filter, and/or a bandpass filter may be used to isolate different frequency ranges of the sound data to which haptic sensations can be applied. The user can set the cutoff and range limits to these filters, where the low pass filter removes frequencies above the user-designated cutoff, the high pass filter removes frequencies below the user-designated cutoff, and the bandpass filter removes frequencies outside the user-designated frequency range.

Since different types of sound rely on different frequency ranges, filters can be useful for sound editing tasks. For example, the meaningful information in speech typically resides in higher frequencies, so a user editing speech may want to apply a high pass filter so that only the pertinent frequencies are present. Desired features of the speech are then more easily found in these pertinent frequencies. Similarly, music that is dependent on heavy and strong beats or rhythms (e.g., rock and roll, dance music, rap) carry much information in low frequencies while much classical music focuses on high and mid-range frequencies; the appropriate filters can be used on the style of music played to isolate the meaningful frequency range. The filters can also be useful when editing individual instrument sounds in the sound data since the frequency content may be controlled to match the characteristics of the instrument.

Harmonic tracking setting **508** can be set by the user as on or off. The harmonic tracking feature, if set to be on, can create a mapping of haptic sensations (e.g., texture or vibrations) to the harmonic content, or timbre, of the sound. A haptic texture is a pattern of short haptic features, such as detents or jolts, spaced or organized in a predetermined way, and which are output as the user manipulandum of the haptic device is moved over each "bump" location (e.g., detent, jolt, etc.) of the texture field. A haptic texture can be related to the timbre of the output sound. For example, a clean, simple haptic texture having "bumps" spaced further apart can be output haptically while pure tones are being output as sound. In contrast, complex and dense textures having closely-spaced bumps can be output haptically when complex tones of sound are being output. The sound of a flute is a rather pure tone and can be mapped to a very light and simple haptic texture, or even no texture at all. At the other end of the spectrum, the sound of an electric guitar distortion is a very complex tone and can be mapped to heavier, complex haptic textures. Textures are more appropriate for position control modes; in rate control modes, vibrations can be similarly output, with low frequency vibrations corresponding to far-spaced textures and high frequency vibrations corresponding to closely-spaced textures.

Effects settings allow the user to adjust how some of the haptic sensations will feel. Continuity setting **510** allows the user to select whether the haptic output continuously changes or is event-based. If "continuous" is selected, then the haptic output changes in real-time as the sound properties change, as described above with reference to FIGS. **9***a* and **9***b*. This might be selected if the user wanted to continually track the amplitude of the sound during navigation. If "event-based" is selected, then only significant events in the sound data, such as the rise in amplitude discussed above with respect to FIG. **6**, trigger haptic events. For example, a beat, an amplitude peak, can trigger a haptic detent. In other embodiments, the user can select an option allowing both continuous haptic output and event-based haptic output, e.g. a continuous resistance supplemented with jolts or detents overlaid on the resistance force.

The sound to force magnitude mapping setting **512** allows the user to select how the haptic output response is output. For example, when direct mapping is selected, greater sound amplitude generates greater magnitude haptic forces, as described above with reference to FIG. **9***a*. When inverted mapping is selected, greater sound amplitude generates weaker magnitude haptic forces, as described above with reference to FIG. **9***b*. This mapping can apply to the continuous setting of the continuity setting **510**, or the event-based setting (e.g., inverse detents can be output).

Waveform **514** is a graphical representation of a waveform representing the sound data loaded into memory. The waveform can be displayed, for example, as the user navigates through the sound data. The entire sound data file can be represented as the waveform, or a section of the sound data can be represented. A cursor **516** is, in the example shown, a vertical bar that signifies the current playback position in the waveform. During navigation and playback of the sound, the cursor **516** moves in the direction corresponding to playback direction and moves at the rate of playback (alternatively, the entire waveform can be scrolled and the cursor remain stationary). The user can thus visually sense when the cursor moves over features in the sound and feel the haptic sensations corresponding to those features. In those pre-processing embodiments storing markers to indicate sound characteristics which have been mapped to haptic sensations (see FIG. **5**), the markers can also be displayed at their locations with respect to the waveform.

The present invention can be used for standalone sound files, such as those used for music or speech, and which can be in one of many standardized formats (wav, mp3, MIDI, etc.). In addition, the present invention can be used for sound data that may be included with other data describing visual presentations, such as video, film, and animations.

While this invention has been described in terms of several preferred embodiments, it is contemplated that alterations, permutations and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. For example, many different embodiments of haptic feedback devices can be used to output the haptic sensations described herein. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention.

What is claimed is:

1. A method for associating haptic sensations with sound data to assist in navigating through and editing said sound data, the method comprising:

loading at least a portion of said sound data into a memory of a computer;

playing said sound data such that an audio signal is generated and used for outputting sound from an audio device, wherein said playing of said sound is controlled by user input received by said computer from a user for navigation through said sound data; and

generating haptic commands based on said sound data, said haptic commands used to output haptic sensations to said user by a haptic feedback device manipulated by said user and in communication with said computer, said haptic sensations corresponding to one or more characteristics of said sound data to assist said user in discerning features of said sound data during said navigation through and editing of said sound data.

2. A method as recited in claim **1** wherein said user can control a speed of said playing of said sound data.

3. A method as recited in claim **1** wherein said user can control a direction of said playing of said sound data, said direction including forward and reverse.

4. A method as recited in claim **1** wherein said haptic sensations are continuously output during said playing of