

Virtual Physics Circus

Don Kimber
FXPAL

3400 Hillview, Bldg. 4
Palo Alto, CA 94304
kimber@fxpal.com

Eleanor Rieffel
FXPAL

3400 Hillview, Bldg. 4
Palo Alto, CA 94304
rieffel@fxpal.com

Jim Vaughan
FXPAL

3400 Hillview, Bldg. 4
Palo Alto, CA 94304
vaughan@fxpal.com

John Doherty
FXPAL

3400 Hillview, Bldg. 4
Palo Alto, CA 94304
doherty@fxpal.com

ABSTRACT

This video shows the Virtual Physics Circus, a kind of playground for experimenting with simple physical models. The system makes it easy to create worlds with common physical objects such as swings, vehicles, ramps, and walls, and interactively play with those worlds. The system can be used as a creative art medium as well as to gain understanding and intuition about physical systems. The system can be controlled by a number of UI devices such as mouse, keyboard, joystick, and tags which are tracked in 6 degrees of freedom.

Categories and Subject Descriptors

J.2 and J.5 [Computer Applications]: Physical Sciences and Engineering – *Physics* and Arts and Humanities – *Arts, fine and performing*.

General Terms

Design, Experimentation, Human Factors

Keywords

Mixed reality; virtual reality; physics; education; design; art

1. INTRODUCTION

Technological advances have made fast rendering of 3D graphical scenes and simulations of physical systems possible. A number of tools enable the creation of scriptable 3D content for virtual worlds. Fast classical mechanics simulation tools also exist. These tools have been widely used for mechanical simulation for such purposes as industrial design and game development. Our application is the development of a virtual ‘Circus of Physics’ which allows users to easily set up models of seemingly simple systems such as swings or bicycles and to explore the behavior those systems. Many other systems use the physical modeling to support the design of actual machines, or to support behavior in a game setting oriented around narrative. In those systems, the physics modeling plays a supporting role, and the user’s focus is not intended to be on the physics. In our system, the physics itself is the primary focus, both for its intellectual and esthetic value. Our system allows users to explore and better understand physical systems which may appear simple but in fact exhibit complex, interesting and beautiful behavior.

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There are two distinctly different aspects of use of our system. One is defining and exploring the models; the other is learning to interact in the virtual circus with those models. From an art perspective, these could be viewed as composition and performance. For example, it is one thing to design a bicycle or motor cart, and another thing to learn to control those models well enough to do tricks. Our system enables users to do both.

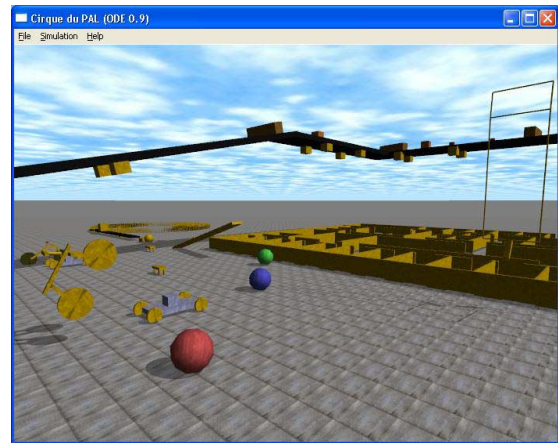


Figure 1. Overview scene of Virtual Physics Circus

One of our themes is to create a fun and playful context in which to explore physics models, and to allow users to work together in this physics playground. The esthetic of the system is towards the silly and surreal rather than realistic, with a focus on the abstractions that get to the core of a physics model. For example, a swing can be modeled as a double pendulum, and the frame supporting it may not be relevant to the model, and so could be left out. Our system also supports multiple users simultaneously manipulating a model. One player may drive a cart using a joystick, while another person controls robot arms on the cart, using tracked tags.

2. SYSTEM

Our system consists of a physics engine, a 3D graphics rendering engine, an assortment of input devices, and an integration and scripting engine. We currently use the open source physics engine ODE [1], but the system can accommodate other physics engines as well. For rendering, we can configure the system to use the OpenGL based system that comes with ODE, or to use the open source Coin3D or OpenSceneGraph engines. Scene definitions may be specified by a simple XML file format we

designed, by Python scripts, or by a combination of the two. The core engine that ties the components together is a C++ application which supports message based interaction with other scripts.

