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ATTITUDE CONTROL OF A NANOSATELLITE USING INVERSE SIMULATION

Abstract

Modern nanosatellites are being more widely utilised for missions that require high pointing accuracy of their payload. Therefore, it is important that research continues to investigate the application of new, novel algorithms for attitude control. This paper proposes the use of Inverse Simulation (InvSim) for attitude control, investigating its feasibility and performance compared to traditional methods, such as Proportional Integral Derivative control (PID).

With InvSim, an accurate model of the spacecraft is developed first, mapping control inputs to states. The model is then inverted to create a history of controls signals which can then be executed by the real satellite to follow the requested trajectory. There are two main methods to complete the inversion of the model. Firstly, the derivative method, where the dynamic equations need to be known and then analytically solved for the inverse dynamics. However, any changes to the model require the solution to be derived again. This paper instead uses the "integral" method, which employs a numerical approach, treating the model as a black box. The inversion is completed iteratively using a Newton-Raphson method. The desired trajectory, y_D, is sampled at fixed timesteps, kT, and the required control values, $u(kT)$, are found at each point to generate the desired output $y(kT) = y_D(kT)$.

InvSim has several features that makes it particularly appealing for attitude control. Desired trajectories that are unrealisable will be rejected by the InvSim algorithm. If utilised during the design stage, it could notify designers that there is insufficient actuator power or limitations within the dynamics preventing a particular trajectory from being followed. The model can be updated in real-time throughout the lifetime of the satellite to deal with actuator degradation or failure. InvSim works for any operating point without the need for any gain scheduling, simplifying the control design workflow. InvSim does however lack any disturbance rejection, which instead must be handled using an extra controller or by implementing InvSim into a model predictive control (MPC) architecture.

The performance of the InvSim controller will be compared to a traditional controller (PID). Comparisons are made in terms of tracking error, final error, peak actuator power, total actuator energy used in the manoeuvre and ease of implementation. The effects of disturbances, model error and noise will be investigated to ascertain the feasibility and performance of InvSim as a method for attitude control.