Development of Mobile-based Augmented Reality Colouring for Preschool Learning

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Abstract—Coloring activity with pens and paper is a natural activity and an important experience for children to practice and express their creative skills. To gain interest and attention of kids making these creative activities are the main challenge faced by teachers and parents. By developing augmented reality coloring to solve this problem require us to design a mobile application with suitable coloring book contents designed suit for kids. This work aims to provide guidelines developing interactive coloring book with augmented reality for kids that integrate with our previous technique. Wonderful Augmented Reality and Arts (wARna) is our previous fast texturing technique as the main core of the framework application that interactively play colored 2D coloring book page by visualizing it in 3D on a user's view of the real world. This work proposed a framework with suitable specification in creation of content so it reusable to create new coloring content that integrated with a mobile application and highlighting issues that need to be solved.

Index Terms—Augmented Reality, Marked-less, Image-based Target, Colouring Activity, Preschool Education

I. INTRODUCTION

Augmented reality (AR) in mobile application is be divided into two categories [1] [2]: Specially designed maker images (posters or cards) and location-based gaming. Poster or cards are still the most popular AR implemented in mobile application platform. Mobile game such Rolling Dead and AR soccer are among previous popular AR based mobile game. DRAKERZ is a battle of monsters and a fierce competition. It is mainly a set of collectible cards in augmented reality. Location-based AR example that hit the mobile platform is Pokemon Go. Pokemon Go is a trending mobile application that was the wildly popular smart-phone game that hit mobile application stores. This application uses AR to send you on a hunt for Pokemon in the real world using user smart-phones camera. The game is getting people out and about on their quest for Pokemon.

AR as creative tool for kid or Augmented Creativity is a term introduced by [3]. Augmented Creativity is concept-employing AR on modern mobile devices to enhance real-world creative activities, support education, and open new interaction possibilities. This concept based on six prototype applications that explore and develop Augmented Creativity in different ways, cultivating creativity through AR interactivity. One of them is mobile-based AR coloring application that bridges coloring and computer-generated animation by allowing children to create their own character design in an AR setting.

A prominent early example of AR technology for interactive book is the Magic-Book [4]. In this work, large markers are integrated into the pages, which enable viewing virtual content through Virtual Reality (VR) glasses, based on which page of the book is open. The user can see only the virtual content and not the book, as the VR glasses are opaque. Then, [2] employ a mixed reality approach to further improve the users experience. In this work, the user can see both, the virtual content as well as the physical book. They add various visual and auditory effects to an existing illustrated book to enhance the readers immersion. The Haunted Book [5] is a prime example of well-integrated AR content in a book. The camera is mounted on a lamp on the table and the augmented book is viewed through a computer screen. Their focus lies on interaction between the virtual content and the physical book. Based on this research, many interactive book integrated AR book seen in market.

Based on previous literature, there are no work or product aims to designing AR coloring contents specifically for preschool activity in Malaysia. Coloring activity using pre-design common activity in preschool for kids start to learn how to use coloring tool. Most AR coloring product in the market focus on coloring only and use AR just for fun. There

are issues in mobile AR itself for kid. One of them is it is difficult to hold a smart device with hands in long time. It was a problem of most mobile AR system [5]. Redesign user experience is important during development of mobile AR coloring applications. Reflective Artificial Intelligence (AI) under OSMO product can solution can be used for AR coloring if the developer to focus how to control kids using AR coloring application [6]. This paper offers a comprehensive development guidelines using previous research for AR coloring for kids. In addition, the paper is deliberately highlighting exiting issue faced by user when dealing with this work still unsolved by any researchers and can be researched in for the future work for improvement in development of AR coloring mobile application.

