Generating a Haptic Feedback Tool for Craftspeople

Ece Dinçer
Paris Lodron University of Salzburg & Salzburg University of Applied Sciences
Salzburg, Austria
ece.dincer@stud.sbg.ac.at

ABSTRACT

With the effects of both increasing digitalisation and measures taken during the pandemic period, people are faced with new remote communication and collaboration technologies and techniques in last 2 years. Although, some employees can work remote with solutions like video conferencing, virtual workspaces and/or collaborative file editing, it is true that those technologies currently limits users of their visual and auditory perceptions, affecting the nature and complexity of ways of working. Especially, when the subjects of this working environment are workers who use traditionally physical tools like handcrafts, learning new skills or introducing the usage of tools to newcomers is restricted. With this starting point, it is aimed to complete this master thesis on using haptic feedback and creating a tool to bridge over craftspersonship and remote work. For this purpose, some related works have been reviewed under the headings of "Haptic Handheld Controllers", "Wearables", "Texture" and "Touchless Feedback". Moreover, it was decided that Research through Design approach will be implemented to reach expected outcome, a high fidelity prototype of a haptically tangible manipulative tool which helps craftspeople to apply their handcraft into remote working spaces in a natural way.

KEYWORDS

Human-Computer Interaction (HCI), haptic I/O, haptic feedback, prototyping, research through design (RtD)

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1 INTRODUCTION & MOTIVATION

Increasing digitalisation as well as pandemic situation in last 2 years have led to new communication and collaboration solutions in both education and working environments. For example, online meetings, virtual work-spaces and collaborative file editing made it possible to work with a variety of collaborators in different places and at different times[14]. Although all these remote setups had been a necessity at beginning of the pandemic to reduce transmission of the virus since there was no other available solution for this new one, today, employers have realised that people can actually work remotely. Therefore, it can be said that, COVID-19 pandemic has brought dramatic workplace changes from "full-time face-time norm" to different work environment concepts such as virtual work-spaces[2]. However, today's collaborative Mixed Reality(MR) technologies currently limits users of their visual and auditory perceptions, affecting the nature and complexity of ways of working[19]. Working through digital communication channels and the ability to work from home is largely limited to worker's post knowledge. Especially, when the subjects of this working environment are workers who use traditionally physical tools like handcrafts, learning new skills or introducing the usage of tools to newcomers is restricted. Traditionally, people perform much of their work in real-world environments and they work with their hands, which is rooted in fine motor precision through the hand's degrees of freedom combined with haptic perception of the hand. In computer-based work and collaboration, both the situational and haptic components are largely absent - in both input and output modalities. The appearance, shape, and texture of tools traditionally used to make furniture, of example, saws, planes, files, and hammers, are fundamentally different from tools, especially software, mouse, and keyboard, used to design objects digitally. Therefore, it can be said that using directly these computer related tools can inhibit the transfer of knowledge and skill of craftspeople in digital production as well as erase the handcraft learning pathway completely. Either facilitating craftspeople insert their handcraft abilities into mixed reality or gain new skills from online working space have not been focused in terms of preserving traditional knowledge and manual skills. To maintain the expertise of said skills and knowledge, this master thesis aims to use haptic feedback and create a tool to bridge over craftspersonship and remote work.

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2 PROBLEM STATEMENT & RELEVANCE

Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR) technologies has been limited mainly to camera-based systems and controllers for gesture, button, and touch-based input. More complex manual actions, as would be necessary for the manual inspection of elements or modeling 3D objects, are not yet possible. In order to make the physical interactions with objects intuitively experienceable over a distance, haptic feedback in a more natural form is missing. Previous solutions are unsatisfactory in terms of user experience and allow only very simplified and therefore imprecise interaction.

The overall goal of this master thesis is to research and develop a new haptic device for MR that dynamically integrates into environments with networked objects and intelligent tools.

3 RELATED WORKS

Today's MR systems are not capable to give natural haptic impressions although they have head-mounted displays (HMDs) and headphones to give more clear visually and auditorly feedbacks[21]. Therefore, additional haptic devices are developed mostly as a VR tools in the literature. Those tools get help from varied in different application areas like handheld controllers, wearables or/and textures as well as even touchless feedback.

3.1 Haptic Handheld Controllers

Haptic handheld controllers can be defined as an external tools mostly used by hand while using VR systems. There are different types of haptic interfaces in the literature to achieve giving natural interaction with VR to users. For example, as a shape changing haptic interface, Zenner and Krüger[21] has got benefit from drag and inertia which is providing kinesthetic sensations in their prototype. In this drag and inertia-based haptic VR controller, moving its hand fan shaped changeable surface area causes different sensations of resistance simultaneously. In another example of haptic controller from Sinclair and colleagues[15], to give haptic feedback during VR usage, friction is used for resisting human finger movements. There are also another type of handheld controllers uses weight shifting to create haptic interface in VR[12][20].

3.2 Wearables

In addition to haptic handheld controllers, there are several wearable haptic devices to use in VR. One of the common haptic wearable devices are glove-based ones. For example, Dexmo[5], "an inexpensive and lightweight mechanical exoskeleton", captures motions of a hand and gives force feedback in VR applications which are mostly game-based ones. CyberGraps[1] is another example for glove-based haptic wearables. Secondly, there are other type of wearables used for haptic feedback via electrical muscle stimulation. For example, Lopes and colleagues[8] has used 8 electrode pairs for wrist, biceps, triceps, and shoulders to create counter force that pulls the arm backwards while holding a "virtual" object.

3.3 Texture

Sometimes, texture could be a clue for what to do as a haptic feedback. That could be on a button as in the paper of Ogawa and colleagues[11] which is introduced as multiple texture button. Moreover, textures can be used for material representation[18]. In the ongoing study named TeslaMirror, researchers are trying to give not only the feedback of position and shape of a virtual object but also information of its texture[4].

3.4 Touchless Feedback

To create real life stimulation over MR/VR/AR setups, touchless haptic feedback is one of the new techniques in the literature. By using ultrasonic haptic devices, researchers have developed mid-air haptic sensation without any other tools as handheld controllers or wearables. This mid-air haptic feedback can be described as a feedback system for touchless interfaces, by using ultrasound or air vortices directed to palm or fingers as means for tactile simulation[13]. This technology has been used for getting feedback from touch surfaces[3] and virtual screens[10] as well as in VR setups[7][9]. Additionally, for a better and immersive experience in a VR setup, mid-air haptic feedback can be combined with other senses for perceiving the virtual environment. For example, Singhal and colleagues have found that mid-air thermo-tactile feedback is significantly more satisfying for participants than thermal only, tactile only, or no feedback in terms of user experience in VR[16].

4 RESEARCH QUESTIONS

In the light of the niche in the field, this master thesis will try to get answers from following questions:

- In the working area of craftspeople context, what would be the MR display?
- How might a haptically tangible manipulable tool can be designed to use remote craftspersonship work in a mixed reality setup?

5 PROPOSED METHODS & APPROACHES

This master thesis will be crated over a literature review, research through design via prototyping and testing those prototypes. Literature review process will be upon, firstly, possible online working environments used VR, AR and MR to make me competent on suitable conditions for online craftspersonship. According to Speicher and colleagues[17], what MR is still negotiated topic and still there is no single definition of MR. Therefore, I need to define some frameworks for my specific context stay within the lines.

Secondly, I will make in-depth research on haptic feedback and its current usage areas and usage patterns as well as other feedback types in VR, AR and MR. I would say that, not only haptic feedback, which is my stable topic, but also other feedbacks such as visual feedback will be helpful to designing a meaningful tangible manipulable tool to use in remote working context. I will follow Research through Design (RtD) approach in this thesis mostly. This approach is aimed to demonstrate the final outcome with product design which will be usable and be innovative that can be used in the future. Accordingly, I will try to go to solution via prototypes which can be seen as "physical hypotheses" to test throughout the research. Basically, I will use my background research data from literature review to create low fidelity prototypes as hypotheses to come up with testable objects[6]. Data from tests will be analysed and documented to gain more knowledge and iterate my design theory. This process will be gyratory until the desirable product will be created.

6 EXPECTED OUTCOME

As I have already mentioned, desired final outcome will be a high fidelity prototype of a haptically tangible manipulable tool which helps craftspeople to apply their handcraft into MR/online workingspaces in a natural way. This tool can be either a handheld controller or wearable. I would also assume that, along with haptic feedback, I will benefit from other types of feedbacks which will be decided on during research phase.

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