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ON-ORBIT INTELLIGENT PROCESSING BASED ON EMBEDDED GPU ON Q-SAT

Abstract

With the rapid development of artificial intelligence in recent years, the combination of satellite applications and AI has become increasingly close. Traditional observation satellites have the disadvantages of low efficiency and poor timeliness. Therefore, on-orbit intelligent processing applications will be one of the important development directions in future satellite engineering. To this end, our team designed a power-efficient AI module based on embedded GPU, which entered orbit onboard our Gravity Atmosphere Scientific Satellite (Q-Sat) on August 6, 2020, whose working state has lasted stably for 7 months. This experiment proved that the embedded AI computing module can support long-term operation in harsh space environments, especially for high and low temperatures. It is worth mentioning that the Q-Sat, developed by Tsinghua University, is a small satellite dedicated to the measurement of the density of the orbital atmosphere and the gravity fieldamong others. Due to the power consumption limits of the Q-Sat, which contradicts the enormous computing power required by the AI algorithms, the designed AI module must have an exceptional energy efficiency ratio to achieve a satisfying computational capability under a low power budget. More specifically, the module can achieve 1.33 TFLOPS AI performance in as little as 7.5 watts, which is more than 25 times the energy efficiency ratio of very advanced desktop processors. This module is responsible for the image processing subsystem of the onboard panoramic camera composed of a pair of 4K resolution fisheye lenses with a 220 viewing angle. In addition to image processing capabilities, it can also act as a horizon for satellite attitude determination, which can mutually be verified with the attitude determination subsystem on the Q-Sat. Last but not least, the photos taken by the Q-Sat can be extended to the training set of AI algorithms to overcome the scarcity of data. With the help of AI algorithms, such as remote sensing object detection, this module can play an important role in finding lost ships, locating large-scale forest fires, and so on. What is more, the AI module can evaluate image quality online and automatically filter out images containing lots of clouds, thus saving communication bandwidth, storage space. To the best of our knowledge, this is the first satellite with an AI module developed and designed by a university, and it will lay the foundation for the realization of onboard intelligent processing for satellites in the future.