[Poster] Device vs. User Perspective Rendering in Google Glass AR Applications

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ABSTRACT

According to Gartner's 2013 Hype Cycle for Emerging Technologies, Augmented Reality will reach its Plateu of Productivity before Wearable User Interfaces. In this work, device and user-perspective rendering are compared regarding their applicability to AR-based solutions for Google Glass. The conducted experiment measured and evaluated the advantages and drawbacks on each method and also got positive and negative feedbacks given by users. The tests showed that users preferred the device-perspective approach.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities

1 INTRODUCTION

Google Glass is a wearable computer in the form of an optical see-through head-mounted display (OST-HMD). It contains a monocular semi-transparent display and a video camera, being suitable for mobile AR systems. The most straightforward way to create AR applications for Google Glass consists in showing the camera image on the display and rendering registered virtual objects over it, which is similar to the device-perspective rendering (DPR) concept used in handheld displays [1, 5, 2]. AR information can also be presented with user-perspective rendering (UPR), in which virtual objects are aligned to the real world with respect to users' view. While handheld displays perform UPR using a video see-through approach [1, 5, 2], Google Glass allows users to view the real world with their own eyes, so that only virtual data need to be rendered on the monocular display. Nevertheless, a calibration procedure has to be performed before using the AR system in order to find a transformation between camera and user view. If an eye tracking camera is available, this calibration can be done in an automatic fashion [3]. However, if an off-the-shelf Google Glass is used, then it will not provide such sensor built-in and a manual calibration has to be performed with a technique such as the Single Point Active Alignment Method (SPAAM) [6]. The difference between DPR and UPR in an AR application running on Google Glass is illustrated in Figure 1. Existing works that compare DPR and UPR on handheld AR displays suggest that in general users prefer UPR [1, 5, 2], while DPR is more suitable in some scenarios, such as search tasks [1].

In this context, this work aims to compare DPR and UPR in AR applications for Google Glass, which differs from handheld displays by being an OST-HMD and having a monocular display with a relatively small size. It was chosen because there are high expectations about the use of Glass in AR scenarios and we wanted to investigate some of them. An experiment was performed in which users had to position real objects in the locations indicated by an AR system. The amount of time spent and the accuracy of objects positioning were taken into account in the evaluation, together with a user survey.

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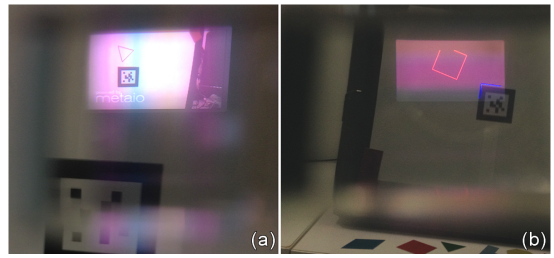

Figure 1: User view on Google Glass using DPR (a) and UPR (b).

2 EXPERIMENT

Users were asked to position magnetic polygonal pieces on a vertical metal surface at the locations highlighted by an AR application, as illustrated in Figure 1. Registration was performed by tracking a marker using Metaio SDK. Manual calibration for UPR was done using SPAAM [6], which required users to align crosshairs shown at different locations of the display with the marker center. For confirming each alignment, the user had to tap the Glass touchpad. Using this procedure, 10 2D-3D correspondences between screen and camera coordinates were obtained. In half of them the marker was placed at arms length distance, while in the other half it was as close as possible to user view. A projection matrix was then estimated from the correspondences by solving a linear system.

Three different approaches were evaluated: DPR, UPR using the calibration done by the current user and UPR using a default calibration (named CUPR). Twelve users (10 male and 2 female) aged from 19 to 36 participated in the evaluation. Seven of them had never used a device like Google Glass before. Each user performed the task using all three methods (DPR, UPR and CUPR) in one of the 6 possible permutations in a way that each order was obeyed by two different users. After each task, users answered a Likert questionnaire to evaluate it. They gave a score ranging from 1 to 5 (1 = "I completely disagree" and 5 = "I completely agree") to 4 statements, which were: **I)** It is possible to correctly and efficiently position the pieces; **II)** It is possible to quickly position the pieces; **III)** It is possible to easily visualize the positions of the pieces; **IV)** The virtual content appears in a coherent way with reality.

It was also asked which approach users liked the most and why, an opinion about the calibration procedure and any additional suggestions. Another measurement was related to how much time each user spent for completing the task and how accurate was the positioning of the pieces. In order to evaluate this precision, a camera was used to capture an image of the final result and an application was developed for detecting the 3D position of each polygon corner and comparing it with ground truth data. The 2D corners were detected on the image and then backprojected onto the marker plane.

