tion based on the detecting signal and transmits the pattern signal to the control unit **100**. In S340, the polymer deformation control unit **120** contracts or expands the polymer **140** by applying a second driving voltage to the polymer **140** based on the pattern signal from the pattern generating unit **150**. In S350, it is determined if there is a finger touching the touch panel. If there is a finger touching the touch panel, in S310, the sensing unit **130** detects the touch point and the touch state and outputs the detecting signal to the control unit **100**. If there is no finger touching the touch panel, the process is ended.

[0034] **FIG. 4** is a flowchart illustrating a polymer movement operation of S320 depicted in **FIG. 3**. The operation will be described in more detail in conjunction with **FIG. 1**.

[0035] Referring to **FIGS. 1 and 4**, in S400, it is determined if there is haptic information on the detected touch point. If there is no haptic information on the touch point, the process goes to S350. If there is haptic information on the touch point, the process goes to S410. In S410, a signal for moving the polymer to the touch point is generated. In S420, the first driving voltage (or current) is applied to the polymer **140** according to the signal generated to move the polymer to the touch point. Here, the driving voltage being applied may be, for example, 0 to 1 kV. If the current is applied, the current may be, for example, less than several mA. At this point, the polymer **140** is moved only when the driving voltage is greater than a first critical valve. The higher the driving voltage, the greater the moving speed of the polymer **140**. In the case of the single electro-active polymer, the polymer is moved in the horizontal direction by the driving voltage higher than the first critical value. In the case of the plurality of electro-active polymers, the polymers are moved in both the horizontal and vertical directions by the driving voltage higher than the first critical value. As shown in **FIG. 2C**, if the driving voltage is higher than a second critical value greater than the first critical valve, the polymer is moved only in the vertical direction.

[0036] In S430, the sensing unit **130** detects the touch point and the touch state of the user's finger with respect to the touch panel. In S440, a distance from the former touch point to the currently detected touch point is calculated and it is determined if the calculated distance is within a predetermined range. If the distance is not within the predetermined range, the process is returned to S400 to perform the polymer movement operation. If the distance is within the predetermined range, the process goes to S330 to perform the polymer deformation operation.

[0037] **FIG. 5** shows a flowchart illustrating a polymer deforming operation of S340 and a pattern generating operation of S330, which are illustrated in **FIG. 3**. This operation will be described hereinafter in conjunction with **FIGS. 1 and 3**.

[0038] Referring to **FIGS. 1 and 5**, in S500, the pattern generating unit generates a pattern of the haptic information corresponding to the touch state and the touch point from the visual information stored in the database **160** based on the detecting signal from the sensing unit **130**. Using the geometry and physical information of the object stored in the database **160**, a predetermined (or calculated) pattern is generated. The pattern may be generated based on artificial computing or actual data. For example, the pattern may be generated based on a polygon or finite element method (FEM).

[0039] In S510, the haptic information pattern is processed based on force (or speed, location, etc.) calculated in real time. At this point, even if the pattern of the haptic information is identical, if the force (or speed, location, etc.) is different, the pattern of the haptic information may have a different value. Such a patterning process of the haptic information is called haptic rendering. The patterning process of the haptic information is performed through, for example, a point-based method regarding the touch point as a single point or a multipoint-base method (or a surface-based method) regarding the touch point as multiple points.

[0040] In S520, the polymer deformation control unit **120** applies the second driving voltage (or current) to the polymer **140** according to the haptic information pattern from the pattern generating unit **150**. Here, the driving voltage being applied may be, for example, 0 to 1 kV. If the current is applied, the current may be, for example, less than several mA. In S530, the polymer **140** contracts or expands according to the applied second driving voltage. At this point, the expansion and contraction may be varied according to the value of the second driving voltage.

[0041] In S540, the sensing unit **130** detects the touch point and the touch state of the user's finger with respect to the touch panel. In S550, a distance from the former touch point to the currently detected touch point is calculated and it is determined if the calculated distance is within a predetermined range. If the distance is not within the predetermined range, the process is returned to S320 to perform the polymer movement operation. If the distance is within the predetermined range, the process goes to S330 to perform the pattern generating operation.

[0042] In another exemplary embodiment, the present invention may be realized as code that can be read by a computer. The code may be recorded in recording media that can be read by the computer. The recording media readable by the computer can be any recording device in which data is stored and can be read by the computer system, such as a ROM, a RAM, a CD-ROM, a magnetic tape, a floppy disk, an optical data storage, etc. Exemplary embodiments of the present invention may also be realized by a carrier wave (e.g., a transmission through the Internet).

[0043] According to the exemplary embodiments of the present invention, a user can feel a texture of a surface of an object and a sense of touch of the object by receiving force feedback and tactile feedback provided by moving and deforming a polymer inserted in a touch panel of an image display device. Additionally, by providing haptic information to the visual information such as a menu and an icon that are displayed on the touch panel, the user can easily operate the computer and input errors may be remarkably reduced.

[0044] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. An apparatus providing fingertip haptics of visual information using electro-active polymer for an image display device, the apparatus comprising: