

**PROJECTED FIELD HAPTIC ACTUATION**

## RELATED APPLICATION

**[0001]** This application claims priority to U.S. Provisional Application No. 61/024,411, filed on Jan. 29, 2008, the disclosure of which is incorporated by reference herein.

## BACKGROUND

**[0002]** Some devices such as mobile phones, hand-held media players, personal digital assistants (PDAs), and the like, can be configured to provide physically-sensible feedback to a user, such as a vibration. Yet, the actuating mechanisms that are utilized to cause this feedback, such as electromagnetic actuators and others, can be prohibitively large in size, can consume a significant amount of power, and/or can be expensive to use.

## SUMMARY

**[0003]** 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 to limit the scope of the claimed subject matter.

**[0004]** In one or more embodiments, an electronic device includes a touch surface that can be physically engaged by a user. The touch surface is operably connected to an actuator arm which, in turn, is connected to an actuator array. Drive electronics sense a user's movement relative to the touch surface and, responsively, drive the actuator array effective to move the actuator arm and, in turn, provide haptic feedback to the user through the touch surface.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0005]** The same numbers are used throughout the drawings to reference like features.

**[0006]** FIG. 1 illustrates an example electronic device in accordance with one or more embodiments.

**[0007]** FIG. 2 illustrates an exploded view of the electronic device of FIG. 1 in accordance with one or more embodiments.

**[0008]** FIG. 3 illustrates an actuator array in accordance with one or more embodiments.

**[0009]** FIG. 4 illustrates an electronic device with its housing removed in accordance with one or more embodiments.

**[0010]** FIG. 5 illustrates an electronic device in a cut-away view as seen from the front of the device in accordance with one or more embodiments.

**[0011]** FIG. 6 illustrates a high-level block diagram of example system in accordance with one or more embodiments.

**[0012]** FIG. 7 illustrates an example voltage regulator in accordance with one or more embodiments.

**[0013]** FIG. 8 illustrates a USB interface that can allow real-time changes of haptic profiles in accordance with one or more embodiments.

**[0014]** FIG. 9 illustrates an electronic circuit in accordance with one or more embodiments.

**[0015]** FIG. 10 illustrates an electronic circuit in accordance with one or more embodiments.

**[0016]** FIG. 11 illustrates an electronic circuit in accordance with one or more embodiments.

**[0017]** FIG. 12a illustrates an example touch surface layout in accordance with one or more embodiments.

**[0018]** FIG. 12b illustrates an example touch surface layout in accordance with one or more embodiments.

**[0019]** FIG. 13 is a flow diagram that describes steps in a method in accordance with one or more embodiments.

## DETAILED DESCRIPTION

## Overview

**[0020]** In one or more embodiments, an electronic device includes a touch surface that can be physically engaged by a user. The touch surface can comprise any suitable type of touch surface and can be formed from any suitable type of material such as, by way of example and not limitation, glass, plastic, and the like. In at least some embodiments, the touch surface can take the form of a touch screen. Touch screens are typically employed to enable a user to provide input by touching portions of the screen. Touch screens can be employed in many different types of devices such as, for example, hand-held devices, printers, copiers, multifunction peripheral devices, and the like.

**[0021]** For example, a touch screen may display a numerical dialing pad to emulate a telephone. By touching individual displayed numbers, the user can enter a telephone number. A touch screen can also be used to provide a virtual keyboard on which a user can type. These types of touch screens are typically employed in hand-held devices such as cellular telephones, smartphones and can be found in computer monitors, tablet PC's, GPS devices, notebook PC's automotive dashboards, etc.

**[0022]** Alternately or additionally, the touch surface can take the form of a touch pad. Touch pads also enable users to provide input to an electronic device. For example, many laptop computers employ some type of touchpad to enable a user to move a cursor around an associated screen.

**[0023]** In one or more embodiments, the touch surface is operably connected to an actuator arm which, in turn, is connected to an actuator array. The actuator array includes an electrically-deformable material that can be electrically deformed responsive to being electrically driven by a voltage. Any suitable type of electrically-deformable material can be utilized such as piezoelectric-electric materials, electromagnetic materials, electro restrictive polymers, electrostatic materials and the like. In at least some embodiments, the electrically-deformable material comprises an electro-active polymer or "EAP." EAP refers to a class of polymers which are formulated to exhibit different physical, electrical, and/or electro-optical behaviors and properties. In general, when EAP is driven by an applied voltage, the EAP undergoes a deformation in a particular direction. This deformation causes the EAP to move in the particular direction. In various embodiments, the electrically-deformable material is driven by one or more drive voltages to effect movement of the touch surface, as will become apparent below. EAP is available from a company named Artificial Muscle Inc. located in Sunnyvale Calif.

**[0024]** Drive electronics sense a user's movement relative to the touch surface and, responsively, drive the actuator array effective to move the actuator arm and, in turn, provide haptic feedback to the user through the touch surface. For example, responsive to a user moving within a predefined area relative