restoring force based on equation (1) can be applied. However, if the deviation direction is angularly incident on surface **358**, then a fraction of the magnitude F of the restoring force calculated by equation (1) might be applied.

After the restoring force is determined in step **502**, step **504** is implemented, in which the process checks whether one or more overlay forces are associated with the determined restoring force. Overlay forces, also known as "effects", are forces applied to the user object in addition to the restoring force and may be used to provide information to the user or provide some other effect. Overlay forces may include such force sensations as jolts, vibrations, wobbles, etc.

For example, a graphical surface **358** may provide a restoring force to control the scrolling of a text document, as described above. The restoring force associated with the scrolling is a background "condition" and can also include an overlay jolt "effect" when particular types of information scrolls by in the window. For example, when a page break **518** (see FIG. **10**) in the document **352** scrolls by, a jolt can be overlaid on the restoring force to indicate this page break to the user through haptic means. The faster the document scrolls by, the faster are the jolts applied to the user object. Similarly, overlay jolts might be provided at the limits of movement, such as when a view is fully zoomed. Thus, the user can more easily track the progress of the isometric function through the use of these force cues combined with the user's visual sense. Also, the magnitude of such jolts can be varied for different situations. For example, when the end of the document is reached in a scrolling window, a larger magnitude jolt than a page break jolt can be output to indicate the end of the document. In other embodiments, a vibration overlay can be used to represent the velocity of scroll, pan, or zoom function. For example, the faster the document is scrolling by, the higher the frequency of the vibration. Other vibrations or jolts might be position related, i.e., when the cursor moves over a line or object, a jolt, texture, etc., is output. Some functions, objects, etc. may have two or more overlay forces associated with them, such as both jolts and vibration.

One or more overlay forces can be associated with a particular restoring force in isometric mode. For example, an overlay force might only be associated with the restoring force for a text scrolling function, and not, for example, a panning or zooming function. Likewise, a zooming function might have a texture or vibration overlay force associated with its restoring force.

If the determined restoring force has an associated overlay force, then the process continues to step **506**, where the process checks whether the current conditions suggest the application of an overlay force. In the example above of providing jolts when a page break scrolls by, this step would check if a page break was currently in a position to dictate applying a jolt. For example, if a jolt is to be applied when page break **518** reaches the top (or center) of the window **350** in which the document is scrolling, then this step checks whether a page break is at the top of the window. Or, a texture or jolt force might be applied when the cursor **306** moves over lines of gradation displayed near surface **358** to indicate to the user the degree of deviation of the user object. Some overlays, such as a vibration proportional to speed of scrolling, might always be applied in isometric mode and not be specific to a condition.

If the current conditions do not suggest applying an overlay force, then the process continues to step **508**, where a TOTAL FORCE is set equal to the restoring force determined in step **502**. The process then continues to step **512**, described below. If the conditions do suggest applying an overlay force, then in step **510** the process adds the applicable overlay forces to the restoring force determined in step **502**, where the resulting force is equal to TOTAL FORCE. The process then continues to step **512**.

In step **512**, TOTAL FORCE is output to the user object **12** using actuators **222** in the appropriate directions and having the appropriate magnitude. The user experiences the restoring force as a resistance to motion, combined with any overlay forces included in the output force. The process is then complete at **514**.

While this invention has been described in terms of several preferred embodiments, it is contemplated that alterations, permutations and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. For example, many different types of forces can be applied to the user object **12** in accordance with different graphical objects or regions appearing on the computer's display screen. Also, many varieties of graphical objects in a GUI can be associated with particular isotonic and isometric forces, and many other types of computer and graphical environments can make use of the isotonic-isometric functionality disclosed herein. In addition, many types of user objects and mechanisms can be provided to transmit the forces to the user, such as a joystick, a mouse, a trackball, a stylus, or other objects. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention. It is therefore intended that the following appended claims include all such alterations, permutations, and equivalents as fall within the true spirit and scope of the present invention.

What is claimed is:

1. An interface device allowing isotonic and isometric interaction with a host computer system from a user, the interface device comprising:

a user manipulatable object physically contacted by a user and movable in physical space in at least two degrees of freedom with respect to a ground;

a sensor operative to detect said movement of said user manipulatable object in physical space in said two degree of freedom with respect to said ground;

an actuator coupled to said user manipulatable object operative to apply an output force in at least one degree of freedom of said user manipulatable object;

a mode selector for selecting an isotonic interaction mode and an isometric interaction mode of said interface device, wherein said isotonic mode provides input to said host computer system based on movement a position of said user manipulatable object in said physical space, and wherein said isometric mode provides input to said host computer system based on an input force applied by said user to said user manipulatable object, said input force being determined based on said movement detected by said sensor in a direction opposing said output force generated by said actuator.

2. An interface device as recited in claim **1** wherein said input force applied by said user is detected based on a measured deviation of said user manipulatable object in physical space from locally-defined origin.

3. An interface device as recited in claim **2** wherein said mode selector includes a physical button provided on said user manipulatable object.

4. An interface device as recited in claim **2** wherein said mode selector includes an interaction between a user-controlled graphical object and a different graphical object, said graphical objects being displayed on a display device of said host computer system.