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12DoF Interaction for Scientific Visualisation

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Abstract

This short extended abstract investigates human-computer interactions in relation to a specific Six Degree of Freedom (6DoF) input device; described is the driver development and calibration required for a novel piece of hardware; and after initial user tests and a questionnaire of satisfaction, we consider areas for further research. This abstract concludes with a discussion of the design and use of dual-6DoF input devices and from feedback how new interaction modes will be exploited.

CCS Concepts

•***Information Interfaces and Presentation*** → *User Interfaces;* •***Computer Graphics*** → *Picture/Image Generation; Application packages; Methodology & Techniques; Computational Geometry and Object Modeling;*

1. Introduction

A common part of computer graphics visualisation, for video creation and 3D data exploration, is to create realistic and easy to control motion. In order to achieve this purpose, various physical rigid bodies have been used which enable an object to act according to physics-based rules. Any possible movement of a rigid body, no matter how complex it is, can be expressed as a combination of three translations and three rotations, defining the basic six degrees of freedom (6DoF) [BKLP04].

This work investigates human-computer interactions in relation to a specific single 6DoF input device called the "Wing", and after evaluation with a test group, including a brief satisfaction questionnaire, we present in this extended abstract a future research project, with industrial support, which aims to develop ideas for faster and improved interactions when using two Wings.

The Wing was developed by Worthington Sharpe Ltd., and combines full 3D control of a precision computer mouse, including a degree of vertical movement (so has all *x*- *y*- and *z*- directions); with the 3D control of a complete roll, pitch and yaw (3-axis) joystick. It aims to meet the demands of computer aided design software, Virtual Reality and simulation or training games. Commercially it has an application in control of UAVs (unmanned air vehicles) where the two functions of mouse and joystick are often considered separately. The Wing is ideal for any application requiring the speed and accuracy of a high-end mouse, as well as a free-flowing joystick, all from just one hand. It has the extra advantage of being a single, compact and easily portable device so ideal to take out into the field.

Although this device extends the functionality of a mouse and joystick creating obvious advantages, it has the anomaly of creating a single device that is a combined isotonic and isometric viscous input device. An isotonic device is a displacement or free moving device which often has zero or constant resistance (e.g. a mouse) allowing the user to be connected to the machine through movement; and an isometric device is one that senses force but does not often perceptibly move (e.g. a desktop joystick), as a result users are connected to the machine through force/torque [Zha95, LM10]. These are potentially contradictory in feel and use; and may require levels of user training in order to be comfortable with their combined use.

2. Scientific Visualisation

To evaluate the combined device it was integrated into a scientific volume exploration tool, Drishti created by Ajay Limaye [LIM12], by writing a custom Python based controller daemon driver [San16]. The Wing device is seen by the PC as a single USB combined mouse and joystick. The daemon comes into its own as it can also calibrate the inputs as well as monitor the levels of change for all the 6DoF. This proved useful as the three Hall-effect sensors to control the 3-axis joystick functions, due to physically different orientations, need separate calibration curves, as opposed to those from the default Windows Game Controller functions (see Figure 3). The software daemon can then connect to various input functions of the volume visualiser so users could perform unusual simultaneous actions such as:

- Positioning and rotating the 3D object (full 6DoF) with one hand, and changing zoom values from the keyboard with the other hand.
- With one hand create free flowing animation paths that are po-

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Figure 1: *Wing 3D computer input device with schematic control features for all 6DoF; roll, pitch, yaw, x-, y- and z. Also shown are top and side buttons and a scroll wheel that are all configurable.*

tentially more aesthetic and faster – rotating and positioning of the 3D object simultaneously.

- Controlling on one hand the viewing direction of a directional light source (roll-pitch joystick function) and then with the mouse changing the colour of the light source using an imaginary colour wheel on the *x-y* dimensions.
- Controlling a clipping plane with the normal of the clipping plane being controlled by the (roll-pitch) joystick components and the position from along the normal controlled by the *x*-direction of the mouse.

To summarise, current users of visualisation systems often have to exploit a single mouse and contrived keystrokes for even the simplest of data exploration and animation task which can now be done with one hand.

