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Enabling Use of a Wearable as a Wireless Computer Mouse

ABSTRACT

Touch gestures made on the touchpad of a laptop lack the natural ergonomics of a physical mouse. This disclosure describes techniques that turn an everyday object into a physical mouse. The techniques leverage the presence of dual magnetometers embedded beneath the laptop base, used conventionally to detect the open/close state of the laptop clamshell. An everyday object with a metal component inside such as an earbud case or smartwatch, when placed near the laptop base, nontrivially distorts the dual-magnetometer readings. The readings are decoded into a set of canonical screen movements (slide up, down, left, or right). Diagonal movements are inferred by combining two canonical directions. In this manner, the described techniques enable everyday objects to mimic the functions of a physical computer mouse.

KEYWORDS

- Human computer interaction (HCI)
- Wearable computing
- Laptop magnetometer
- Computer mouse
- Ad hoc mouse
- Gesture recognition
- Ambient magnetic field
- Spectral filtering
- Earbud
- Smartwatch

BACKGROUND

A laptop is generally equipped with an onboard touchpad for mouse input. However, touch gestures lack the natural ergonomics (e.g., hold, move, scroll) of a physical mouse. Carrying around a separate physical mouse with the laptop is inconvenient and inelegant.

DESCRIPTION

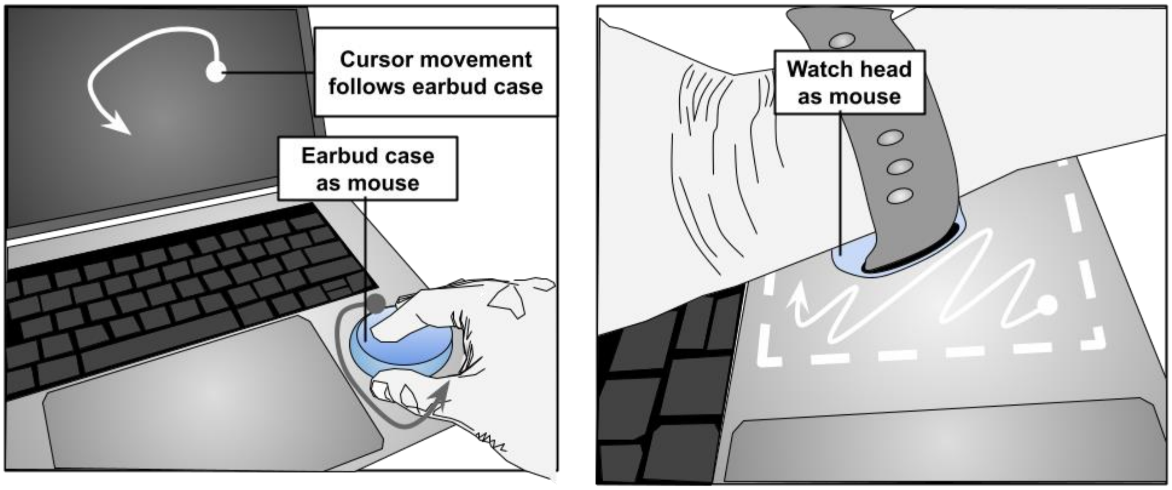
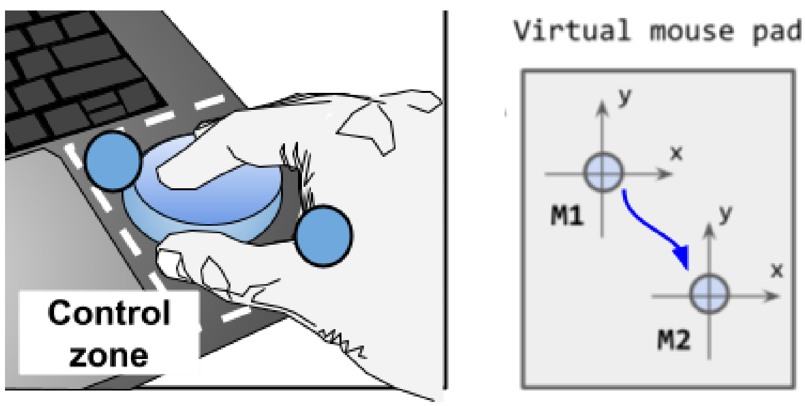


Fig. 1: Turning an everyday object such as an earbud case and a smartwatch into a computer mouse

As illustrated in Fig. 1, this disclosure describes techniques to turn an everyday object, e.g., a smartwatch, an earbud case, etc., into a physical mouse in an ad hoc manner. The techniques leverage the presence of dual Hall-effect magnetometers embedded beneath the laptop base, used conventionally to detect the open/close state of the laptop clamshell.



