Building the Edge-Junction Graph from a Range Image of Curved Objects

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Abstract

This paper presents an approach to the computation of a representation for planar- as well as curved-face objects in range images. The result is an edge-junction graph embedding qualitative and quantitative descriptors of the structure of the discontinuities in the viewed scene. Edges are detected using local operators and triangulation shadow boundary analysis. Edge points are organized into depth- and orientation-continuous segments. Finally, junctions are built from the extremities of these segments by appealing to certain results from line drawing analysis. The resulting structure corresponds to a partial wireframe of the objects.

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La méthode proposée ici permet d'extraire, à partir de l'image télémétrique d'objets aux faces planes et courbes, une description reposant sur les discontinuités présentes dans l'image. La nature tridimensionnelle des données est mise à profit aussi bien dans l'extraction que dans l'organisation des lieux de discontinuité. Les arêtes, détectées par des opérateurs locaux ainsi que par analyse des bordures d'ombres, sont divisées en segments continus en profondeur et en orientation. Les extrémités de ces segments sont groupés en jonctions, en accord avec les configurations derivées des techiques d'analyse de dessin de traits.

Keywords: *range image analysis, scene description, edge detection, triangulation shadows.*

1. Introduction

The research reported in this paper concentrates on the generation of a structured description based on the edges detected in a range image. These edges represent the discontinuities in depth and surface orientation of the surfaces visible in a single range image obtained from a laser rangefinder. The knowledge of the three-dimensional positions of these discontinuities given by the range data permits the construction of a *partial wire-frame* representation. The integration of several of these partial wire-frames, each extracted from a single range image, is a possible avenue for object representation from multiple range images.

Although the results reported in this paper do bear a strong similarity to conventional line-drawing analysis, a distinction needs to be made. Line drawing analysis aims at recovering the types of discontinuities represented by lines, according to the appearance of the junctions of the lines representing edges *in the projection*. These lines may be obtained in principle from human input or edge extraction in intensity images. A range image *explicitly* contains the geometric information relevant to the identification of the type of edge. Therefore, there is no need to actually infer the line type; it can be directly discerned from the edge detection process.

The method described in this paper deals with the extraction and organization of the discontinuities and their junctions, formed by the projection of vertices, curved surfaces and occlusions. Discontinuities in depth and surface orientation are computed from the range data, and structured in the form of a line drawing with supplementary information on the 3D position and orientation of edges at the junction. The resulting structured edge map is in the form of an *edge-junction graph*. The extracted edges and junctions are located in 3D, thus constituting a wire-frame of the discontinuities visible from one viewpoint.

In previous research, much effort has been devoted to the extraction of particular surface primitives from images such as planes, cylinders, cones and spheres. Other research efforts aim at describing the surface in terms of local curvature properties [2, 4, 25] . Edges, or discontinuities in depth or surface orientation, have also been used as segmentation features. A common goal of all these approaches is the decomposition of the image into homogeneous elements, according to a specific geometric criterion. These intermediate scene descriptions may then be employed for higher level interpretation.

Edge extraction and organization is the basis for several methods that have been presented for the analysis of range images. Techniques for the local detection of jump and crease edges have been proposed which analyse local surface height and orientation [6, 11, 13, 18], the scale-space behaviour of features [20], the frequency spectrum of a circular sampling [12], depth coupled with the intensity (or reflectance) [8, 16], and level curves [1, 15]. Edge-oriented scene description methods take this one step further by attempting to organize the detected edges into a meaningful and useful format, often performing additional analysis on the surfaces enclosed by the edges [3, 7, 14, 22, 24].

Herman [9] has presented a system for the extraction of a detailed scene description from the range image of polyhedra. The points are detected using local operators and are grouped into lines by separately applying a 2D Hough transform to each class of edge. A line drawing is then formed by merging segments that are collinear in the plane and extending and shortening lines to form junctions between sufficiently close points.

An a priori knowledge about the possible junctions in a