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The 3D-PITOTI Project with a Focus on Multi-Scale 3D Reconstruction using Autonomous UAVs *

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Abstract
In this talk, we showcase our outcome of the ambitious 3D-PITOTI project, which involves a multi-disciplinary team of over 30 scientists from across Europe. The project focuses on the 3D aspect of recording, storing, processing and visualizing prehistoric rock art in the UNESCO World Heritage site in Valcamonica, Italy. The rock art was pecked into open-air rock formations thousands of years ago and has an inherent 3D nature.
After a project overview, we present the results of the Graz University of Technology's contributions in 3D acquisition and processing with a focus on our novel autonomous UAV system. We elaborate the challenges of 3D reconstruction across vastly different scales, from a valley wide reconstruction down to individual peckings on the rock surface [1]. Within this context, we first present a novel 3D scanning device with sub-millimeter accuracy [2]. Aside from correctly scaled 3D information, the scanning device also provides the surface radiometry without the need for artificial shrouding [3]. Additionally, we point out one application for which this highly accurate 3D data has shown to be crucial: The interactive segmentation of the individually pecked figures [7, 8].
Finally, we present a novel autonomous UAV system for acquiring high-resolution images at a few meters distance [6, 5, 4]. The system optimizes scene coverage, ground resolution and 3D uncertainty, while ensuring that the acquired images are suitable for a specific dense offline 3D reconstruction algorithm. There are three main aspects that set this system apart from others. First, the system operates completely on-site without the need for a prior 3D model of the scene. Second, the system iteratively refines a surface mesh, predicts the fulfillment of requirements and can thus correct for initially wrong geometry estimates and imperfect plan execution. Third, the system uses the already acquired 2D images to predict the chances of a successful reconstruction with a specific offline 3D densification algorithm depending on the observed scene and potential camera constellations. We demonstrate the capabilities of our system in the challenging environment of the prehistoric rock art sites and then register the individual reconstructions of all scales in one consistent coordinate frame.

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