Contribution ID: **1378** Type: **Poster**

Identifying muon rings in VERITAS data using convolutional neural networks trained on Muon Hunters 2-classified images

Tuesday 13 July 2021 13:18 (12 minutes)

Muons from extensive air showers appear as rings in images taken with Cherenkov telescopes, such as VERITAS. These muon ring images are used for the calibration of the VERITAS telescopes, however this calibration process can be improved with a more efficient muon-identification algorithm. Convolutional neural networks (CNNs) are used in many state-of-the-art image-recognition systems and are ideal for this purpose. However, by training a CNN on a dataset labelled by existing algorithms, the performance of the CNN would be limited by the suboptimal muon-identification efficiency of the original algorithms. Muon Hunters 2 is a citizen science project that asks users to label grids of VERITAS telescope images, stating which images contain muon rings. Each image is labelled 10 times by independent volunteers, and the votes are aggregated and used to assign a 'muon' or 'non-muon' label to the corresponding image. An analysis was performed using an expert-labelled dataset in order to determine the optimal vote fraction cut-offs for assigning labels to each image for CNN training. This was optimised so as to identify as many muon images as possible while avoiding false positives. The performance of this model will be presented and compared to existing muon identification algorithms employed in the VERITAS data analysis software. Using any extra images identified for calibration may require improvements to the light-distribution correction algorithm for muon rings with non-zero impact parameters.

Keywords

IACT; Cherenkov radiation; muon ring; machine learning; calibration; citizen science

Collaboration

VERITAS

other Collaboration

Subcategory

Experimental Methods & Instrumentation

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Session Classification: Discussion

Track Classification: Scientific Field: GAI | Gamma Ray Indirect