reFrame: An Alternate Paradigm for Augmented Reality

Mohammad MH. Rahmani
Interactive Telecommunications Program, New York University, New York, NY, USA
mhrahmani@nyu.edu

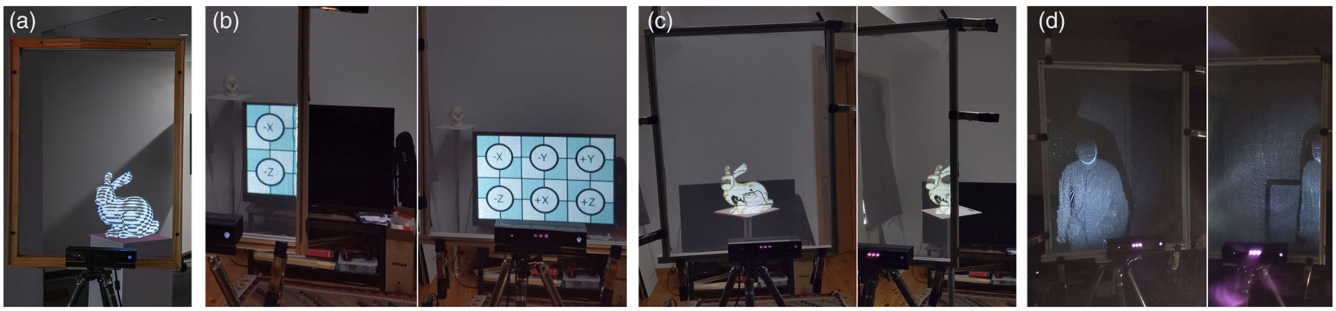

Figure 1: (a) basic reFrame setup and augmenting a virtual 2D plane (b), a 3D model (c), and a volumetric capture (d).

ABSTRACT

“reFrame” is an optically see-through Augmented Reality (AR) platform capable of displaying parallax-free images superimposed over physical objects and the scenery behind it. It uses head-tracking technology and off-axis perspective projection to simulate the motion parallax perspective of a virtual 3D scene in relation to a user’s position in space. This perspective corrected scene is then rendered on an optically see-through display, practically turning into a parallax-free and scalable general-purpose Heads Up Display (HUD). reFrame combines established and affordable technologies to offer an extremely accessible alternative to available mixed-reality systems, as well as a medium to explore the practical and creative possibilities of spatial augmented reality. It provides an opportunity to focus on subject-centered and attention-based embodied interaction paradigms that are less explored in other forms of Mixed Reality (MR). This paper is offered as a proof of concept and a starting point for further research and conversation.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction paradigms; Mixed / augmented reality; Visualization; Visualization systems and tools; Interaction design; Interaction design theory, concepts and paradigms; Human computer interaction (HCI); Interaction devices; Displays and imagers; • **Applied computing** → Arts and humanities; Media arts.

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KEYWORDS

HUD, Spatial Augmented Reality, Head Tracking, Transparent Display, Parallax Correction

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1 INTRODUCTION

The world of augmented reality is usually imagined in the form of composite AR in mobile platforms, or as see-through Head-Mounted Displays (HMDs). While mobile AR experiences are widespread due to the popularity of smartphones, see-through AR experiences have remained less accessible due to their cost and complexity of their devices. This has caused see-through AR to be less explored as a medium, especially as a storytelling tool for creative applications. Optically see-through AR experiences are unique in concept, as they maintain a two-way connection between users and their environment [Milgram et al. 1995], but the bulk and intrusiveness of HMDs heavily disrupt this experience. These issues are addressed in spatial AR platforms [Bimber and Raskar 2005] such as Heads-Up Displays (HUDs) used in airplanes and automobiles, but these devices are also costly and limited to specific use-cases they were designed for. reFrame is proposed here as a way of re-imagining how we look at AR experiences as a whole and provide an accessible and affordable alternative to the world of Mixed Reality experiences. It is a general-purpose Spatial AR platform that brings together established technologies and algorithms to provide a novel experience that shifts how we think about AR for a variety of creative and practical applications.

