Dynamical objects' ephemeris for autonomous navigation

Y. Duchemin, J. Berthier, J-E. Arlot, V. Lainey

IMCCE / Observatoire de Paris / PSL Research University – Paris, France

Aim

Deep space navigation involving an optical camera is now perfectly demonstrated The challenge is to obtain a fully retroactive system with decision maker framework, to avoid error accumulation or anomalies by each subsystem (erroneous data and components reliability) .

Introduction

The future of space exploration will be on dependent of the improvement of autonomous space navigation systems. We use the current

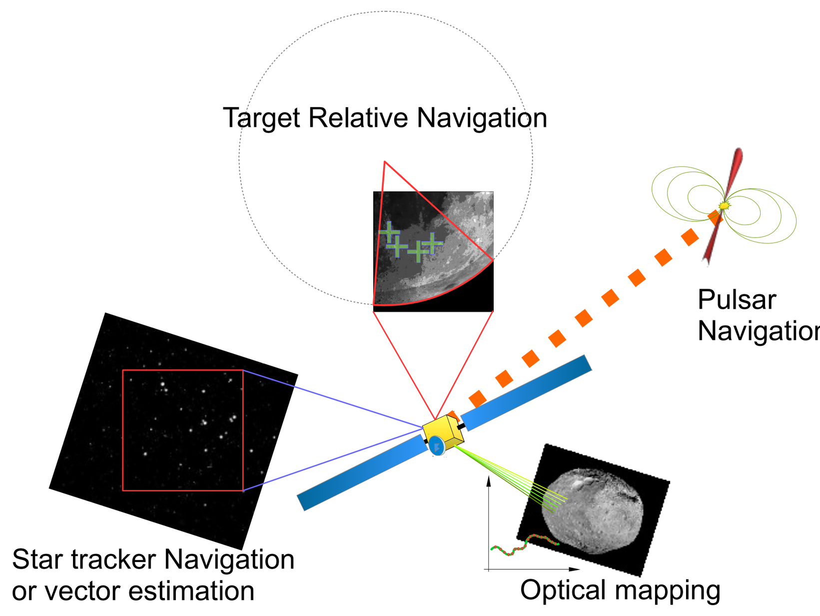


Fig.1: Autonomous navigation methods

methods to present the possibilities offered by the use of dynamic objects in the flight phase, and whose acquisition is based on the fusion of visual sensor data and AOCS/INS in the respect of the ground segment objectives, like “safeguard”.

Method

From an accurate model of the optical chain, we change parameters to optimize the selection of dynamic objects for catalog. The object catalog is commonly created from the expected absolute magnitude limit.

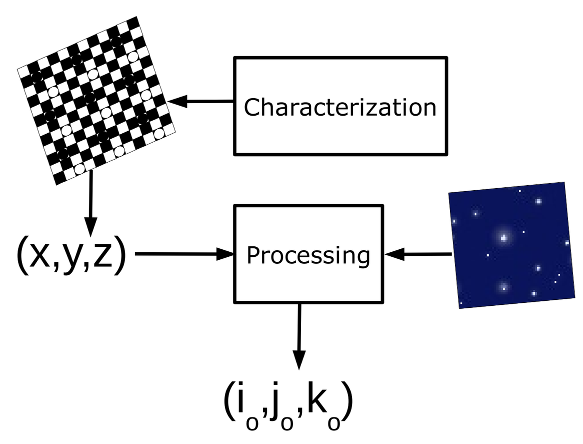


Fig.2: Navigation camera model

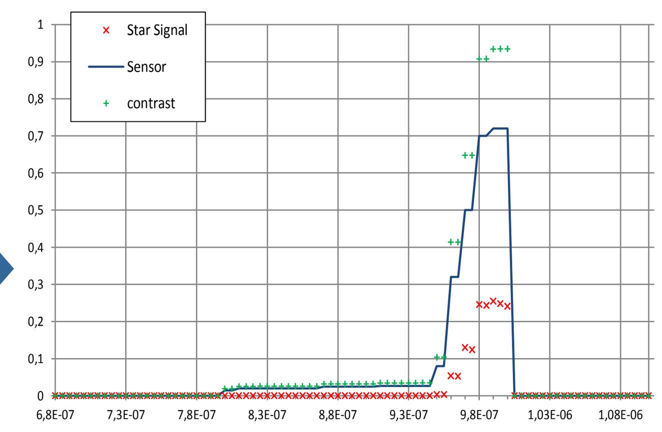
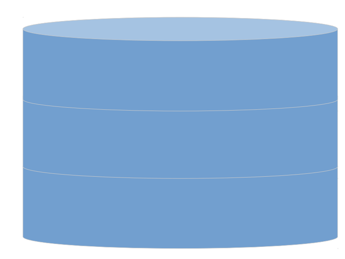


Fig.3: Optical response

$$S(x,y)=B_c(x,y)+D_c(x,y).t+I(x,y).F_\lambda(x,y).t+w.t$$



Objects References

The model allows us to estimate the expected number of objects and their spherical incertitude. Thus, the probe can compute its position with a known error and compare it with the prediction. According to objects references on board, it is possible to obtain the distance on each objects [1,3]. The spacecraft can find the angles by the expression :

$$\begin{cases}\alpha=acos(O_1.O_2)\\ \beta=acos(-O_2.-O_1)\end{cases} \longrightarrow d=O_{1,2}.\frac{\sin\beta}{\sin\alpha}$$