(a) **(b)**

Fig. 2: (a) The control zone of the ad-hoc mouse (b) Decoding magnetometer readings to determine mouse position

As illustrated in Fig. 2(a), dual magnetometers are usually located in a patch (referred to as control zone, indicated by dotted lines) a few centimeters square within the laptop base.

Operating within the control zone, an everyday object with some metal component inside, e.g., an earbud case, nontrivially distorts the dual-magnetometer readings. The readings are decoded into a set of movements (slide up, down, left, or right). For example, as shown in Fig. 2(b), the magnetometer readings can be decoded into a mouse movement from position M1 to position M2. Once the four canonical directions (up, down, left, right) are estimated, diagonal movements can be inferred by combining two neighboring directions, e.g., slide up-left = slide up signal + slide left signal). In this manner, everyday objects can be utilized to mimic the functions of a physical computer mouse.

As mentioned earlier, the dual-magnetometer setup under the laptop base senses the magnetic field variations of an object, e.g., an earbud case, being moved in different directions. An (x, y) asymmetry inherent in the placement of the two magnetometers is leveraged to determine the directionality of movement. In particular, the cue for directionality comes from the magnetometer that responds first. This is illustrated in Fig. 3.

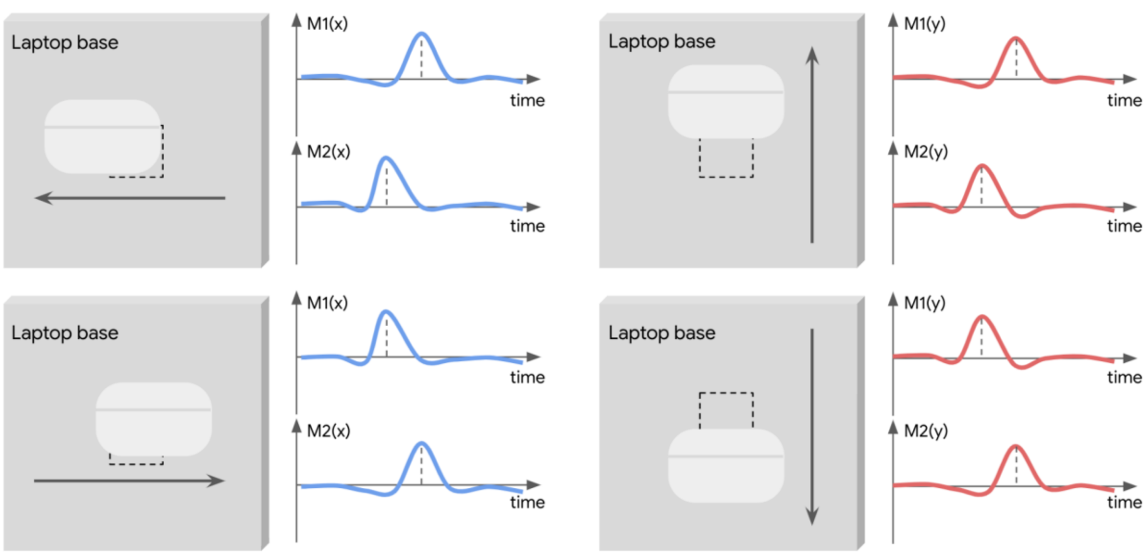


Fig. 3: The relative timing between the signals of the two magnetometers can be used to determine movements of the ad hoc mouse in the four canonical directions

The relative timing between the signals of the two magnetometers can be used to measure the movements of the ad hoc mouse in the four canonical directions. In Fig. 3, the signals $M_i(x)$ and $M_i(y)$ represent the magnetic signal from the X-axis and Y-axis of the base magnetometer with index *i* (*i* = 1 or 2). For left-right (X-axis) movements, the relative time delay between the X-signals $M_1(x)$ and $M_2(x)$ of the two magnetometers is a measure of the X-axis movement of the ad hoc mouse. For up-down (Y-axis) movements, the relative time delay between the Y-signals $M_1(y)$ and $M_2(y)$ of two magnetometers is a measure of the Y-axis movement of the ad hoc mouse.

