Adding Depth to Hand-drawn Images

The human visual system can easily perceive depth in hand-drawn images thanks to understanding of high-level structure encoded in the drawing. Such a knowledge is typically hidden to the computer and thus algorithmic addition of depth becomes a challenging task. We developed new depth assignment techniques which resolve this problem by exploiting a set of sparse user-specified constraints that express pair-wise relationship between selected parts in the scene. Resulting depth values can either be used to improve perception of depth in the scene by generating 3D-like shading including global illumination effects or to produce stereoscopic imagery.

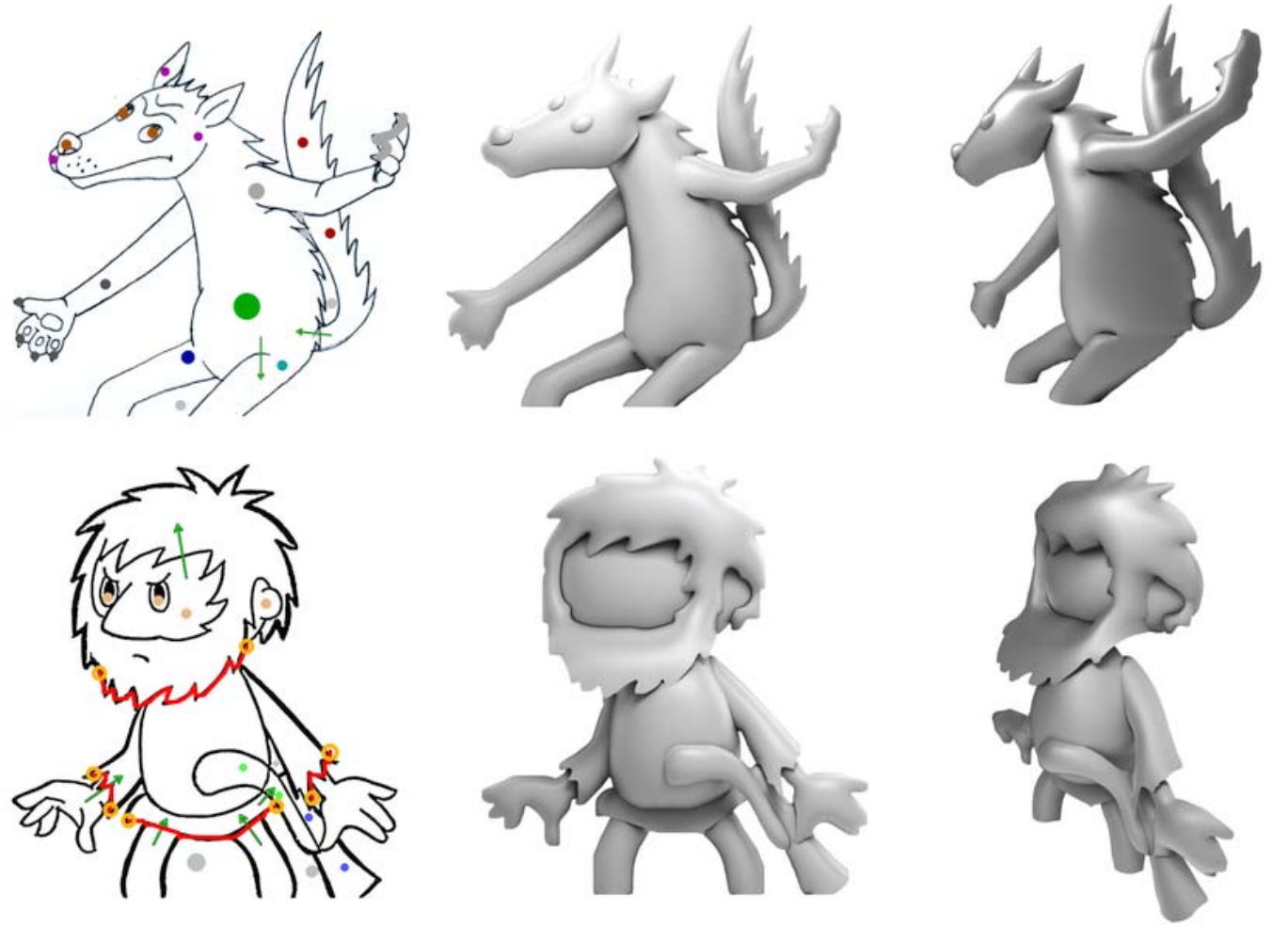

Figure 1: A few user-specified annotations were used (left) to produce bas-relief-type 3D models (middle) out of hand-drawn images. Despite visible inconsistencies when inspected from sideviews (right) these approximative 3D models can be used to compute global illumination as well as stereoscopic imagery, i.e., effects which are normally available only in full 3D pipelines.

Our research

Recovering depth from a single image remains an open problem after decades of active research. In our research we focus on a specific variant of the problem where the input image is hand-crafted line drawing. As opposed to previous attempts to provide complete 3D reconstruction either by imposing various geometric assumptions or using sketch-based interfaces to create the 3D model incrementally we seek for a height field or a bas-relief-type approximation consistent with the observer's perception of depth in the scene (see Figure 1). We formulated the task as an energy minimization problem where we combine user provided constraints together with automatic estimation of relative depth order, inflation, and reconstruction of occluded parts. Resulting proxy 3D models provide rich geometric information sufficient to evoke impression of fully consistent 3D model rendered from orthographic view using global illumination algorithm. Although such approximation cannot provide full 3D modeling capabilities it is sufficient for numerous important tasks that can arise in 2D pipelines.

Applications

Figure 2: A sequence of hand-drawn images (top) as well as static cartoon characters (bottom) were enhanced using global illumination effects thanks to our new technique which allows to add depth information into existing hand-drawn images using only sparse set of user-provided constraints.

Our novel framework allows to maintaining correct visibility and connectivity of individual parts during interactive manipulation, deformable image registration, or fragment composition. In the context of image enhancement it helps to improve perception of depth, generate 3D-like shading including global illumination effects (see Figure 2), or produce stereoscopic imagery. A key advantage of our approach is that it provides complete artistic freedom without the restrictions imposed by a CG environment while still enables to make complex effects such as global illumination which are labor-intensive to create for every frame of a traditionally animated film. We conducted various perceptual studies which confirmed that for observers without prior experience with computer graphics there is no statistically significant difference between usage of a real 3D model and our approximation.

Title: Adding Depth to Hand-drawn Images

Author: Daniel Sýkora (sykorad@fel.cvut.cz)

Department of Computer Graphics and Interaction
Faculty of Electrical Engineering
Czech Technical University in Prague
Karlovo náměstí 13
121 35 Praha 2, Czech Republic
Tel.: +420-22435-7501
E-Mail: office@dcgi.fel.cvut.cz

Research Project: V3C - Visual Computing Competence Center
No. TE01020415
www.v3c.cz
Project Manager: Pavel Zemčík (zemcik@fit.vutbr.cz)
Tel.: +420 603 487 824

Technologická agentura České republiky

Centra kompetence

Acknowledgment

This work was supported by the Technology Agency of the Czech Republic.