Literature Review 3

Computer Graphics I

Zubin Bhuyan (Student id: 01744486)

Paper 1: Krichenbauer, M., Yamamoto, G., Taketom, T., Sandor, C., & Kato, H. (2018). **Augmented Reality versus Virtual Reality for 3D Object Manipulation**. IEEE *Transactions on Visualization and Computer Graphics*, 24, 1038-1048.

Paper 2: Andreas Möller, Matthias Kranz, Stefan Diewald, Luis Roalter, Robert Huitl, Tobias Stockinger, Marion Koelle, and Patrick A. Lindemann. 2014. **Experimental evaluation of user interfaces for visual indoor navigation**. In Proceedings of the *SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 3607-3616. DOI: https://doi.org/10.1145/2556288.2557003

Möller et al. in [Paper 2] proposes and evaluates two user interface models for indoor navigation. Even though mobile applications have successfully been used in outdoor pedestrian settings, these solutions are not viable for indoor navigation. Visual localization, or location recognition by querying with images of the indoor environment is an active area of research with several interdisciplinary open problems. Their two approaches involve Virtual Reality and Augmented Reality, and involve a human-like orientation and way-finding strategy of using landmarks and marker objects.

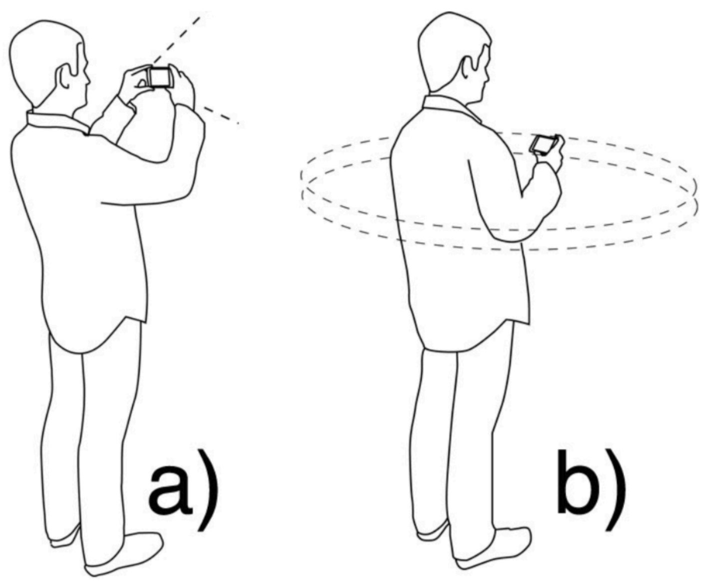


Fig. 1 a) In Augmented Reality mode instructions are shown as an overlay over the live camera image and the phone is held as shown.
b) In Virtual Reality mode, an oriented 360° panorama image is shown when holding the phone.

AR/VR modes of the interface

Their UI for indoor navigation has two modes: Augmented reality (AR) and virtual reality (VR) modes. Both modes work in continuously for navigation assistance. The way users are expected to hols the mobile device, in different modes, is shown in Fig. 1. Augmented Reality mode uses live images from the camera, and so the device has to held upright at a higher level. In virtual reality mode, the device can be held at a lower position as the environment is displayed as a set of prerecorded environment images arranges in a 360 degree view.

Elements of the UI which enable users to position the mobile device correctly:

- Text hint: Notifications to position the phone correctly.
- Blur: Nearer objects appear sharper than those which are far away.
- Color scale: Quality of current scene is indicated by a color scale which goes from green to red.
- Spirit level: Bubble of the level can be used find the optimal inclination.

A feature to highlight objects is also available.

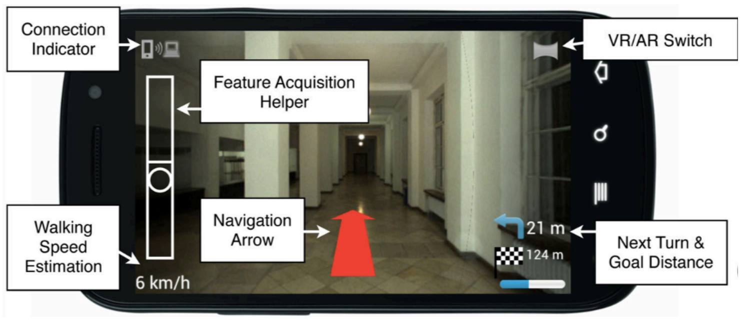


Fig 2. UI prototype of the application in VR mode.