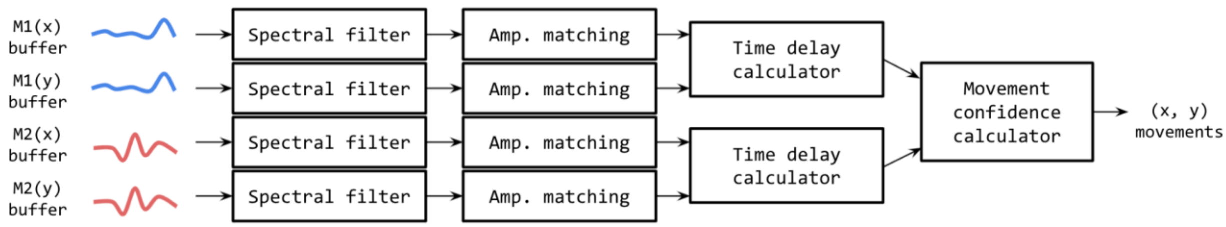
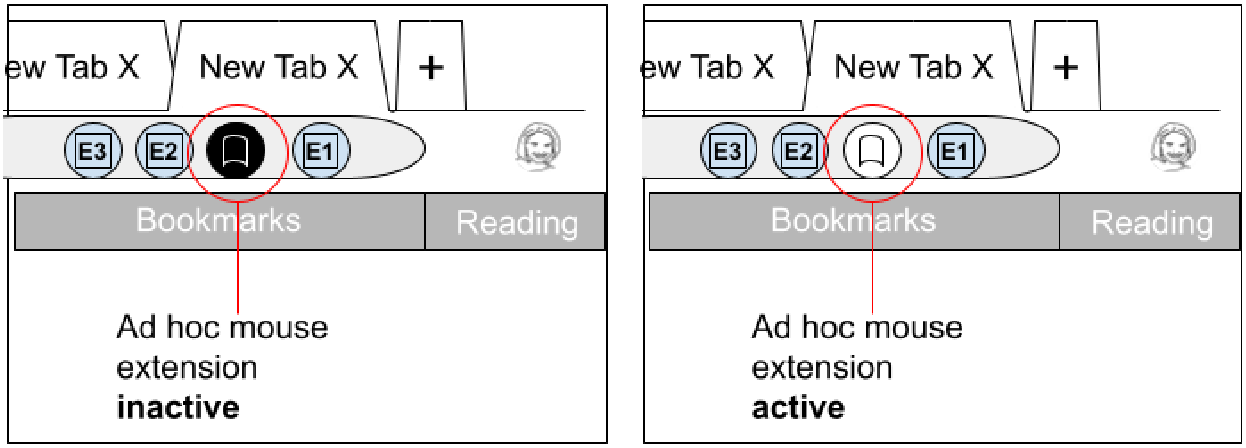


Fig. 4: Computing the exact movement of the cursor on the screen based on raw magnetometer readings

Fig. 4 illustrates the computation of the exact movement of the cursor on a laptop screen based on the raw magnetometer readings induced by the external object that the user is using as a mouse. In a *spectral filtering* stage, ambient field responses such as the earth's magnetic field, are rejected from each axis of each magnetometer. *Amplitude matching* is applied to filtered signals to localize the timestamp of the mouse movement. This can be done by simple dictionary learning, e.g., by computing a dot product of observed signals with a set of expected signals to pick an optimal timestamp result. *Time-delay measurement* outputs the delay between the two magnetometer readings along the same axis. The two axes, X and Y, produce a total of two time-delay readings. A *movement confidence* calculator maps the time-delay values into physical (delta_x, delta_y) distances moved by the mouse. The map can be an inverse linear operation, e.g., one that scales the inverse time-delay values with some pre-calibrated number. Intuitively, inverse-linear maps work because the faster (slower) the physical object moves, the shorter (longer) the time-delay values read by the magnetometers.



(a) **(b)**

Fig. 5: A browser extension to enable the ad hoc computer mouse (a) inactive and (b) active modes

Fig. 5 illustrates an example implementation of the described ad hoc mouse, where a browser extension receives the laptop magnetometer readings and activates the decoding procedures that turn the readings into on-screen cursor coordinates and movements. While Fig. 5 illustrates a browser extension, any suitable software component that is part of the device operating system, or other application can implement the described techniques. When the browser extension is inactive (Fig. 5(a)), the laptop defaults to an existing touchpad or an external USB-connected wired/wireless mouse. When active (Fig. 5(b), the control zone with dual magnetometers reads metallic objects moving above it and transmits the readings to the browser extension, which decodes the readings into mouse movements.

There is no explicit Bluetooth-style pairing established between the object in hand and the laptop. The described ad hoc mouse is wireless (and indeed, doesn't require electrical power) by virtue of leveraging the magnetic interactions of a metallic object and the dual three-axis magnetometer. The fact that many people own and carry around both a laptop and a set of metallic objects such as consumer wearables makes the described ad hoc mouse an easy to implement, convenient, and scalable proxy for an actual, purpose-built mouse.

CONCLUSION

This disclosure describes techniques that can turn an everyday object, e.g., a smartwatch, an earbud case, etc., into a physical mouse in an ad hoc manner. The techniques leverage the presence of dual magnetometers embedded beneath the laptop base, used conventionally to detect the open/close state of the laptop clamshell. An everyday object with some metal component inside, e.g., an earbud case, nontrivially distorts the dual-magnetometer readings. The readings are decoded into a set of canonical screen movements (slide up, down, left, or right). Diagonal movements are inferred by combining two canonical directions (e.g., slide up-left = slide up signal + slide left signal). In this manner, the techniques enable everyday objects to mimic the functions of a physical computer mouse.

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