

## FORCE FEEDBACK DEVICE

### BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a force feedback device and, particularly, to a force feedback device which forms a unit force pattern to be provided to an operation unit by combining unit force patterns.

[0003] 2. Description of the Prior Art

[0004] A force feedback device of the prior art will be described with reference to FIG. 6 and FIGS. 7A to 7C. FIG. 6 is a block diagram of a force feedback device of the prior art and FIGS. 7A to 7C are graphs, each showing the generated force of the force pattern of the force feedback device of the prior art.

[0005] A knob 51 as an operation unit is rotatably provided to output a predetermined function.

[0006] A position sensor 52 is, for example, a rotary encoder which is attached to the rotary shaft (not shown) of the knob 51 to detect the rotation angle position of the knob 51.

[0007] An actuator 54 is, for example, an electromagnetic coil or motor which provides its generated force to the knob 51.

[0008] A control unit 53 is made up of a controller 53a and a memory (ROM) 53b as shown in FIG. 6. The memory 53b stores tables of force patterns (patterns 1 to N) for adding the generated force from the actuator 54 to the knob 51 according to each rotation angle position, and the controller 53a receives a signal indicative of the rotation angle position of the knob 51 from the position sensor 52 and gives the actuator 54 an instruction to output its generated force corresponding to the rotation angle position stored in the specified table. The force pattern tables store generated forces (generated forces 1 to n) for the rotation angle positions (positions 1 to n) of the knob 51 based on the respective force patterns (patterns 1 to N).

[0009] The relationships between the generated forces and the rotation angles of the tables (pattern 1, pattern 2, pattern 3; see FIG. 6) are shown in the graphs of FIGS. 7A to 7C. The force pattern of pattern 1 shown in FIG. 7A provides a click feel sensation at rotation angles of 80°, 120°, 160° and 360° during one 360° rotation of the knob 51 where the inclination of the line of the graph changes. The force pattern of pattern 2 shown in FIG. 7B has three repetitions of the same pattern and provides a click feel sensation at rotation angles of 80°, 120°, 200°, 240°, 320° and 360° where the inclination of the line of the graph changes. The force pattern of pattern 3 shown in FIG. 7C has nine repetitions of the same pattern during one 360° rotation of the knob 51 and provides a click feel sensation at intervals of 40° where the inclination of the line of the graph changes. Since these force patterns have different waveforms, their click feel sensations during one rotation differ from one another.

[0010] The operation of the force feedback device of the prior art will be described hereinbelow. When the knob 51 is turned, the position sensor 52 for detecting rotation angle attached to the rotary shaft of the knob 51 detects the rotation angle of the knob 51. A signal indicative of the

detected rotation angle is supplied to the control unit 53, the control unit 53 which receives the signal reads the specified table from generated force tables (pattern 1, pattern 2, . . . pattern N) corresponding to the rotation angle positions stored in the memory 53b, and the controller 53a gives the actuator 54 an instruction to output its generated force corresponding to the rotation angle position. The actuator 54 outputs the generated force specified by the controller 53a to the knob 51. The knob 51 receives the generated force of the actuator 54 and outputs a predetermined operation feel sensation.

[0011] However, in the above force feedback device of the prior art, when the number of force patterns increases, the required memory capacity grows, thereby making it difficult to prepare the required memory capacity.

### SUMMARY OF THE INVENTION

[0012] It is therefore an object of the present invention to provide a force feedback device which has a small required memory capacity even when the number of different force patterns increases.

[0013] The force feedback device of the present invention includes an operation unit, an actuator for providing a feel sensation (force) to the operation unit and a control unit for controlling the actuator, wherein the control unit stores a plurality of different unit force patterns, forms composite force patterns by combining the unit force patterns and controls the actuator based on the composite force patterns to provide feel sensations to the operation unit.

[0014] Since the unit force patterns are combined together by this constitution, only a memory for storing a small number of unit force patterns and a memory for storing the line-ups of combinations of the unit force patterns are required, thereby making it possible to reduce the required total memory capacity (ROM capacity) even when the number of different force patterns increases.

[0015] One of the plurality of unit force patterns is a mountain-like one of which force increases from a predetermined value and then decreases or a valley-like one of which force decreases from a predetermined value and then increases to provide a click feel sensation.

[0016] Simply by selecting a mountain-like or valley-like unit force pattern with this constitution, a click feel sensation can be easily obtained.

[0017] One of the plurality of unit force patterns has an ascent in which force increases from a predetermined value to provide a deceleration feel sensation.

[0018] Simply by selecting a unit force pattern having an ascent in which force increases from a predetermined value with this constitution, a deceleration feel sensation can be easily obtained.

[0019] One of the plurality of unit force patterns has a descent in which force decreases from a predetermined value to provide an acceleration feel sensation.

[0020] Simply by selecting a unit force pattern having a descent in which force decreases from a predetermined value with this constitution, an acceleration feel sensation can be easily obtained.