2 OVERVIEW OF SYSTEM

A basic reFrame setup consists of two main elements: a transparent display and a 3D head-tracking system. In the setup in Figure

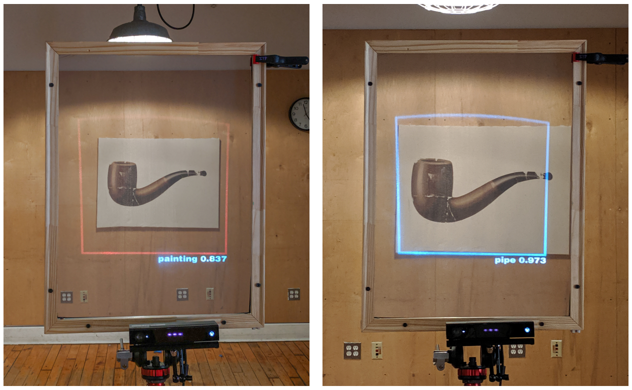

Figure 2: Example for significance of crop-factor and levels of abstractions in object classification. Is it a pipe, or a canvas painting?

1(a), the display is a projector mapped to a semi-transparent scrim stretched over a rectangular frame, and tracking is done using a Kinect. These options are maybe the most affordable variants of the main elements; they can easily be replaced by any similar technology based on availability and use-case scenarios. The benefit of using a projection setup is that it can easily be scaled up or down in size, and the display can be upgraded using transparent "holographic" projection films and higher resolution projectors. Both of these elements are then connected to a PC capable of running a real-time 3D rendering engine. In order to correct for motion-parallax, reFrame uses an off-axis perspective projection algorithm [Kooima 2009] similar to those used in CAVE setups [Cruz-Neira et al. 1993]. Multiple implementations of this projection method can be found for most popular platforms such as Unity and Unreal Engine, but here it is built on TouchDesigner which is widely used for creative applications. The Kinect acts as an origin point to measure every element from, which creates a 1:1 relationship between the physical world and the virtual world. This 1:1 relationship means any virtual object registered to an object in the virtual world must be scaled to its real-world measurements and placed at the same distance/orientation from the origin point as its real-world counterpart's physical distance/orientation from the Kinect. This is the basic setup of a reFrame and other varieties may employ individual eye-tracking, high-speed camera tracking, or even stereoscopic 3D projection for a more polished experience.

A parallax-free, low-cost, and scalable AR display opens a window to exciting new creative and practical possibilities. A large-scale HUD can be imagined for site-specific knowledge-based AR installations, without needing users to wear any trackers or bulky headsets. All they need to do is walking behind the window and looking through it at the background, making reFrame suitable for public installations. It can be used in front of landscapes, historical landmarks, even celestial objects to mark and display important information about them. It is especially suitable for museums as it can be used to put historical artifacts in context by putting them in a related virtual scene, or virtually rebuilding missing parts of them at the correct scale. By mixing 3D virtual scenes such as volumetric captures in Figure 1(d) with background physical elements, we can present portals to an alternate reality and windows to the past or the future.

2.1 Interaction Paradigms

While a variety of input methods can be employed to interact with this platform, at its pure form reFrame employs an embodied interaction paradigm [Tasa and Yurtsever 2010], shifting from the common ego-centered devices to a subject-centered and attention-centered mindset [Velichkovsky and Hansen 1996]. A frame in space excludes more information than it includes, acting as a physical crop tool for users and designers to *frame* what matters. For example, a user's distance from the frame acts as a crop factor for the background, and as they move closer or further, they move up and down levels of detail, and each subject can therefore be presented differently at different levels of abstraction and semantics (Figure 2). The low-cost nature of reFrame allows us to build and set up multiple frames as a creative story-telling tool. Two individual frames can symbolize two different worldviews, each showing a different understanding of the same subject. The act of switching between two abstractions is the embodied action of simply walking between the two and seeing how the subject is *framed* differently by each setup. Multiple setups can show the multiplicity of personal meaning and semantic categorization of the same artifact and deliver it seamlessly to the user.

Development on reFrame will continue and a Unity port is under development for public release. Spatial AR is an untapped world of interactive experiences and reFrame makes it possible for everyone to start exploring and finding the best use-cases for these displays.

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