Dual Phone AR: Exploring the use of Phones as Controllers for Mobile Augmented Reality

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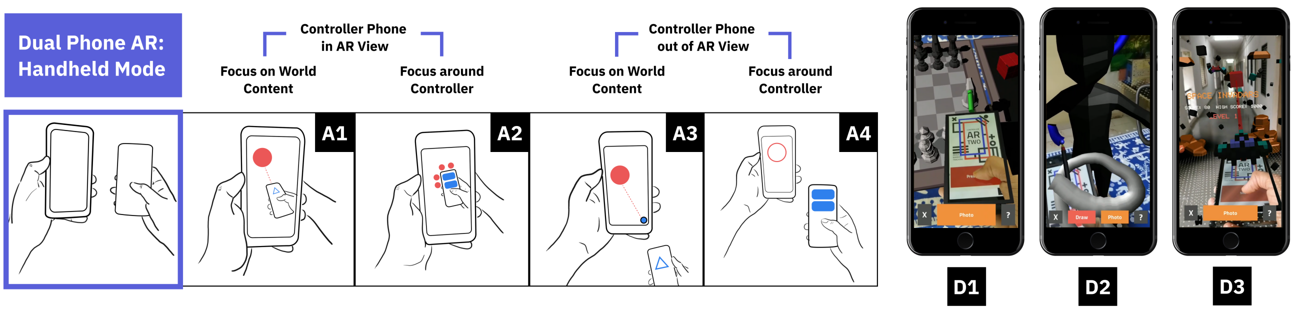

Figure 1: Dual Phone AR: Usage Scenarios and the Application Prototype

ABSTRACT

The possible interactions with Mobile Augmented Reality applications today are largely limited to on-screen gestures and spatial movement. There is an opportunity to design new interaction methods that address common issues and go beyond the screen. Through this project, we explore the idea of using a second phone as a controller for mobile AR experiences. We develop prototypes that demonstrate the use of a second phone controller for tasks such as pointing, selecting, and drawing in 3D space. We use these prototypes and insights from initial remote evaluations to discuss the benefits and drawbacks of such an interaction method. We conclude by outlining opportunities for future research on Dual Phone AR for multiple usage configurations, and in collaborative settings.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**; *Interaction devices.*

KEYWORDS

Augmented Reality, Mobile Interaction, Cross-Device Computing

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1 INTRODUCTION & RELATED WORK

Mobile Augmented Reality is the most widely-used form of AR today. The main ways of interacting with mobile AR apps are by moving around physically, or using gestures on the screen. Screen-based User Interface (UI) elements take up space that could be used to better view the AR environment. Performing pinches and other multi-touch gestures can further obstruct the user's view. In contrast to the excess of screen-based UI, there is not enough real-world UI for spatial content in mobile AR, making it difficult to interact with virtual objects in a similar manner as real ones. Given the 2-dimensional nature of screen interactions and the lack of depth cues, it is currently quite difficult to perform movement and placement operations with objects in AR space [5].

There is a need to design more tangible and spatial forms of interaction that address these problems. Through hand gestures [6], and handheld interface objects such as pens [9] and controllers [4], researchers have been designing new ways to experience AR content in a manner that is much more grounded in the real world. Most research and design efforts in this space have involved the use of additional hardware in the form of external processing units, sensors, or physical controllers. The relative lack of availability of such hardware has made it difficult for these ideas to gain wider adoption. In contrast, mobile phones are ubiquitous computing devices that most AR users would be familiar with. Mobile phones could conceivably support many of the interaction methods that dedicated handheld AR controllers allow for [1]. Recent projects have explored the use of mobile phones for use with head-mounted AR [2, 10], and have shown promising results. We believe that the use of a second mobile phone as a controller for Mobile AR presents an interesting direction for current research on interaction methods, one that we explore through this project.

2 THE IDEA: DUAL PHONE AR

We define Dual Phone AR as a system in which one phone is used to view the AR world (the AR Phone) and a second phone is used to control or interact with it (the Controller Phone). This distinction leads to a few different usage scenarios. The Controller Phone might be inside the view of the AR Phone (and hence be spatially tracked via image markers), or outside of it. The user's focus might be around the screen of the Controller Phone, or towards the AR scene at large (meaning the Controller Phone would need to be used in an eyes-free manner). Focusing on the configuration where both phones are handheld, there are 4 such usage scenarios that arise (Figure 1, A1 - A4), and we developed an application to demonstrate and test these interaction possibilities.

3 THE PROTOTYPE APPLICATION

The Dual Phone AR prototype application was built in Unity [8] using the AR Foundation framework [7], with cross-device communication occurring over the internet. The application requires two Android phones, one of which needs to support markerless tracking through ARCore [3] in order to function as the AR Phone. The application consists of 1 tutorial and 3 demos. The tutorial is designed to introduce users to conventional mobile AR tasks and the idea of the Controller Phone. The first demo (D1) allows users to interact with an AR Chessboard by picking up and moving pieces directly using the Controller Phone. In the second demo, the Controller Phone can be used as a pen to draw lines of different colours and widths in 3D space (D2). The third and final demo is an AR version of a space shooter game (D3), where the controller phone can be used to move the player's spaceship when it is both inside and outside the AR view. The following 4 distinct usage scenarios are illustrated through these demos (Figure 1):

