Haptic Journey: The integration of gesture-controls and mid-air haptic feedback into ticket machines to foster better hygiene in public spaces

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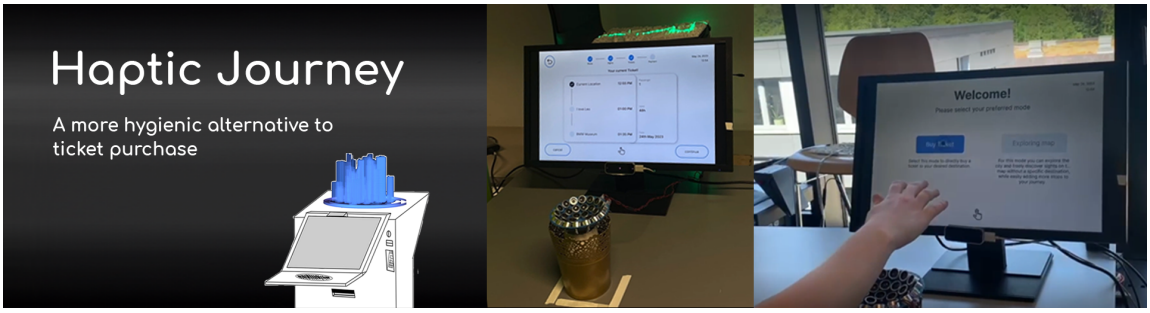

Fig. 1. Prototype for our ticket machine concept "Haptic Journey" deploying gesture-control and a haptic feedback modality

Since the outbreak of Covid-19, hygiene is a major issue, especially in public spaces. One example are public ticket vending machines (TVMs). With their contactless interaction, gesture-controlled interfaces offer a valid alternative to touchscreens and haptic buttons, which are still widely used in current machines. To explore the impact of mid-air haptic feedback combined with gesture-control we conducted interviews, an online survey and a usability study to measure user experience and user satisfaction. Our results show that hygiene plays a major role in public spaces. Furthermore, gesture-control combined with mid-air haptic feedback has the potential to provide more hygienic interaction that enhances user experience and usability compared to traditional TVMs.

Additional Key Words and Phrases: mid-air gestures, mid-air interaction, touchless interaction, haptics, public displays, ticket machine

1 INTRODUCTION

Since the World Health Organization (WHO) has declared Covid-19 a worldwide pandemic in March 2020, our lives have drastically changed, especially with regard to personal hygiene. It became a huge influence on our everyday routines and suddenly everything revolved around hand sanitizers and face masks. Even now that the global state of emergency has officially been lifted in May 2023, hygiene still plays a major role. Due to a Germany-wide survey commissioned by the German Dental Association (BZÄK) in 2021, 86% of the 1.006 respondents stated that hygiene has become a higher priority to them during the pandemic [5]. One area which is particularly affected by bad hygiene are public surfaces since many people touch them every day. An example are TVMs for public transportation. With touchscreens and

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haptic buttons as main means of interaction, they are prone to spreading germs. One possible solution for this problem are contactless gesture-controlled interfaces since they satisfy the wish for better hygiene in public places. As part of a pre-study to define our concept, we conducted a literature review. Our research suggested combining gesture-control with a haptic feedback modality as it can significantly improve usability and aesthetic appeal compared to interfaces that only deploy gesture control [10]. To find out if this combination also provides a satisfactory solution for TVMs, we explore the integration of a touchless interface with haptic feedback into traditional machines.

