

under the respective button area displayed on the touch panel display, 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.

[0121] The force patterns can be freely changed by applying arbitrary control signal to the haptic display. The signal producing unit **102** generates, in accordance with the resultant data from the data processing unit **101**, the control signal that is a voltage function of the time.

[0122] The force pattern can also be adjusted by changing the mass to be mounted on the piezoelectric actuator (see **FIG. 2** and **FIG. 3**). This can increase or decrease the speed of movement, and change force by changing momentum.

[0123] The haptic device of this embodiment is developed specifically as the user interface to be used into mobile or hand-held apparatus, such as PDAs, mobile phones, wearable computers, remote controls for personal musical machines, pen input based apparatus and soon. The reason is that the resulted tactile display is very small and can be installed even in very small appliances, such as remote controls for MD players.

[0124] When haptic device is used for information processing apparatus that has visual screen, such as tablet computers, PDA and others, the haptic feedback should be closely linked to the on-screen user interface. The tactile apparatus can provide different tactile response for different interface elements. **FIG. 11** shows an example for the user changing the shape of the curve by manipulating the small user interface controls. Tactile feedback is provided when user touches the user interface controls with a pen.

[0125] **FIG. 12** shows another example when user moves a slider user interface element and tactile feedback is provided when user selects the slider control element as well while the user moves it on the screen.

[0126] **FIG. 13** shows the user touching the graphical information on screen such as lines, when the user touched lines with the pen a tactile feedback is communicated to the user through the pen.

[0127] The user can receive feedback before interacting with on-screen user interface elements. **FIG. 14** shows the data flow diagram for such interaction. The pen position is monitored (step **S1**). When the pen input detects that the pen is over a interface element (step **S2**), a tactile feedback is communicated to the user informing that the user can select this element (step **S3**). When the user proceeds to select the element another (step **S4**), different tactile feedback pattern is communicated to the user to inform him that the interaction is started with the graphical user interface (step **S5**). This makes it easier to select graphical user interface element that the user wants to interact with.

[0128] A system for realizing the user interaction shown in **FIG. 14** may have the same construction as shown in **FIG. 1** except that the haptic display **105** is included in a pen-type apparatus separately provided from the main part of system. The main part of the system may include the data processing unit **101**, the signal producing unit **102**, the user output device **104** and the user input device **103**. In this example, the user output device **104** and the user input device **103** constitutes the touch panel display accepting data input and/or operation by the pen-type apparatus with the haptic display **105**.

[0129] The main part of the system and the pen-type apparatus may further include wired or wireless communication units for sending the signal from the signal producing unit **102** to the haptic display **105** so as to cause appropriate tactile feedback in accordance with a position of the pen-type apparatus on the touch panel display.

[0130] Alternatively, the signal producing unit **102** maybe placed in the pen-type apparatus, and the communication units transmits and receives the resultant signal from the data processing unit **101**. The resultant signal is inputted to the signal producing unit **102** placed in the pen-type apparatus.

[0131] The use of different tactile feedback pattern for different graphical interfacing elements may also be employed in applications that do not uses the pen-type apparatus. For example, the different tactile feedback pattern may be similarly generated at the touch panel display equipped with the tactile devices depending on the graphical interfacing element selected by the user's finger or any other touching device for selecting and manipulating data.

[0132] The present invention has been described with reference to the specific embodiments. However, in view of this disclosure, it will be apparent to those skilled in the art that numerous changes and modifications can be made without departing from the scope and spirit of the invention. Namely, the disclosed invention is to be considered merely as illustrative. In order to judge the summary of the invention, the scope of the claims described should be considered.

[0133] As described above in detail, in accordance with the embodiments of this invention, it is possible to provide an improved mobile apparatus that can give user effective tactile feedback through the user interaction.

[0134] Further, in accordance with the embodiments of this invention, it is possible to provide an improved mobile apparatus that can create variety of tactile patterns without latency.

[0135] Further, in accordance with the embodiments of this invention, it is possible to provide an improved mobile apparatus that allows effective tactile control of a particular portion or single part of the apparatus body.

[0136] The mobile tactile display can extend interaction with mobile, hand-held and wearable devices in several important ways. The haptic display embodying the present invention can apply tactile feedback on user manual operation with tactile device. The tactile feedback is significantly faster in comparison with visual and audio feedback, therefore the tactile feedback would be more effective in interfaces with mobile devices that require user manual interaction. For example, it can be used:

[0137] a) Tactile feedback for the touch screens, such as PDAs, using finger or pen.

[0138] b) Tactile feedback for the gestural interaction with mobile apparatuses, such as tilting interfaces, shaking and other complex gestures.

[0139] c) Tactile feedback for any conventional operations, such as button presses.

[0140] d) Tactile feedback for drawing operation, such as pen can be augmented with tactile feedback device.