Soft Magnetic Fingertip Devices for Clear Vibrotactile Feedback

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Wearable fingertip devices have gained considerable attention due to the critical role of the fingerpads in fine tactile perception and manipulation. The dense distribution of mechanoreceptors allows for precise detection of a wide range of stimuli [1], making the fingertip an ideal location for delivering localized haptic feedback. While these devices have promising applications in virtual and augmented reality, remote operation, and communication, designing compact, cost-effective, and high-quality fingertip haptic interfaces remains challenging [2], particularly when balancing mechanical transparency, user comfort, and fabrication complexity.

Gertler et al. previously presented a wearable fingertip device that provides clear vibrotactile feedback by embedding a miniature rare-earth magnet in a silicone rubber sheath and actuating it with a nearby air-coil [3]. This device achieves excellent mechanical coupling with the skin, enabling bidirectional motion of an area of skin larger than the magnet itself, which enhances vibration perception. Building upon this foundation, we explore how variations in magnet placement, magnet polarity, encasement material, and encasement design affect the perceived haptic sensation.

This demonstration presents two types of soft wearable fingertip devices that both use 1-mm-diameter permanent magnets but differ in fabrication methods, materials, and structural design. The first type is a curved silicone sheath that fully covers the fingertip and is fabricated by dip-molding, which involves repeated immersion of a mandrel in a silicone solution to form the desired shape. This process enables the fabrication of thin, complex structures that can conform well to curved surfaces, like the fingerpad. However, it is a time-consuming process that requires specialized laboratory equipment and expertise. The second type is a ring of adjustable size, produced by 3D printing of thermoplastic polyurethane. This manufacturing process offers a rapid, simple, and more accessible method for producing soft wearable devices.

Both devices utilize the same actuation principle: a compact external air-coil is driven by a time-varying current, which generates an oscillating magnetic field. When the magnets are nearby in this field, they vibrate against the user's fingerpad at the same frequency as the oscillating current.

Visitors will be able to explore a multimodal, audio-driven haptic experience. They will have the opportunity to test different types of wearable fingertip devices that deliver audio-driven haptic feedback synchronized with pre-recorded videos showing various objects and surfaces. The integration of audiovisual content with haptic replication generally enhances the realism of the experience. Furthermore, access to the physical objects featured in the videos will enable visitors to compare the realism of the perceived haptic sensations against real interactions. Beyond experiencing the sensations, this demonstration will provide users with the opportunity to explore how key design factors – material properties, polymeric encasements, and magnet configurations – affect the perceived haptic sensation. Finally, the integration of these soft haptic devices with commercially available hardware (e.g., a smartphone's audio output) will be showcased, demonstrating a "plug and play" solution to deliver rich, clear, and localized vibrotactile feedback in a compact and accessible format.

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References

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