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Micro Touchpad for Wearables

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Abstract:

Users interact with electronic devices via a variety of input devices, such as buttons, touchpads, touchscreens, keyboards, styluses, and mice. Touchpads allow users to provide the electronic devices with a variety of commands and instructions because of their flexibility in receiving many types of input, including touches, swipes, gestures, taps, and holds from one or more fingers or other input devices. Touchpads also allow for robust construction and ergonomic variability in environments in which other input devices may not function as effectively. In particular, a micro touchpad sized for wearable devices, such as watches, activity trackers, or headphones, that retains the functionality of larger touchpads allows users to interact with electronic devices in ways normally reserved for larger devices. The micro touchpad includes multiple sensor pads arranged in small form factor and configured to receive a variety of inputs from a user of an electronic device.

Keywords:

Touchpad, wearable, electronic, device, capacitance, copper, headphone, input, swipe, gesture, tap, touch, hold.

Background:

Electronic devices exist in many dimensions of modern life. Many of these electronic devices respond to input from users or need input from users to enhance the user experience. Many inputs devices exist, such as mice, keyboards, cameras, joysticks, game controllers, and touchpads. Touchpads, in particular, allow the user significant flexibility in providing gestures, taps, or other inputs and also allow the electronic device significant flexibility in receiving a variety of input signals. Touchpads can receive localized touch input, which is similar to individual clicks of a mouse or keyboard button. Additionally, touchpads can receive input over time, such as gesture or motion input, which may be difficult or cumbersome with other input devices. As technology applications both expand and increase in variety, touchpads may be used to allow user interaction with electronic devices in new ways.

Description:

Users interact with electronic devices via a variety of input devices, such as buttons, touchpads, touchscreens, keyboards, styluses, and mice. Touchpads allow users to provide the electronic devices with a variety of commands and instructions because of their flexibility in receiving many types of input, including touches, swipes, gestures, taps, and holds from one or more fingers or other input devices. Touchpads also allow for robust construction and ergonomic variability in environments in which other input devices may not function as effectively. In particular, a micro touchpad sized for wearable devices, such as watches, activity trackers, or headphones, that retains the functionality of larger touchpads allows users to interact with electronic devices in ways normally reserved for larger devices. The micro touchpad includes multiple sensor pads arranged in small form factor and configured to receive a variety of inputs from a user of an electronic device.

As discussed herein, a micro-sized touchpad allows for inclusion of a multi-functional touchpad capable of receiving a variety of inputs to be incorporated into small form-factor devices, such as in-ear headphones. Mechanically, touchpads can detect changes in capacitance and interpret those changes as touch input, which may include touch input over time like a gesture or a swipe. For example, consider a simple capacitive sensor as illustrated in Figure 1. Here, a finger touches an overlay or protective layer of the capacitive sensor, which also includes separated layers or copper elements on a base laminate layer. Instead of copper, the capacitive sensor could also include other conductive elements such as indium tin oxide or other substances. The conductive elements can be printed or otherwise layered in various layouts, sizes, arrangements, or distributions.

