Development of an autonomous star tracker

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Abstract. *This work presents the development of an autonomous star tracker by the Electro-Optics group of the Aerospace Electronics Division at INPE.*

Keywords: attitude sensors, star trackers, embedded equipment.

1. Introduction

Star trackers (also known as star sensors or star cameras) are among the most accurate attitude sensors in existence, being widely used in missions with stringent pointing requirements [Liebe 2002]. With this in mind, the development of an autonomous star tracker has been selected as one of the top priorities for the Electro-Optics group of the Aerospace Electronics Division at *Instituto Nacional de Pesquisas Espaciais* (INPE).

2. A Brief History

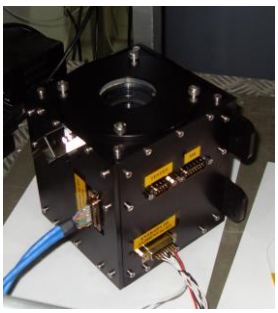
The first initiatives in the development of star trackers in Brazil, as far as the authors of this work know, were the development of a non-autonomous star tracker for the MASCO balloon borne telescope [Cabeza 1997] and the development of a non-autonomous star tracker by the Aerospace Electronics Division (DEA). Another important accomplishment was the Matlab program SIATS, written by Carvalho (2001) and used by him to perform a detailed study classifying star identification algorithms.

During the early 2000s began the effort to develop an autonomous star tracker, having been created in this period the software PTASE [Fialho and Saotome 2005], used to evaluate algorithms in the autonomous attitude determination chain, with emphasis on image processing and star identification algorithms [Fialho 2007]. PTASE was written in C++.

3. Results and Future Steps

In a test performed at INPE's astronomical observatory with an engineering model of the star tracker (Figure 1), attitude was successfully acquired. Nowadays, three models of this star tracker, suitable for use in stratospheric balloons, are being built, two of which will fly aboard the balloon borne experiment protoMirax [Braga *et. al.* 2015].

The purpose of the stratospheric balloon flight is to validate the equipment operation in an environment very similar to the space environment, before commencing the development of the qualification and flight models for spacecraft use.



Attitude determined by the star tracker:
right ascension: 20.415036°
declination : -23.344961°
roll angle : 149.421052°

a) b) c)

Figure 1. Star tracker during field test: a) engineering model; b) test setup at INPE's astronomical observatory; c) obtained attitude.

The star tracker presented in this work can also be used as a test platform for the development of new algorithms and techniques related to the autonomous attitude determination chain, namely: image processing, optics modeling, stellar identification and attitude determination.

4. Conclusion

This work has presented pioneering efforts in the development of an autonomous star tracker in Brazil, a brief history and future perspectives.

Acknowledgments: *We would like to thank everyone that somehow contributed for this work to become a reality, in special for the aid provided by funding and support agencies, among which stand out: FINEP, FUNCATE, FUNDEP and CNPq.*

References

Braga, J. *et. al.* The protoMIRAX Hard X-ray Imaging Balloon Experiment. *Astronomy & Astrophysics*. May 2015. (http://arxiv.org/pdf/1505.06631v1.pdf accessed on 13/jul/2015).

Cabeza, J. M. *Um sensor estelar para o apontamento fino do telescópio MASCO.* 1997. 104f. Master's Dissertation in Astrophysics – INPE, São José dos Campos.

Carvalho, G. B. *Levantamento de técnicas de identificação de estrelas e desenvolvimento de um ambiente de simulação e testes para análise de seus desempenhos em aplicações espaciais.* 2001. 290f. Master's Dissertation (ETE/CMC) – INPE, São José dos Campos.

Fialho, M. A. A.; Saotome, O. An environment for testing and simulating algorithms for autonomous star sensors. In *International Congress of Mechanical Engineering*, 18. 2005, Ouro Preto. Proceedings. ABCM, 2005. 8p. (Paper COBEM2005-1228).

Fialho, M. A. A. *Estudo comparativo entre dois algoritmos de identificação de estrelas para um sensor de estrelas autônomo de campo largo.* 2007. Master's Thesis in Electronics Engineering and Computer Science – ITA, São José dos Campos.

Liebe, C. C. Accuracy performance of star trackers – a tutorial. *IEEE Trans. Aerosp. Electron. Syst.* 38 (2) (2002) 587-599.