Pontifícia Universidade Católica
do Rio de Janeiro

Siniša Kolarić

Towards direct spatial manipulation of virtual 3D objects using visual tracking and gesture recognition of unmarked hands

MSc Thesis

Thesis presented to the post-graduate program in Computer Science of the Department of Computer Science, PUC-Rio as partial fullfillment of the requirements for the degree of Master in Computer Science.

Adviser : Prof. Marcelo Gattass
Co–Adviser: Prof. Alberto Barbosa Raposo

Rio de Janeiro
March 2008

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Siniša Kolarić

Siniša Kolarić received his BSc degree in mathematics with a minor in computer science from the University of Zagreb, Croatia. He also concurrently studied theoretical physics for three years at the same university. Later on he worked in academia and industry for Croatian, USA and German organizations. Since 2006 he has been a graduate student at PUC-Rio and a researcher at Tecgraf/PUC-Rio. His scientific interests include computer-aided design, computational geometry and topology, solid modeling, 3D user interfaces and real-time interactive rendering.

Bibliographic data

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Katarina Kolarić née Bubek (1948–2007)

In memory of my mother.

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Abstract

Kolarić, Siniša; Gattass, Marcelo; Raposo, Alberto Barbosa. **Towards direct spatial manipulation of virtual 3D objects using visual tracking and gesture recognition of unmarked hands**. Rio de Janeiro, 2008. 120p. MSc Thesis — Department of Computer Science, Pontifical Catholic University of Rio de Janeiro.

The need to perform spatial manipulations (like selection, translation, rotation, and scaling) of virtual 3D objects is common to many types of software applications, including computer-aided design (CAD), computer-aided modeling (CAM) and scientific and engineering visualization applications. In this work, a prototype application for manipulation of 3D virtual objects using free-hand 3D movements of bare (that is, unmarked, uninstrumented) hands, as well as using one-handed and two-handed manipulation gestures, is demonstrated. The user moves his hands in the work volume situated immediately above the desktop, and the system effectively integrates both hands (their centroids) into the virtual environment corresponding to this work volume. The hands are being detected and their posture recognized using the Viola-Jones detection method, and the hand posture recognition thus obtained is then used for switching between manipulation modes. Full 3D tracking of up to two hands is obtained by a combination of 2D "flocks-of-KLT-features" tracking and 3D reconstruction based on stereo triangulation.

Keywords

Direct manipulation of virtual 3D objects. Augmented reality. Mixed reality. 3D input devices. 3D interaction techniques. Computer vision. Hand detection. Hand tracking. Hand gesture recognition.

Resumo

Kolarić, Siniša; Gattass, Marcelo; Raposo, Alberto Barbosa. **Rumo à manipulação direta espacial de objetos virtuais 3D usando rastreamento baseado em visão e no reconhecimento de gestos de mãos sem marcadores**. Rio de Janeiro, 2008. 120p. Dissertação de mestrado — Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

A necessidade de executar manipulações espaciais (como seleção, deslocamento, rotação, e escalamento) de objetos virtuais 3D é comum a muitos tipos de aplicações do software, inclusive aplicações de *computer-aided design* (CAD), *computer-aided modeling* (CAM) e aplicações de visualização científica e de engenharia. Neste trabalho é apresentado um protótipo de aplicação para manipulação de objetos virtuais 3D utilizando movimentos livres de mãos e sem o uso de marcadores, podendo-se fazer gestos com uma ou duas mãos. O usuário move as mãos no volume de trabalho situado imediatamente acima da mesa, e o sistema integra ambas as mãos (seus centróides) no ambiente virtual que corresponde a este volume de trabalho. As mãos são detectadas e seus gestos reconhecidos usando o método de detecção de Viola-Jones. Tal reconhecimento de gestos é assim usado para ligar e desligar modalidades da manipulação. O rastreamento 3D de até duas mãos é então obtido por uma combinação de rastreamento 2D chamado "*flocks-of-KLT-features*" e reconstrução 3D baseada em triangulação estéreo.

Palavras–chave

Manipulação direta espacial de objetos virtuais 3D. Realidade aumentada. Realidade mista. Dispositivos de entrada 3D. Técnicas de interação 3D. Visão por computador. Detecção de mãos. Rastreamento de mãos. Reconhecimento de gestos manuais.

Summary

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People don't understand 3D. They experience it.

Ivan E. Sutherland, *American computer scientist*