II. Related Works

Clark and Dunser [7] presented a new type of interactive AR book experience is called AR coloring book. This work allows users to color the pages of a coloring book and the system automatically maps the colored results to virtual pop-up scenes and 3D models. This is pioneering to a commercial product called QuiverVision released [8]. Since then, many other coloring book products, such as Crayola Color Alive, Chromville [9] and Disneys Color and Play [10] have shown immense potential in this field.Magnenat et.al. proposed a method that can detect and track the drawing process alive, enhancing the overall drawing experience further [11]. There is one main limitation among these works that users cannot create the 3D content entirely. Although users can color 3D content, they always need to prepare printed line arts provided by the publishers. The systems do not enable them to create their own virtual character models. Feng et. al. introduced an automatic 2D-to-3D cartoon model creator and an interactive model editor to construct more complicated AR scenes [12]. In 2015, we introduce a simple framework for AR coloring [13].

AR holds unique and promising potential to bridge between real-world activities and digital experiences, allowing users to engage their imagination and boost their creativity. There are many studies about implementation of AR in preschool and the latest one [14]. In this study demonstrates how they can be used as effective educational tools to improve preschool childrens cognition and listening skills. One of our work, TeachAR, for teaching basic English words (colors, shapes, and prepositions) to children for whom English is not a native language [13]. Abdullah and Sunar [13] were studying children's understanding of the instruction metaphor in order to design an engaging, useful, and usable instruction metaphor. Further studies need to be done in order to develop and improve AR coloring application especially mobile-based version for kid's activity especially in preschool.

Development of this work requires two types of pipelines, content creation pipeline and live pipeline. Fig. 1 shows the framework of the development inspired based on prior work [11] . Our work propose to use fast texture mapping technique from our previous work, re-usability specification for easy content creation and transition activity such as poem that suit

for preschool book contents. This work is tested using Huawei MediaPad M3 Lite 8 Tablet with specification of Octa-core 1.4 gHz Cortex-A53, 3GB RAM and 8 Mega-pixel main camera. Two aspects are evaluated which are rendering performance 3D rendering of augmented object and image marker detection based on painted page. Three types of colored pages is used to be evaluated: a) Unpainted page b) page colored by normal colored pencil c) page colored by crayon.

A. Content Creation Pipeline

Content creation pipeline involves preprocessing activities that require marker (coloring page) designed by designer that suit and follow the specification designed for this work. The designing page starts by drawing animal conceptual design then modeling the animal in 3D software and lastly downgrade into 2D drawing of marker design in image file. Fig. 2 shows the processes in developing image marker design in this work.

In this work we suggest specification for content creation pipeline to be evaluated whether its need further improvements. There are three specifications must be followed by content developer: marker design specifications, modeling specification and texture mapping specification. With this specification, creating new coloring book content are fast to be ready to integrate with mobile application. This specification has three advantages: fast marker detection, low memory consumption for mobile applications and reduce redevelopment process time.

1) : Marker Design Specifications

Marker size designed used by this work is a A4 size paper with 300 pixel per inch resolution for printing purpose. Background image for the marker with line width with 4 points. Animal names, animal design and objects to interact by animal within image with bold outside outline width with 8 points. Then, inside outline with 4 points outline width for animal and objects to interact by animal. Fig. 3 shows the design of the marker that represented by conventional coloring page.

2) 3D Modeling Specification: Specification of each 3D model designed by modeler with less than 10000 polys which allows lower high-end mobile devices operate the application smoothly. 3D objects modeled using quads instead of triangles representation and 3D texts are modeled flat and one faced. Each mesh share the same material and texture. All meshes belong to a single parent inside the hierarchy. 3D text meshes are separated by letters for easy animation purposes. Modeling process done using 3D studio max. Fig. 4 shows the modeling of 3D objects in this work.

