Virtual Puppet

A physically based, real-time shading experience

M. Biedermann* M. Geimer† A. Langs‡ T. Ritschel§ R. Trappe¶ S. Müller‖

Computer Graphics Group
Institute for Computational Visualistics
University of Koblenz-Landau

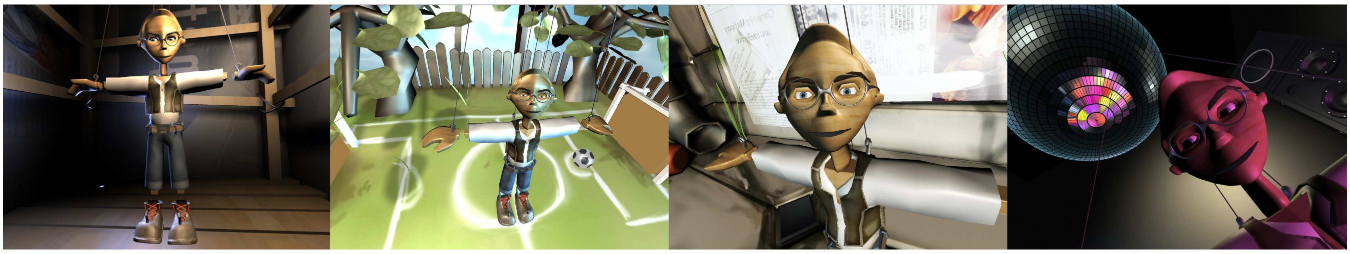

Figure 1: The virtual puppet in different scenes (left to right: entry room, soccer game, painting room, and the disco)

Abstract

We present a virtual reality application that combines the technical possibilities of current graphics systems with a creative and pleasant story. "Virtual Puppet" enables the user to step into the role of a puppet player and control a nice character exploring different locations. In order to be as convincing as possible, the application mimics the real world through an efficient physics simulation, flexible tracking and state-of-the-art shading techniques.
In addition, our system has been designed in a flexible and modular way. It consists of several components not necessarily running on a single machine that share information via event-based communication. This allows us to easily reuse these components in other applications.

CR Categories: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Color, shading, shadowing, and texture I.6.8 [Simulation and Modeling]: Types of Simulation—Combined

Keywords: virtual reality, simulation, real-time shading, tracking

1 About the Demo

1.1 Introduction

Creating virtual reality applications has been greatly simplified by recent advances of computing technology in general and graphics hardware in particular. Thus, more and more people are able to create VR content or at least consume all kinds of applications, presentations, games, etc. Nevertheless, creating both an appealing story and the underlying VR system that is able to give the user an immersive experience remains a demanding task.
Our implementation of a virtual puppet has been realized as a students' research project and tries to combine a flexible and efficient physics simulation, an event-based communcation, and high quality rendering exploiting current graphics hardware with a pleasant and enjoyable story. Users are invited to discover our virtual puppet's capabilities in various scenes, e.g. dancing in a disco, painting on a wall, playing soccer and the like.

1.2 Realization

The main idea behind this demo is the creation of a virtual puppet that gives the user the impression of being a puppet player. To accomplish this goal of an attractive application we needed an intuitive and physically plausible way to control the puppet's behaviour, a convincing real-time visualization in stereo, and an appropriate and amusing story.

Therefore, each site is crafted following the look and feel of a puppet player's miniature set and strives to reflect the proportions and fictive process of construction. Following this idea, many rooms have walls made of newspapers mounted on sticks, fixed with nails etc. As music plays a substantial role in supporting the mood and appearance of each scene, the sound effects are chosen closely related to the style of the settings. Additionally, to provide visual feedback to the user, the character itself is able to react to various events by appropriate facial expressions.

The character's movements are controlled by an optically tracked gamepad that offers an intuitive handling even for unpracticed users. While orientation and movement information is needed by the physics simulation, actions like pressing a button are used to trigger state changes etc. This event-based communication, either within the application running on a single machine or across a network, is the overall basis for processing all data in the different components of our system.

