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Demonstrating XRScissor: Magnetorheological Haptic Interface for Realistic Cutting in XR

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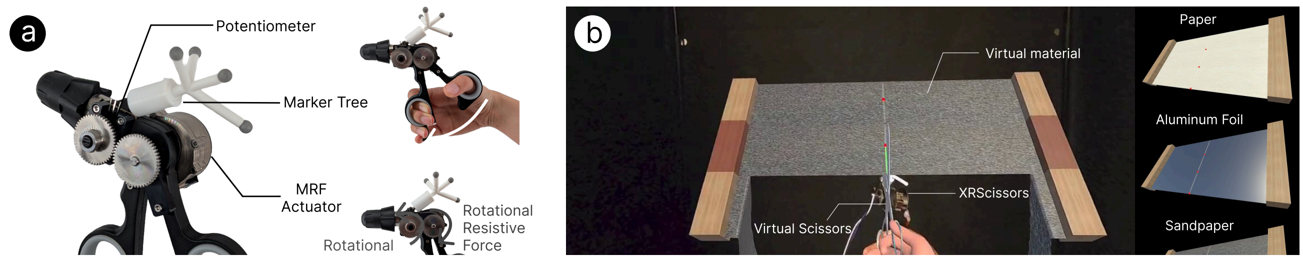

Fig. 1: XRScissors. (a) The structure of the XRScissor and (b) virtual cutting scenario with three materials in XR environment.

***Abstract*—We introduce XRScissor, an XR haptic interface that integrates a magnetorheological fluid (MRF)-based actuator to simulate material-specific cutting sensations for virtual cutting scenarios. To achieve realistic haptic feedback, we developed a data-driven rendering pipeline that leverages dominant frequencies extracted from acceleration data recorded during real-world cutting tasks. XRScissor delivers compelling and material-differentiated cutting experiences across three distinct textures.**

I. Introduction

Cutting with scissors involves nuanced sensory feedback: cutaneous force, vibration, and friction by material's texture. While modern haptic interfaces employing vibration actuators simulate cutting experience in VR [1], vibrotactile feedback alone is insufficient to recreate a realistic cutting sensation due to the lack of cutaneous force and friction. The integration of three key haptic cues for cutting remains under exploration.

To address this limitation, we present XRScissor, a novel XR haptic interface that embeds a magnetorheological fluid (MRF) actuator into the form factor of scissors to simulate cutting sensations (see Figure 1 (a)). Leveraging the MRF's tunable resistance and rapid response, it enables the replication of material-based cutaneous feedback such as variations in resistance, roughness of the texture, and transient force peaks. XRScissor accurately replicates the feeling of real cutting [2].

We implemented a data-driven haptic rendering pipeline to reproduce the tactile characteristics of real-world cutting. We extracted dominant frequency features from physical cutting data and rendered them through real-time pulse-width modulation (PWM) of the MRF actuator. A high-resolution potentiometer embedded in the scissor tracks blade angle for accurate motion onset and synchronized haptic feedback.

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Below, we present the tactile signal profiles rendered for three material (see Figure 1 (b)):

Paper: Smooth and moderately resistant. PWM signals show broad frequency variability ($153 \pm 102\,\mathrm{Hz}$), rendered at medium intensity with stable, continuous feedback.

Aluminum Foil: Pliable and crisp. PWM bursts contain sharp, high-frequency spikes ($165 \pm 75\,\mathrm{Hz}$), rendered at low intensity with brief, irregular pulses.

Sandpaper: Coarse and rigid. PWM signals are skewed toward lower frequencies ($118 \pm 83\,\mathrm{Hz}$), rendered at high intensity with strong, discrete cycles.

XRScissor synthesized visual and physical interaction, enabling immersive, tool-based experiences with high-fidelity haptics, providing distinct feelings of different materials.

II. Demo Experience

At IEEE WHC 2025, we will showcase XRScissor integrated with an augmented reality (AR) setup that delivers synchronized haptic and visual feedback. We will display the AR content through Meta Quest 3 HMD. Six OptiTrack PrimeX 13 cameras mounted around a black-curtained booth will be used for precise motion tracking of the XRScissor's angle and rotation. Attendees will experience mateiral-specific haptic rendering of XRScissor with natural cutting motions for three virtual materials in the AR environment. Each demonstration will last approximately 4–5 minutes, including a brief calibration phase and guided interaction.

References

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