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A NOVEL HIGH-PRECISION INTEGRATED OPTICAL ATTITUDE SENSOR FOR MICRO/NANO SATELLITES

Abstract

Star trackers and sun sensors are important instruments for satellite attitude measurement and celestial navigation. However, in the all-day measurement system for micro/nano satellites, the traditional star trackers and sun sensors both have limitations. Although the all-day star trackers can detect stars in the bright sky background, the complex design of the optomechanical system increases their mass and size, making them inappropriate for micro/nano satellites to carry. Besides, traditional sun sensors cannot work normally when the sun is not in the field of view, and the strong sunlight needs additional filters or artifact elimination algorithm, limiting the measurement accuracy. Due to the significant difference in the light intensity of the two imaging objects, it is generally difficult to realize the integrated design. In view of this, a new method for sun observation is proposed based on Complementary Metal-Oxide-Semiconductor (CMOS) image sensor. Furthermore, the integration of the star tracker and sun sensor is realized in one optical system. The integrated attitude sensor can image the sun and stars in the daytime and at night respectively to realize the satellite attitude measurement. The principle lies in the correlation double sampling (CDS) of the CMOS image sensor. When the light intensity is strong enough, the oversaturation response makes the pixel gray value change from the highest in the saturated state to the lowest. Through the reasonable optical system parameters design, the image of the sun will be a black spot in the bright background. The observation of the sun can be realized through the detection of the black sun spot. When the sun is outside the field of view, the CMOS works in the normal state and determines the attitude by star detection. The experimental results show that the integrated instrument can achieve high-precision attitude measurement for both sun and star sky observation. This method improves the accuracy of the sun sensor and makes full use of the different light intensity response stages of the CMOS image sensor. In addition, the integration miniaturizes the attitude measurement system for micro/nano satellites.