2 RELATED WORK

Mid-air gesture interaction enables users to use their body to interact with digital content or devices without having to touch them. By executing various gestures users can control interfaces that are further away, which makes gestures a very hygienic means of interaction [9] [6]. To ensure a smooth and fast interaction, gestures should be as easy and natural to perform as possible [4]. Mid-air hand gestures are a natural and intuitive way to interact with public displays. Once a user performs the gesture, they will explore the gesture vocabulary, instead of just imitating other users [11]. Nevertheless, hand gestures do not offer tactile feedback [2], which is crucial to improve the usability and aesthetic appeal [10]. To solve this issue we decided to build our gesture-controlled interface including haptic feedback. Mid-air haptic feedback provides contactless interaction using ultrasonic tactile sensation [10] [3] [7] [8]. Additionally, mid-air interaction in 3D visualisation enables a new level of experience. A hybrid interaction, including haptic interaction and mid-air gestural interaction, uses peoples' natural skill for manipulating their surrounding environment and enables fast and precise 3D manipulation [1]. It augments a limited interaction space and reduces the occlusion limitations with tactile interactions [1]. The promising future of this technology leads us to our research topic. Due to our limited capabilities and resources we first of all focused on identifying challenges in the implementation of mid-air haptic feedback and investigating whether or not the technology has the potential to be used for TVMs.

3 METHOD

3.1 Approach

The purpose of this work is to determine whether gesture-controlled interfaces combined with mid-air haptic feedback can provide a fast and hygienic solution for interacting with TVMs. Therefore, we firstly conducted 13 structured interviews with people between 14 and 84 years (10 males, 3 females) to explore issues with current TVMs and investigate opinions on gesture control and haptic feedback as replacement for touchscreens. 4 participants expressed concerns about hygiene in relation to touchscreens. In a separate question about mid-air haptic feedback, 5 participants mentioned that using this technology could improve hygiene. Furthermore, touchscreens are often not sensitive enough and do not respond to inputs properly. Regarding gesture-control and haptic feedback, 9 people stated that they are curious and would like to try it. In a following online survey we wanted to explore in which situations TVMs are usually used to determine our target group. We found that TVMs are mostly used to buy local transportation tickets as well as travelling to distant cities as a foreigner. To make our concept more attractive for foreigners, who rely, according to the survey, on the TVMs as they do not have local transport apps, we also added an "explore mode". It allows them to discover the city via a 3D map and add stops to the route, which eases the transition after moving to Germany. In the future the 3D map should be an interactive hologram providing mid-air interaction. After defining the features we conducted a Wizard of Oz experiment to test if the gesture-interaction and haptic feedback is working properly. We split our participants into two groups, one testing the interface with haptic feedback and one without. The results suggested

that haptic feedback eases the interaction but the implementation needs to be further improved. In the study the haptic device was not directly connected with the interface and had to be triggered manually, leading to an unpleasant delay. Therefore we implemented our prototype in HTML and connected it to the haptic feedback device using HTTP get requests. After the implementation and some adjustments in the UI we conducted the final usability testing.

3.2 Study design

Our final usability test aimed to explore the impact of mid-air haptic feedback on the user experience, satisfaction and the usability of our gesture-controlled TVM. The research questions guiding this investigation were:

RQ1: How does the presence of mid-air haptic feedback affect users' perception of confirmation when interacting with ticket machines?

RQ2: How satisfied are users with the overall usability and user experience of gesture-controlled ticket machines?

We recruited 12 participants (9 males, 3 females) with an age range between 21 and 28 years and a mean age of 25 years. The participants were from six different countries, including Germany (N=6), India (N=4), Turkey (N=1),Indonesia (N=1) and Pakistan (N=1). The usability test was conducted in a controlled environment which closely resembled a real TVM setup. The physical prototype consisted of a screen and a non-interactive 3D model above it. The screen showed the HTML prototype of the ticket purchase process and the ticket exploration process. The physical prototype was controlled by gestures with a leap-motion controller. The user received mid-air haptic feedback through a bowl in front of the screen that could provide only a single focus point. The interaction with the 3D map was simulated using the Wizard of Oz method. The study commenced with an introduction to the process and its objectives. Participants were asked to complete a pre-study questionnaire, which aimed to gather demographic information, previous experience with TVMs, travel behaviour, familiarity with gesture control, expectations and preferences regarding gesture-controlled TVMs, perceptions of mid-air haptic feedback, and overall user experience with interactive systems. For the usability test, participants assumed the role of users who wanted to purchase a ticket. To familiarize them with the main input gestures, a training task was conducted. Two tasks were performed in the study, involving ticket purchase and explorer mode. Each task was carried out in two conditions: with mid-air haptic feedback and without. The tasks were completed using a with-in subject design: All participants completed both tasks in a randomized order to mitigate learning effects. Participants' interactions were observed and documented, capturing gestures, movements, and challenges. Feedback and audio recordings were collected. After each task, participants provided their impression by completing a short UEQ. Usability metrics, including task success rate, task completion time, and error rate, were measured to assess task performance. Following task completion, participants were interviewed to gather qualitative feedback including system intuitiveness, usability in comparison to existing TVMs, the effectiveness of mid-air haptic feedback, ease of ticket purchase, satisfaction with the explore mode, user-friendliness, and suggestions for improvements.

