2025 IEEE World Haptics Conference (WHC)
Suwon Convention Center, Suwon, Korea
July 8 ~ 11, 2025

Directional, Squeezing, and Pulse Feedback for VR Robotic Surgery

Sihan Yang
Department of Mechanical Engineering
Seoul National University
Seoul, South Korea
sihanyang@snu.ac.kr

Seong Joo Byeon
Department of Mechanical Engineering
Seoul National University
Seoul, South Korea
anniesj@snu.ac.kr

Jungmin Ahn
Department of Mechanical Engineering
Seoul National University
Seoul, South Korea
jungmineee@snu.ac.kr

Chan Young Park
Department of Mechanical Engineering
Seoul National University
Seoul, South Korea
pcy048@snu.ac.kr

Amy Kyungwon Han*
Department of Mechanical Engineering
Seoul National University
Seoul, South Korea
amyhan@snu.ac.kr

***Abstract*—This study presents a haptic illusion-based vibrotactile feedback system to provide directional, squeezing, and pulse haptic feedback, enhancing tactile realism in VR-based robotic surgery. Clinical tests confirm high user satisfaction and effectiveness, paving the way for broader integration in surgical training platforms.**

***Index Terms*—Haptic illusion, Haptic feedback, Robotic surgery**

I. Introduction

Virtual reality (VR)-based surgical systems offer valuable platforms for preoperative training and surgical planning, enabling immersive visualization and improved procedural rehearsal; however, the absence of direct tactile feedback remains a critical limitation. This study introduces a haptic illusion-based vibrotactile system enhancing tactile perception in virtual reality surgery by simulating tool-tissue interactions, such as directional movement cues, tissue squeezing awareness, and pulse contact warnings.

II. Methodology

Our proposed system integrates eccentric rotating mass (ERM) motors embedded within a silicone housing placed on the fingertips of the index finger and thumb, delivering precise and localized tactile feedback.

The system implements three tactile feedback modalities: (1) Directional Feedback provides six-directional phantom sensations (left, right, up, down, clockwise, counterclockwise) to create motion illusions, aiding perception of tool-tissue displacement or force direction and reducing unintended slippage. (2) Squeezing Feedback encodes tissue stiffness by adjusting vibration intensity based on finger-to-finger distance, offering intuitive cues that improve grip control and lower excessive pressure. (3) Pulse Feedback simulates arterial pulsation via a strong-long/weak-short vibration pattern, helping prevent excessive force that could damage arteries.

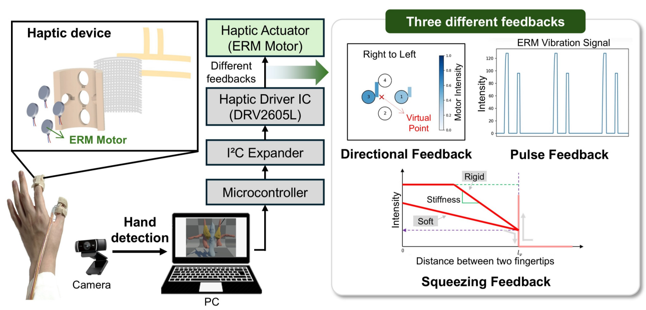

Fig. 1. Block Diagram of the system

Our tactile system is integrated into a VR environment, with pulse feedback mapped to realistic surgical scenarios, and directional and squeezing feedback incorporated into basic simulations.

III. Result

A user study with six clinicians showed high feedback recognition accuracy (82–100%) and strong Likert scale (1–5) satisfaction: squeezing feedback was rated highly necessary (4.3), pulse feedback highest in realism (4.3) and intuitiveness (4.4). Overall, the system scored 3.7 for comfort and 3.8 for willingness to adopt in training, though some users reported fatigue, indicating the need to enhance device wearability and comfort. Future work will focus on deeper integration with complex VR surgical scenarios to boost training realism and applicability.

This study was supported by the NAVER Digital Bio Innovation Research Fund, funded by NAVER Corporation (Grant No. [3720230030]) and the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (MSIT) under Project Number RS-2023-00213383. The authors thank Min Joh and Narin Hyun for their help with user studeis.