A 6-DOF haptic interface and its applications in CAD

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Abstract: In this paper, we propose a new general 6-DOF haptic interface, which is able to provide both force and torque feedback to point clouds, NURBS curves and surfaces and rigid heterogeneous material virtual representations. A feature of this approach is the haptic cursor, which has a shape and size, instead of just a point. We also present two CAD applications based on that haptic interface; an experimental haptic sculpting system for B-spline surfaces and a haptic-based method to draw a NURBS curve upon a point-based model. By taking advantage of our haptic rendering techniques, various haptic sculpting tools are developed to facilitate sculpting B-spline surfaces, resulting in more intuitive virtual sculpting paradigms. To draw a NURBS curve upon a point-based model is normally a difficult problem. However, this problem can be solved with relative ease using our haptic interface.

Keywords: computer-aided design; haptic interface; haptic rendering.

Reference to this paper should be made as follows: Gao, Z. and Gibson, I. (2007) 'A 6-DOF haptic interface and its applications in CAD', *Int. J. Computer Applications in Technology*, Vol. 30, No. 3, pp.163–170.

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1 Introduction

Applications of haptic-based CAD/CAM systems require intuitive approaches for haptic sensing of curves, surfaces, volumetric models or even point clouds. This paper presents a new general haptic rendering approach for several current popular CAD model representations.

The key issue of the new haptic rendering technique is the implicit surface to point cloud haptic rendering algorithm. Recently, point-based modelling has received more and more attention. The reason is convincing: for modern computer graphics, 'in complex models the triangle size is decreasing to pixel resolution', therefore, using non-organised point clouds to represent primary surface models is reasonable (Azariadis and Sapidis, 2005). Also, in reverse engineering, modern acquisition technology can generate highly dense point clouds. The point clouds can be so dense that triangulation becomes meaningless (Azariadis and Sapidis, 2005).

The implicit surface is the representation of the haptic interface object or haptic cursor, which we call probe or tool in this paper. Users manipulate the stylus of a PHANToM robotic haptic feed back device to drive the probe of implicit surface (SensAble). A PHANToM Premium haptic device is used for haptic input/output in this system. The PHANToM Premium device provides 6 Degrees of Freedom (DOFs) force and torque feedback and 6 DOFs position and orientation input. It is a small robot arm equipped with computer-controlled DC motors. The tip of the PHANToM device is attached to a stylus that is to be held by the user.