

# Ghost Fingers: A Hybrid Approach to the Interaction with Remote Displays

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Ghost Fingers is a novel interaction method which enables efficient and intuitive switching between keyboard and multi-touch input on systems where the display is out of arm's reach. In addition, Ghost Fingers provides a translucent real-time visualization of the fingers and hands on the remote display, creating a closed interaction loop that enables direct manipulation even on remote displays. Our solution includes a wireless keyboard with attached imaging sensor that is used to both determine the position of the user's hand and fingers, and to provide a real-time translucent overlay of hand and fingers over the remote UI.



Text input mode (writing email)

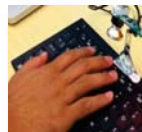


Multi-touch input mode (manipulating card GUI elements)

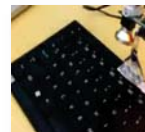
Prototype system: standard QWERTY physical keyboard equipped with an image sensor (e.g., webcam), able to detect the position of one or two hands over the keys. In text-input mode (left), the keyboard works like a normal keyboard. When user presses designated key (e.g., CTRL key), the system switches to "multi-touch mode" (right). In this mode, the sensor detects the user's fingers on the keyboard. Simultaneously (in real time), a highly transparent image of the user's hands (including fingers) is displayed on the remote display (e.g., overlaid over the UI), resulting in "ghost fingers" or hand outlines. These ghost fingers or hand outlines allow the user to easily manipulate the UI on the display, e.g., pressing an icon on the screen.



Prototype overview (left) and image sensor (right)



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Top (input sources):  
(live hand image  
- empty background)  
x transparency  
+ GUI content



Raw image data from the sensor showing significant distortion (left); undistorted and rectified hand image after calibration process (right)



Right (final output):  
Ghost Fingers image rendered in real-time by the prototype system