3. Initial Evaluation Process

An initial test with 9 users was carried out that asked them to match known views from a different starting point, [Zha95], so speed and accuracy could be measured, and afterwards a (Likert scale) questionnaire was completed to assess comfort. In summary, the majority of the users (5) felt they did "very well" in completing the required tasks and (4) felt "neutral". All the users agreed they would want to buy the Wing for playing video games more than use it in

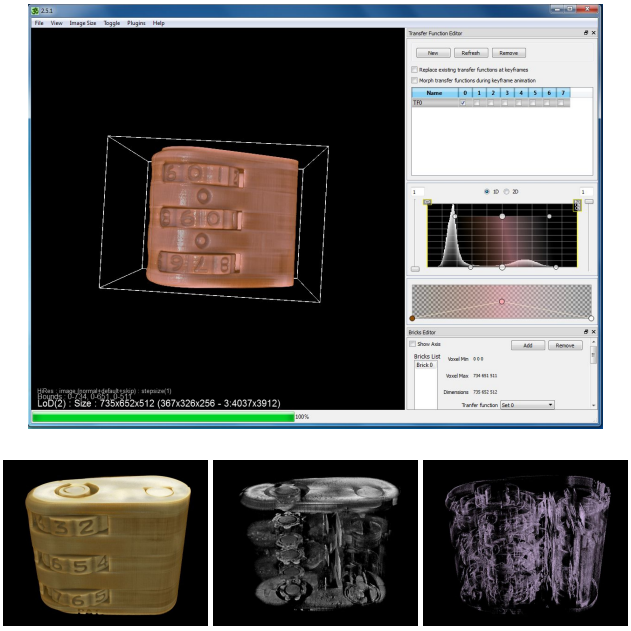

Figure 2: *Volume visualisation integrated within the Wing device showing some of the API commands available and also illustrating the interactive 2D histogram transfer function manipulator with three results. In this example it clearly shows the internal pin mechanism for a dual-lock homeland securite padlock, highlighting, as well as the combination also defects in the metal casting.*

their day-to-day work and gave a "reasonable price range" of 10 to 50 pounds. Moreover, the evaluation test with the users showed that the Wing is relatively easy to be used producing a "pleasant" experience; although one stated that the "button's position was not optimal" which could be because of hand size. The users were generally impressed by the design of the Wing and by the fact they have a tactile response when they rotated the object.

4. Future Work: extension to the Wing

A more extensive survey and evaluation is planned on a larger user group. There are extensions available to be explored within the device and the survey asked for details which are being taken forward and descibed here.

The Wing has a series of buttons, as well as a speed wheel, which can be programmed so any frequently used function or user defined keyboard macro can be integrated. From suggestions interesting additions to the functionalities of the Wing include:

- object selection, done previously using a keyboard, can now be done via the buttons, with the same hand that then can manipulate the object.
- users want to control multiple scientific visualisation parameters that are often on-off or pre-programmed and this would include changing or enabling clipping plane and object transparency when needed.

Now the other hand is free from keyboard use there is the option

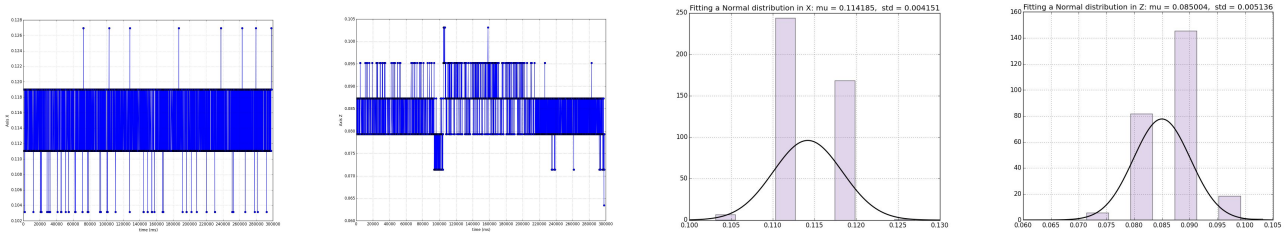

Figure 3: *Statistics and calibration of the pitch and yaw values without any force/torque applied show the requirements for a dual level driver deamon.*

for connecting two Wing devices. This means two hands can control 12DoF simultaneously and potentially intuitively – with some training.

- Full 6DoF fly through of an object can be carried out controlling both camera looking direction and movement directions with one hand on one device; simultaneously while manipulating on a second controller the object to be viewed or the lights. This allows a single operator to be cameraman and lighting rig operator at the same time.
- Control of multiple lighting rig units can be mapped to the 12DoF available and then manipulated simultaneously.
- There is a need to control object rotation and position while changing clipping or brick excavation features simultaneously. As any parameter can be mapped to the 12DoF available this repertoire of functions is very large.

Initial work has only considered manipulation and visualisation in terms of animated movement. An important future work proposed will involve the ability to control and create volume visualisation, transfer functions. Figure 2 shows the interface for interacting (small right hand panel) to create a transfer function on top of a 2D histogram. This results in a coloured curve that can be defined as a multi-dimentional B-spline. From user demand and request we plan on having the ability to use the 12DoF to control this B-spline and initial tests show (bottom images of Figure 2) morphing between three different transfer functions.

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