3) Texture Mapping Specification: UV mapping technique used to map texture for each 3D model using 3D Studio Max.Vertex of each model does not overlap with outlines drawn on their respective textures. Occluded faces refers nearby or the opposite texture to reduce seams. Faces of 3D text only refers a small portion of the text area on the texture. Fig. 3 shows the UV mapping data for butterfly page.
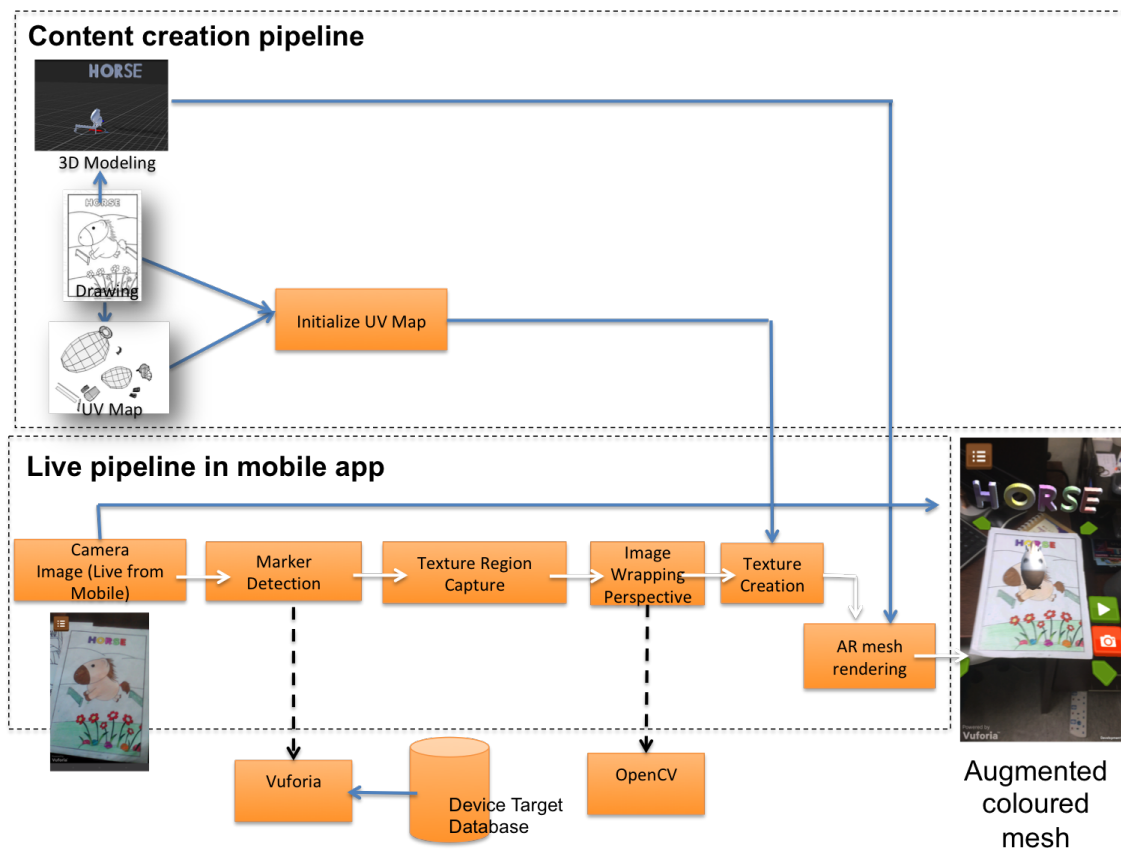
Fig. 1. Framework of development for our Mobile-based AR coloring.

B. Live Pipeline in Mobile Application

Live pipeline involves processing activities that process real-time images from mobile camera to rendering painted 3D model in AR. The processes are started by detecting marker using AR mobile engine called Vuforia [15] which is the most popular AR engine exist in the market. After detected the marker or current coloring book page, texture region capture module will extract image of marker from view of the live camera [16]. The captured texture then will be set to pre-processing UV mapping texture in texture creation process. This process requires OpenCV library to do image wrapping perspective this is part of wARna technique. The last process is rendering process for the 3D object with UV mapping texture created using wARna fast mapping technique [13]. Fig.6 shows fast texture mapping technique used by this work using technique called wARna [13].

In the live pipeline, this work suggests edutainment content included in the application and not solely purpose to view painted page in 3D visualization. By enrich the multimedia content such as sound effects, animation and user interaction, the kid can have more activities which initially we purposed the application transition to learning spelling activities.

