THREE-DIMENSIONAL OBJECT SIMULATION USING AUDIO, VISUAL, AND TACTILE FEEDBACK

BACKGROUND

[0001] Touch-sensitive display screens have become increasingly common as an alternative to traditional keyboards and other human-machine interfaces ("HMI") to receive data entry or other input from a user. Touch screens are used in a variety of devices including both portable and fixed location devices. Portable devices with touch screens commonly include, for example, mobile phones, personal digital assistants ("PDAs"), and personal media players that play music and video. Devices fixed in location that use touch screens commonly include, for example, those used in vehicles, point-of-sale ("POS") terminals, and equipment used in medical and industrial applications.

[0002] Touch screens can serve both to display output from the computing device to the user and receive input from the user. In some cases, the user "writes" with a stylus on the screen, and the writing is transformed into input to the computing device. In other cases, the user's input options are displayed, for example, as control, navigation, or object icons on the screen. When the user selects an input option by touching the associated icon on the screen with a stylus or finger, the computing device senses the location of the touch and sends a message to the application or utility that presented the icon.

[0003] To enter text, a "virtual keyboard," typically a set of icons that look like the keycaps of a conventional physically-embodied keyboard is displayed on the touch-screen. The user then "types" by successively touching areas of the touch screen associated with specific keycap icons. Some devices are configured to emit an audible click or other sound to provide feedback to the user when a key or icon is actuated. Other devices may be configured to change the appearance of the key or icon to provide a visual cue to the user when it gets pressed.

[0004] While current touch screens work well in most applications, they are not well suited for "blind" data entry or touch-typing where the user wishes to make inputs without using the sense of sight to find and use the icons or keys on the touch screen. In addition, in some environments it is not always possible to rely on visual and auditory cues to provide feedback. For example, sometimes touch screens are operated in direct sunlight which can make them difficult to see or in a noisy environment where it can be difficult to hear. And in an automobile, it may not be safe for the driver to look away from the road when operating the touch screen.

[0005] Traditional HMI devices typically enable operation by feel. For example, with a physical keyboard, the user can feel individual keys. And in some cases, several keys such as the "F" and "J" have small raised dots or bars that enable the user to orient their fingers over the "home" row of keys by feel without having to look at the keys. By comparison current touch screens, even those which provide audible or visual feedback when buttons or keys are pressed, do not enable users to locate and operate icons or keys by feel.

[0006] This Background is provided to introduce a brief context for the Summary and Detailed Description that follow. This Background is not intended to be an aid in determining the scope of the claimed subject matter nor be viewed as limiting the claimed subject matter to implementations that solve any or all of the disadvantages or problems presented above.

SUMMARY

[0007] A multi-sensory experience is provided to a user of a device that has a touch screen through an arrangement in which audio, visual, and tactile feedback is utilized to create a sensation that the user is interacting with a physically-embodied, three-dimensional ("3-D") object. Motion having a particular magnitude, duration, or direction is imparted to the touch screen so that the user may locate objects displayed on the touch screen by feel. Such objects can include icons representing controls or files, keycaps in a virtual keyboard, or other elements that are used to provide an experience or feature for the user. For example, when combined with sound, and visual effects such as animation, the tactile feedback creates a perception that a button on the touch screen moves when it is pressed by the user just like a real, physically-embodied button. The button changes its appearance, an audible "click" is played by the device, and the touch screen moves (e.g., vibrates) to provide a tactile feedback force against the user's finger or stylus.

[0008] In various illustrative examples, one or more motion actuators such as vibration-producing motors are fixedly coupled to a portable device having an integrated touch screen. In applications where the device is typically in a fixed location, such as with a POS terminal, the motion actuators may be attached to a movable touch screen. The motion actuators generate tactile feedback forces that can vary in magnitude, duration, and intensity in response to user interaction with objects displayed on the touch screen so that a variety of distinctive touch experiences can be generated to simulate different interactions with objects on the touch screen as if they had three dimensions. Thus, the edge of a keycap in a virtual keyboard will feel differently from the center of the keycap when it is pressed to actuate it. Such differentiation of touch effects can advantageously enable a user to make inputs to the touch screen by feel without the need to rely on visual cues.

[0009] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** shows an illustrative portable computing environment in which a user interacts with a device using a touch screen;

[0011] FIG. **2** shows an illustrative touch screen that supports user interaction through icons and a virtual keyboard;

[0012] FIGS. **3**A and **3**B show an alternative illustrative form-factor for a portable computing device which uses physical controls to supplement the controls provided by the touch screen;

[0013] FIG. **4**A shows an illustrative button icon that is arranged to appear to have a dimension of depth when in its un-actuated state;

[0014] FIG. **4**B shows the illustrative button icon as it appears in its actuated state;