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ORIGINAL ARTICLE

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Shape recovery and viewpoint planning for reverse engineering

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Abstract In this paper, a new methodology for surface reconstruction from sets of points for reverse engineering is described. The sets of points are obtained using stereovision techniques. Techniques for minimizing the number of images required for a complete object reconstruction are explored based on characterizing the shapes to be recovered in terms of visibility and number and nature of cavities. The ultimate goal of our viewpoint planning technique is to minimize the number of images when no prior information about the objects is available.

Keywords Reverse engineering · Surface reconstruction · Viewpoint planning

1 Introduction

Generating models of unknown objects automatically from multiple images is a critical problem in reverse engineering. The recovery of three-dimensional (3D) models in reverse engineering can be accomplished using laser scanners [1] or stereovision [2] to scan the objects to be reconstructed. Both techniques are based on extracting points of the object in three-dimensional space and subsequently reconstructing the surfaces from these sets of points.

The particularities of range images are that they generate dense sets of points and that only one image is required to extract the 3D information (depth) of the scene viewed in that particular image. Most techniques that simultaneously consider surface reconstruction and viewpoint planning build the surfaces incrementally, by adding surface data to the partial models as new images are acquired.

In case of stereovision, the sets of points are not dense and at least two images of the same scene are required for depth extraction. In this case, one may or may not be able to control the camera location before acquiring images, depending on the technology used. Our goal is to develop a surface reconstruction and viewpoint planning method that does not require camera location information before the image acquisition process.

In this paper, we describe first a methodology for recovering the shape of objects from non-dense sets of points. Second, we attempt to characterize the shapes based on the number and nature of the cavities (notches). When characterizing the shapes, we assume that information exists about the shapes (in terms of triangular meshes) and subsequently translate the concepts to the case when no information exists. The viewpoint planning technique is applied on a real life object based on human visual interpretation of the scene as related to the number and nature of the cavities.

The remainder of this paper is organized as follows. Related work is discussed in Sect. 2. In Sect. 3, the shape recovery technique is presented and the viewpoint planning methodology is discussed in Sect. 4. Examples are given in Sect. 5 and conclusions are drawn in Sect. 6.

2 Previous work

We are presenting previous work in two contexts: surface reconstruction from scattered points and viewpoint planning.

Most techniques for surface reconstruction from a set of scattered points start with the Delaunay triangulation of the set. The final product of the Delaunay triangulation is the convex hull of the set of points. The convex hull cannot capture any information about the cavities of an object. Therefore, we need to "carve" the convex hull until we are left with a set of triangles that best

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