

TACTILE FORCE FEEDBACK DEVICE

BACKGROUND OF THE INVENTION

[0001] This invention relates to force feedback devices. In a computer system, a visual environment is shown to a user on a display with which the user can interact to perform functions on the computer through a user manipulable device or an input device such as a mouse, a trackball, a joystick, or the like. The user can interact with the computer to operate a graphical user interface, play a game, perform file manipulation, and the like. The user receives visual and/or audio feedback from the computer during the interaction. Providing force feedback to the user further enhances the user's experience of the simulated or virtual environment created by the computer. For example, the impact of an object against a virtual wall in the simulated environment during user manipulation may produce a force feedback to the user to feel the impact of a hard object against a wall. A force feedback interface device provides physical sensations to the user through the use of computer controlled actuators in the interface device.

SUMMARY OF THE INVENTION

[0002] The present invention is directed to a simple and effective tactile force feedback mechanism for a user manipulable device. In accordance with specific embodiments of the invention, the user manipulable or interface device has the capability to effect tactile screen boundaries, as well as virtual walls which correspond to button bar functions or icon placement on a drag-down menu. For instance, the device may produce force feedback by increasing and decreasing resistance to further manipulation or movement of the interface device by the user or by aiding motion of the interface device, by increasing and decreasing the vibration or impact force sensed by the user's hand on the interface device.

[0003] In accordance with an aspect of the present invention, a tactile force feedback apparatus for an input device comprises an inertial member having a movable portion being movable relative to the input device. A magnetically actuatable member is connected to the movable portion of the inertial member. A magnetic driver is configured to generate a magnetic field to move the magnetically actuatable member and the movable portion of the inertial member with respect to the input device to generate tactile force feedback in response to a user's manipulation of the input device.

[0004] In some embodiments, the magnetically actuatable member is a permanent magnet or a metallic member. The magnetic drive comprises an electromagnet fixed to the input device. The magnetically actuatable member is connected to the movable portion of the inertial member to be movable by the magnetic driver in a generally linear manner. The movable portion of the inertial member comprises a contact member movable to strike the input device. The contact member of the inertial member is movable between two surfaces of the input device to strike at least one of the two surfaces. The magnetic driver may be configured to generate a magnetic field in synchronization with a graphical user interface.

[0005] In accordance with another aspect of the invention, a tactile force feedback apparatus for an input device com-

prises an inertial member having an attachment portion attached to the input device and a movable portion being movable relative to the input device. A magnetically actuatable member is connected to the movable portion of the inertial member and being movable with respect to the input device in a substantially linear manner by a magnetic field generated in response to a user's manipulation of the input device to move the movable portion of the inertial member to produce tactile force feedback.

[0006] In accordance with another aspect of the present invention, a tactile force feedback apparatus for an input device comprises an inertial member having a movable portion being movable relative to the input device. A contact member is connected to the movable portion of the inertial member. A magnetically actuatable member is connected to the movable portion of the inertial member and being movable with respect to the input device by a magnetic field generated in response to a user's manipulation of the input device to move the contact member and the movable portion of the inertial member to produce tactile force feedback in a contact mode and in a noncontact mode. The contact member makes contact with the input device during movement in the contact mode. The contact member moves in vibration without contacting the input device during movement in the noncontact mode.

[0007] In some embodiments, the contact member comprises an elastomeric material. The contact member is movable to make contact with the input device at a plurality of different contact locations during movement of the contact member. The input device comprises an elastomeric material in at least one of the contact locations. The contact member comprises different contact portions for making contact with different contact locations of the input device, and wherein the different contact portions comprise different elastomeric materials. The different elastomeric materials have different durometer levels.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a perspective sectional view of a mouse device having a tactile force feedback mechanism according to one embodiment of the present invention;

[0009] FIG. 2 is a front sectional view of the mouse device of FIG. 1;

[0010] FIG. 3 is a front sectional view of the mouse device of FIG. 1 illustrating a top striking position of the inertial member;

[0011] FIG. 4 is a front sectional view of the mouse device of FIG. 1 illustrating a bottom striking position of the inertial member;

[0012] FIG. 5 is an exploded perspective view of the mouse device of FIG. 1;

[0013] FIG. 5a is a schematic view of the contact member according to another embodiment of the present invention;

[0014] FIG. 5b is a schematic view of the top and bottom sides adjacent the contact member according to another embodiment of the present invention;

[0015] FIG. 5c is a sectional view of the inertial arm integrally formed with the key button plate according to another embodiment of the present invention;