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3D reconstruction of free-formed line-like objects using NURBS representation ☆

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Abstract

3D reconstruction of arbitrary free-formed objects is an important and challenging problem in computer vision. In this paper, we first discuss the importance of primitive selection in 3D reconstruction. Subsequently, a theorem, which reveals the perspective invariance of NURBS, is shown, making it a good choice as primitive in 3D reconstruction. Consequently, based on this theorem a new paradigm of free-formed line-like object reconstruction using NURBS as primitives is proposed. Furthermore, an approach for determining weights for 3D NURBS is presented, and the width effect of curved line-like objects is analyzed. Finally, experiments with line-like objects and machine part demonstrate the feasibility of our approach and prove the superiority of our approach over the point- or segment-based approaches as well as the B-spline-based reconstruction approach in terms of robustness and accuracy. © 2003 Published by Elsevier Science Ltd on behalf of Pattern Recognition Society.

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1. Introduction

Humans, almost effortlessly, can understand a wide variety of shapes. However, finding a useful and general method for machine representation of shapes has been proven to be nontrivial. In fact, inferring 3D shape of objects in a scene from their perspective views is one of the most important and challenging problems in computer vision and has been at the core of computer vision from the early days. There are at least three reasons why solving this problem is a formidable endeavor. Firstly, by acquiring an image of 3D world using a camera, the information in depth dimension is lost during imaging process. Secondly, 2D images are related in a complex way to the structure of real world through the physics of image formation and its mapping geometry. Thirdly, since we are dealing with real sensors, we are confronted with the problem of processing noisy signals. This turns out to be a very complicated problem since this initial uncertainty must be tracked through all the representations that are built up by the system in order to achieve a final high accuracy 3D representation. Since the milestone work by Marr and Poggio two decades ago [1], a variety of approaches have been proposed worldwide. Among these approaches, the most difficult and time-consuming problem is to find corresponding

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