MODELLING WAVE OVERTOPPING AND WAVE IMPACTS BY MEANS OF IMAGE CLUSTERING TECHNIQUES

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AIM AND MOTIVATION

The experimental modelling of the wave-structure interaction processes is a very complicated issue, due to the highly non-linear turbulent flow conditions, including wave breaking and air entrainment (Stringari et al., 2021). Recently, Formentin et al. (2021) demonstrated that videography can provide a reliable representation of the wave breaking, of the wave overtopping and of the wave impact at walls. They filmed laboratory tests of wave overtopping at smooth dikes with crown walls (Formentin et al., 2018; Palma et al., 2020) with a low-cost full-HD camera and compared the results of the video-cluster analysis applied to its records with the measurements obtained through traditional techniques. They derived accurate quantitative estimations of free-surface elevation, wave overtopping discharge, volumes, velocities and celerities. The aim of this paper is to further investigate the possibilities of the videography by focusing on the analysis of the wave impacts at the walls and on the detection of the amount of air entrapped during the impacts themselves.

METHODOLOGY

The records of the wave impacts filmed by the full-HD camera installed in correspondence of the dike crest and crown wall were elaborated with the image processing technique developed by Formentin et al. (2021). Such procedure is based on the cluster analysis of the frames (K-means method) for the automatic detection of elements and patterns and includes advanced pre- and post-processing filtering techniques to ease the clustering phase and to achieve a more realistic recognition of the patterns.

Specifically, Formentin et al. (2021) applied the clustering technique to automatically recognize the frame-by-frame free-surface elevation and the air bubbles entrapped in the water phase during the wave breaking and wave impacts. Fig. 1 provides an example of the contour of the element "air" as detected by the automatic cluster mapping of a frame reproducing an overtopping event propagating along the dike crest just before hitting against the crown wall at the inshore side.

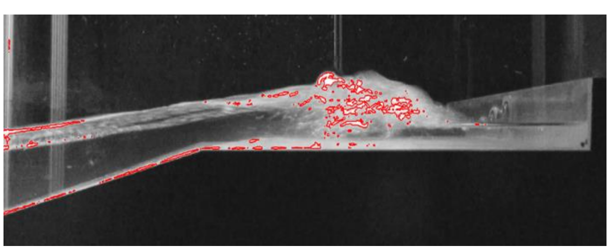

Figure 1 – Contour of the element "air" as detected by the cluster analysis of a frame reproducing an overtopping event.

The methodology developed by the authors involves other procedures to calculate the celerities of propagation of the waves along the dike crest from the elaboration of the time-signals of the free-surface elevations (Formentin and Zanuttigh, 2018).

ANALYSIS AND PRELIMINARY RESULTS

The methodology developed by Formentin et al. (2021) was further elaborated to model the wave impacts at the walls, reconstructing the run-up and the thickness of the water tongue overtopping, and to estimate the flow velocities and the amount of air entrapped during the impacts against the wall. Fig. 2 shows an example of the run-up at the wall reconstructed with the cluster technique. The orange profile represents the free-surface elevation directly prompted out by the cluster analysis of the frame, while the blue line is the filtered profile obtained with the abovementioned post-processing optimization techniques. The values of the impact velocities were used to estimate the wave impact pressures, which were compared in turn to the measurements from the pressure transducers installed in the crown wall (see Palma et al., 2020).

Finally, the maps of the air phase detected were analyzed to evaluate the areas of the walls most frequently subjected to air entrainment.

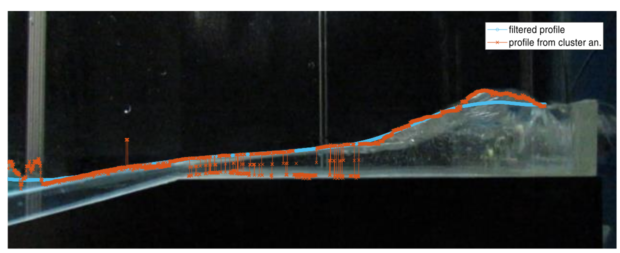

Figure 2 – Reconstruction of the run-up at the wall from the video-cluster analysis of an impact event.

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