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DESIGN AND CASES STUDIES OF CORTO, AN OPEN ACCESS RENDERING TOOL FOR CELESTIAL AND ARTIFICIAL BODIES

Abstract

Access to high-quality image-label pairs is fundamental both for data-driven algorithms trained with supervised learning methods and for traditional image processing methods. Unfortunately, due to the limited number of celestial bodies that have been imaged throughout the history of space exploration, especially considering small bodies, and due to geometric and illumination constraints that are intrinsic to the existing datasets from previously flown missions, the availability of high-quality data is restricted. This adversely affects the capability to create and train data-driven algorithms and to perform robust statistical characterization of traditional image processing pipelines.

Synthetic renderings offer a powerful alternative to have control over dataset properties and generate large amounts of annotated images. To accomplish this and other tasks, this paper presents an exhaustive overview of the Celestial Objects Rendering TOol (CORTO), an open-access, object-oriented, Python repository that exploits Blender's functionalities to synthetically generate large, annotated datasets to be used for computer vision tasks. CORTO has been designed with modularity and accessibility as its core strengths. These should foster collaboration between researchers in the development of a reliable, simple-to-use image-label pairs generator. The end goal of CORTO is to remove the complexity of dataset generation and allow image processing designers to focus on pipeline design and testing rather than data generation. This is particularly relevant for optical navigation tasks, which require challenging and inter-disciplinary pipelines that elaborate image content into relative pose solutions. While the tool currently covers a range of celestial body scenarios, focused on minor bodies and the Moon, future enhancements could broaden its capabilities to encompass additional planetary phenomena and environments. This is promoted by the tool's modularity, which encourages external contributions via dedicated merge requests in underdeveloped areas. Thus, CORTO can be used both by the interested users as a simple-to-use black box to handle dataset generation with the existing functionalities or be further developed for specific scenarios and applications. To encourage usage and co-development, the tool's repository is made publicly

available, and contributions and collaborations are encouraged.

In this work CORTO's architecture and functionality are highlighted considering several application scenarios: small body missions, Moon's missions, and relative navigation with uncooperative man-made objects. CORTO has been already successfully employed for research and at various capacity in ESA's missions, such as in LUMIO and Milani CubeSats missions, as well as in ESA and ASI projects, such as in DeepNAV and StarNAV.