

# Augmented Reality Coloring Book with Transitional User Interface

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## Abstract

**Background/Objectives:** There has been a growing interest in augmented reality with the recent advancements in computer technologies. Head mounted displays which were once very expensive hardware devices are now available at low cost, which has led to the increase in the applications of AR technology. **Methods/Statistical Analysis:** In this paper, we describe an AR coloring book with a transitional user interface. It comprises a paper book and a smart phone application. The proposed AR coloring book enables the user to enjoy content by switching between real world, augmented reality, virtual reality, and networked virtual reality. **Findings:** All worlds are seamlessly connected to each other, thereby enabling the users to the same content with different modality and visualization ways. To evaluate our proposed idea, we developed the PlayingHouse, which is a transitional user interface AR coloring book. **Improvements:** We believe our work will lead to the popularization of AR coloring books in the future.

**Keywords:** Augmented Reality, Coloring Book, Transitional User Interface, Virtual Reality

## 1. Introduction

Recently, there has been a growing interest in augmented reality (AR) with the development of computer technologies. Head mounted displays (HMDs), which were once very expensive hardware devices, are now developed at a much lower cost. For example, companies like SONY and Microsoft provide their own head mounted devices. Various other input/output devices have also been developed at a lower cost. Moreover, software development tools like Unreal and Unity3D, which were once very expensive software, are now available to users at free of cost. Hence, one can develop software on their own based on customers' request. Many researchers are developing products based on augmented reality using these technical enhancements.

Augmented reality is a technology that displays superimposed virtual objects in the real world<sup>1</sup>. HMDs are the primary devices used for AR. AR requires the use of human senses like hearing, touch, smell, and taste along with visual

display technology. According to Ronald Azuma, AR is based on three characteristics; fusion of real and virtual, real time interaction and registration in 3D space.

AR has been applied to various fields, such as games, advertisement, and broadcasting as well as publication<sup>2</sup>. In particular, the Magic book is widely recognized for its publications using AR technology<sup>3</sup>. Magic book comprises a paper book, display device, and digital content. A user can see the magic book by using portable display device with a mounted camera. After more than 10 years, the AR technology has been developed rapidly. With augmented reality coloring books, after coloring the book, the children can view 3D animation of the coloring book covered by the painted colors when they take real-time video using their smart phone<sup>4</sup>.

In this study, we propose an AR coloring book with transitional user interface. It comprises a paper book and a smart phone application. Using the proposed AR coloring book, children can enjoy content by transitioning between

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the real world, the augmented world, and the networked virtual world. All worlds are seamlessly connected to each other to enable the user to enjoy the similar content with different modality and visualization ways.

This paper is organized as follows. In Section 2, we introduce the current industrial trends in AR based coloring books. Based on these technical trends, we propose the design of an AR coloring book with transitional user interface in Section 3. Further, in Section 4, the implementation of the prototype, 'PlayingHouse' is described. Finally, we conclude the finding of our study in Section 5.

## 2. Related Works

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With the advancement in technologies such as computer graphics, computer vision, deep learning algorithms, and mobile display devices, AR and virtual reality (VR) technologies have become popular. In the early 1990s, Rekimoto proposed an AR system with 2D matrix code. Subsequently, the Magic book was proposed by Billinghurst and Kato. It was one of the first books that applied AR technology; the users could view virtual content superimposed over the real pages of book by looking at the real pages of book through a hand held display device<sup>5,6</sup>. The Magic book also provides user interaction and navigation methods. Saso developed "Little Red", an AR Book that supports user interaction and displays the storyline of a famous novel<sup>7</sup>. These AR books used AR markers, which are dark, rectangular shaped markers for visual tracking. Because of the presence of AR markers, these text books were different from general text books.

The virtual pop-up book displays 3D animated models using an approach that is similar to the approach used by the magic book<sup>8</sup>. The virtual pop-up book uses natural feature tracking algorithm, thereby eliminating the need for markers on a real paper book. The Digilog book integrated visual and haptic feedback into AR book and provided authoring tools with 3D UI for the author, thereby enabling users to rotate and translate virtual objects using hand-held manipulation tools. It solved the problem of marker-based AR books. It also provided many convenient methods for user interaction. This AR book was technically excellent, however was not a commercial success as it was not very efficient and did not have any clear advantages over watching video clips or 3D graphic animation displays on AR displays.

