FORCE FEEDBACK INTERFACE HAVING ISOTONIC AND ISOMETRIC FUNCTIONALITY

BACKGROUND OF THE INVENTION

The present invention relates generally to interface devices for allowing humans to interface with computer systems, and more particularly to computer interface devices that allow the user to provide input to computer systems and provide force feedback to the user.

Computer systems are used extensively in many different industries to implement many applications, such as word processing, data management, simulations, games, and other tasks. A computer system typically displays a visual environment to a user on a display screen or other visual output device. Users can interact with the displayed environment to perform functions on the computer, play a game, experience a simulation or "virtual reality" environment, use a computer aided design (CAD) system, or otherwise influence events or images depicted on the screen.

One visual environment that is particularly common is a graphical user interface (GUI). GUI's present visual images which describe various graphical metaphors of a program or operating system implemented on the computer. Common GUI's include the Windows® operating system from Microsoft Corporation and the System 7.5 operating system from Apple Computer, Inc. These interfaces allows a user to graphically select and manipulate functions of the operating system and application programs by using an input interface device. The user typically moves a user-controlled graphical object, such as a cursor or pointer, across a computer screen and onto other displayed graphical objects or predefined screen regions, and then inputs a command to execute a given selection or operation. The objects or regions ("targets") can include, for example, icons, windows, pull-down menus, buttons, and scroll bars. Most GUI's are currently 2-dimensional as displayed on a computer screen; however, three dimensional (3-D) GUI's that present simulated 3-D environments on a 2-D screen can also be provided.

Other programs or environments that may provide user-controlled graphical objects such as a cursor include graphical "web pages" or other environments offered on the World Wide Web of the Internet, CAD programs, video games, virtual reality simulations, etc. In some graphical computer environments, the user may provide input to control a 3-D "view" of the graphical environment, i.e., the user-controlled graphical "object" can be considered the view displayed on the video screen. The user can manipulate the interface device to move the view, as if moving a camera through which the user is looking. This type of graphical manipulation is common in CAD or 3-D virtual reality applications.

The user interaction with and manipulation of the computer environment is achieved using any of a variety of types of human-computer interface devices that are connected to the computer system controlling the displayed environment. In most systems, the computer updates the environment in response to the user's manipulation of a user-manipulatable physical object ("user object") that is included in the interface device, such as a mouse, joystick, etc. The computer provides feedback to the user utilizing the display screen and, typically, audio speakers.

Presently, there are two types of interface devices which use different sensing modes and different mappings to allow a user to interact with and manipulate a computer environment: isotonic sensing devices and isometric sensing devices. Isotonic sensing utilizes motion of a physical user object in physical space in predefined degrees of freedom to provide input to the computer. For example, a mouse is an isotonic controller often used to control a cursor in a GUI. The mouse may be moved in two degrees of freedom in the plane of a mousepad or other surface, and the cursor on the screen is moved directly in response to the movement of the mouse. A joystick is another example of an isotonic controller, where the movement of the stick in rotary or linear degrees of freedom of physical space is sensed and input to the computer. Other isotonic interface devices include trackballs, styluses and tablets, steering wheels, etc.

In contrast, isometric sensing utilizes a user's force or pressure on the user object rather than the movement of the user object through physical space. The force magnitude and direction that the user exerts on the interface device is sensed and input to the computer to be used in the manipulation and interaction of the computer environment. For example, the "Space Ball" from Space-Tec and the "Magellan" from Logitec are common isometric controllers. The Space Ball is a sphere having pressure sensors provided between the ball and the mounting surface. When the user touches the sphere, the sensor detects the direction and magnitude of force exerted by the touch. In ideal isometric sensing, there is no perceived deflection of the user object in response to the user's pressure. However, if there is a small amount of deflection or movement in the user object perceived by the user, the sensing can be referred to as "elastic" control. In many cases, isometric controllers are actually elastic controllers, since there is a small amount of deflection of the user object by which the magnitude of force is measured. Some users prefer this small deflection, as it provides some intuitive feedback as to the degree of pressure applied by the user. In many cases, elastic controllers have been found to induce smaller errors in user manipulation of computer objects than pure isometric controllers.

Human factors research has shown that isotonic controllers excel at position control tasks, while isometric controllers are more intuitive for use with rate control tasks. "Position control" refers to a direct mapping of the position of the user object with a user-controlled graphical object. For example, a cursor in a GUI is controlled with a mouse under a position control paradigm, since the cursor is moved a distance corresponding to the distance the mouse is moved. "Rate control," in contrast, refers to an indirect or abstract mapping of user object to graphical object. For example, scrolling text in a window or zooming to a larger view in a window of a GUI are rate control tasks, since the scrolling and zooming is not directly related to the position of a mouse. Similarly, the controlled velocity of a simulated vehicle is suitable for a rate control paradigm.

A problem with the current use of isotonic controllers, such as mice and trackballs, within GUI's and other graphical environments is that both position control and rate control tasks are required in a single computer environment. For example, as described above, a GUI includes many position control tasks such as target acquisition, i.e., moving the cursor onto icons, buttons, menu items, text, etc. An isotonic controller such as a mouse is ideal for these types of interactions. However, other GUI interactions, such as scrolling text, zooming, panning/rotating a view, or sizing, are more appropriate for a rate control interface. To provide simple rate control interactions using an isotonic controller, several graphical metaphors have been invented. For example, in a position control interface, sliders are displayed which can be moved using a mouse to allow the scrolling of