(1) **A1 - Controller Phone in AR View, World Focus:** With the Controller Phone being visually tracked, users can perform distant spatial interactions with AR content. In the space shooter game, the Controller Phone directly represents the player's spaceship, and is used to point and shoot at approaching enemy spacecrafts.
(2) **A2 - Controller Phone in AR View, Controller Focus:** Shifting focus from the AR Scene towards the Controller area allows for direct manipulation of AR content. We can also use the Controller Phone's screen for more involved UI tasks. The use of the Controller Phone to pick up chess pieces and draw lines in 3D space are examples of this.
(3) **A3 - Controller Phone out of AR View, World Focus:** When the Controller Phone is out of the AR view, visual tracking is no longer possible. The Controller Phone can still help with basic UI tasks that do not require visual feedback, such as taps or swipes, and could also send orientation data back to the AR Phone (as is the case in the Space shooter demo), thereby allowing some level of spatial interaction.
(4) **A4 - Controller Phone out of AR View, Controller Focus:** This usage scenario largely consists of non-AR tasks, as the focus is on the screen of the controller phone outside AR view. Such tasks would mostly be more complex user interface operations, such as changing the pen color and size in the 3D drawing demo. While not involving AR as such, these are an important class of interactions because of their mediating role in situations where all 4 scenarios occur when performing more complex tasks.

4 INITIAL EVALUATION & FEEDBACK

We recruited 8 university students with experience in designing and developing AR applications for an initial round of evaluations of the prototype application. We allowed participants to try the prototype, and then sought their feedback through brief remote interviews. All participants found the idea of using a second phone as a controller to be an interesting one. Participants were quite comfortable when performing simple touch operations on the Controller Phone. However, most participants preferred the 'out of AR view' interactions, because of the eyes-free nature of control, and how the AR Phone's view was unobstructed as a consequence. Two participants remarked that their hands were quickly tired while using the demos. Despite these issues, two users drew parallels between Dual Phone AR and Controller-driven VR experiences, expressing hope that Dual Phone AR could achieve similar levels of fidelity, making highly spatial experiences (like VR or head-mounted AR) more accessible to people without headsets.

5 DISCUSSION

Using a Controller Phone eliminates the need to have screen based UI on the AR Phone for all but the most simple tasks, thereby reducing occlusion of the AR scene. Controller Phones help facilitate spatial, tangible forms of interaction with virtual objects that otherwise do not allow direct manipulation. Spatial perception of content might be increased when people use a second reference point - the hand that holds the Controller Phone - to judge distance and depth in addition to feedback from the screen. However, while users are more likely to have two phones than specialised controllers, they are also likely to not have two mobile devices. Dual Phone AR might therefore be more practical for collaborative AR experiences. In groups, phones can be shared among team members, with the AR-capable phones being used to view content, and the remaining phones as Controllers to perform tasks. The term 'Dual Phone AR' implies that both phones are equally capable of supporting AR in some manner, but that is not the case in our current implementation. It would be interesting to see what an AR-capable Controller Phone (like Pocket6 [1]) might bring to this idea.

6 CONCLUSION

Building upon recent work on the use of phones as controllers for head-mounted AR, we developed a prototype of Dual Phone AR, an interaction method that can potentially address the issues faced by mobile AR interactions today. Having conducted an initial user evaluation, we believe that there is promise in exploring this idea in more detail. The development of Dual Phone AR can benefit from the Design-space exploration approach taken by the BISHARE project [10], and we are currently looking at design dimensions such as usage configuration and technical capabilities of the phones. Moving forward, we hope to improve our prototypes and conduct more empirical studies to assess the use of a Controller Phone when compared to conventional interaction techniques, as well as in collaborative settings in the near future.

REFERENCES

[1] Teo Babic, Harald Reiterer, and Michael Haller. 2018. Pocket6: A 6DOF controller based on a simple smartphone application. In *Proceedings of the Symposium on Spatial User Interaction*. 2–10.

[2] Rahul Budhiraja, Gun A Lee, and Mark Billinghurst. 2013. Using a HHD with a HMD for Mobile AR interaction. In *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. IEEE, 1–6.

[3] Google. 2020. *AR Core*. Retrieved August 24, 2020 from https://developers.google.com/ar

[4] LITHO. 2020. *LITHO: A controller for the real world*. Retrieved August 24, 2020 from https://www.litho.cc/

[5] Mark A Livingston, Zhuming Ai, J Edward Swan, and Harvey S Smallman. 2009. Indoor vs. outdoor depth perception for mobile augmented reality. In *2009 IEEE Virtual Reality Conference*. IEEE, 55–62.

[6] Jing Qian, Jiaju Ma, Xiangyu Li, Benjamin Attal, Haoming Lai, James Tompkin, John F Hughes, and Jeff Huang. 2019. Portal-ble: Intuitive free-hand manipulation in unbounded smartphone-based augmented reality. In *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology*. 133–145.

[7] Unity. 2020. *AR Foundation Cross Platform Development Framework*. Retrieved August 24, 2020 from https://unity.com/unity/features/arfoundation

[8] Unity. 2020. *Unity Real-Time Development Platform*. Retrieved August 24, 2020 from https://unity.com/

[9] Philipp Wacker, Oliver Nowak, Simon Voelker, and Jan Borchers. 2019. ARpen: Mid-air object manipulation techniques for a bimanual ar system with pen & smartphone. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–12.

[10] Fengyuan Zhu and Tovi Grossman. 2020. BISHARE: Exploring Bidirectional Interactions Between Smartphones and Head-Mounted Augmented Reality. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–14.