PointPose Demo: Using a Depth Camera for Finger Pose Estimation on Touch-Based Mobile Devices

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Abstract
We present PointPose, a prototype that allows finger pose information (tilt and rotation) to be obtained at the point of touch on touch-based mobile device, thus adding to the expressiveness of touch input. PointPose uses a short-range depth sensor viewing the touch screen that provides a point cloud that is used to infer finger pose information. Our prototype is lightweight, does not require any additional tracking, and can be adapted to work with most touch-based mobile devices, making it ideal for prototyping touch-based applications that make use of finger pose information.

Author Keywords
Mobile Device, Touch Input, Finger Pose, Depth Sensor, Point Cloud, Mobile Interaction

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
Most present touch displays can only recognize the 2D touch location of a user input. However, it would be beneficial to capture further properties of the user’s touch, for instance the fingers rotation around the vertical axis.
Estimating finger pose at a touch location increases the expressiveness of the user interface by providing additional local degrees of freedom of input at a given touch location. This, for instance, allows the user interface designer to remap established multi-touch gestures such as pinch-to-zoom \[1\] to other user interface functions or to free up screen space by allowing input (e.g., adjusting a slider value, scrolling a list, panning a map view, enlarging a picture) to be performed at a single touch location that usually need (multi-)touch gestures that require a significant amount of screen space. New graphical user interface widgets that make use of finger pose information, such as rolling context menus, hidden flaps or occlusion-aware widgets \[7\] have also been suggested.

We present a novel technique, PointPose, to estimate tilt and rotation parameters for touch input on mobile devices using a depth camera. We use a depth camera for sensing because the size of such devices has been decreasing over the past few years, and they are likely to be incorporated on mobile devices in the future \[2\].

Our proposed finger pose estimation algorithm uses a point cloud generated by a depth camera as input to infer tilt and rotation values of a user’s finger performing a touch. Our technique can cover the entire touchable area of a tablet, the only constraint being the field of vision of the depth camera. Existing mobile devices can thus be extended with finger pose estimation capabilities by adding a depth camera.

**Related Work**

For reasons of brevity, we only discuss directly related work in the domain of finger pose estimation. Readers may refer to the PointPose archival publication \[6\] for a broader overview of related work.

Rogers et al. demonstrate the detection of finger tilt and rotation using a grid of capacitive sensors in combination with particle filters \[7\]. They apply their prototype to explore if touch precision can be improved by making use of finger pose information. With a similar goal, Holz et al. use an external camera to gather finger pose information to analyze how finger pose relates to perceived touch locations \[4\]. They use these insights in their implementation of a highly accurate touch input device based on a commercial fingerprint scanner \[5\]. \textit{ZTouch} \[8\] uses a multilayer array of illuminating lasers above a touch surface to infer the 3D position and pose of the user’s fingers.

![Figure 2](binary://data/583531f55206c8cb86485f864e720747/583531f55206c8cb86485f864e720747.png)

*Figure 2*: For finger pose detection, a depth camera is placed on or incorporated into the horizontal or vertical bezel of a touch screen device. This setup can be used to detect finger tilt and rotation.

In contrast to the systems we discussed previously, we argue that our system has the advantage of being lightweight: it does not need an external tracking system specially modified touchscreens—a suitable depth sensor clipped to any tablet-sized device will suffice. This makes...
our approach ideal for prototyping or research into touch input with finger pose estimation.

**The PointPose Prototype**

PointPose estimates the finger pose (tilt and rotation; see Figure 1) of the user’s finger at a touch location by processing point cloud data obtained from a depth sensor. In order for finger pose estimation using a depth camera to work, we must first consider the placement of the depth-imaging camera.

Figure 2 shows a possible placement of the depth-imaging camera in relation to the mobile device and the users hands. The depth-imaging camera is incorporated into or attached to the mobile devices body with its field of view comprising the devices touch screen, and its orientation parallel to the plane of devices touch screen, in order to optimally capture the users finger(s) while touching. This arrangement allows the detection of finger tilt relative to the touch screen as well as the fingers rotation around the axis perpendicular to the plane of the touch screen (rotation). Thus, two additional degrees of freedom for input are provided for each touch point.

Figure 3 shows an image of a hardware prototype of the system we developed. The current prototype consists of a Creative Senz3D short-range depth-imaging camera attached to a Microsoft Surface Pro touchscreen device.

Please refer to the archival publication [6] for a full description on the point cloud-based finger pose estimation algorithm.

**Demo Applications**

We will be able to demonstrate our prototype in the following ways:

- a demonstration of tilt and rotation control of a cursor, as well as a joystick mode combining both tilt and rotation.
- a game application that uses finger tilt and rotation as a virtual joystick.
- a map navigation application that uses finger tilt and rotation for map zoom and tilt (Figure 5).
- an image viewing application that uses finger tilt for resizing images.
Conclusion
We have developed light-weight method for finger-pose estimation on touch-based devices. Using a small external sensor, our method allows developers to extend existing devices with finger pose estimation functionality. The rapid development of depth imaging technology makes it plausible that such sensors will soon be incorporated into mobile devices, making our method feasible for deployment on actual devices.

By demonstrating our prototype to a large professional audience, we would like to encourage discussion about its possible uses as well as opportunities for to improving and expanding it.

References