FUSION OF ABSOLUTE VISION-BASED LOCALIZATION AND VISUAL ODOMETRY FOR SPACECRAFT PINPOINT LANDING

Bach Van Pham*[(1)], Simon Lacroix[(1)], Michel Devy[(1)], Thomas Voirin[(2)], Marc Drieux[(3)] and Clement Bourdarias[(3)]

LAAS-CNRS[(1)], ESA/ESTEC[(2)], EADS-ASTRIUM Space Transportation[(3)]
e-mail: bvpham@laas.fr, simon.lacroix@laas.fr, michel.devy@laas.fr,
thomas.voirin@esa.int, marc.drieux@astrium.eads.net,
clement.bourdarias@astrium.eads.net

ABSTRACT

Precise landing position is required for future planetary exploration missions in order to avoid obstacles or to get close to scientifically interesting areas. Therefore, much research has been conducted to obtain a better spacecraft information both in local and in global coordinate frames. Various solutions which use different sensors like camera, lidar or radar altimeter have been introduced. Among these sensors, the camera sensor receives most of the attention due to its light weight, low energy consumption and large field of view. For example, the DIMES [Cheng05] system was implemented on the two Mars Exploration Rovers in 2003 to estimate the spacecraft ground-relative horizontal velocity by tracking interest points during the Mars descent. Another visual odometry currently developed by the European Space Agency, the NPAL [Frapard02] camera, also tracks a set of interest points to estimate the spacecraft relative movement and complement the inertial unit measures.

For the spacecraft's global state estimation problem, various solutions based on a passive camera have been introduced, such as the crater detection and matching [Cheng05], the template matching [Trawny07] or recently the landmark constellation matching ["Landstel" – Pham09] etc. The common architecture of these absolute visual localization (AVL in short) techniques is to extract surface landmarks in the descent image and then match them to the landmarks extracted in the ortho-rectified image of the scene previously acquired by an orbiter. These matched points are then used to estimate the global position of the lander thanks to the Digital Elevation Map associated with the ortho-image. In contrast to the precise, relative and local spacecraft's movement estimation of visual odometry, the output of an AVL sensor is the spacecraft's global position whose precision mostly depends on the resolution of the digital map.

Given the complementary characteristics of AVL and visual odometry, there is an interest to fuse their information. This paper introduces a tight integration of the two sensors (Landstel and visual odometry) in the spacecraft's global navigation system. Through several experiments, the coupling scheme shows a lot of interest. First, similarly to a GPS-INS fusion system, the integration system exhibits a more precise, faster and more robust behavior in comparison with a stand-alone AVL. Second, since both algorithms exploits the descent image interest points, the interest points used by visual odometry can be used to improve the robustness of the AVL. Finally, the visual odometry interest points are fed to a vision-based fault detection module to observe and verify the behavior of the AVL. The first results obtained with a difficult surface type have shown that the system improves the overall performance up to 80% in comparison with the stand-alone Landstel AVL solution. Moreover, the system can detect up to 35 percent of the Landstel estimation faults. Various results with different surface types will be presented in the final paper.