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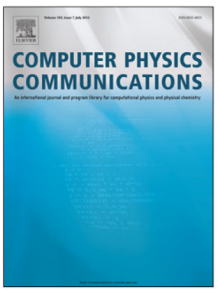

Statistical algorithms for particle trajectography

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Statistical algorithms for particle trajectography

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Abstract

The various algorithms used to extrapolate particle trajectories from measurements are often very time-consuming with computational complexities which are typically quadratic. In this article, we propose a new algorithm called GEM with a lower complexity and reasonable performance on linear tracks. It is an extension of the EM algorithm used to fit Gaussian mixtures. It works in arbitrary dimension and with an arbitrary number of simultaneous particles. In a second part, we extend it to circular tracks (for charged particles) and even a mix of linear and circular tracks. This algorithm is implemented in an open-source library called "libgem" and two applications are proposed, based on data-sets from two kind of particle trackers.

Keywords: particle tracking; algorithm; multiple linear regression; multiple circular regression

1. Introduction

Particle detectors rely on devices, called trackers, recording points where particles passed through them and allowing thus to infer the parameters of their movements. This operation relies on the estimation of the trajectory of the particles from the measured points. As the detector is often in a magnetic field, the trajectories are linear for neutral particles or helical for charged ones. In the latter case, the radius of the trajectory is proportional to the momentum of the particle.

Extrapolating linear trajectories is done easily by a linear regression if the detector manages only one particle at a time. But as the phenomena we look for are extremely rare, physicists designing particle accelerators tend to increase the rate of event pile-up (i.e. simultaneous events) to aquire more data and get more chance to observe these events. Thus, in such detectors, it is necessary to use algorithms, which are able to discriminate the different tracks and reconstruct them at the same time.

The Hough transform is a powerfull tool to make such reconstructions [1]. In two dimensions, it is a spectral method based on a histogram of all the directions of the point pairs. By extracting the peaks of the histograms, the track directions