Softly Elastic Device for 6DOF Input

Zlatko Franjcic, Marcin Anglart, Martin Sundin, Morten Fjeld
TableTop Interaction Lab (www.t2i.se), CSE, Chalmers University of Technology, Sweden
zlatko@franjcic.name, anglart@itstud.chalmers.se, martin.sundin@axiglaze.com, morten@fjeld.ch

ABSTRACT

A central component of 3D computer applications is the six degrees of freedom (6DOF) in interaction with the virtual environment. In recent years, 3D computer graphics have been widely adopted, even in traditionally 2D applications such as web browsers and window managers. Along with this development, the need for multidimensional input devices has increased and prompted the proposals of several novel input concepts and devices for different kinds of applications. In this paper we present a prototypical showcase application for the SpaceCat, a softly elastic six degrees of freedom input device, in order to demonstrate its suitability for game applications where precise short-range movements are required. The application shows how sword handling and camera control can be performed with the SpaceCat.

Keywords

Six Degrees of Freedom, Softly Elastic Computer Input, Rate Control, Position Control, Virtual Environments, Computer Games, Motion Capture

1. INTRODUCTION

With the widespread use of advanced computer graphics and sophisticated visualization and interactive tools in human computer interaction, a new class of multiple degrees of freedom (DOF) input devices has followed. Such devices offer novel ways of interacting with virtual environments. A major challenge in designing these devices is defining useful parameters and features that bridge the gap between conventional mouse and keyboard oriented user interfaces (UIs) while still meeting the growing demands of interaction with virtual environments.

A key feature in many devices tailored to three dimensional (3D) applications is the six degrees of freedom (6DOF) in motion control. These are usually defined as the translation along and rotation about the three perpendicular axes (x, y, z) defining 3D space. Another characteristic of any input device is its stiffness which is generally regarded as isotonic, elastic, or isometric. Isotonic implies no stiffness or self-centering at all (i.e. the traditional mouse device), while isometric is attributed to devices with infinite stiffness. Elastic devices can be further sub-divided into softly elastic and stiffly elastic ones.

SpaceCat was first introduced as the outcome of a research project [1] and later as a commercial product. It is a 6DOF input device with a range of motion adapted to finger manipulation and softly elastic suspension providing rich sensory feedback (Fig. 1). It is experimentally proven that these properties benefit short-range tasks with high precision requirements for 3D object manipulation as well as 3D navigation [1].

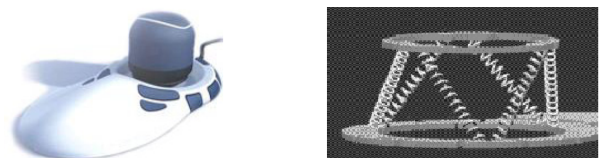

Figure 1 The SpaceCat 6DOF device (left). The handle is suspended with inductive metal springs (right); these springs also serve as sensors [1].

The aim of using SpaceCat[1] for games[2] is to provide prototypical applications wherein the proven benefits of the softly elastic 6DOF input device [1] are showcased. Using advanced computer graphics and simulated physics to enhance user experience and immersion, this will place SpaceCat in an environment close to its potential market. The following section briefly introduces the concepts of position and rate control and relates them to application domains such as motion capture and gaming. This is followed by implementation details of a sword fighting application. The last section summarizes the results and gives an outlook on future research.

2. SpaceCat USE CASES

It can be assumed that SpaceCat is beneficial to both position and rate control in up to six degrees of freedom [1]. Next, we present some cases of usage where these properties may benefit 3D interaction.

Position control with the dominant hand is suitable for tasks requiring precise control within a small range of virtual motion, e.g. *motion capture* of a puppet's body part (Fig. 2, left). The manipulated degrees of freedom depend on the body part. For example, the head requires three rotations whereas the hands and feet need interaction in five or six degrees of freedom. The hips can probably be connected to all 6DOF since the body parts connected to hips give sufficient depth cues. Other examples include *fine positioning of objects or light sources*, which can take place in 5 or 6 DOFs depending on whether or not sufficient depth cues are present, and *modeling*, i.e. manipulation of a control mesh for NURBS or surface splines, e.g. extruding faces in 5 or 6 DOFs or 3D manipulation of vertices or edges.

Rate control with the dominant hand is suitable for *motion capture of camera paths and light animations*. Rate control with the non-dominant hand is suitable for *low precision navigation.* This is how 6DOF input devices are being used in CAD, i.e. navigating the scene with a SpaceCat, while selecting objects and adjusting their parameters is performed with the mouse.

Position control with the non-dominant hand is suitable for *adjusting the view port while an object is being manipulated*. This

[1] SpaceCat is currently distributed under the name Monkfish 3D Desktop Controller, http://www.monkfish.se

[2] Video presentation: http://www.t2i.se/pub/media/2008_6DOF.mpg

might allow for faster work than rate control with the non-dominant hand, as currently used in CAD. The actual manipulation could be done with the mouse like in today's CAD or even with a second SpaceCat.

