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Photocells for Small Satellite, Single-axis Attitude Determination

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Abstract

Light-dependent resistors are an inexpensive means to measure light intensity as a function of incidence angle. Also known as photocells, these sensors have a long history of use in terrestrial applications such as automatic control of street lights. Since their output varies with incidence angle, they may also be used to measure a body's orientation with respect to a light source. This property, with their low cost and simplicity, makes them attractive candidates for use on small satellites. However, with low cost comes an increased need for calibration accuracy and computational rigor. This paper seeks to apply calibration and computational rigor to the use of photocells on small satellites by implementing such a system on the Air Force Academy's EyasSat[3] classroom satellite demonstrator, which has photocells on all sides. Five algorithms for determining single-axis attitude are explained and compared. These algorithms include a sinusoidal curve fit, a tangent fit, as well as methods that use least-squares linear regression to reduce calibration error. The algorithms are applied to experimental data using the EyasSat[3], resulting in single-axis attitude estimation error ranging from 1.8° to 3.5°.

1. Introduction

From the dawn of civilization, man has optimized his means to travel from place to place in a given medium. Whether building sleds or rafts to transit snow-covered or water-borne areas, or avoiding obstacles with wheeled vehicles, estimating one's position and orientation has been critical for gathering food, killing game, exploring the countryside, or otherwise transporting oneself. For centuries, to achieve such mobility, people have relied on rotational and transitional position estimates through human senses coupled with evolving travel modes, from camels and horses in ancient times, to automobiles and sea-faring

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