

image unit includes an upper magnetic force unit 170, a display module 172, and a lower magnetic force unit 174.

[0076] The upper magnetic force unit 170 illustrated in FIG. 11 includes a plurality of electromagnetic cells 180, 182, and 184. Dark protrusions in each of the electromagnetic cells 180, 182, and 184 denote wires of coils.

[0077] Parts (a) and (b) of FIG. 12 are diagrams illustrating the change of a magnetic force F.

[0078] It is assumed that the image unit is realized as shown in FIG. 11 and the user touches the image unit using his or her body part (e.g., fingertip) as shown in parts (a) and (b) of FIG. 12. At this time, the control signal generating unit 110 of FIG. 6 may control the upper and lower magnetic force units 112 and 114 so that the upper magnetic force unit 170 can generate a repulsive force F as shown in part (a) of FIG. 12 or the upper magnetic force unit 170 can generate an attractive force F as shown in part (b) of FIG. 12.

[0079] If electromagnets are circular coils, as shown in parts (a) and (b) of FIG. 13, four electromagnets 190, 192, 194, and 196 are included in an upper magnetic force unit 210 and four electromagnets 200, 202, 204, and 206 are included in a lower magnetic force unit 212.

[0080] The magnetic force changing unit 14A can provide concavo or convex feedback to the user by generating a repulsive force or an attractive force according to electromagnets as shown in parts (a) and (b) of FIG. 12. That is, if the repulse force provides convex feedback to the user and the attractive force provides concave feedback to the user, the concavo-convex feedback, that is, force feedback, can be provided as haptics of the displayed image to the user.

[0081] Alternatively, since the magnetic force changing unit 14A differently controls the change of current of electromagnets for differently changing magnetic forces among electromagnets as shown in part (b) of FIG. 13, the magnetic force changing unit 14A can provide tactile feedback of an object, such as button feedback, to the user. That is, if a concavo-convex contour of a magnetic force is used as shown in part (b) of FIG. 13, tactile feedback of an object, such as button feedback, can be provided as haptics of the displayed image to the user.

[0082] As a result, an attractive force and a repulsive force in a vertical direction provide force feedback, and an attractive force and a repulsive force in a horizontal direction provide tactile feedback. Also, the attractive force and the repulsive force in the horizontal and vertical directions provide temperature feedback or vibration feedback.

[0083] FIG. 14 is a flowchart of a method of providing haptics of an image according to another embodiment of the present invention. The method includes operation 230 in which haptic information is generated, operations 232 and 234 in which when a desired portion in an image displayed on the image unit is touched, a position of the touched portion is searched for, operation 236 in which the upper magnetic force unit 112 is moved to the touched portion, and operation 238 in which a magnetic force corresponding to haptics of the touched portion is changed.

[0084] Operations 230, 232, 234, and 238 illustrated in FIG. 14 correspond to and perform the same functions and roles as operations 30, 32, 34, and 36 illustrated in FIG. 2, respectively, and thus a detailed explanation thereof is omitted.

[0085] Referring to FIGS. 6 and 14, in operation 236, the movement control unit 116 moves the upper magnetic force unit 112 from its current position to the searched position of the touched portion input through the input terminal IN4 from the touch unit 12. To this end, the movement control unit 116 generates a movement control signal and outputs the generated movement control signal to the upper magnetic force unit 112, and the upper magnetic force unit 112 is moved from its current position to the touched portion in response to the movement control signal input from the movement control unit 116. At this time, to perform operation 238 after operation 236, when the movement of the upper magnetic force unit 112 is completed, the control signal generating unit 110 generates upper and lower magnetic force control signals. To this end, the movement control unit 116 checks when the movement of the upper magnetic force unit 112 is completed, and outputs checked results to the control signal generating unit 110. If it is recognized through the checked results input from the movement control unit 116 that the movement of the upper magnetic force unit 112 is completed, the control signal generating unit 110 generates upper and lower magnetic force control signals.

[0086] FIG. 15 is a diagram for explaining a state where an upper magnetic force unit 250 is moved from its current position to the touched portion when the upper magnetic force unit 112 illustrated in FIG. 6 is realized as shown in FIG. 10. Here, it is assumed that an upper magnetic force unit 250 includes one electromagnetic cell.

[0087] It is assumed that an electromagnetic cell of the upper magnetic force unit 250 is currently located at position 1. At this time, to generate an attractive force between the electromagnetic cell of the upper magnetic force unit 250 located at position 1 and an electromagnetic cell of a lower magnetic force unit 252 located at position 2, the control signal generating unit 110 generates upper and lower control signals and outputs the same to the upper and lower magnetic force units 250 and 252, respectively.

[0088] If the user touches position 7 to feel haptics, the control signal generating unit 110 controls an attractive force and a repulsive force of electromagnetic cells of the lower magnetic force unit 252 located at positions 2 and 4 so that the upper magnetic force unit 250 is moved from position 1 to position 3. That is, the control signal generating unit 110 controls the upper magnetic force unit 250 and the lower magnetic force unit 252 so that a repulsive force can be generated between the electromagnetic cell located at position 2 and the electromagnetic cell located at position 1 and a repulsive force can be generated between the electromagnetic cell located at position 4 and the electromagnetic cell located at position 1. Accordingly, the upper magnetic force unit 250 is moved from position 1 to position 3.

[0089] In this way, the control signal generating unit 110 sequentially controls electromagnetic cells of the lower magnetic force unit 252 located at positions 4, 6, and 8 so that the upper magnetic force unit 250 can be sequentially moved from position 3 through position 5 to position 7.

[0090] As a consequence, the control signal generating unit 110 can move the upper magnetic force unit 250 from position 1 to position 7 using an attractive force and a repulsive force among electromagnetic cells.