In some cases a combination of position and rate control for different degrees of freedom could be advantageous, e.g. rate control for translations and position control for rotations in architecture or game applications. It would create a flying helicopter metaphor using rate control to regulate the speed of the helicopter while turning the viewpoint (the head of the pilot) with position control. For the translations, rate control would be needed for movements over long distances. For rotations, there is hardly ever a need for a large range of virtual motion since any rotation can be achieved with 180° or less. Another example is rate control for controlling the depth or forwards direction and position control for all other DOF in a first person shooting game such as Acclaim's[3] Forsaken (Fig. 2, right). In this game the player navigates narrow passages and needs to control his speed, while at the same time targeting enemies through quick and precisely controlled sideways translations or rotations.

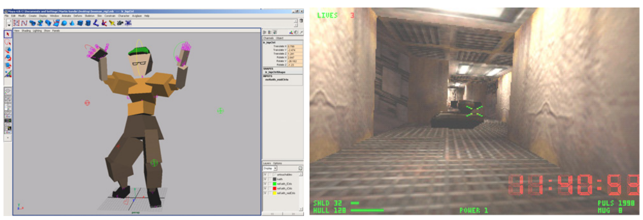

Figure 2 Two example applications: motion capture application (left); a scene from the game Forsaken (right).

In furthering the idea of using SpaceCat for games – where precise short-range movements are required – we next present a prototypical sword fighting application. Sword handling mainly features position control with the dominant hand and realizes a 3D simulation of a virtual environment with physics, lighting, and other customizable features such as model loading and modification utilities.

3. SWORD FIGHTING APPLICATION

As a basis for realizing the sword fighting application the open source Java-based 3D engine, jMonkeyEngine (jME)[4], was used. This 3D engine accounts for a wide set of libraries supporting graphics development and advanced 3D application management. It also includes an interface for connecting input devices under Microsoft Windows employing Direct Input[5] through a layer of Java. Physics simulation is provided by the jMEPhysics[6] extension for jME. Based on jME's standard game template, a virtual environment with a built-in customization tool was implemented. Models of an arm and a sword were created using Autodesk VIZ[7] and exported to a format supported by jME's model loading system. The arm model consists of four parts which are linked together through joints provided by the physics engine in order to obtain a more natural movement. The virtual environment consists of a height map with natural texture, a skybox, and visual effects such as lighting/shadows and lens flare. An accompanying video[2] and video screenshots (Fig. 3) show the current state of the application. The SpaceCat can be used in two distinctive ways, both of which are presented in this video[2]. Firstly, smaller deflections only affect the sword (Fig. 3), allowing the sword to be moved with all 6DOFs. Secondly, larger deflection combined with a relatively low device movement delta (i.e. the device is close to or fully stationary) affects the camera as well, controlling camera yaw, pitch, and roll.

Figure 3 Basic movements: Left deflection of the device moves the sword to the left (left); right deflection of the device moves the sword to the right (right).

Even though basic camera control was implemented, navigation using the SpaceCat is limited to rotations of the camera. Navigational tasks involving camera translation still need to be performed using mouse and keyboard. Also, we found that although the SpaceCat device has a number of buttons which could be used to switch between object manipulation and navigation mode, they are arranged on the device in such a way that renders it nearly impossible to operate the device with only one hand. Therefore we decided not to implement such functionality but rather use the keyboard and mouse for navigation, a feature already provided by jME.

4. SUMMARY AND OUTLOOK

In this paper, we have shown the need for softly elastic six degrees of freedom (6DOF) input devices for use with virtual environments. This was followed by a brief introduction to position and rate control in such environments. Particular focus was given to the use of 6DOF input in the cases of motion capture and game applications. Some implementation details of a sword fighting application were presented. In its current state the sword fighting application is used to demonstrate the SpaceCat's most prominent features. However, there are some issues that derogate from a completely satisfactory user experience. 6DOF devices, and more generally, a new generation of input devices, have evolved to such a level that they are on the market and are widely used for CAD tasks and gaming. With several successful devices already available – such as the Nintendo Wii – it would be of interest to more closely study one or several such devices comparatively with the SpaceCat. Such comparative studies would help contrast the devices' mutual strengths and weaknesses, as well as provide insight about the usability of the SpaceCat device as compared to a leading market product. Besides the comparative and software implementation issues, there is a lot to investigate with regard to the physical appearance of 6DOF devices, both in terms of ergonomics and usability.

5. REFERENCES

[1] Sundin, M., Fjeld, M. (in press): Softly Elastic 6DOF Input. To appear in *Int. Journal of Human-Computer Interaction*.

[3] http://www.acclaim.com

[4] http://www.jmonkeyengine.com

[5] http://www.microsoft.com/directx

[6] https://jmephysics.dev.java.net

[7] http://www.autodesk.com/viz