Experiment and Evaluation

The navigation mechanism has been implemented Wizard of Oz approach [Kelly, SIGCHI1983]. The UI prototype was implemented on the Android platform. Subjects were asked to perform a navigation task in a university building on a path of 220 meters length.

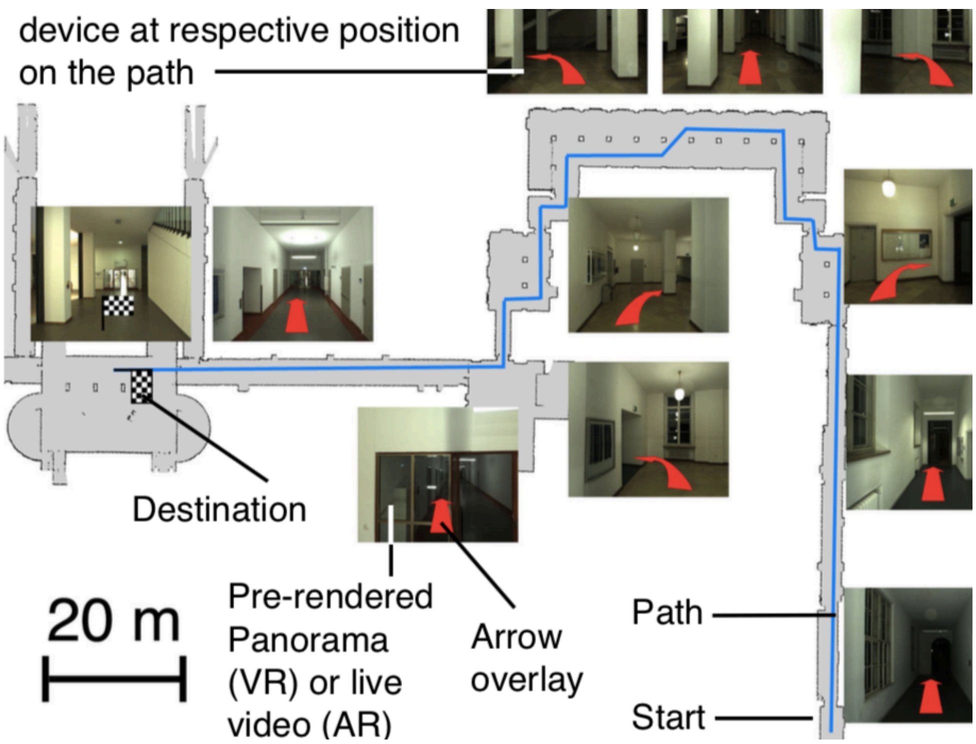
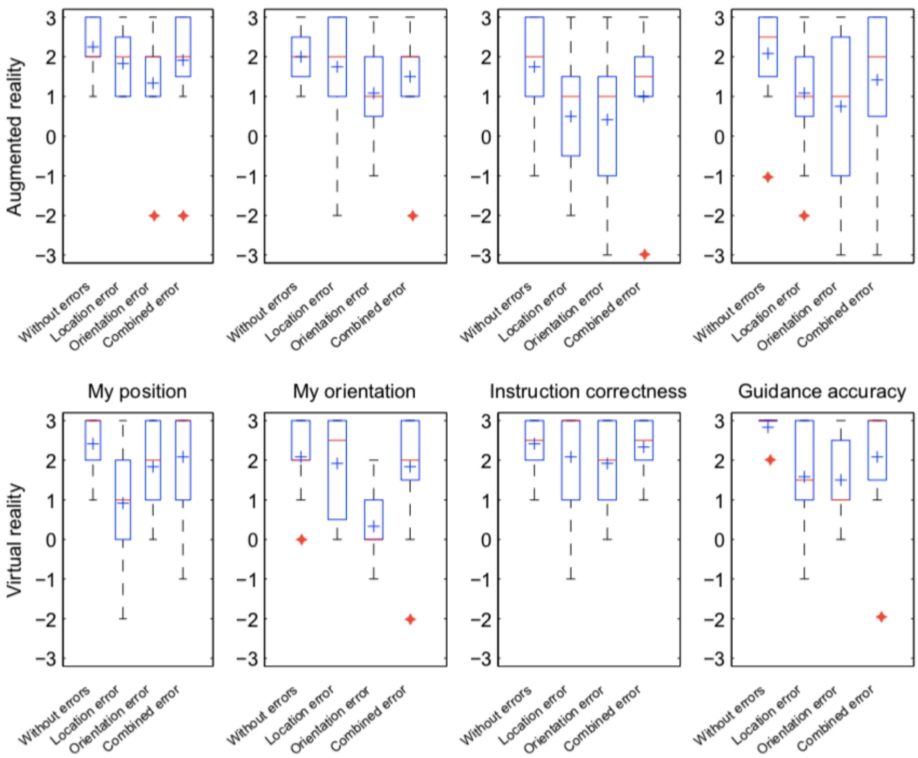


