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Using Deep Learning in Ultra-High Energy Cosmic Ray Experiments

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The extremely low flux of ultra-high energy cosmic rays (UHECR) makes their direct observation by orbital experiments practically impossible. For this reason all current and planning UHECR experiments detect cosmic rays indirectly observing extensive air showers (EAS) initiated by cosmic ray particles in the atmosphere. Various types of shower observables are analysed in modern UHECR experiments including secondary radio signal and fluorescent light from excited nitrogen molecules. The most of data is collected by the network of surface area detectors which allows to measure horizontal EAS profile directly. The raw observables in this case are the time-resolved signals for the set of adjacent triggered detectors. To recover primary particle properties Monte Carlo shower simulation is performed. In traditional techniques the MC simulation is used to fit some synthetic observable such as shower rise time, shower front curvature and particle density normalized to a given distance from the core. In this talk we consider an alternative approach based on the deep convolutional neural network using detector signal time series as an input and trained on a large Monte-Carlo dataset. The above approach has proven its efficiency with the Monte-Carlo simulations of the Telescope Array Observatory surface detector. We will discuss in detail how we optimize network architecture for the particular task.

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