Using Smartphones as 3D Human Interface Devices

Problem statement

Navigating and interacting with objects in 3d environments using desktop PC peripherals is not easy for a novice user.

Problem Description

As computing devices become more and more capable in terms of rendering 3D objects, new ways of interacting with digital systems are becoming possible.

These include

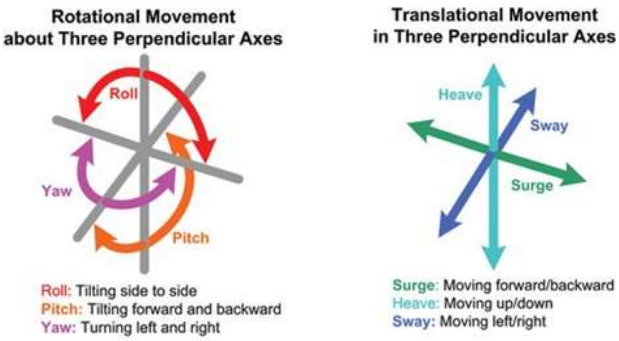
- Exploring 3D recordings of interior and exterior spaces
- Visualizing and interacting with data in 3D
- Viewing and navigating 3D maps
- 3D CAD and sculpture

Despite continued advances in 3D rendering capability, the means by which we interface with desktop computing devices and laptops has not significantly changed in the past decades. The technologies used to achieve this Human-Device interaction are normally referred to as Human Interface Devices: These can be broadly categorized as follows:

- Keyboard
- Mice or trackballs
- Trackpads
- Touchscreens
- Game controllers

Degrees of Freedom

With most of the above HIDs a significant challenge that presents itself is how to move around in a 3D space while simultaneously being able to look around. This ability to move is often described in terms of 'Degrees of Freedom', with 2 principals categories defined as Translational and Rotational freedom.



Examples of using existing HID solutions to deliver 4-6 DOF

First Person games

In the case of desktop first person computer games (where the camera view is mapped to the players characters field of view). 4 Degrees of freedom are generally achieved by using mouse movements to roll and yaw the camera with keyboard keys used to move the camera forwards/backwards, left/right within the 3D space. In some cases, additional keys might be used to allow the camera to move vertically upwards and downwards. In the case of console games, 2 joysticks are often used with one stick controlling rotation and another controlling translation.

3D CAD

However, for some applications, this approach is not appropriate. In the case of 3D CAD tools, the mouse pointer must be used to select menu options and interact with the 3D object being manipulated, so it cannot be used solely for camera movement. As a result, CAD tools often use several keyboard keys or mouse button to modify the mouse input function to allow for rotation, yaw and translation of the camera.

In both of the cases above, it's rare to see 6 degrees of freedom made accessible to the user and where these options are made available, it requires application specific knowledge to make these functions accessible.

Existing solutions to deliver 6DOF

For professional purposes, several options are available to provide 6 DOF camera control, in particular '3D Mice' are often used by CAD designers and digital artists. However, these tools are both expensive and require specific experience and/or training to be useful.

Figure 1 Example of 3D Mouse

Learning form Virtual Reality

The burgeoning field of consumer virtual reality headsets has spawned a variety of new paradigms for interacting with 3D Digital environments.

In particular, the use of handheld controllers that allow the user to directly interact with the 3D environment has exposed a number of new means of movement and interaction. A popular means of using these controllers is to use them as a virtual laser pointer, where the pointer is used to select and interact with game elements and also to 'teleport' the camera to a new location.

Point to move (teleporting)

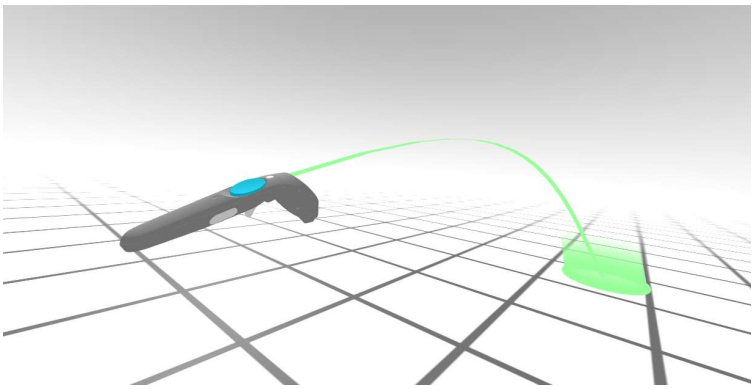


Figure 2 Using a VR controller to Teleport to a new location

Point to select

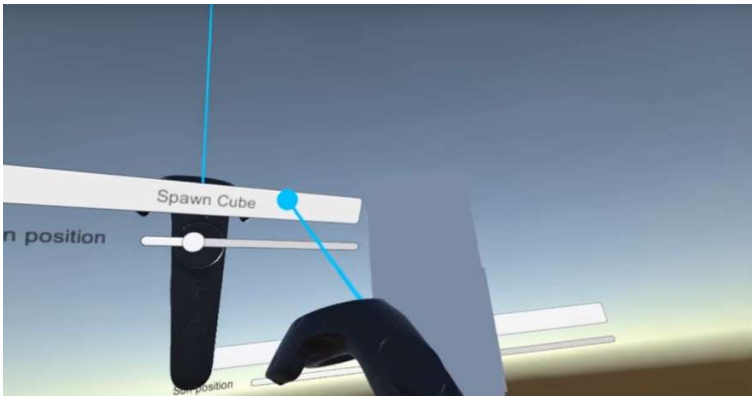


Figure 3 Using a VR controller 'laser pointer' to select menus items

The key underlining technologies that allow these sensors to be used in this way are Bluetooth wireless networks, 3D localization (tracking) and Inertial Measurement Units (IMUs). These allow the device to be accurately mapped to a specific point in 3D space and for any translation or rotation of the controller in 'real-space' to be mapped to equivalent changes to a virtual object in the digital environment.

Smart Phones can be used as VR controllers

The same technologies that are used in VR controllers are also available in commodity Smart phones (although localization) is done using cameras and yet smartphones are not currently used for this purpose. In part this is because in some cases the Smart phone is used as part of a VR headset but also because the VR device ecosystems are relatively immature, so cross platform integrations have yet to be considered for mass market.

Delivering 5DOF navigation with a smart phone

It would be practical to create a Smartphone app that converts the phone into a 3D HID device that leverages the 9DOF IMU that is ubiquitous in Smartphones as well as specific touch screen functions that deliver trackpad features like pinch-zoom and 2-finger gestures as used in smartphone map applications. The rotation and movement of the phone itself could allow for a laser-pointer style selection and movement feature, similar to that of a VR controller.

Arguably, this would provide a more accessible and lower cost means of improving 3D navigation for desktop applications that is informed by the new paradigms exposed by VR controller development.

Other ideas.

3D printed cradle to make the smartphone easier to hold

Desktop cradle to attach smartphone to mouse as a ‘Hybrid’ HID device.