Dual Phone AR: Using a Second Phone as a Controller for Mobile Augmented Reality

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ABSTRACT
Mobile Augmented Reality applications have become increasingly popular, however the possible interactions with AR content are largely limited to on-screen gestures and spatial movement. There has been a renewed interest in designing interaction methods for mobile AR that go beyond the screen. Mobile phones present a rich range of input, output, and tracking capabilities, and have been used as controllers for Virtual Reality and head-mounted Augmented Reality applications. In this project, we explore the use of a second phone as a controller for Mobile AR. We developed ARTWO, an application that showcases Handheld Dual Phone AR through a series of small demos in which a second phone can be used to perform basic tasks such as pointing, selecting, and drawing, in the context of real use cases. We believe that the Dual Phone AR approach can help address many of the issues faced when using conventional mobile AR interactions, and also serves as a stepping stone to the general use of phones with head-mounted AR systems in the near future.

Author Keywords
Augmented Reality; Mobile Interaction; Cross-Device Computing

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

INTRODUCTION
The most common form of Augmented Reality that people experience today is through handheld mobile and tablet devices. The main ways of interacting with such AR experiences are by moving around physically, or via touches, taps, and swipes on the screen. Given the intrinsically spatial nature of AR content, there is an opportunity to design more tangible, spatial forms of interaction, and over the last few years, there has been a great deal of work towards that goal. Through handheld interface objects such as pens [7], hand gestures [4], and controllers [3], 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, either in the form of external processing units and sensors, or physical controllers. The relative lack of availability of the required hardware has made it difficult for such ideas to gain wider adoption.

In contrast, mobile phones are ubiquitous computing devices that most AR users would be familiar with. Recent projects have explored the use of mobile phones for use with head-mounted AR [2, 8], and have shown promising results. We believe that the use of a second mobile phone as a controller for Mobile AR presents an interesting, if counter-intuitive, direction for current research on interaction methods, one that we explore through this project.

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 was made to reduce the requirement of phones that support markerless AR, keeping in mind the low availability of such devices today. In an ongoing project, we are exploring the broader design space of Dual Phone AR, guided by three design principles: *Offload UI Tasks to the Controller Phone*, *Leverage Spatial and Cross Device Feedback*, and, *Preserve Known Interaction Patterns* [8]. Focusing on the configuration where both the AR Phone and Controller Phone are handheld, we developed ARTWO - a prototype application to demonstrate the interaction possibilities of Dual Phone AR.

THE DEMONSTRATION: ARTWO
ARTWO was built in Unity [6] using the AR Foundation framework [5], with cross-device communication occurring over the internet. Two Android phones, both running the same app, are required for the demo, only one of which needs to support markerless AR. Care was taken to design the interface and user flow in a manner that makes the functioning of the application clear at every step, even to users with potentially no prior experience with AR (Figure 1). We also incorporated a number of tutorial sequences and troubleshooting help screens. Users have the option of restarting the demos at any time. The application consists of 1 tutorial and 3 demos (Figure 2):

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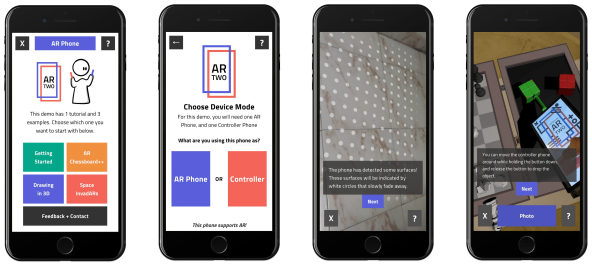

Figure 1. Dual Phone AR: ARTWO Demo Application Screens

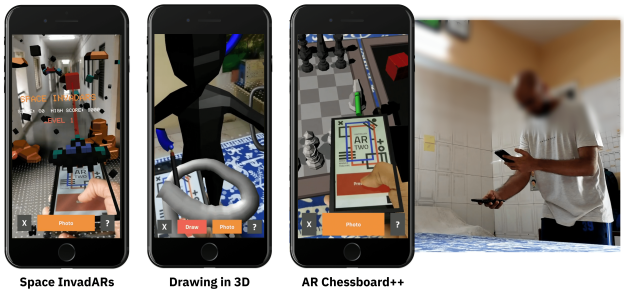

Figure 2. The Main Demos (from left to right - Space InvadARs, Drawing in 3D, and AR Chessboard ++)

Getting Started

In this tutorial, users are taken through the process of surface detection, AR object placement, and object manipulation using common touchscreen gestures. Once this is complete, users are introduced to the visual tracking of the Controller Phone, the use of controller buttons to send information to the AR Phone, as well as the transmission of orientation data from the Controller Phone to the AR Phone when the Controller Phone is out of view of the AR Phone.

AR Chessboard ++

In this demo, users can use a virtual wand attached to the Controller Phone (when it is in view of the AR Phone) to pick up and move pieces on an AR Chessboard. This demo aims to give users the experience of 'tangible' interactions with AR objects, while also making them familiar with the idea of moving around while keeping the Controller Phone in view of the AR Phone.

Drawing in 3D

Here, the Controller Phone is used as a pen that can draw lines of varying colour and width in 3D space. Users have the option of placing an AR 3D model of a human on a surface around them to draw upon. We also added the feature of using the AR Phone itself to draw in 3D, to allow users to compare conventional interactions with those that a Controller Phone enables.

Space InvadARs

This demo allows users to play an AR version of the classic space shooter game 'Space Invaders'. The Controller Phone directly represents the player's spaceship when it is in view of the AR Phone. When out of view, the controller phone transmits its orientation to the spaceship which becomes attached to the AR Phone. The context of the game was used as a proxy for pointing tasks in AR.

Dual Phone AR Features

Beyond the obvious communication and tracking features afforded by the idea of Dual Phone AR, we implemented a few more unique functions:

Contextual UI

With two different states of the Controller Phone - in view of the AR Phone or outside it - there is an opportunity to modify the Controller's interface according to whether or not it is visible to the AR Phone. In the Space InvadARs demo, the buttons on screen reduce to just the primary shooting button when the Controller Phone is in view of the AR Phone.

Cross-Device Feedback

In AR Chessboard ++, the wand lights up when intersecting AR objects, and the Controller Phone receives a haptic feedback message. In the Drawing in 3D app, the Controller Phone plays a constant sound while a line is being drawn in space. In Space InvadARs, the sound of the launching missiles moves from the AR Phone to the Controller, depending on whether the Controller Phone is inside or outside the AR Phone's view.

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 for direct manipulation. Spatial perception of content is 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. This reduces the need for over-exaggerated movements in use cases such as 3D drawing, where existing forms of interaction require users to move the AR Phone itself while keeping track of the moving screen. The term 'Dual Phone AR' implies that both phones are equally capable of supporting AR in some manner, however we have had to impose the hierarchy of AR Phones and Controller Phones due to issues with device availability today. It would be interesting to see what a markerless AR-capable Controller Phone (like Pocket6 [1]) might bring to this idea in the future.

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. We are conducting an ongoing user study to generate interest and gain initial feedback about the idea of Dual Phone AR. 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, and in collaborative settings where team members can share phones among each other to view and interact with AR experiences.

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