The concept of AR book has been researched for more than 10 years and originated from HITLab NZ. ColAR allows users to paint in the book pages, and then users can view 3D models with the painted color<sup>3</sup>. The ColAR developers built a company named Quiver, which sells coloring papers through an online market. A user can download a page pack through the website, and then he/she prints it out for drawing. Their smart phone application could be downloaded from app store<sup>9</sup>.

The Korea-based company, AIARA, produces an AR coloring book<sup>10</sup>. Their vision is to combine AR and Internet of Things (IoT) in order to merge analog and digital media. VUiDEA made several types of AR coloring books<sup>11-15</sup>. Further, Disney research demonstrated live texturing of AR characters from colored drawings<sup>16</sup>. AR coloring books are different from traditional AR books because users need to paint color to watch their own 3D animations. However, the fact it displays only painted animation is still a limitation.

## 3 AR Coloring Book with Transitional User Interface

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In this section, we describe the extension of the usual coloring book to augmented reality and virtual reality. Our proposed AR coloring book is designed for applicability across the real world, the AR world, and the VR world. In order to realize this, we consider the utilization of the characteristics of the different spaces. In general, the children who use coloring books, paint on real paper in the real world. However, children, using AR coloring books, paint 3D models in the AR world by taking a photo with a smart phone. If the children use AR coloring book with transitional user interface, they can watch many 3D animated models painted by the children in VR world. Finally, the user can enjoy puzzles or games using the painted animated models.

The following are the key principles for designing interactive AR coloring book with transitional user interface:-

- 1) Coloring book shall have sufficient content for children, by itself.
- 2) When a child experiences the AR world, the duration of the experience should be short and simple because it is difficult for a child to hold a smart

- phone for an extended period; AR is a connection between real world and VR.
- 3) When the user enjoys the VR world, the content of the virtual world should be connected with story of the two previous spaces (Real world and AR).

The primary reason is that if a child is required to necessarily experience augmented reality whenever this coloring book, then it limits the choice of the child. In other words, painting itself is meaningful even if there is no AR content.

Secondly, with not only painted drawing but also live 3D animation through augmented reality technology, it makes the reason two times more valuable. However, when a child has long fed up with carrying the equipment, there are several difficulties. If the child is an elementary school student, the book can evoke interest by providing a lot of interaction methods. Moreover, if we consider the age of child who wants to use the coloring book, we cannot provide higher difficulty level tasks to the child.

Finally, the virtual reality content complements the shortcomings of augmented reality content and com-

pletes the coloring. It brings augmented reality content with painting combined with virtual world. The virtual world has to match and map the theme of the coloring book rather than creating a stimulating smart phone game.

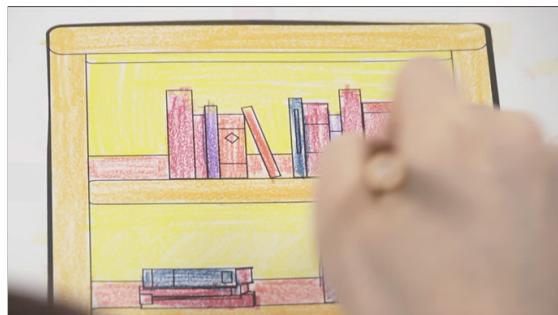
Users using the augmented reality coloring books built on these three main principles will experience the same steps as shown in Figure 1. Firstly, the user can feel a sense of accomplishment by the painting designs using crayons. Secondly, by using a smart phone the user paints the color digitally in augmented reality environment. At this stage, watching the animation moving in augmented reality space gives the user a sense of accomplishment. Finally, a virtual reality world is created in one place to enable the user to view various painted objects.

