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Topic: CNN Based Star Tracker for High-Precision Spacecraft Navigation

1. What are you going to do?

I am going to propose an idea of using the Convolutional Neural Network for the star tracker sensor of the spacecraft which is the important part for attitude determination and navigation of the spacecraft. To create a reliable and optimal deep learning model data will be gathered from various open-source planetarium applications and real star images. The deep-learning implementation of this program will be carried out using the tensorflow software library followed by testing using the Hardware-in-the-loop (HIL) simulation method.

2. How is it done today? Current Limitations?

Currently, star tracking for spacecraft navigation is typically performed using traditional methods such as the centroiding technique or the star pattern matching approach. These methods involve identifying stars in captured images and calculating the spacecraft's attitude based on their positions.

However, these traditional methods have certain limitations. One limitation is their susceptibility to errors caused by image noise, star blooming or background light. Additionally, these methods can be affected by the presence of multiple stars in the same field of view, leading to ambiguity in determining the spacecraft's precise orientation.

Moreover, traditional star trackers often require complex hardware and extensive databases, making them expensive and resource-intensive. The processing time can also be relatively long, limiting their real-time applicability in high-precision spacecraft navigation scenarios.

3. What is your idea to do something better?

Because of the above limitations, there is a need for advancements in star tracking techniques to achieve higher precision and efficiency. This is where the proposed CNN-based star tracker for high-precision spacecraft navigation aims to address these challenges by leveraging deep learning algorithms to enhance accuracy, robustness, and computational efficiency.

4. Who will benefit from your work? Why?

If the model is successful, many space industry companies can gain advantages from my work. This is because the cost of star-trackers is very high due to their complex hardware and extensive database. However, my model is expected to eliminate the need for such complexity. It will detect constellations and stars using a smaller database, which will make it more accessible and cost-effective.

5. What risks do you anticipate?

There are several risks that could be anticipated in the implementation of a CNN-based star tracker for high-precision spacecraft navigation. These risks include:

- **Data quality**: It is almost impossible to find the open-source dataset that was captured using the star-tracker. That is why the synthetic datasets and even real star images that were captured on earth can potentially affect the model in a bad way.
- **Model generalization:** The model needs to be able to generalize well to different star patterns and conditions encountered in space. Overfitting to the training data or being unable to adapt to variations in star images during real-world scenarios could lead to inaccurate navigation results.

- **Reliability and robustness:** It is essential to ensure that the CNN-based star tracker can operate reliably in various space environments including extreme temperatures, radiation and vibrations.

6. Out of pocket costs? Complete within 11 weeks?
There can be some out-of-pocket costs for testing the model. It includes buying and creating the environment using the embedded board (planned to be Nucleo-L552ZE-Q), motors, cameras, and sensors for conducting the testing. However, I already have most of the parts at home, which is why hopefully out-of-pocket costs will be minimal.

I am not sure I will complete all of it within 11 weeks, especially the HIL simulation part. The reason is that it needs special treatment and time for creating such a mechanism, and because we will be in the US, I will not be able to create that test environment at my current home laboratory except if I bring all of the embedded devices to the US.

7. Midterm results?
Until the midterm, I expect to be done by collecting the dataset and creating the base model that will serve as a basis for further development and improvement.

8. Final Demonstration?
For the final demonstration, I will present to you my presentation, and show the initial results of my model. I will also talk about the limitations of my current model and further methods to develop that model. Also I want to mention that this paper was already accepted by IAC 2023 as well to present it there in October. That is why I will still continue to improve the performance of the model, conduct the essential simulation tests and enhance the research paper that I will present at the conference.