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SCALE PROPAGATION IN MONOCULAR VISUAL ODOMETRY FOR THE EXTRATERRESTRIAL OPERATIONS OF UNMANNED AERIAL VEHICLES

Abstract

From drone-like objects to more challenging landing probes, developing aerial vehicles capable of operating autonomously in the proximity of extraterrestrial surfaces will represent a key milestone for unmanned space exploration. For a wide range of missions the most interesting payload to enable autonomy from a navigation perspective is represented by purely visual sensors, which optimize the trade-off between information provided and cost. The two most common configurations for these payloads are stereo (two) and monocular (one) camera setups. Whereas the former intrinsically gives the ability to compute depth, this is effectively possible only within a certain range of distances, constrained by the physical architecture of the sensor. On the other hand, a monocular camera is able to generate at most an up to scale solution, unless the solution is augmented through the fusion of additional data. Appropriate monocular scaling approaches may lead to a complete reconstruction of the estimated trajectory, either using supplementary sensing information or a priori knowledge about the environment. In this work, we expand on the latter, and propose a scaling solution relying solely on images acquired from the monocular camera mounted on the aerial platform. The trajectory is estimated from the images stream using a visual odometry algorithm, and is unscaled until the first environmental prior is detected. This algorithmic combination provides a passive and inexpensive approach, independent from its operational environment, and which will eventually facilitate fully autonomous navigation within any extraterrestrial environment.

The proposed algorithm is able to propagate depth after being initialised with the visual detection of a single landmark. This possesses an unambiguous structure, well-known from prior knowledge, and enables scale recovery as soon as it appears within the field of view of the camera, establishing navigation to actual scale. The main advantage of the approach discussed is that once the process has been initialised, the landmark target does not need to remain within the field of view of the camera anymore to provide scale disambiguation.

The algorithm was tested in simulation using procedurally generated abstract environments. From this, Monte Carlo analyses are ultimately used to determine the behaviour and the covariance of the process.