feedback. In this example, an object used for implementing a "virtual pet," such as a cat **909** as shown, is displayed by an application running on the device **105** on the touch screen **110**. The virtual pet cat **909** is typically utilized as part of an entertainment or game scenario in which users interact with their virtual pets by grooming them, petting them, scratching them behind their ears, etc. Such interaction, in this example, is enhanced by applying the present techniques for 3-D object simulation. For example, when the user **102** pets the virtual pet cat (the object), the image of the cat **909** may be animated to show its furs being smoothed in response to the user's touch on the touch screen **110**. An appropriate sound sample, which may include the purring of the cat, or the sound of fur smoothing or patting the cat (as respectively indicated by reference numerals **915** and **918**) is rendered by the speaker **606** or coupled external headset (not shown).

[0055] In implementations in which the touch screen **110** is pressure-sensitive, the sensory feedback to the user can change responsively to changing pressure from the user on the touch screen. For example, the cat **909** might purr louder as the user **102** strokes the cat with more pressure on the touch screen **110**.

[0056] In addition to the sound and visual feedback provided when the user **102** pets the cat **909**, the device **105** is configured to provide tactile feedback such as vibration using one or more vibration units (e.g., vibration unit **712** shown in FIG. **7** and described in the accompanying text). By varying the direction, duration, and magnitude of the feedback force in response to the user's touch on the touch screen **110**, various tactile sensations may be simulated including, for example, the feeling of stroking the cat **909**, and/or having the cat **909** move in response to being touched by the user **102**. While the audio, visual, and tactile feedback may be used singly or in various combinations of two, it is envisioned that the utilization of a combination of the three will often provide the most complete 3-D object simulation and the richest user experience in settings such as that provided by the illustrative entertainment or game application described above.

[0057] FIG. **10** shows another illustrative application of the present 3-D object simulation using audio, visual, and tactile feedback. In this example, device **305** is configured to enable the user **102** to browse among multiple pages in a document by touching the edge of page **322** on the touch screen **310** and then turning the page through a flick, or other motion, of the user's finger. For example, to move ahead to the next page in the document, the user **102** touches and then moves the right edge of page **322** from right to left (by dragging the user's finger across the touch screen **310**) in a similar motion as turning the page in a real book. To go back to a previous page, the user **102** can touch the left edge of page **322** and move it to the right.

[0058] Tactile feedback is provided when the user **102** locates an edge of page **322** by touching the touch screen **310** in a similar manner as that described above in the text accompanying FIGS. **8**A and **8**B. Additional tactile feedback forces can be applied with device **305** as the virtual page is being turned, for example, to simulate the feeling the user **102** might experience when turning a real page (e.g., overcoming a small amount of air resistance, stiffness of the page and/or binding in the book, etc., as the page is turned).

[0059] The tactile feedback will typically be combined with audio and visual feedback in many applications. For example, an audio sample of the rustling of a page as it turns is played, as indicated by reference numeral **1015**, over the speaker **1006** in the device **305**, or a coupled external headset (not shown). However, as with the illustrative example shown in FIG. **6** and described in the accompanying text, alternative audio samples may be utilized including arbitrary sounds (such as a beep, jingle, tone, musical note, etc.) which do not simulate a particular physical action, or may be user selectable from a variety of such sounds. In all cases, the utilization of the audio sample provides auditory feedback when the user turns the virtual page **322**.

[0060] The visual feedback utilized in the example shown in FIG. **10** may comprise an animation of the page **322** for which the animation motion is performed responsively to the motion of the user's finger or stylus. Thus, for example, page **322** may flip over, slide, or dissolve, etc., to reveal the next page or previous page in the document in response to the user's touch to the page **322** on the touch screen **310**.

[0061] As in the illustrative example above, in implementations in which the touch screen **310** is pressure-sensitive, the sensory feedback to the user can change responsively to changing pressure on the touch screen from the user **102**. For example, if the user **102** flicks the page more quickly or with more force (i.e., by applying more pressure to the touch screen **310**), the page **322** will turn or slide more quickly, and the sound of the page being turned may be more intense or louder.

[0062] FIG. **11** is an illustrative architecture **1104** that shows the functional components that may be installed on a device to facilitate implementation of the present 3-D object simulation using audio, visual, and tactile feedback. The functional components are alternatively implementable using software, hardware, firmware, or various combinations of software, hardware, and firmware. For example, the functional components in the illustrative architecture **1104** may be created during runtime through execution of instructions stored in the memory **719** by the processor **721** shown in FIG. **7**C.

[0063] A host application **1107** is typically utilized to provide a particular desired functionality such as the entertainment or game environment shown in FIG. **9** and described in the accompanying text. However, in some cases, the features and functions implemented by the host applications **1107** can alternatively be provided by the device's operating system or middleware. For example, file system operations and input through a virtual keyboard may be supported as basic operating system functions in some implementations.

[0064] A sensory feedback logic component **1120** is configured to expose a variety of feedback methods to the host application **1107** and functions as an intermediary between the host application and the hardware-specific controllers. These controllers include a touch screen controller **1125**, audio controller **1128**, and a motion controller **1134** which may typically be implemented as device drivers in software. Touch screen controller **1125**, audio controller **1128**, and motion controller **1134** interact respectively with the touch screen, audio generator, and one or more vibration units which are abstracted in a single hardware layer **1140** in FIG. **11**. Among other functions, the touch screen controller **1125** is configured to capture data indicative of touch coordinates and/or pressure being applied to the touch screen and sending the captured data back to the sensory feedback logic component **1120**, typically in the form of input events. The motion controller **1134** may be configured to interoperate with one or