Paper ID: 10327
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 2 (6)

Author: Mr. Craig Maclean
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom,
craig.maclean@strath.ac.uk

Mr. Daniele Pagnozzi
University of Strathclyde, United Kingdom, daniele.pagnozzi@strath.ac.uk
Dr. James Biggs
University of Strathclyde, United Kingdom, james.biggs@strath.ac.uk

COMPUTATIONALLY LIGHT ATTITUDE CONTROLS FOR RESOURCE LIMITED NANO-SPACECRAFT

Abstract

Nano-spacecraft have emerged as practical alternatives to large conventional spacecraft for specific missions (e.g. as technology demonstrators) due to their low cost and short time to launch. However these spacecraft have a number of limitations compared to larger spacecraft: a tendency to tumble post-launch; lower computational power in relation to larger satellites and limited propulsion systems due to small payload capacity. As a result new methodologies for attitude control are required to meet the challenges associated with nano-spacecraft.

This paper presents two novel attitude control methods to tackle two phases of a mission using zero-propellant (i) the detumbling post-launch and (ii) the repointing of nano-spacecraft. The first method consists of a time-delayed feedback control (TDFC) law which is applied to a magnetically actuated spacecraft and used for autonomous detumbling. The second uses geometric mechanics to construct zero propellant reference manoeuvres (e.g. for repointing) which are then tracked using conventional quaternion feedback control.

The problem of detumbling a magnetically actuated spacecraft in the first phase of a mission is conventionally tackled using a Bdot controller. This involves calculating the derivative of the magnetic field which is then used by the actuator to generate the necessary control torques. However real systems contain sensor noise which can lead to discontinuities in the signal and problems with computing the numerical derivative. This means that a noise filter must be used and this increases the computational overhead of the system. It is shown here that a TDFC law is advantageous as it negates the need for such a filter by using a delayed signal to generate the required torques rather than a derivative thus reducing computational overhead.

The second phase of the mission is the repointing of the spacecraft to a desired target. Exploiting the analytic solutions of the angular velocities of a symmetric spacecraft and further using Lax pair integration it is possible to derive exact equations of the natural motions including the time evolution of the quaternions. It is shown that parametric optimisation of these solutions can be used to generate low torque reference motions that match prescribed boundary conditions on the initial and final configurations. Through numerical simulation it is shown that these references can be tracked using magnetorquers or reaction wheels. As the method requires parameter optimisation as opposed to a method that requires numerical integration the computational effort is significantly reduced.