universität innsbruck

Kernel Density Estimation for Sky Maps in Ground-Based Gamma-Ray Astronomy

Bachelorarbeit - Sommersemester 2020

Context/Keywords: Astroparticle Physics; Analysis Methods

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Abstract

Because of low source fluxes and a high background level, sophisticated analysis techniques are required to detect and investigate TeV gamma-ray sources with Imaging Atmospheric Cherenkov Telescopes (IACTs). Correspondingly, for the generation of sky maps to be used in publications it is necessary to apply imaging techniques that enhance the visibility. The current standard here is to fill the reconstructed directions into a binned map and apply a smoothing algorithm whose width is usually at the level of the Point Spread Function (see below). While this approach is well-established, it has the disadvantage that the informational content in the image is reduced and smeared out.
The goal of this Bachelor topic is to test an alternative method for generating sky maps based on Kernel Density Estimation (KDE, see e.g. here). This approach provides an interesting alternative as it works with the unbinned directional information of the gamma-ray events and can also be further expanded by exploiting the event-wise estimated error on this direction. You will be working with data of the H.E.S.S. telescopes, an array of IACTs located in Namibia.

Helpful Skills

- Basic knowledge of *python* or programming in general
- Interest in analysis methods of ground-based gamma-ray astronomy

Bottom left: Unsmoothed bin counts map of a typical H.E.S.S. source.
Bottom middle: Same map as on the *left*, but smoothed (corresponding to the current standard approach).
Bottom right: One-dimensional example comparison of binned histograms (top row) vs. KDE techniques (bottom row). Figure taken from here.