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# ON-ORBIT MOTION CAPTURE SYSTEM

**Abstract**

We propose a distributed electro-optical space system, consisting of a formation of observer nanosatellites, which, orbiting in proximity of one or more orbiting target objects, determines their kinematic state (translational and rotational) in real time. Using the same principle of traditional MOCAP systems, two or more observer satellites in formation, collect simultaneous and overlapping electro-optical (EO) observations of an orbiting target(s) while orbiting in its (their) proximity. The overlapping EO observations simultaneously acquired are processed to triangulate the 3D position of the orbiting target(s) and to infer their full translational and rotational kinematic state ('motion') in real-time. When using nanosatellites as observers in an earth orbit, an autonomous on-board navigation system estimates their relative poses in real time and with high accuracy, which are required to track the motion of the target(s). This is based on a tight fusion of carrier phase GNSS (Global Navigation Satellite System) observations and monocular images collected on board each observer, which provides position and attitude estimation with millimeter and sub-degree accuracy. Thanks to the vision-based observations, it is possible to fully exploit the GNSS carrier phase observations and solve the integer ambiguity faster, with higher probability of success, and higher accuracy when in degraded GNSS signal conditions with high Geometric Dilution of Precision (GDOP), such as higher earth orbits. In particular, we propose a factor graph based GNSS system that allows for the utilization of existing distributed estimation techniques. Applications of the proposed on-orbit MOCAP include real-time motion capture of heterogeneous space segments during any kind of proximity operation, i.e., for On-Orbit Assembly, On-Orbit Servicing, Active Debris Removal, and any kind of rendezvous and docking mission. The captured motion can support the guidance and control system of the heterogeneous space segments or simply be used for monitoring and surveillance. In this paper, we describe the architecture of the proposed system, investigate its feasibility, analyzing technological constraints and limitations and discuss potential applications. A preliminary performance analysis is also carried out in simulations by processing synthetically generated images and experimentally by collecting real images while using the advanced spacecraft simulator testbed available at Caltech.