Lens Flare Removal for Lunar-SLAM

Dave van der Meer, Alejandro Serna Medina and Miguel Angel Olivares-Mendez.

SpaceR
Space Robotics Research Group

Introduction

The Lunar environment are subject to strong changes in lighting conditions which vary from dark shadows to unfiltered sunlight. The appearance of bright sunlight paired with imperfections in camera lenses such as dust or light refractions in the lens can lead to visual artifacts on the final image. In the context of visual Simultaneous Localisation And Mapping (vSLAM), these artifacts can lead to outliers in the resulting map. Using a convolutional neural network (CNN) [2] to remove the lens flares allows to reduce the number of outliers which can lead to increased vSLAM robustness (see Fig. 1).

Scenario

The CNN receives images that include lens flares and removes them. It also provides a map of the changes made to the picture, which can be used as a mask to show uncertainties. To evaluate the effect of the lens flare removal for vSLAM applications, the same input data is used for trajectory estimation with and without lens flare removal. Since the default model has been trained on urban environment, a new training dataset is developed based on a simulated Lunar surface and a simulated light source with artificial lens flares. This allows to have the same environment with and without lens flares for training data.

Metrics

- Number of outliers
- Accuracy of the trajectory estimation
- Time of the Task

Hardware & Software

- SnT-LunaLab PC
- Blender 3D

Outcomes

1. Artificial training data for lens flare removal in space
2. Insights in effectiveness of lens flare removal for vSLAM

Fig. 1: The lens flare removal reduces visual artifacts from an input image (left) such as glares and strokes to generate the final image (right)

Simulated Lunar environment

The access to real Lunar images is significantly restricted and not many images are available. Additionally, creating realistic images with and without lens flare usually means that the lens flares are added artificially [1] so that the lighting conditions do not match a realistic image with lens flares, or it would require to label the data by hand, a labour intensive task. Using a simulated scene (see Fig. 2), adding and removing the lens flares is done by simply not rendering the light source in the final image.

Fig. 2: Simulated environment in Blender 3D with procedurally generated terrain and simulated lens flares from light source

References

[1] Dai, Yuekun, Chongyi Li, Shangchen Zhou, Ruicheng Feng, and Chen Change Loy. "Flare7K: A Phenomenological Nighttime Flare Removal Dataset." Advances in Neural Information Processing Systems 35 (December 6, 2022): 3926–37. https://papers.nips.cc/paper_files/paper/2022/hash/1909ac72220bf5016b6c93f08b66cf36-Abstract-Datasets_and_Benchmarks.html.

[2] Y. Wu et al., "How to Train Neural Networks for Flare Removal," 2021 IEEE/CVF International Conference on Computer Vision (ICCV), Montreal, QC, Canada, 2021, pp. 2219-2227, doi: 10.1109/ICCV48922.2021.00224.

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