[0020] According to still another aspect of the present invention, there is provided a haptic button including an electro-active polymer layer divided into regions, a plurality of pairs of electrodes which partially contact two sides of the electro-active polymer, a power supply to supply a voltage to the plurality of pairs of electrodes, a sensor to sense a button input from a user, a fixing portion which fixes the electro-active polymer layer at an edge of the haptic button, and at least one separator which extends in at least one direction between a widthwise direction and a lengthwise direction of the haptic button, wherein each separator fixes a portion of the electro-active polymer contacting the at least one separator, wherein one of the pairs of electrodes is disposed in each of the regions into which the haptic button is divided by the at least one separator.

[0021] According to a further aspect of the present invention, there is provided a haptic device including a contact surface to physically contact a user, an actuator to provide a displacement or a force to the contact surface, a sensor to sense a button input from a user, and a controller to control an operation of the actuator by applying a voltage, wherein the actuator comprises an electro-active polymer layer and at least a pair of electrodes to which the voltage is applied and which contact the electro-active polymer layer, and stimulation provided from the electro-active polymer layer to the user is changed by changing a waveform of the voltage.

[0022] According to a further aspect of the present invention, there is provided a haptic button including an electro-active polymer layer; a pair of electrodes which partially contact two sides of the electro-active polymer layer; a power supply to supply a voltage to the pair of electrodes; a sensor to sense a button input from a user; and a fixing portion which fixes the electro-active polymer layer so that a part of the electro-active polymer layer is not expanded, wherein another part of the electro-active polymer layer expands when voltage is applied.

[0023] According to a further aspect of the present invention, there is provided a method for changing at least one of stiffness and texture in a haptic button having an electro-polymer layer which contacts at least one pair of electrodes on opposite sides of the electro-polymer layer, the method including generating a voltage having a waveform; and supplying the voltage to the at least one pair of electrodes to expand the electro-polymer layer to change at least one of stiffness and texture of the haptic button.

[0024] According to a further aspect of the present invention, there is provided at least one computer readable medium storing instructions that control at least one processor to perform a method for changing at least one of stiffness and texture in a haptic button having an electro-polymer layer which contacts at least one pair of electrodes on opposite sides of the electro-polymer layer, the method including generating a voltage having a waveform; and supplying the voltage to the at least one pair of electrodes to expand the electro-polymer layer to change at least one of stiffness and texture of the haptic button.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and/or other aspects, features, and advantages of the invention will become apparent and more readily appreciated from the following description of exemplary embodiments, taken in conjunction with the accompanying drawings of which:

[0026] FIG. **1** illustrates a conventional button input device;

[0027] FIG. **2** is a graph of force versus displacement in the conventional button input device illustrated in FIG. **1**;

[0028] FIGS. **3**A and **3**B illustrate the characteristics of an electro-active polymer and particularly a dielectric polymer;

[0029] FIGS. **4**A and **4**B illustrate the basic concept of a haptic button according to a first exemplary embodiment of the present invention;

[0030] FIGS. **5**A and **5**B illustrate the basic concept of a haptic button according to a second exemplary embodiment of the present invention;

[0031] FIGS. **6**A and **6**B illustrate the basic concept of haptic buttons according to a third exemplary embodiment of the present invention;

[0032] FIG. **7** illustrates the appearance of a portable device including the haptic button according to any one among the first through third exemplary embodiments of the present invention;

[0033] FIGS. **8**A through **8**F are diagrams for explaining the detailed structure of the haptic button according to the first exemplary embodiment of the present invention;

[0034] FIGS. **9**A and **9**B are cross sectional views illustrating the detailed structure of the haptic button according to the second exemplary embodiment of the present invention;

[0035] FIGS. **10**A through **10**F are diagrams for explaining the detailed structures of haptic buttons according to the third exemplary embodiment of the present invention; and

[0036] FIG. **11** is a block diagram of a haptic device according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Reference will now be made in detail to exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. Exemplary embodiments are described below to explain the present invention by referring to the figures.

[0038] The present invention may, however, be embodied in many different forms and should not be construed as being limited to exemplary embodiments set forth herein. Rather, these exemplary embodiments are provided so that this disclosure will be thorough and complete and will fully convey the concept of the invention to those skilled in the art.

[0039] The present invention provides a haptic button that provides diverse stimulations to a user according to an application status using an electro-active polymer having a fixing portion. The application status indicates a current status of an application that is being performed at a current time. For example, the application status includes event generation such as car collision or gunshot and an input mode such as a telephone number input mode.

[0040] Electro-active polymers (EAPs) are polymers that have a wide range of physical and electrical properties.

[0041] Upon application of an electrical current, EAPs exhibit a considerable displacement or strain, generally called deformation. Such strain may differ depending on the length, width, thickness, or radial direction of a polymer material, and it is known that the strain is in a range of 10%