expressing the position of the finger are computed. More specifically, the position of the finger is computed according to

$$X=k1+k2((i2+i3)/(i1+i2+i3+i4))$$

$$Y=k1+k2((i1+i2)/(i1+i2+i3+i4))$$

wherein k1 and k2 express offset and scale factors, respectively.

[0075] However, it should be appreciated that the position sensor **121** is configurable in ways other than that shown in FIG. **4**, and may be realized by means of existing sensor technology such that the finger's position and movement over a two-dimensional plane are detected. For example, the position sensor **121** may be configured as an optical, infrared, or laser sensor that optically detects the position of the user's finger, or as an electrical or pressure sensor that detects the finger's contact position. The pressure sensor **122** is for acquiring information regarding user operations performed with respect to the switches or other elements displayed on the operable element **110**. For example, the pressure sensor **122** may acquire user operation information regarding push operations.

[0076] The detected data from the above sensors is input into a processing unit **124** via the data acquisition module **123**. The processing unit **124** may be realized by means of a microprocessor or a personal computer, for example.

[0077] On the basis of the sensor information, the processing unit **124** analyzes the user operation performed with respect to the operable element **110**, and conducts processing in accordance with that operation. Additionally, the processing unit **124** may also conduct processing to update the information being displayed on the display **125**, or conduct audio output processing in accordance with user operations performed with respect to an audio output unit (i.e., one or more speakers) **126**.

[0078] The processing unit **124** also outputs commands to a tactile control module **127**. Such commands are for controlling the electrical signal output to the electrode sheet **111** of the operable element **110** by the tactile control module **127**. For example, values such as the position and pressure of the user's finger may be detected by the sensors, whereupon the processing unit **124** determines voltages and frequencies in accordance with the information detected by the sensors. The processing unit **124** then outputs a command specifying the above parameters to the tactile control module **127**. Herein, the processing unit **124** also conducts processing to acquire the position information detected by the sensors, determine the motion of the user's finger **150** (i.e., motion information) on the basis of the time-rate-of-change of the position information, and determine a voltage and frequency on the basis of the motion information results.

[0079] In response to a command input from the processing unit **124**, the tactile control module **127** outputs an electrical signal to the electrode sheet **111** of the operable element **110**.

[0080] The electrical signal output by the tactile control module **127** is time-variant, and may be an alternating voltage signal, for example. If the user then drags his or her finger **150** over the insulator **112** of the operable element **110** while the electrical signal is being fed to the electrode sheet **111**, then friction corresponding to the electrical signal will be produced, and the user will experience user interface feedback.

[0081] The principles of this feedback will now be described with reference to FIG. **5**. As shown in FIG. **5**, the tactile control module **127** inputs into the electrode sheet **111** of the operable element **110** a time-variant alternating voltage signal varying between +Va and −Va, for example.

[0082] Assume that the user's finger **150** moves from right to left as shown in FIG. **5** over the insulator **112** of the operable element **110**. In response to such motion, frictional force fr is produced between the user's finger **150** and the surface of the insulator **112**. By applying a periodically varying voltage signal to the electrode sheet **111** of the operable element **110** at this point, an attractive force fe is produced that draws the user's finger **150** towards the electrode sheet **111**. The principle behind the production of this attractive force is identical to that described earlier with reference to FIG. **1**.

[0083] Herein, in order to sufficiently utilize the effect of varying the magnitude of the friction on the basis of an electrical signal, it is preferable to prevent charge from accumulating in the user him- or herself, such as by grounding the user to set his or her potential to the ground potential. To set a person's body to the ground potential, it is preferable to connect an earth cable to the user's skin, for example. Alternatively, the user's electrical potential may be kept at the ground potential by having the user's accumulated charge discharged via the floor he or she is standing on. Alternatively, the device provided with the operable element may be designed to include an earthing part that the user him- or herself touches. The user's accumulated charge may also be discharged via other protective accessories or clothing.

[0084] In keeping with the principle described earlier with reference to FIG. **1**, an attractive force fe is produced that draws the user's finger **150** to the electrode sheet **111**, thereby increasing the frictional force fr. The magnitude of the attractive force fe varies according to magnitude and period of the voltage applied to the electrode sheet **111** of the operable element **110** by the tactile control module **127**. As a result, the magnitude of the frictional force fr also varies according to the magnitude and period of the applied voltage. The user thus experiences a varying frictional force from his or her fingertip. More specifically, the user also experiences vibration due to the varying frictional force. This tactile sensation is perceived by the user as user interface feedback.

[0085] It is possible to modify the user's tactile sensation by modifying the magnitude and period of the voltage applied to the electrode sheet **111** of the operable element **110** by the tactile control module **127**. The magnitude and period of the voltage is determined by the commands output to the tactile control module **127** from the processing unit **124**.

[0086] As described with reference to FIG. **2**, the processing unit **124** acquires sensor information regarding factors such as the position, motion, and pressure of the user's finger **150** from the position sensor **121** and the pressure sensor **122**. The processing unit **124** then sets commands in accordance with the above sensor information.

[0087] For example, if it is detected that a slider displayed on the operable element is being operated, then the processing unit **124** outputs a command to the tactile control module **127** specifying the output of an electrical signal having a voltage magnitude and period set such that a frictional sensation corresponding to the slider's motion is produced. In response to this command, the tactile control module **127** generates an electrical signal having the set voltage magnitude and period, and then applies the generated electrical signal to the electrode sheet **111** of the operable element **110**.

[0088] If it is detected by sensor information that the user's finger **150** is operating a dial displayed on the operable ele-