4 RESULTS

The majority of the participants (53.8%) expressed a preference for gesture-based TVMs over traditional ones, indicating a strong inclination towards gesture control. The presence of mid-air haptic feedback positively enhances users‘ perception of confirmation when interacting with the TVM (69.2%) and they reported that the feedback enhanced their understanding of the system, was not distracting (84.7%), and provided sufficient guidance. While some participants expressed concerns about restricted motion and desired different types of feedback, the overall impact of mid-air haptic feedback was favorable, indicating its effectiveness in improving user experience with TVMs. However, it is worth

noting that participants identified challenges with hand tracking and perceived gesture-interaction as more difficult than touch. The users were overall satisfied (81,6%) with the gesture-based TVM. The button size and the challenge of making small movements with the cursor with the help of the leap motion tracker were criticized. Big buttons would be necessary to solve this as well as to reduce the time needed. After a certain time interacting with the gesture-based TVM, it was easier for the users to interact with it. The city exploration mode proved to be highly engaging, as reported by the majority of participants (92.3%). Participants expressed a keen interest in various improvements to further enhance the system. These improvements included incorporating sound feedback upon button clicks, displaying stops on the route, enabling complete elements to be clickable, and providing personalised recommendations based on the destination.

5 DISCUSSION

The study's findings support our hypothesis (RQ1) by indicating that mid-air haptic feedback positively influences users' confirmation perception when interacting with TVMs, enhancing the user experience by providing tangible feedback. Participants expressed high satisfaction with the overall usability and user experience of our TVM, supporting our hypothesis (RQ2) and highlighting the novel and engaging nature of gesture-based interactions. Challenges with hand tracking and the perceived difficulty of gesture-interaction compared to touch underscore the need for refining the technology to ensure good user experience. Incorporating user feedback and implementing suggested improvements has the potential to further enhance usability and user satisfaction with the gesture-controlled TVM.

6 CONTRIBUTION TO THE FIELD OF HUMAN-COMPUTER INTERACTION

Our study significantly contributes to the field of Human-Computer Interaction (HCI) by exploring the benefit of gesture control and mid-air haptics in TVMs. We address hygiene concerns in public spaces by enabling touchless interaction through gesture control and enhancing usability with mid-air haptics. Our research informs future improvements in gesture recognition, button accuracy, and hand tracking. This advancement in HCI knowledge improves the design, functionality, and user satisfaction of gesture-controlled TVMs, with implications for enhancing interactions in public transportation settings. Furthermore, our innovative concept, featuring explorer mode and a holographic 3D map, anticipates future demands and trends in the industry. While certain aspects of our concept require further improvement, its transferability to other gesture control-based systems makes it highly valuable in various domains, offering potential benefit for improving user interactions in public spaces and healthcare settings.

7 CONCLUSION AND FUTURE WORK

In conclusion, our study demonstrates the positive impact of gesture-control and mid-air haptic feedback in public TVMs, enhancing usability and user experience and providing a more hygienic alternative to touchscreens. During the study we noticed several limitations of our prototype regarding gesture recognition, button accuracy, and hand tracking, informing future concept iterations. In addition, since the average age of our study participants was rather low, we suggest testing the concept also with older people to check if it would be really feasible in public spaces. Finally, our concept has to be tested in terms of mid-air interaction in 3D visualisation. Therefore a functional interactive 3D hologram map has to be created and tested with the TVM.

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