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APPLICATION OF COMPUTER VISION TECHNOLOGIES FOR ENVISIONING PROSPECTIVE DEEP SPACE PROPULSION

Abstract

Nowadays, CubeSats are increasingly used for deep space exploration missions. Application of a propulsion system can increase the efficiency of such vehicles, expanding the range of maneuvers performed. One of the factors affecting the accuracy of maneuver performance by the spacecraft is the thrust vector directionality, which can vary depending on the mode of operation. This can lead to uncalculated deviations. In order to assess the thrust vector directivity, a number of on-ground tests are conducted, resulting in a large array of plasma flow images (more than 10000 frames). Such an array is almost impossible to process manually, which actualizes the application of artificial intelligence (AI) technologies to automate the processing of the obtained results.

This paper demonstrates the AI techniques possibilities for determination the angle of flow divergence, angle of flow deviation from the thruster horizontal axis and classification of plasma formations regions. Those parametrs allow to determinate the thrust vector direction, which is required to correct thruster operation in space. In a series of experiments conducted, a dataset of about 25,000 frames was generated. Then the array was prepared for training the neural network (frame partitioning, image compression, etc.). Based on the obtained array, a convolutional neural network was trained to detect the plasma flow on the frames and classify separate regions in it. A set of author's algorithms for image post-processing was developed in order to facilitate human interpretation of the obtained results. Also developed a separate code module that allows analyzing the flow frames in real time from a remote computer.

Thus, a unique dataset for training a recurrent neural network was formed and labeled within the framework of this work. Object detection model allowing to detect the plasma flow and classify its separate regions has been trained. And also prepared a code module together with a user interface for remote operation with the experimental bench, in order to determine the angle of flow divergence and the angle of its deviation from the horizontal axis of the engine in real time.

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