Offshore remote sensing of the ocean by stereo vision systems

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In recent years, remote sensing imaging systems for the measurement of oceanic sea states have attracted renovated attention. Imaging technology is economical, non-invasive and enables a better understanding of the space-time dynamics of ocean waves over an area rather than at selected point locations of previous monitoring methods (buoys, wave gauges, etc.). We present recent progress in space-time measurement of ocean waves using stereo vision systems on offshore platforms, which focus on sea states with wavelengths in the range of 0.01 m to 1 m. Both traditional disparity-based systems and modern elevation-based ones are presented in a variational optimization framework: the main idea is to pose the stereoscopic reconstruction problem of the surface of the ocean in a variational setting and design an energy functional whose minimizer is the desired temporal sequence of wave heights. The functional combines photometric observations as well as spatial and temporal smoothness priors. Disparity methods estimate the disparity between images as an intermediate step toward retrieving the depth of the waves with respect to the cameras, whereas elevation methods estimate the ocean surface displacements directly in 3-D space. Both techniques are used to measure ocean waves from real data collected at offshore platforms in the Black Sea (Crimean Peninsula, Ukraine) and the Northern Adriatic Sea (Venice coast, Italy). Then, the statistical and spectral properties of the resulting oberved waves are analyzed. We show the advantages and disadvantages of the presented stereo vision systems and discuss furure lines of research to improve their performance in critical issues such as the robustness of the camera calibration in spite of undesired variations of the camera parameters or the processing time that it takes to retrieve ocean wave measurements from the stereo videos, which are very large datasets that need to be processed efficiently to be of practical usage. Multiresolution and short-time approaches would improve efficiency and scalability of the techniques so that wave displacements are obtained in feasible times.