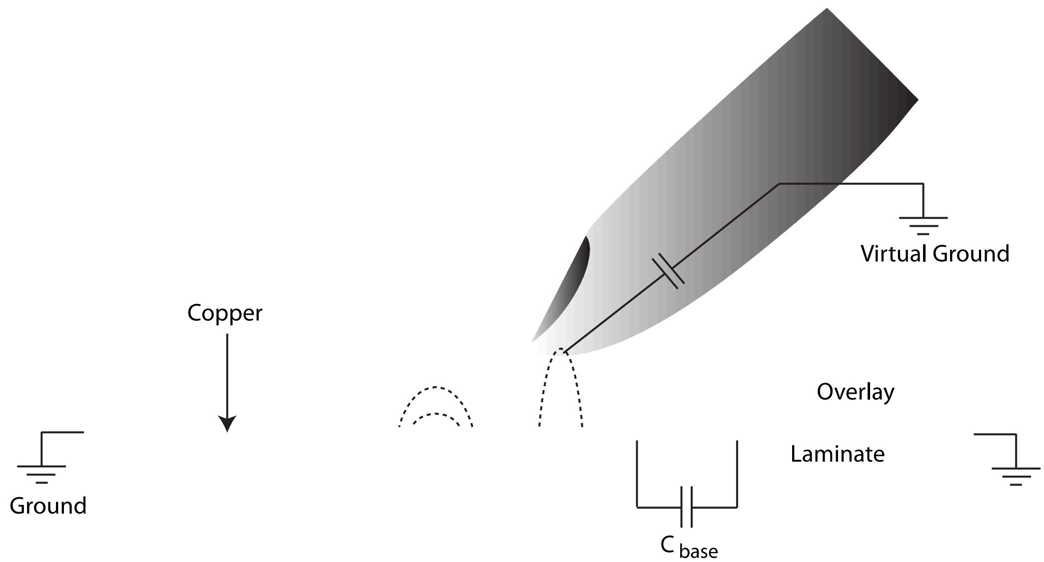

Figure 1

As shown in Figure 1, when a charge is applied to the conductive elements electric fields are formed. When the human finger touches the sensor, the electric fields change among the various conductive elements because the finger itself acts as a conductor and alters a detected capacitance. The changes in electric fields or capacitance can be measured as analog signals and converted into digital signals. The electronic device interprets these changes as inputs.

In some variations on this simple sensor, a number of pins or sensor elements can be increased, decreased, or spaced in various configurations (sometimes referred to as a sensor pad) to increase the sensitivity of the capacitance sensor. In particular, measurement at the boundary of a particular sensor pad may be difficult or may only provide a distance measurement. Ideally, a triangulation measurement provides more-robust and reliable sensor data but requires measurements from multiple sensor pads. However, as the number of pins in a particular sensor pad or the number of sensor pads in a particular area increases, the potential for signal noise also increases.

In the various sensor-pad arrangements, the touchpad can determine various inputs as touches, taps, long taps, holds, swipes, or other gestures by centroiding, which involves discarding a largest capacitance value and using a remaining set of values. By discarding a largest value, the system may achieve a more-robust measurement by eliminating outliers or other anomalous data points.

In limited geographic space, such as a wearable device like a watch or activity tracker or in-ear headphones, the arrangement and size of sensor pads can significantly impact the ability of a touchpad to reliably receive user input. For example, consider a runner using a pair of in-ear headphones. In-ear headphones appeal to many runners because of a small form factor and adequate sound quality. The in-ear headphones can also connect to a mobile device, like a smartphone or a computing watch, via a wireless or wired connection. In-ear headphones represent a design balance among size and functionality, battery-life, wireless connections, weight, water/sweat resistance, desired inputs, or the ability to be powered by the mobile device without placing a significant burden on the mobile device. Here, a runner would like to be able to interact with the mobile device without needing to divert his or her attention away from the physical area in which he or she is running.

A human fingertip ranges in size from around five to ten millimeters. The in-ear headphones can include a micro-sized touchpad, which could receive inputs and communicate the inputs to the mobile device, appropriately sized for both human-finger input and incorporation into the headphones. The touchpad can also include enough sensor pins or sensor pads to allow for a variety of detailed user inputs, such as changes in volume, moving among media tracks, or pausing media content, while minimizing an amount of signal noise. Additionally, functions such as answering a telephone call, forwarding a call to voice mail, activating an electronic assistant, initiating audible reading of a received text message, or other activities common to electronic devices could be initiated via inputs at the touchpad. Consider four optional arrangements of sensor pads within a touchpad as shown Figure 2 that could be used to receive such inputs.