Fig 3. Indoor path used for navigation task.

Hypothesis 1: Users reach navigation destination faster with VR than with AR.
Hypothesis 2: VR is more accurate.
Hypothesis 3: VR will be more favored by users.

On average, subjects were 25 seconds faster to reach their destination with VR (averagely 2:39 minutes for the 220 m path) when compared to the AR mode.



Mode	Condition	Time m:ss	Avg./ Mode
AR	No Errors	2:52	3:04
	Position	2:53	
	Orientation	3:23	
	Combined	3:07	
VR	No Errors	2:36	2:39
	Position	2:41	
	Orientation	2:44	
	Combined	2:36	

Interquartile range (25%-75%)
Mean
Median
Min/Max
Outlier

My position: The system seemed to know well where I am.
My orientation: The system seemed to know well in which direction I am looking.
Instruction correctness: The navigation instructions were always correct.
Guidance accuracy: Overall, I found the guidance accurate.

Fig 4. Perceived guidance accuracies (left). The table on the right is for the task completion time.

From [Paper 2]:

> "Subject rated the perceived accuracy in the conditions *With- out Error*, *Position Error*, *Orientation Error* and *Combined Error*. Subjects were presented the following statements: *"The system seemed to know well where I am"* (relating to the position estimate), *"The system seemed to know well in which direction I am looking"* (relating to the orientation es-timate), *"The navigation instructions were always correct"* (relating to the perceived correctness of individual instruc- tions), and *"Overall, I found the guidance accurate"* (relating to the general guidance accuracy). "

Though the solution provided are not perfect, this paper provides an excellent starting point for working on visual localization.

Another VR / AR comparison is made in [Paper 1]. In contrast to the previous paper, [Paper 2] uses head mounted displays for VR. They asked participants to transform an object to resemble a given target object using 2 different inout devices. They compared performance between a 6DOF 3D input device and a traditional mouse. The mouse was used as they believed that it could further reveal the performance difference between AR and VR. They find a statistically significant increase in performance in AR over VR when a 6DOF 3D input device is used.

They provide a quantitative, statistically relevant result indicating that AR can outperform VR. Also, because their tasks are simple, the results are relevant for other sitar tasks.

