The use of convolutional neural networks for processing images from multiple IACTs in the TAIGA experiment

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Abstract: TAIGA experiment uses hybrid detection system for cosmic and gamma rays that currently includes three imaging atmospheric Cherenkov telescopes (IACTs). Previously we used convolutional neural networks to select gamma ray events and estimate the energy of the gamma rays based on an image from a single telescope. Subsequently we adapted these techniques to use data from multiple telescopes, increasing the quality of selection and the accuracy of estimates. All the results have been obtained with the simulated data of TAIGA Monte Carlo software.

An extensive air shower caused by a high-energy particle (cosmic or gamma ray) interacting with upper atmosphere can be detected by several methods including imaging atmospheric Cherenkov telescopes (IACTs). It was previously demonstrated that convolutional neural networks (CNNs) trained on simulated images from a single TAIGA IACT have good quality of selection of gamma ray events and accuracy of estimation of the energy of the gamma rays.

We present the results of applying CNNs to simulated stereoscopic IACT images from two TAIGA telescopes. We demonstrate that CNNS using additional data from the second IACT have higher quality of selection of gamma ray events and estimate the energy of the gamma rays more accurately.

For the best-performing CNNs for identification of the event type, adding data from a second telescope decreases the fraction of misidentified background proton events by a factor of 4-5 while the fraction of correctly identified gamma events remains approximately the same. This corresponds to an increase in quality of selection factor Q from 6.9-7.1 to 14.8-17.0.

For the best-performing CNNs for estimation of the gamma ray energy, adding data from a second telescope decreases the average relative error by a factor of 1.3-2.