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# INVESTIGATION INTO THE CONTROLLABILITY OF UNDERACTUATED MAGNETICALLY STABILIZED SPACECRAFT

**Abstract**

Magnetic control has been used successfully for momentum dumping and attitude control when pointing precision requirements are minimal. Typically, such systems are constructed using configurations of magnetic coils or torque rods orientated in a way to provide command authority via varying magnetic moment about all three body axes. Although magnetic control actuators and related systems are typically robust and not as prone to failure, it is of interest to see if coarse 3 axis attitude pointing can be attempted with the loss of control about one of the 3 axes of magnetic moment actuation. These types of cases could occur during the normal life of the spacecraft and any control modes that could prolong the life of a damaged satellite just a little longer could be justifiable for some missions. This case is also of interest to teams looking at single PCB satellites, or satellites on a chip where 3 dimensions of magnetic torquers may be difficult to design for or too costly in terms of board or chip space to implement. Finally, this case is of interest to systems engineers who may be willing to sacrifice pointing accuracy for lower weight or volume requirements of the attitude control system (although arguably this seems to be a poor choice given the relative simplicity of magnetic actuators) This paper investigates the feasibility of 3-axis pointing of a small spacecraft using only two axes of magnetic moment actuation. Reachability to controllable attitudes will be tested by finding the existence of an optimal control trajectory using an automated solving tool. The reachability analysis begins with a simplified model and eventually expands to a more complete IGRF model to test the reachability in a more realistic case. The preliminary results indicate that it is feasible to control with only two axes of magnetic moment, although with the expected increased complexity to the control law, and increased time to achieve targeted attitudes.