Current trends in spacecraft are leading to smaller, more inexpensive options whenever possible. This shift has been primarily pursued by budget-restricted communities such as universities and amateur radio operators in order to open a new frontier for their technologies. Limited power, processing, pointing, and communication capabilities are all common issues which must be considered when miniaturizing systems and implementing low-cost components. This thesis addresses some of these concerns by applying two methods, in attitude estimation and control. Additionally, these methods are not restricted to only small, inexpensive satellites, but offer a benefit to large-scale spacecraft as well.

First, star cameras are examined for the tendency to generate streaked star images during maneuvers. This issue also comes into play when pointing capabilities and camera hardware quality are low, as is often the case in small, budget-constrained spacecraft. When pointing capabilities are low, small residual velocities can cause movement of the stars in the focal plane during an exposure, causing them to streak across the image. Additionally, if the camera quality is low, longer exposures may be required to gather sufficient light from a star, further contributing to streaking. Rather than improving the pointing or hardware directly, an algorithm is presented to retrieve and utilize the endpoints of streaked stars to provide feedback where traditional methods do not. This allows attitude and angular rate to be derived from an image which, with traditional methods, would return large attitude and rate error. Simulation results are presented which demonstrate endpoint error of approximately half a pixel and rate estimates within 2% of the truth.

Three methods are also considered to remove overlapping star streaks and resident space objects from images to improve performance of both attitude and rate estimates. Results from a large-scale Monte Carlo simulation are presented in order to characterize the performance of the method.

Additionally, a rapid optimal attitude guidance method is experimentally validated in a ground-based, pico-scale satellite test bed. Fast slewing performance is demonstrated for an incremental step maneuver with an average power consumption of 0.1 W. Though the focus of this thesis is primarily on increasing the capabilities of small, inexpensive spacecraft, the methods discussed have the potential to increase the capabilities of current and future large-scale missions as well.

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The public is welcome to attend.