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SPACECRAFT RENDEZVOUS THROUGH MOTION CAMOUFLAGE

Abstract

Motion camouflage is a widely used technique in nature intended to allow a moving body (a shadower) to conceal its motion from another stationary or moving body (the prey). The shadower adopts a trajectory such that its image projected onto the prey's retina appears to be that that of a distant, stationary object (the fixed point). This trajectory requires the shadower, to remain at all times, directly in between the fixed point and the prey, i.e. on the imaginary line (camouflage constraint line) that connects the prey and the fixed point. During a discrete approach (such as a cricket's jumping movement), constraint lines are redefined between each leap. The predator would close up to the prey extremely quickly and at the same time maintain on those constraint lines before the last one where it would do pinpoint capture.

This paper develops a novel dynamical model, based on the concept of motion camouflage for the relative motion of spacecraft. To achieve rapid convergence to the target, a multi-shooting method was implemented to optimize the flight time. To define the convergence trajectory the shadower accurately predicts the upcoming location of the constraint line and moves there accordingly. This type of dynamical model was then implemented in a number of different rendezvous scenarios.

Simulation results show that small intervals between thrusts of a constant magnitude produce shorter convergence times but incur in greater fuel consumption. During the motion the shadower will deviate from the constraint line in between propulsive thrusts. The magnitude of the error in the angle subtended at the target by the shadower and the fixed point increases as the shadower approaches the target. Additionally, smaller thrusting intervals result in lower deviation peaks. If there is the intention of implementing this rendezvous strategy while remaining invisible to the target, some measures such as reducing impulse interval, increasing size rate of shadower to background and spacecraft deformation should be considered.