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AUTONOMOUS ORBIT DETERMINATION BASED ON GROUND IMAGING.

Abstract

Orbit determination has been typically carried out by means of radio tracking from a ground station, or better a network of stations, requiring significant personnel and hardware costs. Recently, the adoption of GNSS receivers, available at quite reasonable prices, enabled effectiveautonomous orbit determination. Still, there are scenarios where GNSS services could become unavailable (GNSS-denied conditions) or basically not existing (orbits around the Moon, or Mars). Furthermore, having a backup for a fundamental spacecraft function such as navigation can be an important asset. The research in the field is therefore open and potentially quite valuable. Most recent satellites include high-resolution cameras. In specific scenarios where good knowledge of the ground is available, it would be possible to determine the current position of the satellite, i.e., its point of view, from captured images. This is certainly the case for the Earth, but also for Moon and Mars, already surveyed at a very good resolution level by means of telescopes and, far better, by several exploration missions. Such a process requires the detection of some landmarks and then by means of comparing them to an existing database, followed by the computation of the point in space from where these landmarks would appear the same way as captured, and finally the iteration of the process a bit later to obtain a sequence of spacecraft's positions. By recovering the positions of the satellites at different times (time will be known from the images' timestamps), it is possible to adopt classical astrodynamics formulas.to compute the orbit, and complete the position-velocity-time fix. As usual, the adoption of filtering techniques can provide a smoother and more accurate solution. The emergence of efficient image processing techniques, mainly based on deep-learning algorithms, makes such an approach a viable option, which is indeed gaining momentum in space navigation. The paper, based on studies currently carried on at Sapienza Università di Roma, discusses the approach in detail, presenting some preliminary findings referred to low-earth orbit spacecraft with images available from Landsat and Copernicus missions. Different classical astrodynamics methods, namely Gibbs' and Herrick-Gibbs', are tested depending on the time spacing of the observations. The different errors or inaccuracies to be considered all along the process are identified, and their effects on the attainable performance are investigated.