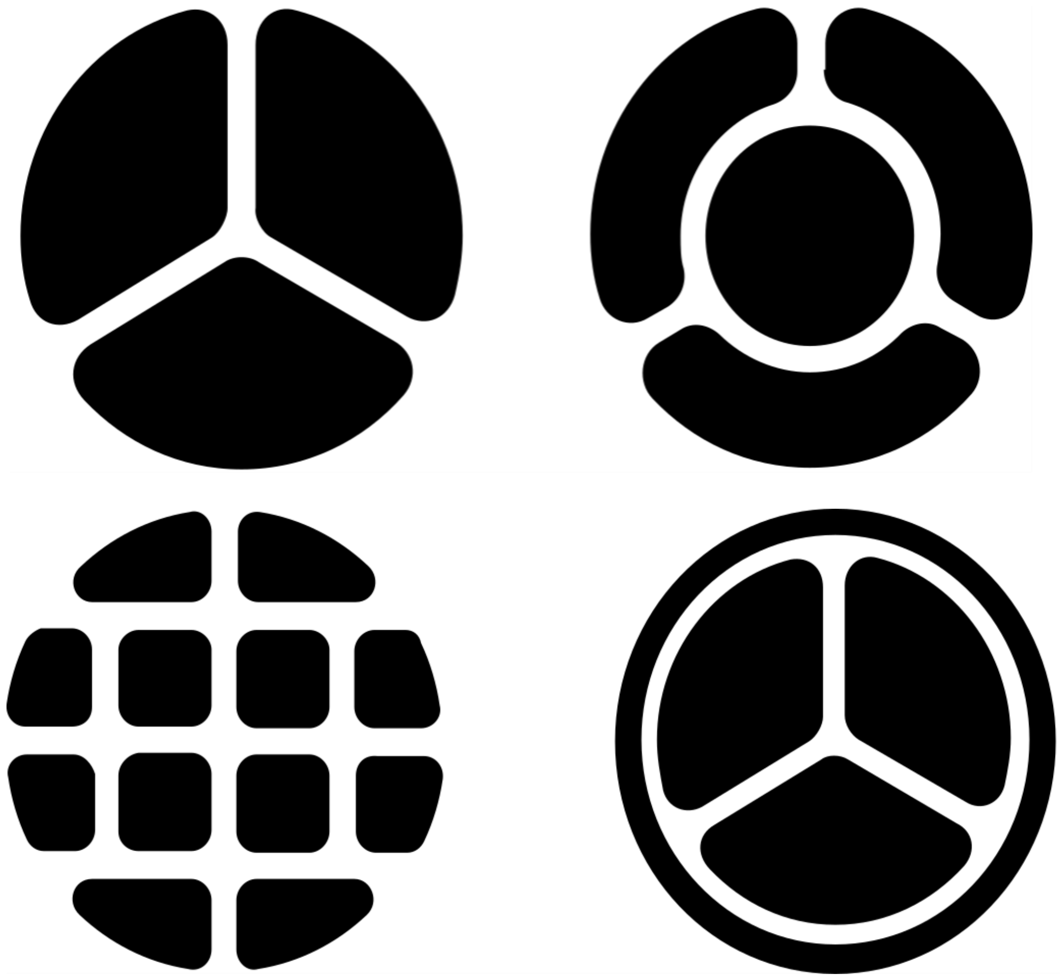

Figure 2

The individual sensor pads can be different sizes and be arranged in differing layouts. In many touchpads, contact with at least three sensor pads is necessary to receive some inputs, such as swipes or other gestures. In some designs, such as the lower-right representation in Figure 2, an outer sensor can surround several smaller sensors, which may increase the sensing of contact at an edge of the touchpad. Although shown as primarily overall round arrangements, the touchpad described herein could take an overall square, linear, rectangular, oblong, or other shape depending on application needs or electronic device constraints.

As shown in Figure 2, some arrangements of the sensor pads of the touchpad may feature radial or clockwise symmetry. In other variations, as in the lower-left representation in Figure 2, the touch-pad sensors may instead incorporate a vertical or horizontal symmetry. In a symmetrical arrangement, the touchpad would not have an established up/down or left/right configuration. For some gestures, such as taps, long taps, or holds, or for some environments, such as devices where gesture input accuracy is essential or where lower cost devices are sufficient, a symmetrical arrangement would allow for a reduced set of input commands that could be received with great accuracy. For other gestures, such as swipes, motions, or combinations of motion and tap/hold inputs, or for other environments, where an accelerometer or other component establishes an up/down orientation for the sensor or where orientation relative to a user is preferred (e.g., a runner stretching would prefer to have an up swipe gesture remain relative to the runner's head instead of relative to the ground), a non-symmetrical arrangement may be preferred.

Selection of either a particular type of symmetry or an unsymmetrical sensor pad arrangement can be tailored to the particular input needs or other components of an electronic device. For example, other arrangements of the sensor pads, which may or may not incorporate both symmetrical and non-symmetrical elements, could be customized to the physical structure of the in-ear headphones to make particular input needs or options available to the user. Consider the sensor pad arrangement of Figure 3, which incorporates both symmetric and non-symmetric elements.

Figure 3

Additionally, the individual sensor pads can be sized or shaped to achieve particular objectives. Capacitance can be correlated to the surface area of a sensing pad. Thus, similarly-sized sensor pads or differently-sized sensor pads may be selected to customize input options for a particular device. For example, consider the arrangement of Figure 4. The six individual sensor pads each cover an identically-sized area, which may aid in input detection.

Figure 4

Although discussed in the context of in-ear headphones, the touchpad described herein could function equally well or be included in many other electronic devices, such as computing watches, computing rings, smartphones, activity trackers, or other devices. Further, the touchpad can be constructed of materials to allow for use in many different environments or environmental factors, such as water, sweat, dust, temperature fluctuation, vibration, or impact. Touchpads allow for robust construction and ergonomic variability and flexibility in receiving many types of input, including touches, swipes, gestures, and holds from one or more fingers or other input devices in environments in which other input devices may not function as effectively.