ZCAL: MACHINE LEARNING FOR CALIBRATING RADIO INTERFEROMETRIC DATA

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ABSTRACT

Calibration is the most critical data processing step needed for generating images of high dynamic range (CASA cookbook, 2009). With ever-increasing data volumes produced by modern radio telescopes Aniyan & Thorat (2017), astronomers are overwhelmed by the amount of data that needs to be manually processed and analyzed using limited computational resources (Yatawatta, 2020). Therefore, intelligent and automated systems are required to overcome these challenges. Traditionally, astronomers use a package such as Common Astronomy Software Applications (CASA) to compute the gain solutions based on regular observations of a known calibrator source (Thompson et al., 2017) (Abebe, 2015) (Grobler et al., 2016) (CASA cookbook, 2009). The traditional approach to calibration is iterative and time-consuming (Jajarmizadeh et al., 2017), thus, the proposal of machine learning techniques. The applications of machine learning have created an opportunity to deal with complex problems currently encountered in radio astronomy data processing (Aniyan & Thorat, 2017). In this work, we propose the use of supervised machine learning models to first generation calibration (1GC), using the KAT-7 telescope environmental and pointing sensor data recorded during observations. Applying machine learning to 1GC, as opposed to calculating the gain solutions in CASA, has shown evidence of reducing computation, as well as accurately predicting the 1GC gain solutions and antenna behaviour. These methods are computationally less expensive, however they have not fully learned to generalise in predicting accurate 1GC solutions by looking at environmental and pointing sensors. We use an ensemble multi-output regression models based on random forest, decision trees, extremely randomized trees and K-nearest neighbor algorithms. The average prediction error obtained during the testing of our models on testing data is $\approx 0.01 < rmse < 0.09$ for gain amplitude per antenna, and $0.2rad < rmse < 0.5rad$ for gain phase. This shows that the instrumental parameters used to train our model strongly correlate with gain amplitude effects than a phase.

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