Title: Review of Nonlinear Attitude Control Algorithms for Small Satellites

Abstract:

Small satellites have made missions such as Earth observation much simpler and cheaper. However, with remote sensing applications comes a requirement for increased precision in attitude control. More specifically, 3-axis active attitude controllers that use nonlinear algorithms for better approximations of the attitude equations of motion of the satellite. The main challenges for small satellite missions is to develop cost effective attitude control systems with sufficient attitude control and stability to point the onboard sensors accurately at a known target and capture useful readings for remote sensing applications and also tracking applications. This paper presents the various nonlinear approaches to the problem of 3-axis nonlinear attitude control that have been adopted/proposed in the literature so far. Controller algorithms range from adaptive techniques, to optimal and intelligent control schemes. An overall survey of the state-of-the-art technologies that have been put forward for small satellite attitude control is presented, along with their advantages and disadvantages. Precision in pointing and accurate attitude control helps with complex earth observation missions and science research. Also, reliability needs to be improved for autonomous missions. While advancements in hardware (attitude sensors and actuators) continue to improve and enhanced technologies get more miniaturized and better, the attitude control system will only be as good as the algorithms that process the estimated attitude and send control commands to the appropriate hardware. Furthermore, small satellites present challenges such as limited weight, volume, and power available for the attitude control system. Advanced algorithms have been proposed, but a trade-off between attainable accuracy and computational cost will remain. Computational efforts of the advanced algorithms may be reduced through various mathematical approximations, and the literature presents ways around this too. A comparison of the attitude controller algorithms is presented at the end of the paper.