Demo: Turning a Mobile Device into a Mouse in the Air

Sangki Yun, Yi-Chao Chen, Wenguang Mao, Lili Qiu
The University of Texas at Austin
{sangki,yichao,wmao,lili}@cs.utexas.edu

Motivation: A mouse is widely popular for controlling the graphic user interface due to its ease of use. Its attraction will soon penetrate well beyond just computers. There already have been mice designed for game consoles and smart TVs. A smart TV allows a user to run popular computer programs and smartphone applications. More and more devices in the future, such as Google Glasses, baby monitors, and new generation of home appliances, will all desire mouse functionalities, which allow users to choose from a wide variety of options and easily click on different parts of the view.

However, a traditional mouse, which requires a flat and smooth surface to operate, cannot satisfy many new usage scenarios. A user wants to interact with the remote device on the move. For example, a speaker wants to freely move around and click on different objects in his slide; a smart TV user wants to watch TV in any part of a room; a Google Glass user wants to query about objects while touring around. Wouldn't it be nice if a user can simply turn his smartphone or smart watch into a mouse by moving it in the air?

Challenges: To enable the air mouse capability, device movement should be tracked accurately, within a few centimeters. Existing indoor localization that provides meter-level accuracy cannot achieve this goal. Some smart TV and set-top box manufacturers provide motion control and gesture recognition using inertial sensors, such as accelerometers and gyroscopes. Accelerometers are well known for their significant measurement errors and cannot provide accurate tracking. We also confirm this using our measurement. Gyrosopes achieve better accuracy in tracking rotation. However, a user has to learn to how to rotate in order to control the displacement in a 2-D space. This is not intuitive, and is especially hard for moving in a diagonal direction, which degrades user experience and speed of control. A few recent works track RFID tags in centimeter-level [1, 2], but they require multiple special RFID readers, each with 4 antennas. Using external devices, such as depth sensor (*e.g.*, Kinect) and IR sensor (*e.g.*, Wii), incurs significant additional cost and limits the types of devices that can be controlled.

Our approach: In this demo, we will show Accurate Air Mouse (AAMouse) that accurately tracks device movement in real time. It enables any mobile device with a microphone, such as a smart phone and smart watch, to serve as a mouse to control an electronic device with speakers. A unique feature of our approach is that it uses existing hardware in mobile and electronic devices. Figure 1 shows an example of our system, where a mobile device with a microphone serves as a mouse for a smart TV with two speakers. The smart TV emits inaudible acoustic signals, and the mobile device records and feeds it back to the smart TV, which estimates the device position based on the Doppler shift.

Figure 1: Enabling accurate device tracking using the Doppler effect of the acoustic signal.

There are some existing work that leverages the Doppler shift for gesture recognition, but tracking is more challenging since gesture recognition only requires matching against one of the training patterns whereas tracking requires accurate positioning of the device. This not only requires accurate estimation of frequency shift, but also translating the frequency shift into a position involves significant additional research issues, such as how to estimate the distance between the speakers, the device's initial device position, and its new position based on the frequency shift.

We address these challenging issues as follow. We first estimate frequency shift and use it to position the device assuming that the distance between the speakers and the device's initial position are both known. Then we develop techniques to quickly calibrate the distance between the speakers using the Doppler shift. To address the device's unknown initial position, we employ particle filter, which generates many particles corresponding to the device's possible positions and filters the particles whose locations are inconsistent with the measured frequency shifts. The device's position is estimated as the centroid of the remaining particles. To further enhance robustness, we transmit signals at multiple frequencies, perform outlier removal, and combine the remaining estimations.

This demo will show our prototype on a smart phone and a laptop. We will let users hold our smart phone to control a cursor on the laptop screen. We will also ask users to trace simple shapes on the screen using the smart phone. Tracking is performed using either our approach or Gyroscope based approach for users to compare the accuracy and ease of use between these two schemes.

1. REFERENCES

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