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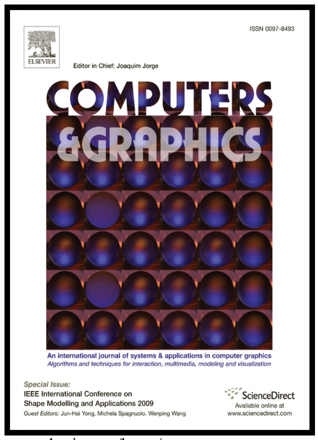

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Signed Distance based 3D Surface Reconstruction from Unorganized Planar Cross-sections

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Abstract

In this paper, we propose an algorithm for closed and smooth 3D surface reconstruction from unorganized planar cross-sections. We address the problem in its full generality, and show its effectiveness on sparse sets of cutting planes. Our algorithm is based on the construction of a globally consistent signed distance function over the cutting planes. It uses a split-and-merge approach utilising Hermite mean-value interpolation for triangular meshes. This work improves on recent approaches by providing a simplified construction that avoids need for post-processing to smooth the reconstructed object boundary. We provide results of reconstruction and its comparison with other algorithms. We build on our recent work by providing a better estimate of normals along the cross-sectional curves, and by showing robustness of the algorithm under increasing number of cutting planes.

Keywords: 3D reconstruction, Planar cross-sections, Signed distance, Hermite mean-value interpolation

1. Introduction

Reconstructing an object from a finite set of planar cross-sections is an interesting variant of the much studied problem of surface reconstruction from a point cloud [1]. The difference between the two problems is due to the nature of intersections. Planar cross-sections provide dense and very localised object information only on the respective cutting planes. A sparse set of such cross-sections provides little information about the global topology of the underlying object. As a consequence, multiple topological configurations are possible for a given set of cross-sections, as discussed by Sidlesky et al. [2]. Amini et al. [3] call it *geometric tomography* and provide an in-depth study of theoretical guarantees on reconstruction and sampling conditions. The problem has recently received some attention for potential uses in medical reconstructions such as in ultrasound, where the acoustic beams from the probe form a set of planar cross-sections penetrating the subject non-invasively. 3D reconstruction of organs are widely considered to be an important diagnostic aid in the medical world [4, 5]. Other application domains include underwater acoustic reconstructions in fisheries research and terrain modelling.

The specific case of reconstruction from parallel cross-sections has been extensively studied in literature (see [6, 7, 8, 9]), and can be considered as a solved problem. Various approaches to solve this problem include constrained energy minimization via level sets, minimum surface surface triangulations. The problem of reconstruction from unorganized cross-sections is relatively new and has been considered in both 2D and 3D settings [10, 11, 4, 12, 13, 2]. In most of the reconstruction algorithms, it is typically assumed that the provided input is already segmented into two or more regions that delimit the “inside” and “outside” regions of objects on each cross-section. The goal is to create a compact manifold (curve or surface) that passes through all the intersections, while consistently preserving the inside and outside information.

The algorithm described here solves the problem in its most general setting, with no constraints on the objective. We follow a split-and-merge approach to solve the problem in 3D. Our reconstruction is continuous and smooth that results from a simple and robust algorithm. In particular, this is based on our recent work [14] and we improve parts of the algorithm for better reconstruction.

2. Previous work

Sidlesky et al. [2] analyzed topological properties of solution to this reconstruction problem in the plane. The authors observe that a line not intersecting the object does not contribute to the reconstruction. Their algorithm enumerates all possible reconstructions that satisfy the interpolation and topological equivalence with the given input. Due to a large number of possible reconstructions, complexity of their algorithm is exponential in nature. There may be cases for which several reconstructions are topologically valid for a unique set of given cross-sections.

Memari and Boissonnat [12] used the Delaunay triangulation for reconstruction. Input to the algorithm is a set of intersecting planes along with their intersections with the object. The authors consider a partitioning of space by all cutting planes in the space, and extract a closed triangular mesh within

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