Our system can run as a single application, or as a server with multiple distributed clients. Users can interact in the same scene, each using their own client and with their own view of the scene. But multiple clients can also be given the same view, or views offset in different directions so that each client drives a different screen, to create a more immersive multi screen setup.

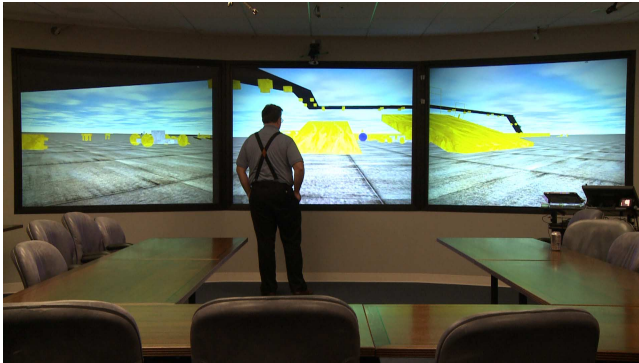


Figure 2. Multi display of circus scene.

2.1 User Input

Once a scene has been defined and the simulation is running, users may interact with the scene via various input methods. The simplest method is the use of the keyboard and mouse. The keyboard can control navigation in the virtual world and trigger some actions such as shooting balls. The mouse can control navigation and the camera view. Sliders can control aspects of the virtual world such as gravity, default friction, and can control ‘motors’ which apply forces within the model. The user may control the circus using a Joystick or Wiimote.

Another input method uses the SensingUI technology developed at FX research that can track the position and orientation of small badges containing infrared red light emitting diodes in known configurations [2]. The SensingUI supports multiple badges and determines the unique ID of each badge and the 6 degrees of freedom pose of the badge. Scripts can map the tracked degrees of freedom of the badges to control dynamical variables in the model. For example, if the badge is placed on a rigid body, the system can determine the position of that body, and apply forces to move a virtual surrogate of the body to a desired position. This method can be used to control simple systems such as robot arms.

Another method of control uses tracking by an overhead camera. In our main meeting room we can use an overhead camera to track the position of someone standing under the camera and in front of three large screens. This method can be used to control the position of an ‘avatar’ or to apply forces to a body on a swing.

In addition to user input for generating forces to control models, inputs generated from audio analysis can also be used. For

example, we have explored the use of beat analysis of music as input, using the VAMP audio analysis modules [3].

2.2 Content specification

Virtual Physics Circus allows content to be specified by a markup language or via Python scripts. This language supports definition of geometries, physical bodies, joints, and ‘motors’ that apply forces or torques. Scripts can be used to define extra-physical behaviors; for example the collision of a ball with a certain geometry may trigger the application of a force or the introduction of new bodies.

3. Description of video

The video opens with a simple double pendulum. While the bars and joints that make up the double pendulum are easy to describe, its dynamics are complex and beautiful. Using a slider or joystick interface, a user can apply forces to the block to get the double pendulum to perform tricks. In the process, the user learns about the physics of a double pendulum system.

Instead of user input, the double pendulum can be controlled by music. We hooked up a simple beat detector [3] and apply force to the double pendulum on each beat enabling the pendulum to dance to the music.

A simple joystick interface enables a user to control a simple cart to perform tricks like wheelies, or balancing on two wheels while moving. The physics of bicycles is quite complicated. The user can play with bicycles of various styles to understand their relative maneuverability and stability.

We designed a two armed rover that can be driven over to objects which can be manipulated by two arms controlled by the SensingUI. The Sensing UI controls the pitch and yaw of the arms as well as the length. This rover is used to move a table out of the way so that an interesting dynamical interaction occurs. Another style of rover, with hinged arms, instead of slider arms, is used to lock on to an object and move it.

The video ends with a scene showing a variety of terrains, cannonball fountains, domino trails, conveyor belt systems and parts sorters, a model of our building, and various vehicles both conventional and highly unconventional.

4. ACKNOWLEDGMENTS

Many thanks to FXPAL for supporting this work. We also thank Yasuji Seko and FX research for providing the SensingUI.

5. REFERENCES

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