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Stability assessment of coastal rocky cliffs based on UAV close-range photogrammetry and geomechanical finite element modeling

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The present research explores the combination of unmanned aerial vehicle (UAV) photogrammetry and three-dimensional geomechanical modeling in the investigation of instability processes of long sectors of coastal rocky cliffs. The need of a reliable and detailed reconstruction of the geometry of the cliff surfaces, beside the geomechanical characterization of the rock materials, could present a very challenging requirement for sub-vertical coastal cliffs overlooking the sea.

Very often, no information could be acquired by alternative surveying methodologies, due to the absence of vantage points, and the fieldwork could pose a risk for personnel. The case study is represented by a 600 m long sea cliff located at Sant'Andrea (Melendugno, Apulia, Italy). The cliff is characterized by a very complex geometrical setting, with a suggestive alternation of 10 to 20 m high vertical walls, with frequent caves, arches and rock-stacks. Initially, the rocky cliff surface was reconstructed at very fine spatial resolution from the combination of nadir and oblique images acquired by unmanned aerial vehicles. Successively, a limited area has been selected for further investigation. In particular, data refinement/decimation procedure has been assessed to find a convenient three-dimensional model to be used in the finite element geomechanical modeling without loss of information on the surface complexity. Finally, to test integrated procedure, the potential modes of failure of such sector of the investigated cliff were achieved. Results indicate that the most likely failure mechanism along the sea cliff examined is represented by the possible propagation of shear fractures or tensile failures along concave cliff portions or over-hanging due to previous collapses or erosion of the underlying rock volumes. The proposed approach to the investigation of coastal cliff stability has proven to be a possible and flexible tool in the rapid and highly-automated investigation of hazards to slope failure in coastal areas. The progress of the work is now focused on applying the approach to the entire 600 m long sea cliff; when facing such a big extent the surface modeling strategy should be improved and the computational burden take into account. An effective solution to model large natural environments is provided by the design of NURBS (Non-Uniform Rational B-Spline) surface patch thanks to the ability to model complex free-form curves and surfaces. This strategy has been applied to the whole sea cliff length in order to test the novel approach and obtain a suitable 3D model with enough accuracy for geomechanical simulations.