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Technical Section

A simple normal enhancement technique for interactive non-photorealistic renderings

Paolo Cignoni, Roberto Scopigno, Marco Tarini*

Istituto di Scienza e Tecnologia dell'Informazione, Consiglio Nazionale delle Ricerche, Via Moruzzi 1, Pisa 56124, Italy

Abstract

We present a simple technique to improve the perception of an object's shape. Bump mapping is well known in the computer graphics community for providing the impression of small-scale geometrical features, which are not explicitly modelled. Here, we propose a similar approach (variation of normals) for the purpose of enhancing the perception of a given geometry. Our approach is based on a simple modification of the surface normals in order to enhance the geometric features of the object during the rendering. The enhanced normals produced by this approach can be used in any rendering technique. The technique presented is particularly well suited to improve the rendering of mechanical parts where common straightforward shading techniques can often generate shading ambiguities.

Keywords: Display algorithms; Non-photorealistic rendering (NPR); Computer-aided design (CAD)

1. Introduction

In this paper we consider a class of 3D objects, including but not limited to typical mechanical parts used in computer-aided design (CAD) systems, that have a common set of features: flat surfaces, many of which facing the same direction, sharp straight edges, overall regularity. Straightforward rendering of such objects often results in visually unsatisfactory, dull, flat looking, or even unclear and ambiguous images (see Figs. 1 and 2).

Adding enough realism, the problem could disappear: complex realistic effects (common in off line rendering), like cast soft-shadows, inter-reflections, radiosity, local (as opposed to at infinity) light positions, and so on, can produce a much less *flat* result, and are known to provide many intuitive visual hints to the viewer.

In graphic design illustrations (either hand-made, or made with vector-based drawing programs) the problem has been solved in a different, simpler yet effective way: professional illustrators can reduce flatness (or unclarity) "by hand", shading surfaces according to their esthetic sense (see for example Fig. 1) rather than solving difficult physical problems (shadow projection, light diffused by surfaces, etc.).

The implicit idea behind this is that appropriate shading supplies a kind of information that is more *qualitative* than *quantitative* in the perception of an image. Conversely, the shape of the silhouette and the shading discontinuity bring us the most significant information about the real shape of the object. Moreover, to obtain an improved perception, shading does not have to be physically correct (see Fig. 1).

Along these lines, we designed a new perception-oriented, non-realistic, automatic technique for interactive rendering systems. We aim at synthesizing images that are qualitatively similar to the illustration style visible, for example, in Fig. 2. It is based on

*Corresponding author. Tel.: +39 050 315 2925.
E-mail addresses: cignoni@isti.cnr.it (P. Cignoni), scopigno@isti.cnr.it (R. Scopigno), tarini@iei.pi.cnr.it (M. Tarini).

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enhancing high-frequency components of the model; the key issue is that, rather than working on the geometry (vertex positions) of the digital model, we apply the enhancement to the surface orientation alone, leaving the silhouette unchanged. This technique, hereafter called *normal enhancement*, is done on the mesh in a preprocessing stage: the enhanced normals are integrated into the model, making this technique view-independent.

In contrast with most non-photorealistic techniques, this approach is de-coupled from the rendering algorithm used to effectively produce the image. For this reason the enhanced normals can be used into any rendering subsystem that support user-specified normals, like for example the standard VRML browsers. Moreover, a visualization tool or a geometry browser that uses this technique can easily allow the user to toggle between the normal-enhanced and standard rendering modes.

2. Related work

Computer graphics algorithms and techniques that aim to imitate non-photographic illustration styles are usually referred to as *non-photorealistic rendering* [1]

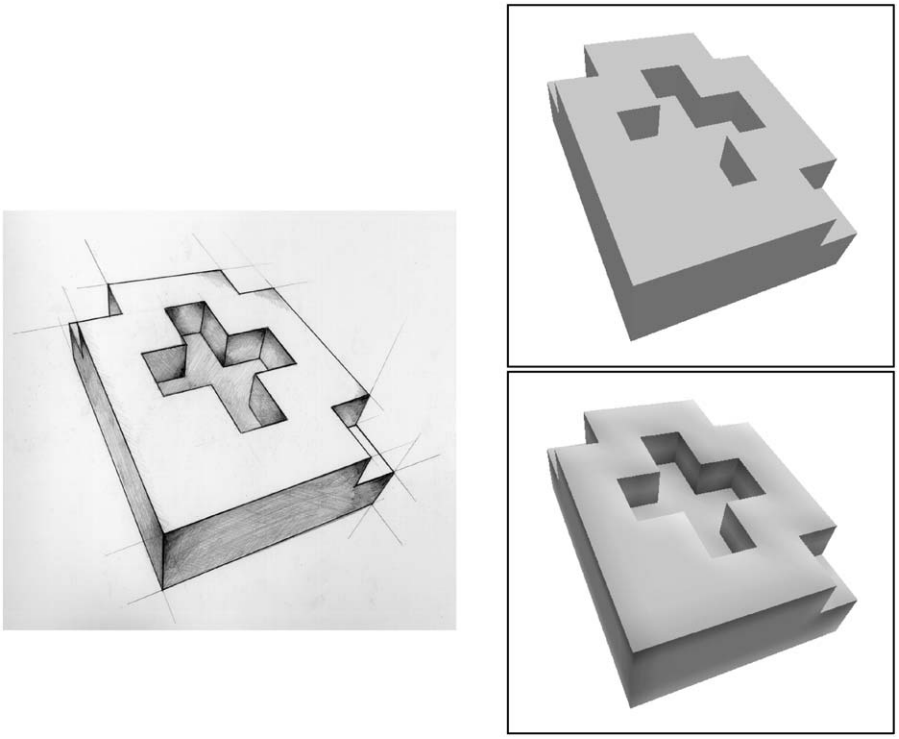

Fig. 1. A hand-drawn pencil drawing with a non-photorealistic shading that enhances the mesh features (left), courtesy of Alessandro Briglia; real-time rendering of a similar object without (top right) and with the proposed method (bottom right).

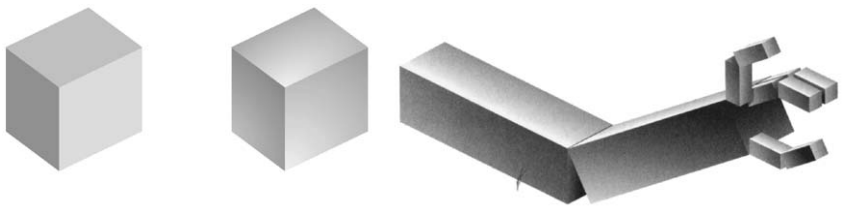

Fig. 2. Examples of non-synthetic, perceptual-oriented drawings of two simple 3D objects: the cube above is drawn in a non-constant, non-realistic manner on the right; the robot arm is a drawing published in Fig. 3.26 of the red book on OpenGL [24].