Progress Report (November)

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New Model

The dataset and model were changed compared to the dataset and model that were presented in the guided research course. Thus a new script was coded to collect the new dataset using Stellarium planetarium.

The script initiates by configuring the environment, encompassing time settings via Julian date, atmospheric conditions, and landscape preparation. Subsequently, it configures the viewport to replicate the perspective of a star tracker. Core functions handle the conversion of angular coordinates to radians, assessment of star visibility within the observer's field of view and calculation of the fraction of visible stars within constellations. Within the main loop, random celestial coordinates and field of view are generated to establish the observer's position and orientation. Then, the script captures these images and records the corresponding sky image positions saving them to a CSV file as target values. This process is repeated iteratively, generating a dataset of simulated celestial images with associated sky image positions for subsequent analysis. After the completion of the script it was uploaded to the Stellarium GUI. The value of the “ImageCount” variable was set to 20,000 for the number of images. The script was then executed on an same c Asus ROG Strix laptop which was chosen due to its i9-12th generation processors and Nvidia 3070 Ti GPU which are considered sufficient for data collection and model testing.

Following the termination of the program, a total of 20,000 images were captured by the program for each of the input and corresponding celestial positions. This quantity is deemed sufficient for creating a model to test the model's ability to predict the positions in sky images. Figure 1 displays the one of the input image, and the subsequent Table 1 presents the corresponding celestial position associated with this image.

Figure 1: One of the input sky image

Table 1. Position of the above input sky image

	RA	DEC	Theta	FOV
Input image	55.275°	4.516°	229.248°	70.773

RA - represents right ascension which is a celestial coordinate that measures the east-west position of a celestial body (Earth in our case). On the other hand, Declination measures the north-south position of a celestial body. Theta is the angular position of the simulated view in a celestial observation program. FOV is the Field of View which is basically the part of the sky that is visible to the star tracker. It won't be used for training of the model, it is just for information purposes.

Research papers:

Several papers were researched to understand the traditional algorithms of the star tracker.

One of the seminal contributions to the field of star trackers for spacecraft navigation is Liebe's work that introduced the concept that the angular distance to the first and second neighboring stars and the angle between them could be leveraged for nearly unique star identification [1]. The analysis presented in the paper demonstrated the developed method's capability to determine satellite attitudes with remarkable accuracy surpassing 15 arc seconds. Additionally, by employing accumulated averages this method could achieve accuracies better than 2 arc seconds.

Another paper in the realm of star trackers by Jian Hong and Julie A. Dickerson introduced an autonomous star identification system that utilizes fuzzy neural logic networks (NLNs) [2]. Their findings indicated that in comparison to direct-match algorithms, this system can achieve a remarkable balance between high accuracy and swift recognition speed even when handling extensive star catalogs. Moreover the NLN exhibited the capacity to adapt to new patterns by adding additional cluster nodes to the network when novel celestial patterns were introduced to the catalog.

References

[1] C. C. Liebe, "Pattern recognition of star constellations for spacecraft applications," IEEE Aerosp. Electron. Syst. Mag., vol.8, no.1, pp.31-39.

[2] J. Hong and J. Dickerson, “Neural-Network-Based Autonomous Star Identification Algorithm”, Journal of Guidance, Control and Dynamics, vol.23, no.4, July 2000.