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Title

Thermal image generation tool for spacecraft relative navigation in proximity maneouvering phases

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Abstract
On orbit autonomous relative navigation performance strongly depends on both sensor suite and state reconstruction selection. Whenever that suite relies on image based sensors working on visible spectral band, the illumination conditions strongly affect the accuracy and robustness of the state reconstruction outputs.
To cope with that limitation the ASTRA PoliMi team started investigating the effectiveness of exploiting image sensors active in the IR spectral band, not limited by the lighting conditions [1][2][3]. To run effective and comprehensive testing and validation campaigns on navigation algorithms a large dataset of images is requested, either available or easy to settle in the visible band[4][5], not trivial and not accessible for the thermal band [6].
The paper presents the full open-source tool under development at PoliMi-ASTRA that exploits an accurate finite volume thermal model of a celestial object and creates thermal images based on the camera dynamic. In particular, a use case of flight proximity with small celestial bodies is discussed.
The thermal model relies on open CFD code (OpenFOAM) [7] pushed to catch the finest details of the terrain and computes its time-varying temperature field. The temperature field is processed in order to compute the view factors between the camera and each face of the mesh, thus the radiative flux emitted by each face is extracted. Such data feeds the rendering engine (Blender) that together with the camera position and attitude outputs the thermal image.
The complete pipeline, fed by orbiting target and the imaging sensor kinematic, outputs a proper synthetic thermal image dataset, exploitable either by a relative navigation block or any other scope of research [8]. Furthermore, in the same framework, the dataset could be used as input for a thermal sensor model [2] providing full customization of the output. The tool performance, bench-marked against the Ryugu asteroid geometry, is critically discussed, and the images qualitatively compared to those available from the Hayabusa mission. Moreover, a scenario with an artificial satellite as target is discussed and obtained results, challenges and capabilities of the implemented tool for synthetic thermal images generation challenges are highlighted.

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