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Enabling Low-power Radiometers with Machine Learning Calibration

John W. Bradburn(1), Mustafa Aksoy(1), and Paul E. Racette(2)
(1) University at Albany, SUNY, Albany NY, USA, e-mail: jbradburn@albany.edu; maksoy@albany.edu
(2) NASA Goddard Space Flight Center, Greenbelt MD, USA; e-mail: paul.e.racette@nasa.gov

In the future, smart sensors will be designed to extract maximum value information, while minimizing the resources needed to acquire, downlink, and process data. Typically, radiometers may only produce calibrated measurements after reaching steady state. However, this results in delays in data acquisition and wasted power. Power cycling a radiometer is one approach to managing power, but leads to other challenges, at the expense of higher uncertainties and errors. Turning the power off to the instrument stops data acquisition until it is powered on again, but also results in data loss until the instrument reaches stability required for quality measurements. Such data loss was experienced with IceCube, a CubeSat radiometer mission flown in 2017 [1]. To manage power,

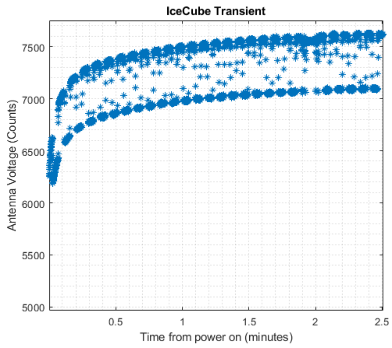

Figure 1. IceCube pre-launch antenna voltage data with receiver power-on transient response present.

the receiver was powered off during eclipse. Figure 1 illustrates IceCube's receiver transient response after power-on; due to increased measurement uncertainty in calibrating across the transient response, several minutes of data were discarded until the instrument stabilized. Rapid power cycling is another technique used to reduce the average power draw of an instrument but can result in increased uncertainties due to thermal fluctuations in the sensor electronics. In a step towards realizing smart sensors, this study seeks to develop intelligent algorithms to calibrate measurements over an instrument's transient response.

An initial study on intelligent radiometer calibration using machine learning has showed an improvement over conventional least-mean-square (LMS) calibration methods. An Artificial Neural Network (ANN) model was trained on synthetic radiometer data generated over a broad range of operational conditions with a variety of systematic and random fluctuations. The ANN produced lower root-mean-square-error (RMSE) values than the LMS calibration across a wide range of conditions. This presentation will describe the development of a framework which uses machine learning algorithms to enable the calibration of a radiometer during its transient state and present comparative analyses of calibration using traditional techniques.

1. Dong L. Wu, Jeffrey R. Piepmeier, Jaime Esper, Negar Ehsan, Paul E. Racette, Thomas E. Johnson, Brian S. Abresch, Eric Bryerton, "IceCube: spaceflight demonstration of 883-GHz cloud radiometer for future science," Proc. SPIE 11131, CubeSats and SmallSats for Remote Sensing III, 1113103 (30 August 2019); https://doi.org/10.1117/12.2530589