

Research on Precise Ship Attitude Determination Based on Dual Star Sensors

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Abstract. The method of ship attitude determination based on dual star sensors is researched in this paper. Experiment results show that, the method of ship attitude determination based on dual star sensors has high precision of attitude determination of 5 arcsecond, it can be a complementarity of the precise ship attitude determination.

1. Introduction

As high-precision attitude measurement devices, star sensors are widely used in satellite or other spacecraft attitude determination system[1]. But due to the influence of atmospheric refraction and weather condition, the use of star sensor on ground is not deeply researched.

In order to solve the above-mentioned problem, a method of high-precision ship attitude determination based on dual star sensors is researched in this paper. Firstly, the relation between the measuring precision of attitude and the structure of two star sensors is analyzed, and the optimal structure of two star sensors is obtained. Secondly, a new atmospheric refraction correction method which based on reference quantity correction is introduced, which is simple in star apparent zenith distance calculation and dose not require the information of carrier attitude. Finally, the method of ship attitude determination based on dual star sensors is proposed, which fuses the two fields of view of dual star sensors into one and can improve the accuracy of ship attitude determination.

2. Structure of dual star sensors

Dual star sensors have advantages compared with conventional single star sensor, and becomes an important development trend with a better accuracy and reliability. In order to realize the best measurement results, structure optimization for dual star sensor is the first problem in the design and application. The structure optimization for dual star sensor was researched. The results show that dual star sensors have better accuracy with the increase of the angles between optical axes of FOVs, and realize the highest precision when the optical axes are orthogonal, as shown in figure 1.

3. New atmospheric refraction correction method

The atmospheric refraction correction is the most important problem when using star sensor on ground[2]. In order to simplify the atmospheric refraction correction process and improve the independent attitude measurement capability of star sensor, a new atmospheric refraction correction method which based on reference quantity correction is proposed. The proposed method is simple in star apparent zenith distance calculation and dose not require the information of carrier attitude, the



refraction correction does not need to solve the dual nonlinear equations, it only needs simply addition. Simulation and experimental results show that the results of attitude estimation using the reference quantity refraction correction method and the observed quantity refraction correction method is consistent with the results, the relative error between them is within 0.1 arcsecond. For star sensor attitude measuring application, the proposed refraction correction method does not need external posture information, is simple and no loss of attitude measuring precision.

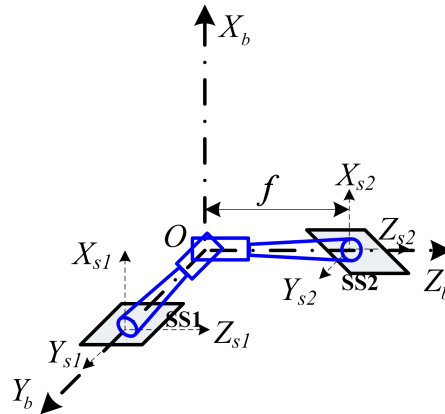


Figure 1. Structure of dual orthogonal star sensors.

4. Measurement model of dual star sensors

The attitude measurement model of star sensor is shown as formula(1):

$$w = Av \quad (1)$$

As for two star sensors, the measurement model is not variational, but the observed quantities in one star sensor coordinate should be transformed into the other star sensor coordinate. The details is shown as follows.

5. Experiment results

Experiment results show that, the method of ship attitude determination based on dual star sensors has high precision of attitude determination of 5 arcsecond, as shown in figure 2, it can be a complementarity of the precise ship attitude determination.

6. Conclusion

The method of ship attitude determination based on dual star sensors is proposed, which fuses the two fields of view of dual star sensors into one and can improve the accuracy of ship attitude determination. Experimental results show that, the method of ship attitude determination based on dual star sensors has high precision of attitude determination of 5 arcsecond, it can be a complementarity of the precise ship attitude determination.

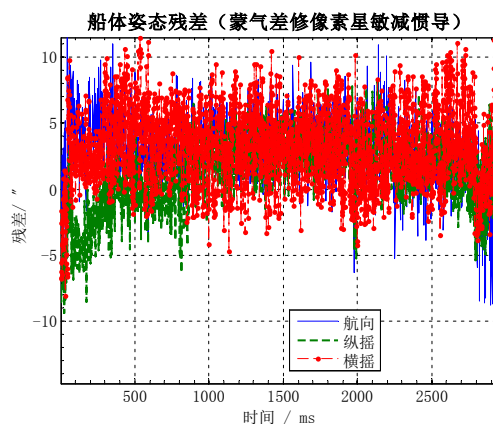


Figure 2. Ship attitude error of dual star sensors.

References

- [1] Ju G, Junkins J L. 2003 Overview of star tracker technology and its trends in research and development *Advances in the Astronautical Sciences* **115** 461
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