III. RESULT

The animal drawing concept and 3D model are based on activity used in preschool coloring activity. In this work,

development process of content creation have been specified for easy development in previous section. The concept of book involves spelling and short story that suitable for kid especially between 3 to 6 years old. The short story can be related to other pages. 3 animals have chosen those are butterfly, chicken and sheep as prototypes. Fig. 7 shows left page is for short story or poem and the right page is for coloring.

Fig. 8 shows scan screen. User needs to point the camera to marker (one page of book) that was colored by a kid. When the camera point full images of marker. One buttons appear to play animation of the 3D model. The drawing were colored by normal colored pencil.

3D modeling and texture specifications contribute rendering performance and rendering quality. Performance rendering achieved at 30 fps shows that our specification on modeling and texture mapping allows rendering augmented 3D effect run smoothly on mobile devices. Texture mapped beautifully to 3D model appeared based on image painted attract kids to do coloring activity in more fun and interactive ways.

Image marker detection performance is easy to perform to detect unpainted page because natural features still remain intact as in target database. For image painted by colored pencil, image marker detection sometime take more time to recognize page as the marker because natural features for image painted by colored pencil slight difference with target database. Detection unable to perform on painted page by
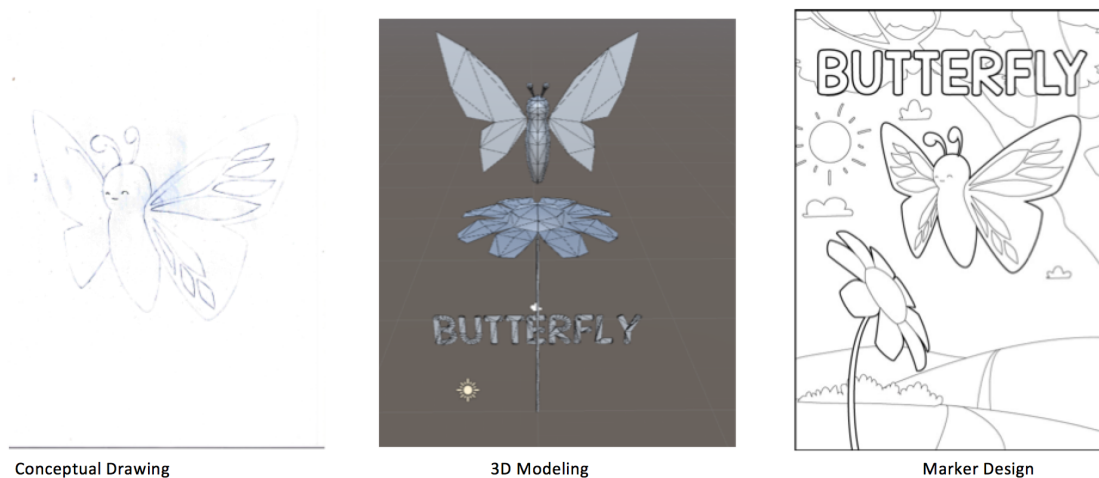
| Conceptual Drawing | 3D Modeling | Marker Design |

Fig. 2. Marker design processes of butterfly page.
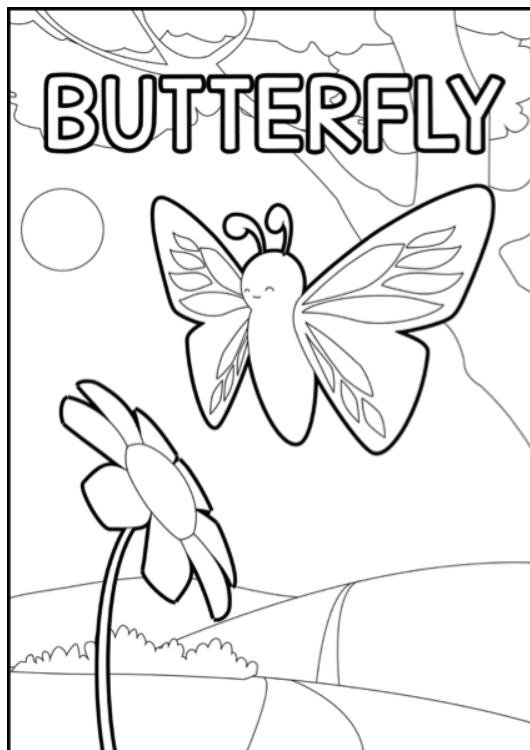
Fig. 3. Coloring page proposed as AR marker.

