

[0046] The haptic display may include a plurality of haptic devices each of which generates tactile pattern independently.

[0047] A plurality of the haptic displays may be located within the body of the mobile apparatus, attached to movable parts or actuate movable parts of the mobile apparatus.

[0048] By providing the haptic devices under the respective button area displayed on the display screen, it is possible to stimulate the specific button in response to the user-input-operation and directly give the user's finger the tactile feedback.

[0049] Alternatively, various graphic elements may be displayed on the display screen instead of the button in order to accept user's input operation.

[0050] The signal producing unit can apply arbitrary electric signal to the haptic display so that the force patterns can be changed. The signal producing unit may also generate signal of the voltage function that expresses the resultant data from the data processing unit.

[0051] The haptic apparatus can be embedded into the pen that is used for data input in information processing systems where visual screen is enhanced with pen input capability. The user can control information system by interacting with screen interface using a pen. The user will then receive tactile feedback from the pen. Another possibility is when a separate tablet-style input device is used for interaction.

[0052] More specifically, a pen-type apparatus enhanced with the haptic actuator may be used in combination with on-screen visual interface to facilitate input and control of data in computer systems, such as tablet-type computers, touch screens, as well as any other computing devices that facilitate the use of the pen-type apparatus as an input device.

[0053] The present invention is not limited to the pen-type apparatus, and may also be applicable to any other type of input device that is held by the user.

[0054] The tactile feedback provided through the pen-type apparatus may be used to aid user in selecting small elements of graphical object comprised in the visual interface, such as slider controls, controls for creating graphics such as Bezier curves.

[0055] The tactile feedback provided through the pen-type apparatus may allow the user to feel elements of graphical object comprised in the visual interface before operating and modifying them.

[0056] The tactile feedback provided by haptic apparatus may be comprised of different wave shapes, the wave shapes depend on the screen interface elements that the user interacts with, such as graphical buttons, sliders, check boxes, graphical controls for moving interface elements on the screen, controls for creating and modifying computer graphics objects such as curves and others. Therefore, there is a strong correspondence between the visual interface and haptic feedback that the user received from the pen.

[0057] One particular method of interaction with interface elements is when tactile feedback is provided before the user start interacting with a graphical control, and then different tactile feedback is provided after the user started interacting with graphical controls.

[0058] According to another aspect of the present invention, there is provided a system including a main apparatus having a visual interface function and a data input apparatus to be used in combination with the visual interface function. The system further includes; a data processing unit for executing data processing operation; a signal producing unit for producing a signal having a waveform defined by resultant data of the data processing operation in the data processing unit; one or a plurality of haptic actuator for generating tactile pattern, which is to be communicated to a user who touches the data input apparatus, in accordance with the signal produced in the signal producing unit; and an input/output unit for visual displaying data and detecting data input performed by the data input apparatus. Furthermore, the haptic actuator is placed in the data input apparatus, and the haptic actuator comprises a bending-type actuator having a multi-layer configuration.

[0059] The data input apparatus may be used for selecting an element of graphical object visually displayed on the input/output unit. Furthermore, the data input apparatus may provide tactile feedback before operating and/or modifying selected element of graphical object. Furthermore, the data input apparatus may provide different tactile feedback depending on an attribute of selected element of graphical object.

BRIEF DESCRIPTION OF THE DRAWINGS

[0060] The above and other objects, features and advantages of the present invention will become more apparent from the following description of the presently preferred exemplary embodiment of the invention taken in conjunction with the accompanying drawings, in which:

[0061] **FIG. 1** depicts a schematic diagram showing a hardware configuration of a mobile apparatus **100** embodying this invention;

[0062] **FIG. 2** schematically shows a physical configuration of the haptic device;

[0063] **FIG. 3** illustrates another example of the structure of the haptic device;

[0064] **FIG. 4** schematically shows the structure and the principle of the operation of the multiple layer piezoelectric bending actuator;

[0065] **FIG. 5** shows the haptic device as depicted in **FIG. 2** and **FIG. 3** installed into the flat type mobile apparatus like PDA;

[0066] **FIG. 6** also shows the haptic device as depicted in **FIG. 2** and **FIG. 3** installed into the flat type mobile apparatus like PDA;

[0067] **FIG. 7** depicts the pen type information handling apparatus that accommodates the haptic display;

[0068] **FIG. 8** depicts the pen type information handling apparatus that accommodates the haptic display;

[0069] **FIG. 9** depicts the mobile apparatus, that installs the haptic display **105**, applies the force on the user's hand that holds the apparatus;

[0070] **FIG. 10** shows the display screen that embeds the haptic device and applies the immediate tactile feedback directly to the user's finger;