Contribution ID: **1271** Type: **Poster**

Fast simulation of gamma/proton event images for the TAIGA-IACT experiment using generative adversarial networks

Tuesday, July 13, 2021 1:18 PM (12 minutes)

High energy cosmic rays and gamma rays interacting the atmosphere produce extensive air showers (EAS) of secondary particles emitting Cherenkov light. Being detected with a telescope this light forms “images” of the air shower. In the TAIGA project, in addition to images obtained experimentally, model data are widely used. The difficulty is that the computational models of the underlying physical processes are very resource intensive, since they track the type, energy, position and direction of all secondary particles born in EAS. This can lead to a lack of model data for future experiments. To address this challenge, we applied a machine learning technique called Generative Adversarial Networks (GAN) to quickly generate images of two types: from gamma and protons events. As a training set, we used a sample of 2D images obtained using TAIGA Monte Carlo simulation software, containing about 50,000 events. It has been experimentally established that the generation results best fit the training set in the case when for two different types of events we create two different networks and train them separately. For gamma events a discriminator with a minimum number of convolutional layers was required, while for proton events, more stable and high-quality results are obtained if two additional fully connected layers are added to the discriminator. Testing the generators of both networks using third-party software showed that more than 90% of the generated images were found to be correct. Thus, the use of GAN provides reasonably fast and accurate simulations for the TAIGA project.

Keywords

gamma event images; proton event images; fast simulation; generative adversarial networks; neural networks; machine learning

Collaboration

TAIGA

other Collaboration

Subcategory

Experimental Results

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Session Classification: Discussion

Track Classification: Scientific Field: GAI | Gamma Ray Indirect