Development of a Wearable Embedded System providing Tactile and Kinesthetic Haptics Feedback for 3D Interactive Applications

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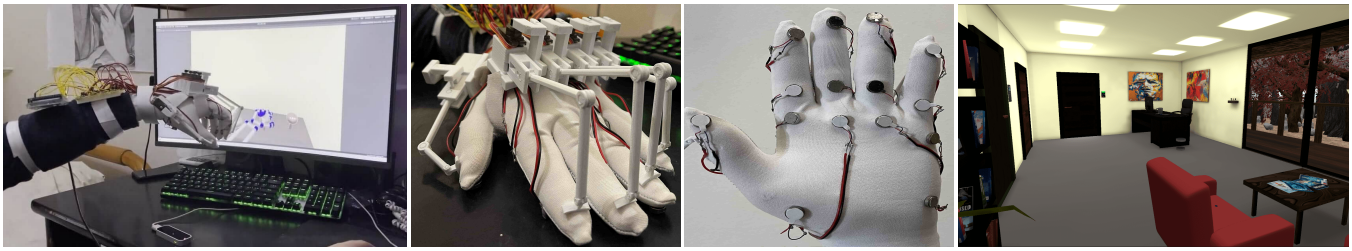

Figure 1: (a) Haptic interface side view (b) Exoskeleton view (c) Vibration motors placement in the hand (d) Game application

ABSTRACT

Existing haptic interfaces providing both tactile and kinesthetic feedback for virtual object manipulation are still bulky, expensive and often grounded, limiting users' motion. In this work, we present a wearable, lightweight and affordable embedded system aiming to provide both tactile and kinesthetic feedback in 3D applications. We created a PCB for the circuitry and used inexpensive components. The kinesthetic feedback is provided to the user's hand through a 3D-printed exoskeleton and five servo motors placed on the back of the glove. Tactile feedback is provided to the user's hand through fifteen coin vibration motors, placed in the inner side of the hand and vibrating at three levels. The system is ideal for prototyping and could be customized, thus, making it scalable and upgradable.

CCS CONCEPTS

• **Computer systems organization** → *Firmware*; **Sensors and actuators**; • **Human-centered computing** → **Haptic devices**.

KEYWORDS

Embedded Systems, Haptics, 3D Environments

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1 INTRODUCTION

Touch is a sense deployed on touch screens or along with haptics. Haptic technology simulates touch while interacting with 3D objects, employed in virtual reality (VR), tele-operation, robotics, cultural heritage etc [Pierce et al. 2014], [Ma et al. 2015]. Haptic devices that provide tactile and kinesthetic feedback are heavy and cumbersome because of exoskeletons, motors and circuitry placed on the upper side of the hand [Pacchierotti et al. 2017]. Past work focused mainly on grounded implementations rather than wearable ones, limiting user's motion and sense of immersion [FundamentalVR 2018], [Roboligent 2018], [Nisar et al. 2019]. Haptics for cultural heritage utilized grounded devices [Ceccacci et al. 2021], [Jamil et al. 2018]. Microfluidic technology for tactile feedback and an exoskeleton for kinesthetic feedback results in a wearable but expensive and heavy system [Haptx 2018]. A haptic glove provides tactile, kinesthetic and temperature feedback, but, only for one finger [Kato et al. 2019]. Recently, wireless embedded systems for hand motion capture and tactile feedback either lack kinesthetic feedback [Efraimidis and Mania 2020] or even with superb tactile and kinesthetic capabilities, are quite expensive and cannot be fully customized [Gu et al. 2016]. In this poster, we propose an innovative, wearable, embedded system on a glove consisting of an exoskeleton comprising of 5 servo motors placed on the back of the hand for kinesthetic feedback (Figure 1b). On top, we used 15 vibration motors placed on the palm and the fingers, controlled by an Arduino microcontroller providing scalable tactile feedback to the user. Our system is lightweight providing both tactile and kinesthetic feedback to be deployed along diverse 3D scenes.

2 IMPLEMENTATION

We propose a wearable, lightweight, embedded haptics system providing both tactile and kinesthetic feedback for 3D interactive applications. The motors providing the haptic feedback are controlled by the Arduino Mega 2560 Rev3 (Figure 2, black box 3),