3 Results

The results can be seen in Figure 2. Chart (a) shows the users' average precision, measured with the precision evaluator. It points out that users achieved better precision using DPR (M = 3.6433 mm; σ = 1.8292 mm). It is almost 70% more precise than the CUPR approach, which had the worst score (M = 6.1438 mm; σ = 2.112 mm). Regarding the time to complete the task, Figure 2 (b) shows that users took 169 sec. to calibrate the system (σ = 142 sec.). Moreover, this chart shows that users placed all the pieces faster in the DPR application (M = 161 sec.; σ = 89 sec.) and the slowest approach was the UPR (M = 204 sec.; σ = 70 sec.).

The Likert questionnaire Cronbach's alpha is 0.8684 and the results are shown in Figure 2 (c). Users answered that DPR helped them to position the pieces in a more correct, efficient and quick way than CUPR and UPR, with UPR receiving the lowest scores. The users' answers in the Likert questionnaire also show that the DPR approach provided an easier visualization and also the best visual coherence between virtual objects and real environment.

When asked which method they liked the most, 5 users preferred DPR, 5 preferred CUPR and the other 2 could not tell which one was the best. All of them complained about the calibration. Further, 10 users said their calibration was not better than the one provided.

3.1 Discussion

Despite the fact that the results show that the precision on the UPR was better than CUPR, one of the users had an error of 10.964 mm while his average error on the other two methods was 6.741 mm. In case he performed the same precision, the two user-perspective approaches would have equivalent errors. In addition, the results obtained from the Likert questionnaire showed that most users preferred CUPR over UPR. One factor that may explain this is that in Google Glass the relative position between camera and display never changes. Thus, an accurate calibration previously obtained can be applied to different users with acceptable degradation. Regarding the calibration process, users said that it was tedious and that they preferred to use the provided calibration, once that no improvement was noticed when compared to its own calibration. This indicates that the best approach to use an user-perspective visualization would be to provide an accurate calibration beforehand.

The users also pointed out that the small size of Google Glass display provides a small field of view. This characteristic results in virtual objects that are too large to fit the screen in both UPR and CUPR. Even complaining about the small size of the pieces in DPR, users still preferred this approach because they had a broader view of the entire scene and they did not have to move their head too much to see the pieces.

Tracking jitter is more perceptible in both UPR and CUPR, since virtual objects appear larger on screen. Users said that it disturbed them while placing the pieces on the correct position. It is important to mention that some users also pointed out that the delay on virtual information superposition harmed the visual coherence, which is an inherent issue of OST-HMDs.

4 Conclusion

The experiment performed showed that, differently from what has been reported for handheld AR displays, AR on Google Glass using DPR was preferred over UPR. As future work, other methods for alignment confirmation should be implemented, since the tapping gesture may cause the glass to move on user's head and harm the calibration. The Waiting method, which obtained the best results in the evaluation performed in [4], can be implemented by taking into account both visual tracking and Glass built-in inertial sensors. User's field of view in UPR may be improved by employing a multi-marker approach, allowing the user to have a broader view of the scene without tracking failures or jitter. The delay on virtual elements exhibition may also be tackled by employing video see-through UPR approaches such as the ones described in [5].

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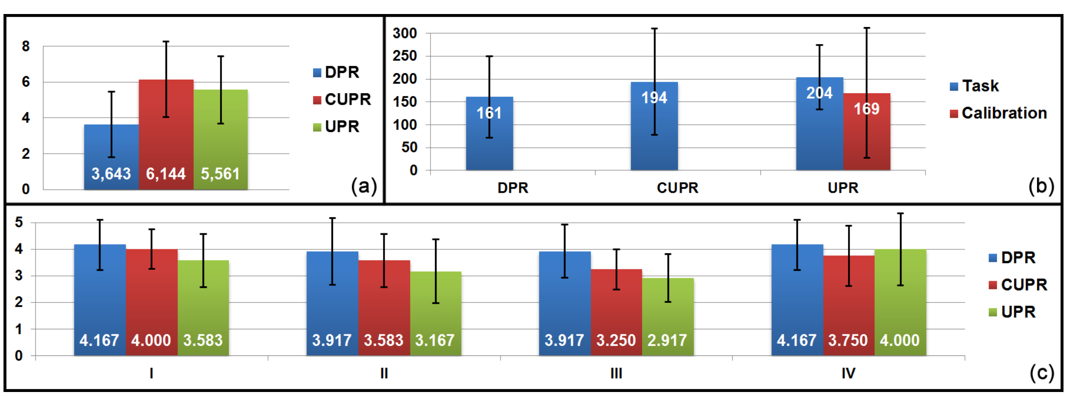

Figure 2: Results from the experiment with 12 users. Chart (a) shows the average precision measured with the precision evaluator; chart (b) points out the time spent to calibrate and place all the pieces; chart (c) illustrates the users' answers in Likert questionnaire.