國立臺灣大學電機資訊學院資訊網路與多媒體研究所

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智慧型眼鏡在公眾場合中的使用者定義遊戲操作

User-Defined Game Input for Smart Glasses in Public Space

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口試委員會審定書

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本論文係王瀚宇君 (R02944002) 在國立臺灣大學資訊網路與多媒體研究所完成之碩士學位論文，於民國 104 年 6 月 2 日承下列考試委員審查通過及口試及格，特此證明

口試委員：

所　長：

誌謝

感謝實驗室的夥伴們對於我的幫助，尤其是同組的夥伴們，我們互相學習、互相加油打氣，我們一起努力的日子是我最難忘的回憶。也感謝我的指導教授陳彥仰老師，給予了我許多的建議，且十分支持我的研究。感謝所有在過程中給予我幫忙的朋友，你們的每一分付出，都成就了這篇論文的每字每句，謝謝你們。

摘要

智慧型眼鏡（如：Google Glasses），具備有

Abstract

Smart glasses, such as Google Glass, provide always-available displays not offered by console and mobile gaming devices, and could potentially offer a pervasive gaming experience. However, research on input for games on smart glasses has been constrained by the available sensors to date. To help inform design directions, this paper explores user-defined game input for smart glasses beyond the capabilities of current sensors, and focuses on the interaction in public settings. We conducted a user-defined input study with 24 participants, each performing 17 common game control tasks using 3 classes of interaction and 2 form factors of smart glasses, for a total of 2448 trials. Results show that users significantly preferred non-touch and non-handheld interaction over using handheld input devices, such as in-air gestures. Also, for touch input without handheld devices, users preferred interacting with their palms over wearable devices (51% vs 20%). In addition, users preferred interactions that are less noticeable due to concerns with social acceptance, and preferred in-air gestures in front of the torso rather than in front of the face (63% vs 37%).

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Figure 1: A study participant performing an in-air gesture to drag an object seen through the immersive smart glasses in a public coffee shop.

0.1 Introduction

Smart glasses provide always-available displays and offer the opportunity for instantly available information and pervasive gaming experiences. Compared to game consoles and mobile gaming devices, smart glasses do not have touchscreens and currently do not support handheld controllers specifically designed for gaming. Current smart glasses, such as Google Glass and the Epson Moverio, support input via voice, touchpads, cameras, gyroscopes, accelerometers, and GPS. Games designed specifically for Google Glass [1] utilize these sensors as game control. For example, “Clay Shooter” utilizes the user’s voice to trigger a shotgun, and “Shape Splitter” detects in-air gestures via the built-in cameras. For the Epson Moverio glasses, wired trackpads are used as handheld inputs.

To better inform the interaction design of games for smart glasses, we aimed to explore the design space without being constrained by the capabilities of current sensors. We used the guessability study methodology [2], and presented the *effects* of game controls to the participants in a real-world, public environment. We then elicited what the participants felt was the most appropriate *causes* to invoke the corresponding effects.

For input tasks, we analyzed 90 popular games to identify the game controls used by more than one game, which resulted in a set of 17 tasks. We also explored the form factors of smart glasses displays, and included both types in the study: 1) *immersive*, with display content spanning the user's field of view (e.g. Epson and Sony's smart glasses), and 2) *off-to-the-side*, with display content in the corners of the user's field of view (e.g. Google Glass).

In order to compare different types of interaction while keeping the experiment tractable, we grouped the different types of input into the following 3 classes:

- *handheld*: input types that make use of handheld controllers, such as smartphones and the wired trackpads used by Sony's SmartEyeglass and Epson's Moverio glasses.

- *touch*: non-handheld touch input, such as gesturing and tapping on body surfaces, and touch-sensing wearable devices (e.g. smart rings, watches, and glasses). These provide tactile feedback.

- *non-touch*: non-handheld, non-touch input, such as in-air gestures, head/body movement, and voice recognition. These do not have tactile feedback.

We recruited 24 participants and asked them to wear the two form factors of smart glasses in a coffee shop. On-screen instructions prompted participants to perform each of the 17 common game control tasks using the 3 classes of input types. For each game control task, form factor, and input type, participants first explored all possible interactions they could think of, then reported the one they most preferred. After completing the 3

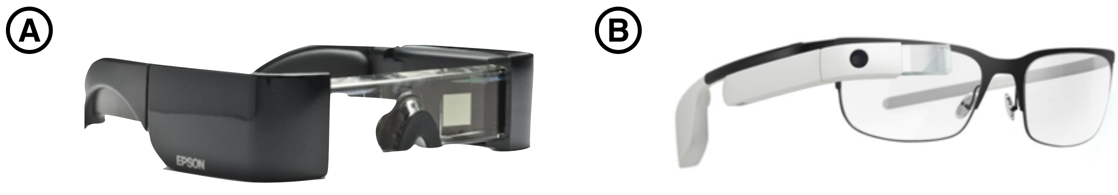

Figure 2: (A) Epson Moverio, (B) Google Glass.

types of interactions for that task and form factor, they then rated their preferences for 3 interactions. Overall, each participant reported 102 interactions, for a total of 2448.

We collected quantitative and qualitative data through video analysis, preference ratings, and interviews. Our key observations are as follows:

- Participants significantly preferred non-handheld, non-touch interactions over handheld interactions (3.81 vs 3.68 on a 5-point Likert scale, $p<0.01$).
- For touch input without using handheld devices, users preferred interacting with their body surface over wearable devices (80% vs 20%), and the most frequently used body surface was the palm (51%).
- Participants preferred interactions that are more subtle due to concerns with social acceptance. Also, participants preferred using in-air gestures in front of the torso than in front of the face (63% vs 37%), even though those gestures were reported to be less intuitive and less precise.
- There is a significant mismatch between participants' preferred input methods and those supported by the current smart glasses. For example, less than 2% of the participants used voice and less than 2% of the participants used touch input on the smart glasses – which are Google Glass' two primary input methods. In addition, current cameras can only detect in-air gestures in front of users' faces, missing most 63% of the gestures performed.

The contribution of this paper are as follows: (1) the first quantitative and qualitative characterization of user-defined input for games on smart glasses, including a taxonomy, (2) set of user-defined input for common game tasks, which is reflective of user behavior. (3) insight into users' mental models when playing smart glasses games in a public space, and an understanding of implications for mobile input technology and user interface design. Our results will help designers create better smart glasses experience informed by user behavior.

Bibliography

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