SYSTEM AND METHOD FOR CONTROLLING AUDIO OUTPUT ASSOCIATED WITH HAPTIC EFFECTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit under 35 U.S.C. 119(e) of U.S. Provisional Application Ser. No. 60/590,432, entitled "System and Method for Controlling Audio Output Associated with Haptic Effects," filed Jul. 23, 2004, which is incorporated herein by reference in its entirety

BACKGROUND

[0002] The invention relates generally to haptic feedback devices. More specifically, the invention relates to a system and method for controlling audio output associated with haptic effects.

[0003] Devices that provide haptics, such as tactile feedback, have enjoyed increased popularity in recent years. These devices are used in a variety of different applications. For example, devices providing haptics are popular in various applications, where the haptic feedback enhances the overall gaming experience of a user. For example, haptic-enabled controllers, such as mouse devices, can be configured to provide haptic feedback to a user while the user interacts with an operating system (OS), or other application.

[0004] Existing devices, however, do not effectively control audio output associated with haptic feedback. Accordingly, it would be desirable to control effectively audio output associated with haptic effects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] **FIG. 1** is a block diagram of a processor system, according to an embodiment of the invention.

[0006] **FIG. 2** is a diagram illustrating a haptic device, a controller, and a sensor, according to an embodiment of the invention.

[0007] **FIG. 3** is a block diagram of a haptic device, according to an embodiment of the invention.

[0008] **FIG. 4** is a diagram of multiple frequency ranges of haptic effects output by a haptic device, according to an embodiment of the invention.

[0009] **FIG. 5** is a plot of a magnitude versus frequency response of a haptic device, according to an embodiment of the invention.

[0010] **FIG. 6** is a diagram of a control signal used to control a haptic device, according to an embodiment of the invention.

[0011] **FIG. 7** is a diagram of a control signal used to control a haptic device, according to an embodiment of the invention.

[0012] **FIG. 8** is a diagram of a control signal used to control a haptic device, according to an embodiment of the invention.

[0013] **FIG. 9** is a diagram of a control signal used to control a haptic device, according to an embodiment of the invention

[0014] **FIG. 10** is a diagram of linearization of voltages of a haptic device, according to an embodiment of the invention.

[0015] **FIG. 11** is a diagram of various parameters associated with a smooth effect according to an embodiment of the invention.

[0016] **FIG. 12** is a diagram of various parameters associated with a strong effect according to an embodiment of the invention.

[0017] **FIG. 13** is a diagram of various parameters associated with a sharp effect according to an embodiment of the invention.

DESCRIPTION

[0018] A system and method for controlling audio output associated with haptic effects are described. More specifically, audio output associated with haptic effects can be controlled to modify a perceived experience of the haptic effects. For example, by modifying the audio output, a user can be made to perceive a frequency of a haptic effect as being different than the actual frequency.

[0019] According to one or more embodiments of the invention, control signals can be configured to cause haptic effects to be output across a wide range of frequencies. These control signals can independently control haptic effects within any frequency range from among multiple frequency ranges. This can occur, for example, using either a single controller or multiple controllers configured to output control signals from each frequency range. For example, a single controller can output control signals that independently control haptic effects in each of multiple frequency ranges. Alternatively, multiple controllers can be used, such that each controller outputs control signals within a single frequency range of multiple frequency ranges, each controller being uniquely associated with each frequency range.

[0020] Audio output associated with a haptic effect is generated in at least one frequency range of multiple frequency ranges when that haptic effect is output in response to a corresponding control signal. For example, when a haptic effect is output by a haptic device in response to a control signal, the haptic device can also create audible sound or, in other words, an audio output based on the movement of the haptic device. The audio signal heard by a user can correspond to a frequency of a haptic effect that is beyond the tactile detection capabilities of the user. In other words, although a user cannot feel a difference in the frequency of a haptic effect above a certain threshold frequency, the user can hear audio associated with such higher frequencies. Thus, although varying such tactile-imperceptible frequencies will not cause a user to feel a difference in a frequency of a haptic effect, the user will be able to hear such a variation. Because a user can hear an increase or decrease in frequency of the audio output, the user will perceive that the haptic effect has changed, and in many cases will believe that he or she has felt the change in the overall experience.

[0021] One or more embodiments of the invention provide an extended perceived frequency range of haptic effects. More specifically, in addition to the range of haptic effects that can be tactilely detected by the user, a range of effects