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SPACECRAFT ATTITUDE CONTROL USING INERTIAL MORPHING

Abstract

The aim of the paper is the application of the novel concept introduced in 2020 by P. M. Trivailo and H. Kojima called as “Inertial Morphing”. As per their research, Inertial Morphing is the deliberate change of the inertial properties of the rigid body system in real time which is utilised to control the attitude of the spacecraft spinning along the axis of intermediate principal moment of inertia. This concept can be used to replace or enhance the gyroscopic systems that are currently used to manoeuvre the spacecraft, which are heavy and energy consuming.

The concept of “Inertial Morphing” was prompted by the observation of rigid bodies in space performing the flipping motion. The phenomenon was first observed by famous US scientist-astronaut Owen Garriott during his experiments on-board of Skylab space station in the year 1973. The effect is based on the “Tennis Racket Theorem”. This flipping phenomenon can be explained by the Euler equations for rigid bodies.

A prototype representing a spacecraft has been developed that can perform Inertial Morphing in real time. Autodesk’s Fusion 360 is a capable CAD software and was used to design a very accurate CAD model. The design involves a unique mechatronic system that is compact and requires minimum movements to perform Inertial Morphing. This design complies with all the requirements of ESA’s parabolic flight to possibly perform the test in micro gravity in the future. Alternate test setups will be built and the effect of inertial Morphing will be observed in these setups and any difference due to the test setups will be noted. Internal sensors and an external monitoring system is used to obtain accurate data from the prototype.

With this innovative system, it is possible to change the inertial properties in all 3 axes while on its trajectory. Depending upon the objectives of the mission, the prototype gives options to initiate the flipping motions with varying periods or completely cease flipping motion or even perform transfer of the system’s spin to the spin about nominated body axis. This enables spacecraft to perform various acrobatic attitude manoeuvres and the paper will provide details on the proposed innovative spacecraft design. Simplicity of utilised control method and energy efficiency of the system’s design show promise for the application in autonomous spacecraft missions.