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Neutrino Classification Through Deep Learning

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Neutrinos are a kind of subatomic particle that has become widely studied in several experiments around the world because of its characteristics of only interacting via the so-called weak-interactions and presenting a special behavior called oscillation. It is expected that by analyzing them we could gather insight into some of the Universe's mightiest enigmas such as confronting elementary particle unification theories and the mysteries of the Universe's evolution. The way in which neutrinos are studied in some of such international experiments is by gathering the data of the Cherenkov radiation that neutrinos produce when they collide with the charged particles within the ultra-purified water contained in the detection tanks of the observatories developed to analyze them, this radiation commonly has the shape of a ring or a cone. The first step after gathering the data in the detector is to reconstruct the event, which implies the identification of particle types and the determination of properties of the detected particle such as energy levels and the position and direction of travel of the particle when its detected. Hence, we propose this project where the aim is to improve the identification of the type of neutrino involved in an event by employing deep learning architectures, which are VGG19, ResNet50, PointNet and Vision Transformer. These architectures are trained and tested using simulated data of single-ring neutrino events and corresponding to a detection tank called Intermediate Water Cherenkov Detector or IWCD which is currently being built in Japan as part of the Hyper-Kamiokande Collaboration, the simulated data are contained within h5 files and range from 9 thousand to 8 million events per type of particle. After training the models, different evaluation metrics were computed to properly compare the architectures among themselves and with the ones found in the state of art to determine which of all the models, if any, classified neutrinos the best.

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