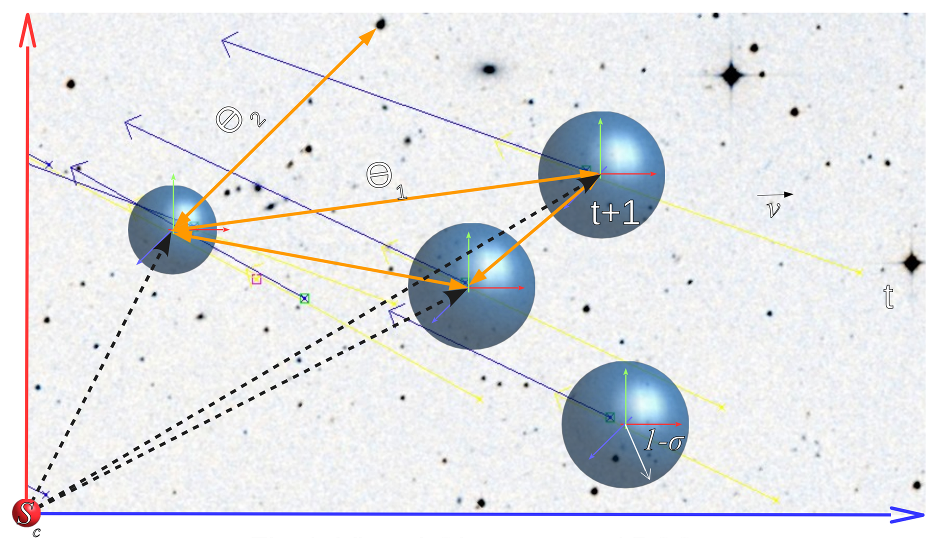


Fig.4: Virtual Observatory / DSS

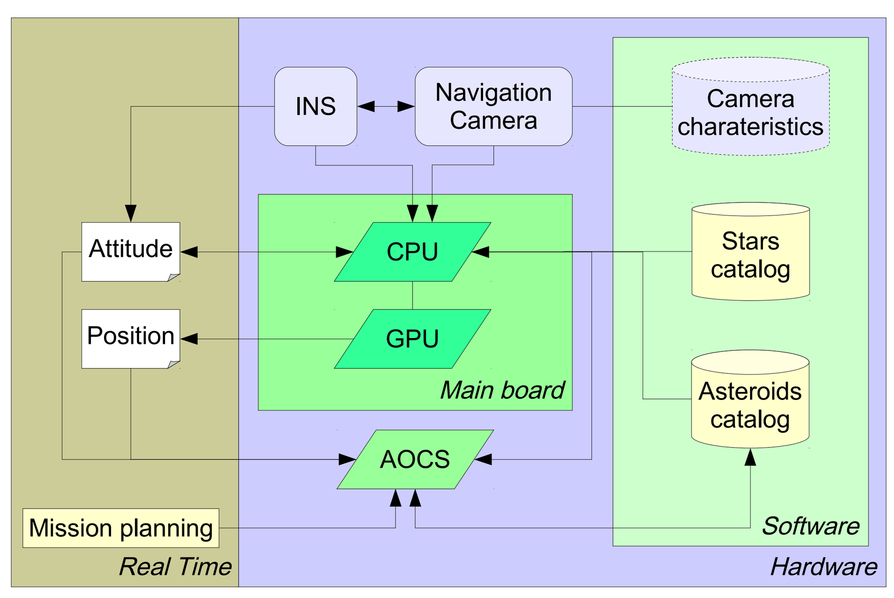


Fig.5: CPS Autonav system

(1). Solve the angle between object center and spacecraft (s_c) subtended to the center of mass distance (d) . [4]

$$\sin\frac{\Theta_1}{2}=\frac{d_{1,2}}{|d-s_c|} \qquad (1)$$

(2). Solve the angle between two objects, where d is the distance from the object center and the center of mass. [4]

$$\cos\Theta_2=\frac{(s_c+d).(s_c+d')}{|s_c+d|.|s_c+d'|} \qquad (2)$$

Results

This study is a part of my PhD work on space exploration, and shows that modeling work upstream of the missions, particularly in the design of equipment is very important for their successful. This first step based on the use of classical methods and innovative tools permit to improve the mission preparation. The preliminary results are based on a classical camera in the visible spectral sensitivity. The preparation of test trajectory to check the available objects is in progress. In the same time, a test-bed should give some terrestrial positioning results.

Conclusion

Most of the observation campaigns are often conducted from ground, which is not sufficiently precise for enhancing the flight data. The predictions provided are often very different from the encountered conditions during mission, in particular for the vision systems. GAIA will provide a high accuracy catalog, but in the meantime a redundant method of data reduction (astrometry, and light curve) for navigation is essential to avoid a continuous ground-segment control. This redundancy system is also a key point in ensuring the accomplishment of objectives and investments in unknown environment.

References

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Institut de Mécanique Céleste et de Calcul des Éphémérides (IMCCE), Paris - France

Observatoire de Paris / Paris Sciences et Lettres, Research University

Virtual Observatory Paris Data Centre

ESIGELEC, Graduate school of engineering, Rouen - France

Contacts

AutoNav, Yann.Duchemin@obsmp.fr

Virtual Observatory, Jerome.Berthier@obspm.fr

Astrometry, Jean-Eudes.Arlot@obspm.fr

Astrometry, Valery.Lainey@obsmp.fr