An Accessible Virtual Reality Model of Surgical Microscopy for Microsurgical Practice

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Microsurgery is one of the most technically demanding surgical techniques. Because it enables visualization of fine details beyond the visibility of the bare eye, microsurgery is one of the most fundamental components of many modern surgical procedures, such as in plastic surgery, neurosurgery, and oncological surgery (Milling *et al.*, 2022). A standardized eight-week course in residency can improve the time-to-completion and latency in microsurgical procedures significantly (Di Cataldo *et al.*, 1998; Ko *et al.*, 2015). Sufficient microsurgical practice is also beneficial for residents outside of plastic surgery, as the experience improves hand-eye coordination during surgery (Lascar *et al.*, 2007). Despite the benefits of microsurgical practice, availability of the surgical-grade microscopes is scarce. First, the cost of microscopes can exceed $100k USD, forcing the medical schools to limit the number of units available for microsurgical practice (Zhang *et al.*, 2020). Second, access to microscopes is further restricted by the fragility and relatively low portability of the devices (Ma and Fei, 2021). There is a gap in the commercial market for a more affordable and portable solution for microsurgical practice, and the COVID-19 pandemic further increased demand for remote instruction paradigms(Higgins *et al.*, 2021).

To perceive the relative distance between objects on the surgical station, a microsurgeon needs a dedicated visual channel for each eye, as the disparities between images of each visual channel is interpreted by the brain as cues for depth perception. A previous study confirmed the importance of stereoscopic vision, in which errors in thickness estimation were observed using a smartphone that produced a single visual channel (Jianmongkol *et al.*, 2022). Currently, no alternative devices to the surgical microscope can achieve stereoscopic vision.

To address the need of stereoscopic vision, the VR Microsurgery team adopts a design consisting of two Logitech webcams that capture the microsurgical field from two different perspectives. The cameras are placed at 63 mm apart horizontally to replicate the average interpupillary distance of humans. The angle of capture is determined to account for the difference in viewing angle of the eyes, thus forming disparity in perspective between the visual channels of the two cameras. A raspberry pi reads the captured signal via its USB ports, and the images are ported to an Oculus Quest 2 VR headset via wireless connection. Real-time video captured from the Webcams are displayed via a Unity software program though Oculus, such that when the user wears the VR headset, each of the eyes receives a unique visual channel from one of the Webcams. The total cost of the setup is less than $600, offering an affordable and promising substitute for surgical microscopes that can provide opportunities for microsurgical practice. Additionally, the small footprint of the device allows for a high degree of flexibility in its use, making this design an ideal solution for operating rooms with limited access to resources.