

vibration strength of each vibrator may be determined by following Equation (1):

$$\begin{aligned} \text{Strength 1} &= [100 \times \{(m2 \times m4) / (\text{width} \times \text{height})\}] \\ \text{Strength 2} &= [100 \times \{(m1 \times m4) / (\text{width} \times \text{height})\}] \\ \text{Strength 3} &= [100 \times \{(m3 \times m2) / (\text{width} \times \text{height})\}] \\ \text{Strength 4} &= [100 \times \{(m1 \times m3) / (\text{width} \times \text{height})\}] \end{aligned} \quad (1)$$

[0037] where the strengths 1 to 4 represent the vibration strength level of each vibrator V1 to V4, i.e., 301 to 304, the width represents the total width of the screen, and the height represents the total height of the screen. As expressed in Equation (1) above, the vibration strength level of each vibrator has different values depending on the touched positions. As the touch position that is closer to the respective vibrator would yield a stronger vibration.

[0038] In addition, when the touch duration of the specific position is represented as Z, the vibration strength level of each vibrator may be re-adjusted by following Equation (2):

$$\begin{aligned} \text{Strength 1} &= [100 \times \{(m2 \times m4) / (\text{width} \times \text{height})\}] \times Z \text{ value} \\ \text{Strength 2} &= [100 \times \{(m1 \times m4) / (\text{width} \times \text{height})\}] \times Z \text{ value} \\ \text{Strength 3} &= [100 \times \{(m3 \times m2) / (\text{width} \times \text{height})\}] \times Z \text{ value} \\ \text{Strength 4} &= [100 \times \{(m1 \times m3) / (\text{width} \times \text{height})\}] \times Z \text{ value} \end{aligned} \quad (2)$$

[0039] As expressed in Equation (2) above, the vibration strength level of each vibrator increases as the touch duration increases.

[0040] Referring back to FIG. 2, in step 211, the portable terminal allows the respective vibrators to vibrate according to the re-determined vibration strength level. In step 213, the portable terminal detects whether the user continues to touch the screen. If the user input is not maintained, the portable terminal terminates an algorithm.

[0041] On the contrary, if the user input is maintained, the portable terminal detects, in step 215, whether the user's input position is changed. That is, the portable terminal detects whether the user's touch position is shifted to another position. If it is determined that the user's input position is changed, the procedure returns to step 203 and the portable terminal determines a coordinate corresponding to the changed input position and re-performs subsequent steps. If the user's input position is not changed, the procedure returns to step 205 and the portable terminal counts a duration of input time and re-performs subsequent steps. Here, the portable terminal may count the input time by adding 1 to the previously counted the duration of input.

[0042] Alternatively, while the vibration strength level of each vibrator is determined based on the touch position and duration during operation, the vibration strength level of each vibrator may be determined based on only one of the touch position or the touch duration.

[0043] Moreover, even when an object or position selected by an input unit of a character, number or direction, for example, a keyboard and a keypad, is shifted, the vibration strength level of each vibrator may be determined according to the shift action of the selected object or position. That is, it may be possible to determine and generate different vibration strength level of each vibrator according to the position of the user's input received via a keypad of the portable terminal, where the area of key pad serves as a touch screen for the purpose of recognizing the touch position and duration.

[0044] Hereinafter, various examples to which the present invention is applicable in the operation of touch screen according to the teachings of the present invention will be described with reference to FIGS. 4 to 10. FIGS. 4 to 10 are schematic diagrams illustrating examples of generating a haptic effect in a portable terminal including four vibrators according to embodiments of the present invention.

[0045] Referring to FIG. 4, an icon located at an A position 401 is shifted to a B position 403 through the drag-and-drop operation of a user in the portable terminal. Here, the user continues to touch the screen while shifting the icon from the A position 401 to the B position 403. Accordingly, the vibrators V1 and V2 generate vibrations of which strengths are higher than those of vibrations generated by the vibrators V3 and V4 at the beginning when the user touches the A position 401. However, as the touch position is shifted, the vibration strengths of the vibrators V1 and V2 gradually decrease but the vibration strengths of the vibrators V3 and V4 gradually increase. Finally, after the touch position is shifted to the B position 403, the vibrators V3 and V4 generate vibrations of which strengths are higher than those of vibrations generated by the vibrators V1 and V2.

[0046] FIG. 5 illustrates that a vehicle is cornering to the right on a vehicle driving game in the portable terminal. In this case, the vibration strengths of the vibrators V1 and V2 are increased higher than those of the vibrators V3 and V4 at the time of cornering. As a result, a user may feel that the center of gravity shifts to the left while the vehicle is cornering to the right in the display. To simulate the centrifugal force acting on the vehicle becomes greater as it corners, the strengths of the vibrators V1 and V2 may be set even higher. Similarly, when the vehicle corners to the left, the vibration strength of each vibrator may be controlled such that the vibration strengths of the vibrators V3 and V4 are higher than those of the vibrators V1 and V2.

[0047] FIGS. 6A and 6B illustrate an obstacle avoiding game of getting through continuously-changing obstacles by a user's touch in the portable terminal. Here, the user moves the touch position from an A position 601 to a B position 603 so as to get through an obstacle. The portable terminal determines the vibration strength of each vibrator at the touch position A 601 and B 603, and generates two different set of vibrations with the determined vibration strength at two different positions, thus allowing the user to feel the change in the movement.

[0048] FIG. 7 illustrates a game of bouncing an object according to a touch or user's input in the portable terminal. Since a bounce height of the object changes depending on the touch or user's input duration in this game, the portable terminal allows the user to feel how strongly he/she has bounced an object by changing the vibration strength of each vibrator according to the touch or user's input duration. The longer duration would yield a stronger bouncing action by increasing the vibration strength of each vibrator.

[0049] FIG. 8 illustrates a screen configuration controlling a 3-dimensionally rotating user interface (UI) in the portable terminal. When a user touches the screen from an A position to an F position for rotating the screen, the portable terminal may calculate vibration strengths of vibrators V1 to V4 and generate vibration with the determined vibration strength as described with reference to FIG. 2 to simulate the rotation. Intervals of the x-axis between respective positions indicate time intervals taken for next vibration to be generated. Thus, the vibration is rapidly generated when the user touches the