GestureSock: Exploring toe gestures as alternative input method

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Figure 1: GestureSock: (Left) the sock with pressure sensors (Middle) Video stills of the "extend hallux toe" gesture to play the next music track, (Right) Applications for the demonstration

Abstract

In daily life, our hands are often occupied—whether holding a child and a dog leash or riding a bicycle—making it difficult to interact with devices. This challenge has led HCI research to explore "hands-free" interactions like voice commands, though these are limited in noisy environments and certain social settings. A recent lab study using motion capture demonstrated the potential of toe movements for interaction. Building on this, we investigate toe-based interactions by embedding pressure sensors into a sock. Our work tackles practical implementation challenges and explores the feasibility of an interactive sock that captures toe movements. We demonstrate that combining pressure and motion sensing expands interaction possibilities, enabling a richer interaction vocabulary.

CCS Concepts

• **Human-centered computing** → **Ubiquitous and mobile computing**; **Ubiquitous and mobile devices**; **Gestural input**.

Keywords

Foot Interaction, Augmented Foot, Gestures, Touchless Interfaces

CHI EA '25, Yokohama, Japan

ACM ISBN 979-8-4007-1395-8/25/04
https://doi.org/10.1145/3706599.3721350

ACM Reference Format:
Vincent van Rheden, Sasindu Abewickrema, Florian 'Floyd' Mueller, and Don Samitha Elvitigala. 2025. GestureSock: Exploring toe gestures as alternative input method. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '25), April 26–May 01, 2025, Yokohama, Japan.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3706599.3721350

1 Introduction

Human-Computer Interaction (HCI) research has extensively explored hand- and touch-based interactions, which are deeply integrated into daily life through devices like smartphones and keyboards. However, our hands are often occupied in everyday situations, prompting us to explore foot gestures as an alternative interaction method. Foot and toe-based gestures offer a unique advantage for hands-free interaction, particularly because they can be seamlessly integrated into everyday footwear like socks. Despite this potential, few studies have examined foot gestures in a wearable form, with most focusing on whole-foot movements rather than individual toe gestures.

While CHI has thoroughly investigated hand gestures using external and wearable tracking devices [1, 4], foot gesture research remains relatively underexplored. To address this gap, our interactive demo, GestureShock, showcases how sock-based gesture interfaces can serve as an alternative input method for interacting with computing devices such as mobile phones, screens, and head-mounted displays (HMDs).

2 Designing GestureSock

To investigate toe gestures, we conducted an elicitation study to understand toe movements and gather a set of toe-based interactions. We recruited 15 participants and asked them to explore the range of motions they could perform with their toes. Starting with a baseline of gestures from [3]—such as all toes flexing or extending, hallux (big toe) flexing or extending, and lateral toes flexing or extending—we introduced three additional gestures: pressing the hallux, pressing the lateral toes, splitting the toes, and pressing the small toe. Any movement a participant could successfully repeat three times was considered a distinct gesture. As new participants joined, they attempted the updated list of gestures and proposed additional ones.

For sensing, we created pressure sensors using Velostat, a conductive material that changes resistance when pressed. Through experimentation with different sizes and placements, we found that these sensors effectively captured toe flexes (via pressure from the joints), toe lifts (through reduced pressure at the toe tips), and toe splits (by detecting pressure changes between the toes). Velostat proved to be an ideal material due to its flexibility and adaptability.

To showcase GestureSock, we integrated it with a simple music application designed for use while cycling. Since cyclists' hands are occupied with steering, changing music via a touchscreen is difficult, dangerous, and in some countries, illegal [2]. We mapped key music controls to toe gestures: pressing the hallux to pause/play, lifting the hallux to skip a song, extending all toes upward to increase volume, and flexing all toes downward to decrease volume. Visitors will have the opportunity to wear GestureSock and interact with these controls in a VR cycling setup, as illustrated in Figure 1, right.

3 Conclusion and Future Work

We introduced GestureSock, a wearable device designed for explicit toe-based interactions. Our approach was informed by an elicitation study that guided the design and implementation of GestureSock. Using six integrated pressure sensors, we demonstrated the ability to detect five distinct toe gestures. As a proof of concept, we enabled cyclists to control music playback hands-free. For future work, we plan to quantify the findings from our elicitation study and extend GestureSock's applications to other physical activities, such as walking and running. Additionally, we aim to explore dynamic toe gestures as input for video games and VR interactions, further expanding the potential of GestureSock.

Acknowledgments

Vincent van Rheden gratefully acknowledges the financial support from the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, the Federal Ministry for Digital and Economic Affairs, and the federal state of Salzburg under the research programme COMET - Competence Centers for Excellent Technologies - in the project DiMoNEXT Digital Motion in Sports, Fitness and Well-being (Project number: FO999904898). Florian 'Floyd' Mueller thanks the Australian Research Council, especially DP190102068, DP200102612 and LP210200656.

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