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An alternative approach to interface detection in muon tomography experiments: Algebraic surfaces

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With the continuous development of muon tomography its applications have spread into various disciplines. Be it from civil engineering applications on nuclear power plants or bridges over archaeological ones in the pyramids in Gizeh to even geologically interesting objects such as volcanoes and glaciers, this technology has become an interesting inverse problem for geophysicists. In tomographic practice, the usual approach is to parametrise the space into so-called voxels, i.e. virtual cubes with a fixed size, and to determine the physical parameter of interest within each voxel. In the specific case of muon tomography, this quantity is the mass density of the material. Structural information is then retrieved by analysing the spatial density distribution. Inconveniently, this sort of inversion needs a very good data coverage, as the number of parameters to be determined rises fast, especially in 3D. This generally leads to correlated parameters, which yield a rather smooth picture of the density distribution. However, if the interest lies primarily in inferring precise structural information (e.g. interfaces) the voxel approach might be unsuitable. Here, we present an alternative procedure for interface detection, by parametrising a surface as a polynomial series in space, i.e. an algebraic surface. This effectively reduces the number of parameters to be resolved as one needs now to determine the coefficients of a polynomial instead of the density of each voxel. The densities of the materials on each side of the surface enter then as side constraints of the inverse problem. In a muon tomographic experiment, where the focus usually lies in the topmost kilometre of the crust, material samples can be collected and independent measurements in the laboratory can be performed, which yield a solid constraint for the mass density. The new approach will furthermore allow to infer the structural parameters directly from the measured muon flux without having to resort to intermediary data processing steps, that might introduce additional errors which are potentially hard to deal with.