## 4. Implementation

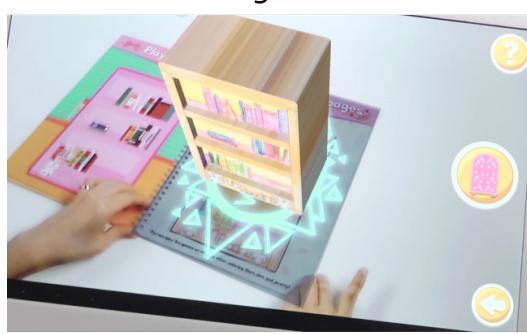
Based on the abovementioned three principles, we implemented an augmented reality coloring book with transitional user interface, 'Playing House'. The implemented AR coloring book consists of a coloring book



Coloring Books



Painting with crayon



Painting in AR



Playing in VR

**Figure 1.** User experiences in three worlds; real, augmented and virtual worlds.

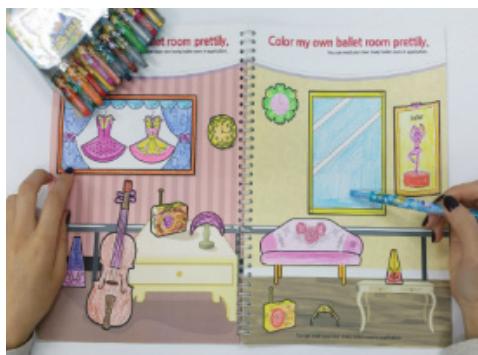
and a smart phone application. The book is composed of stickers, mazes, tasks requiring the reader to find different features, drawings, furniture painting tasks, etc.. The smart phone application is divided into an augmented reality part for acquiring colors from papers and a virtual house, wherein users can place the painted objects.

The smart phone application is developed using the Vuforia SDK and Unity3D software. Unity3D version 5 and Vuforia version 5.0 or higher are used. C# language is used to implement an algorithm for color image acquisition and processing. Matrix calculation and image processing algorithms are also implemented. The matrix calculation algorithm included basic operations of addition, multiplication, and inverse matrix, while the image processing algorithm included histogram equalization, image warping, etc.

The proposed paper book is shown in Figure 2. This coloring book includes stickers, tasks requiring the user to find different pictures, maze-based games and various ballet item drawings tasks. The left image in Figure 2 shows the furniture in ballerina rooms and right image shows ballet clothes.

After the children paint the paper book, they digitally paint 3D animated models as shown in Figure 3. Figure 3 (a) shows various digitally painted furniture and Figure 3 (b) shows the animation of ballerina after coloring the ballet clothes on the paper.

Finally, the painted 3-dimensional animated characters are gathered in the virtual world. As shown in Figure 4, all furniture put in a room along with ballerina in the virtual room. Users can change the placement of furniture. Children can change the color of the furniture and



**Figure 2.** Implemented AR coloring paper book. The subject is ballet house.



(a)



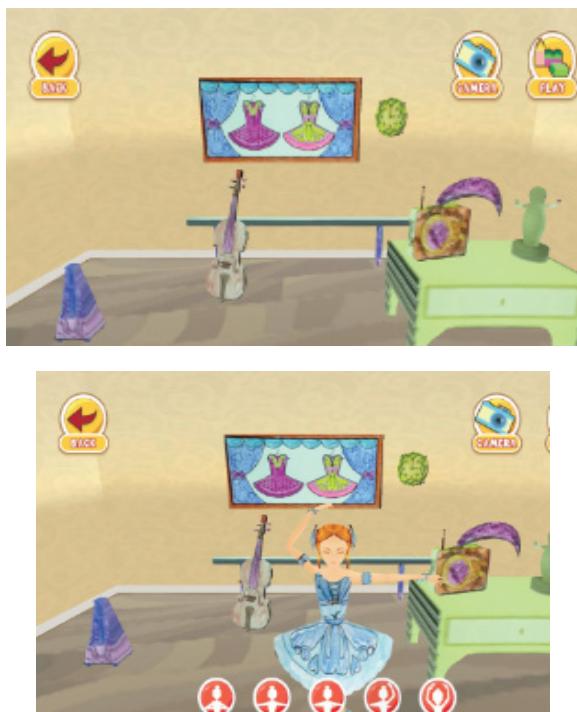
(b)

**Figure 3.** (a)Furniture in AR world (b) Ballerina in AR world.

ballerina by painting with their chosen color again. They can also watch an animation of the ballerina in the room.

## 5. Conclusions

This paper proposed an AR coloring book with transitional user interface. An AR coloring, 'Playing House' was designed and implemented. We expect that our proposed AR book can overcome the limitations of AR books. As part of our future work, we will attempt to evaluate our AR book and design the next book.



**Figure 4.** Furniture and ballerina in VR world.

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