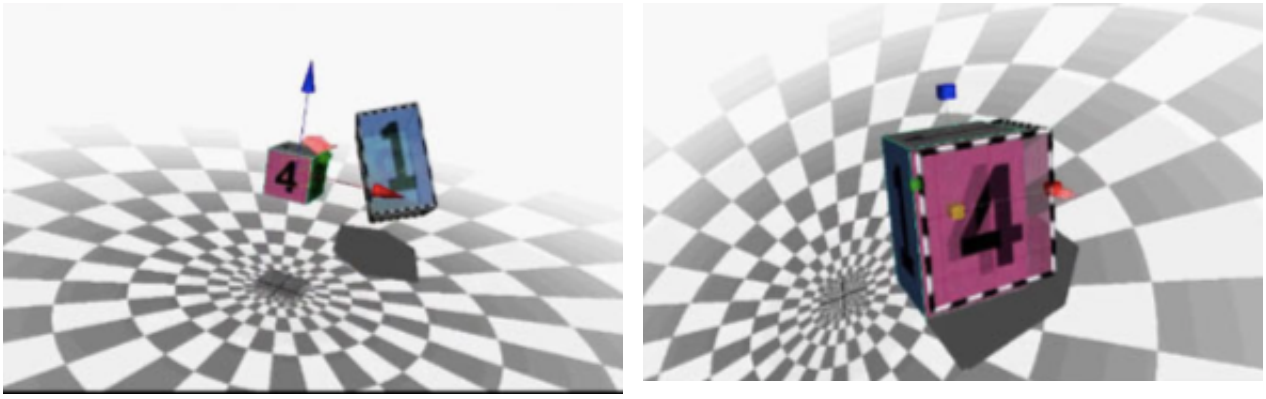


FIg. 5 The 3D task in [Paper 1] was to transform one block to a given target block.

The primary hypothesis of [Paper 1] is: “Task performance with a 6DOF input device will be significantly improved when the user is able to see the real environment.” Further, they also performed a comparison between VR and AR with 2D/3D mouse. For testing their hypothesis, they developed an UI based on Autodesk Maya. Participant performance by two-way measures ANOVA showed an effect of the environment (AR or VR) with $F(1,328) = 4.1$, $p < 0.044$, but not for input device used. Based on the results they could accept the hypothesis that AR has beneficial effects on task performance compared to VR when using a 6DOF input device.

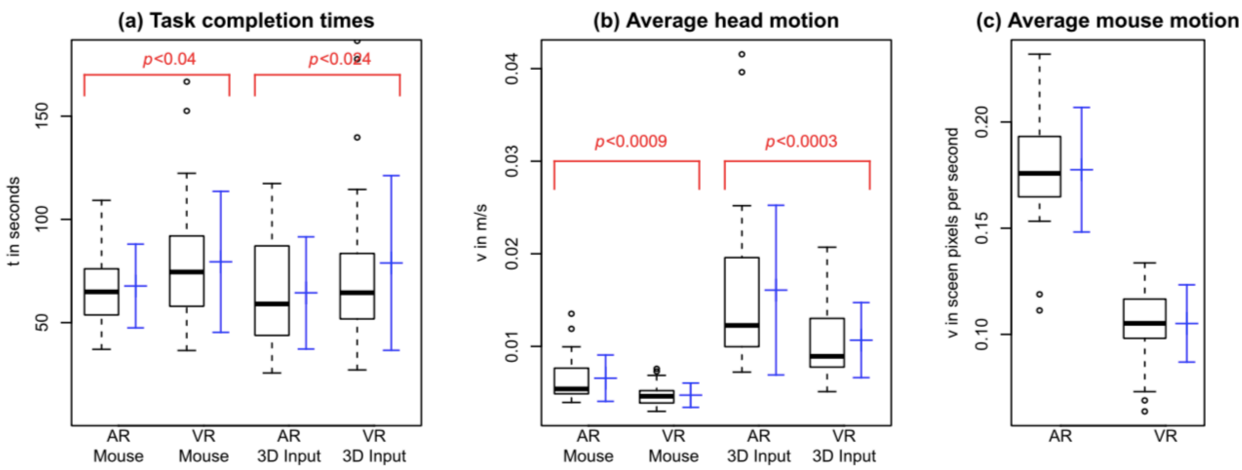


Fig. 6 Experimental results.

The experimental results are tabulated in Fig. 6. The results indicate that Augmented Reality UX outperformed VR every time. One interesting point to note is that even while using 2D mouse, AR performed better than VR.

Comparing this work with [Paper 2], we observe that there are a number of differences in conclusions. These are most likely because of the flawed definition and implementation of VR mode in [Paper 2]. Also, experiments of [Paper 2] did not consider several significant details such as environment isolation. But the test environment of [Paper 1] was an isolated area of 1.5 sq.m with neutral gray color. For AR, the setup was also draped with patterned cloth so that favorable lighting condition is achieved. They also recorded 6 trial per condition for each test participant. Both papers, however, did not consider long-term effects of fatigue or decreased attention due to monotonic nature of the experiments.

===============