

TACTILE AND FORCE FEEDBACK DEVICE

TECHNICAL FIELD

[0001] This invention relates to an apparatus for presenting tactile feedback for a user. More particularly, the present invention relates to a tactile feedback apparatus for a human interface control device directly acted on by a user's finger, such as a switch, a button or a joystick.

[0002] The present invention contains subject matter related to Japanese Patent Application JP 2003-287988, filed in the Japanese Patent Office on Aug. 6, 2003, the entire contents of which being incorporated herein by reference.

BACKGROUND ART

[0003] The force feedback is among critical elementary functions for a variety of control devices, such as buttons or joysticks. A rubber pad, provided on a mechanical switch or mechanism, is routinely used for presenting such tactile feedback. In such conventional control devices, the sort of the tactile feedback may not be changed, while it is not possible to change the tactile sense on actuation by the user of the interfacing element, using a computer application program, for presenting the sense of actuation of the user interface element more effectively to the user.

[0004] An example of adding a tactile feedback function to a force joystick has been disclosed in Campbell, C., S. Zhai, K. May and P. Maglio, What you feel must be what you see: Adding tactile feedback to the trackpoint, In *Interact '99*, 1999 p. 383-390.

[0005] An example of a mouse button having a tactile feedback function is disclosed in Akamatsu, M. and S. Sato, A multi-modal mouse with tactile and force feedback, *International Journal of Human-Computer Studies*, 1994, 40(3): p. 443-453.

[0006] In the examples, disclosed in the above Publications, there is used a solenoid element limited in the bandwidth of the frequency of the vibrations that can be presented. Moreover, the solenoid element is so large in size that it cannot be mounted on a small-sized device, such as joystick of a controller for a game or a button used on a camera. In addition, in the above devices, the tactile feedback is not correlated with the magnitude of the force that has been applied.

[0007] In a mobile phone or a game controller, a motor for generation of vibrations is used. As an example, there is a game controller having two motors generating vibrations for presenting the tactile feedback. Such motor, adapted for generating vibrations, includes a non-symmetrical shaft, and vibrations are initiated when the rpm of the motor has surpassed a preset value. However, the motor for generating the vibrations is extremely slow in reaction and hence is difficult to use for interactive usage in need of prompt response. Moreover, for a usage such as for a game, vibrations at higher frequencies do not prove to be effective feedback.

[0008] In Yoshie M., Yano H. and Iwata, H., Development of non-grounded force display using gyro moments, *Proceedings of Human Interface Society Meeting 2001*, pp. 25-30, and in Fukui Y., Nishihara S., Nakata K., Nakamura, J. and Yamashita J., Hand-held torque feedback display,

Proceedings of SIGGRAPH01 Abstracts and Applications, 2001, ACM, pp 192), there is proposed a torque-based tactile feedback apparatus.

[0009] In the techniques disclosed in the above Publications, a rotating motor is used, and the torque generating on starting and terminating the motor rotation is used as feedback. The devices used in these techniques are large in size and weight and hence are difficult to use on a small-sized site on a game controller. In addition, only a highly limited tactile pattern may be generated by these devices. Moreover, the tactile bandwidth is narrow due to the force of inertia of the motor. For these reasons, the usage of these devices is mainly limited to force feedback devices.

[0010] The technique of directly stimulating the user's hand by plural piezo actuators, arranged in a matrix configuration, has been disclosed in Cholewiak, R. and C. Sherrick, A computer-controlled matrix system for presentation to skin of complex spatiotemporal pattern, *Behavior Research Methods and instrumentation*, 1981. 13(5): pp. 667-673. This piezo actuator is used by itself and is not intended to be used along with an interface controller mechanism, such as a switch or a button.

[0011] The technique of generating the tactile feedback using a voice coil has been disclosed in Fukumoto M. and Toshiaki, S., Active Click: Tactile Feedback for Touch Panels, *Proceedings of CHI '2001, Extended Abstracts 2001, ACM*, pp. 121-122. This tactile feedback is limited to local oscillations. Moreover, the voice coil is large-sized and usually can generate only the vibrations at a natural frequency proper to the voice coil. Hence, the tactile feedback has only a limited pattern.

[0012] In the JP Laid-open Patent Publication H-11-212725, there are disclosed an information display apparatus and an operation inputting apparatus employing plural piezoelectric elements for detecting a user's input on an information display and for presenting tactile feedback consistent with the user's input. In the technique disclosed in this Laid-open Patent Publication, high frequency signals are supplied for driving the piezoelectric elements and vibrations are generated for presenting the tactile feedback.

[0013] With the technique disclosed in this Laid-open Patent Publication, the amplitude of vibrations of the piezoelectric elements is small, while there lacks the disclosure of a mechanism for generating larger tactile feedback. An extremely large voltage is required for these piezoelectric elements per se to generate larger tactile feedback. Furthermore, only the method for application to an LCD is disclosed in the above Patent Publication 1. The system disclosed is such that, if an LCD display is thrust with a force larger than a preset threshold value, the tactile feedback having a preset magnitude is presented.

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0014] It is an object of the present invention to provide a novel tactile feedback apparatus whereby the problems of the above-described conventional techniques may be resolved.

[0015] It is another object of the present invention to provide a tactile feedback apparatus that may be applied to