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Stereograph: stereoscopic event reconstruction using graph neural networks applied to CTAO

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The CTAO (Cherenkov Telescope Array Observatory) is an international observatory currently under construction. With more than sixty telescopes, it will eventually be the largest and most sensitive ground-based gamma-ray observatory.

CTAO studies the high-energy universe by observing gamma rays emitted by violent phenomena (supernovae, black hole environments, etc.). These gamma rays produce an atmospheric shower upon entering the atmosphere, which emits faint blue light, observed by CTAO's highly sensitive cameras. The event reconstruction consists of analyzing the images produced by the telescopes to retrieve the physical properties of the incident particle (mainly direction, energy, and type).

A standard method for performing this reconstruction consists of combining traditional image parameter calculations with machine learning algorithms, such as random forests, to estimate the particle's energy and class for each telescope. A second step, called stereoscopy, combines these monoscopic reconstructions into a global one using engineered weighted averages.

In this work, we explore the possibility of using Graph Neural Networks (GNNs) as a suitable solution for combining information from each telescope. The "graph" approach aims to link observations from different telescopes, allowing analysis of the shower from multiple angles and producing a stereoscopic reconstruction of the events. We apply GNNs to CTAO-simulated data from the Northern hemisphere and show that they are a very promising approach to improving event reconstruction, providing a more performant stereoscopic reconstruction. In particular, we observe better energy and angular resolutions and enhanced separation between gamma photons and protons compared to the Random Forest method.

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