In addition to evaluating the user input data, we need to ensure a proper interaction between the puppet and the scene. Thus, we have implemented an efficient and numerically stable physics engine that can be used as an integrated library or running separately

*e-mail:mbmann@uni-koblenz.de
†e-mail:mgm@uni-koblenz.de
‡e-mail:alangs@uni-koblenz.de
§e-mail:ritschel@uni-koblenz.de
¶e-mail:trappe@uni-koblenz.de
‖e-mail:stefanm@uni-koblenz.de

on a server. It is able to simulate analytical rigid bodies like spheres, capsules, planes and boxes while evaluating friction, drag, elasticity and propagation of momenta in real-time, together with the handling of colliding objects. Ball and hinge joints can be established between different bodies and are calculated based on D. Baraff's algorithm satisfying O(n) complexity. In addition, particle and cloth simulation can be applied to the whole setting while supporting force feedback to rigid bodies.

After new positions and orientations have been calculated by the physics simulation, these updates are sent back in the form of dedicated events. The central component of our system evaluates the current state of the application (e.g., room, pressed buttons) and controls the output that comprises the aforementioned sound and rendering system. The former uses a surround sound system for an appropriate combination of ambient music and localized sound effects that match the state and action of the current scene. The latter is based on OpenSG which is capable of both stereo rendering and (heterogeneous) clustering. As stated in the introduction, we also use a variety of shaders that enhance the visual quality while allowing for real-time performance on current commodity graphics hardware.

1.3 Requirements

In order to present our system in a demo, we finally summarize the required devices and facilities. A stereo projection system driven by computers with state-of-the-art graphics hardware yields convincing visualization results. In addition, two more computers are needed for the application and the physics simulation, respectively. All the PCs should be directly connected by an up-to-date ethernet switching hub providing sufficiently fast communication between all components. The optical tracking system (A.R.T.) and a wireless gamepad modified for tracking are required for the user input, whereas a conventional 5.1 dolby sound system completes the infrastructure for ”Virtual Puppet”.
Upon request, all of these devices can be made available by our group, excluding the stereo projection (screen and projectors).

2 About the lab

2.1 History

The graphics group in Koblenz was founded in 1990. The research focus was on traditional rendering algorithms like radiosity and ray tracing. With the invention of a new course of studies called computational visualistics in 1998, two courses in computer graphics became compulsory lectures in its curriculum. Furthermore, the group offers additional lectures, seminars and lab courses.

After the retirement of the former head of the group, the professorship has been assigned to Stefan Müller in July 2002. Since then, the research focus has shifted towards photorealistic image synthesis, real-time rendering and different aspects of virtual and augmented reality.

Head of the computer graphics group: Stefan Müller

2.2 Staff

1 Professor: Stefan Müller
3 Research assistants: Matthias Biedermann, Markus Geimer, Thorsten Grosch
1 Secretary: Angelika Bräunig de Colán

2.3 Current research

The main research area of the computer graphics group is the synthesis of three-dimensional images in interactive, immersive and augmented environments, covering the whole workflow including modelling, interaction, simulation and rendering.

In a previous project, an interactive VR presentation was created showing the UNESCO world heritage ”Mittelrheintal”, the region along the river Rhine from Koblenz to Bingen. In this edutainment application, the user is able to explore selected locations like ”Ehrenbreitstein Fortress” and ”Marksburg Castle”, where he can get information about the region and its history by talking to virtual avatars.

Besides different virtual reality projects like the virtual puppet and the aforementioned one, the group especially focuses on ray tracing complex data sets in real-time, image based lighting algorithms (e.g. spherical harmonics), the reconstruction of lighting conditions from photographs and the photorealistic augmentation of images with virtual objects.

2.4 Rooms and locations

The computer graphics group occupies approximately 150 square meters and is located in building B of the campus Koblenz. This includes the offices as well as a mixed reality lab, equipped with a passive, 2.5×2 m back-projection stereo display and an optical as well as an electro-magnetic tracking system. Augmented reality devices like different cameras, optical-, and video-see-through eye glasses are also available. In addition, 15 PC based work places provide the students the necessary infrastructure for application development, modelling, and the documentation of results.