineering, National Taiwan University, Taipei, Taiwan (haocheho@ntu.edu.tw)

River discharge measurement is the most important topic for the open channel flow. How to estimate the discharge correctly in extreme events might affect the water resources management. Using acoustic instruments, such as ADCP, is the common way to obtain depth-averaged velocity and discharge for the open channel flow, but it is very costly and dangerous under extreme events. Another choice is to adopt the image-based techniques, such as Large-Scale Particle Image Velocimetry (LSPIV). The advantage of the image-based method is non-intrusive that can avoid the dangerous and simultaneously have the two-dimensional velocity field. However, it was shown that velocity vectors on water surface would be underestimated by using LSPIV. The major errors came from the seeding density, illumination and the setting of the interrogation area in the successive images.

Conducting the computer vision ideas to improve the surface velocity measurement seems promising. Because of the application of artificial intelligence, the development of deep-learning methods has made computer vision much more powerful and suitable for the image recognition. The conception of convolution neural network (CNN), therefore, could be possibly conducted for the image-based flow measurement. The major difficulties for CNN method applied to velocity measurement is to locate the pattern coordinate in specific time. Using Faster R-CNN (Faster Region Convolutional Neural Networks) to measure surface velocity, on the other hand, can be the proper candidate to simultaneously recognize and locate the pattern. This Faster R-CNN method won't be affected by illumination and no necessary to set the interrogation area that can diminish the sources of errors when processing LSPIV. Laboratory experiments were conducted with a compound channel flume of 27m (L) x 1m (W) x 1.1m (H) to demonstrate the capability of Faster R-CNN. Smooth and rough bed roughness conditions were designed as different flow conditions. The flow velocities measured by acoustic Doppler Velocimetry (ADV) were used as benchmarks. Comparing the velocities measured with LSPIV, the results of Faster R-CNN was 5$\sim$10% higher, and had closer value to ADV data. This study demonstrates that object detection with Faster R-CNN in streamflow velocimetry is feasible and can be applied to discharge measurement.