

[0021] FIG. 6 is a block diagram of a magnetic force changing unit shown in FIG. 1;

[0022] FIG. 7 is a diagram for explaining a shape where an image unit and upper and lower magnetic force units shown in FIG. 6 are arranged;

[0023] FIG. 8, parts (a)-(d), are diagrams illustrating shapes of electromagnets;

[0024] FIG. 9 is a diagram of an example of an upper magnetic force unit shown in FIG. 6;

[0025] FIG. 10 is a diagram of another example of the upper magnetic force unit shown in FIG. 6;

[0026] FIG. 11 is a cross-sectional view of an image unit according to an embodiment of the present invention;

[0027] FIG. 12, parts (a) and (b), are diagrams illustrating changes of magnetic forces;

[0028] FIG. 13, parts (a) and (b), are diagrams illustrating electromagnets included in an upper magnetic force unit and electromagnets included in a lower magnetic force unit when the electromagnets are circular coils;

[0029] FIG. 14 is a flowchart of a method of providing haptics of an image according to another embodiment of the present invention;

[0030] FIG. 15 is a diagram for explaining a state where the upper magnetic force unit shown in FIG. 6 is moved from its current position to a touched portion when the upper magnetic force unit is configured as shown in FIG. 10;

[0031] FIG. 16 is a graph illustrating a waveform of current supplied to electromagnetic cells;

[0032] FIG. 17, parts (a) and (b), are a graph illustrating a waveform of another current supplied to the electromagnetic cells and a diagram illustrating an example of a pull-down menu, respectively;

[0033] FIG. 18 is a graph illustrating a waveform of a magnetic force occurring from the electromagnetic cells; and

[0034] FIG. 19 is a diagram for explaining examples of used concavo-convex feedback.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

[0036] FIG. 1 is a block diagram of an apparatus for providing haptics of an image according to an embodiment of the present invention. The image haptics providing apparatus includes a haptic information generating unit 10, a touch unit 12, and a magnetic force changing unit 14.

[0037] FIG. 2 is a flowchart of a method of providing haptics of an image according to an embodiment of the present invention. The image haptics providing method includes generating haptic information in operation 30, searching for a position of a touched portion when it is determined that an image is touched in respective operations

34 and 32, and changing magnetic forces corresponding to haptics of the touched portion in operation 36.

[0038] The image haptics providing apparatus provides haptics of an image, which is displayed through an image unit, to a user as follows.

[0039] Referring to FIGS. 1 and 2, in operation 30, the haptic information generating unit 10 receives the image to be displayed through an input terminal IN1, generates haptic information on haptics of the input image, and outputs the generated haptic information to the magnetic force changing unit 14.

[0040] FIG. 3 is a block diagram of an example 10A of the haptic information generating unit 10 shown in FIG. 1 according to an embodiment of the present invention. The haptic information generating unit 10A includes a haptics numerically calculating unit 50, a haptics compressing unit 52, and a storing unit 54.

[0041] FIG. 4 is a flowchart of an example 30A of operation 30 shown in FIG. 2 according to the present embodiment. Operation 30A includes numerically calculating regions obtained by dividing the displayed image, compressing the numerically calculated regions, and storing the compressed regions in respective operations 70, 72, and 74.

[0042] Referring to FIGS. 3 and 4, in operation 70, the haptics numerically calculating unit 50 shown in FIG. 3 receives an image to be displayed on the image unit through an input terminal IN3, divides the input image into a plurality of regions, and numerically calculates haptics of each region. Here, each region obtained by dividing the image to be displayed contains a designated number of pixels or voxels. According to the present embodiment, the designated number is determined depending on at least one of a resolution of haptics to be provided to the user and a size of a portion to be touched. For example, the greater the resolution, the smaller the designated number is set. That is, to provide more precise haptics to the user, the designated number should be set to a small number.

[0043] In general, an image to be displayed may have various kinds of haptics. For example, the image may have as a haptics at least one of force feedback, tactile feedback, temperature feedback, and vibration feedback. Here, the force feedback includes rigidity or hardness, softness or deformability, repulsiveness, and attractiveness. The tactile feedback includes softness, roughness, coarseness, and slipperiness, smoothness, or slickness. The temperature feedback includes coldness, coolness or chillness, and warmth. The vibration feedback includes vibration. In this regard, the regions obtained by dividing the image to be displayed may have various haptics. Accordingly, in operation 70, the image is divided into a plurality of regions and haptics of each region can be numerically calculated, for example, as a digital value. When it is assumed that each region is represented using one of the aforesaid 15 haptics, the haptics numerically calculating unit 50 can numerically calculate the haptics of each region as a 4-bit digital value. For example, the force feedback may be set to 0000, the tactile feedback to 0001, the temperature feedback to 0010, the vibration feedback to 0011, the rigidity to 0100, the deformability to 0101, the repulsiveness to 0110, the attractiveness to 0111, the softness to 1000, the roughness to 1001, the coarseness to 1010, the slipperiness to 1011, the coldness to