Fig. 4. 3D model of a butterfly interact with a flower with 3D text.

crayon color shows that there are many chances on natural features on that page compare to target database. Fig. 9 shows us the changes of natural features distribution when paged colored affecting image marker detection.

DISCUSSION AND CONCLUSION

The main issue to be focused on this project is to develop the interactive content suit to preschool kids teaching because available product in market more on fun-based concept only and limit to just coloring the page their favorite design. This

is because kids between 3-5 years olds start used pre-designed coloring sheet to start learn recognize colors and coloring activity one of activities to start learning certain subject. There are no products in market specially designed for preschool because they are more focus on fun only. We here aim to design the product only focus to develop interactive book that suit with preschool class. The reason is because preschool level the only stage suitable to introduce coloring book based on pre-designed page.

Issue on image marker detection on colored page can be study deeply for improvement. Still no clear references focus on colored page marker specifically on AR coloring. Improvement on detection of changes natural features data on painted drawing can be future work of this paper.We suggest
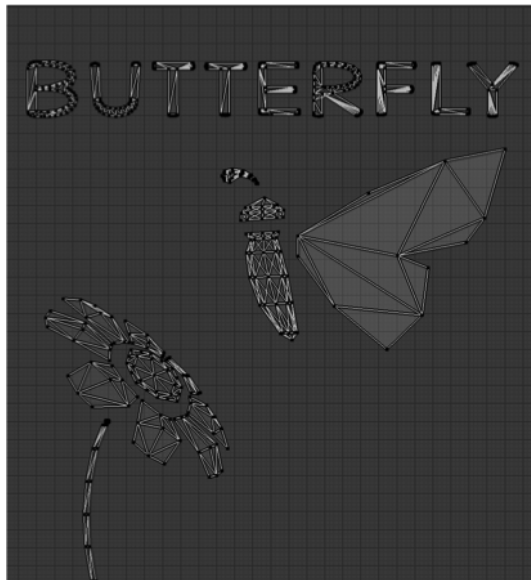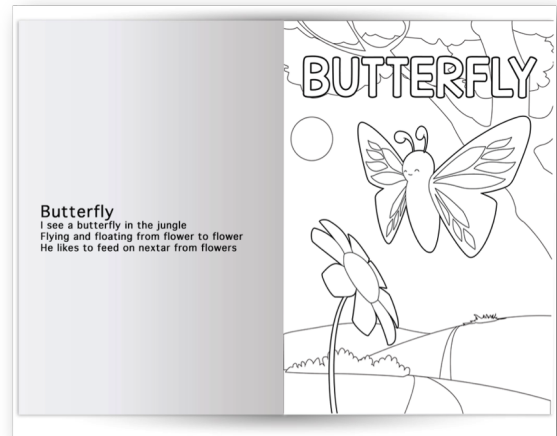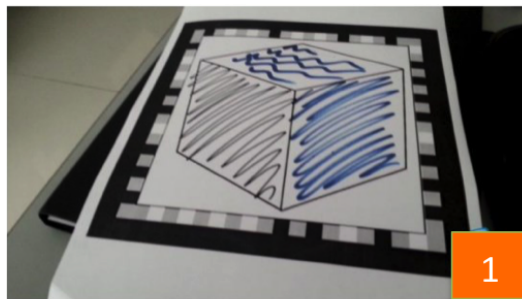
Fig. 5. UV mapping data.

a) Page coloured

b) The augmented 3D with texture extracted

Fig. 6. wARna texture mapping technique.

Fig. 7. Coloring pages proposed for preschool activities.
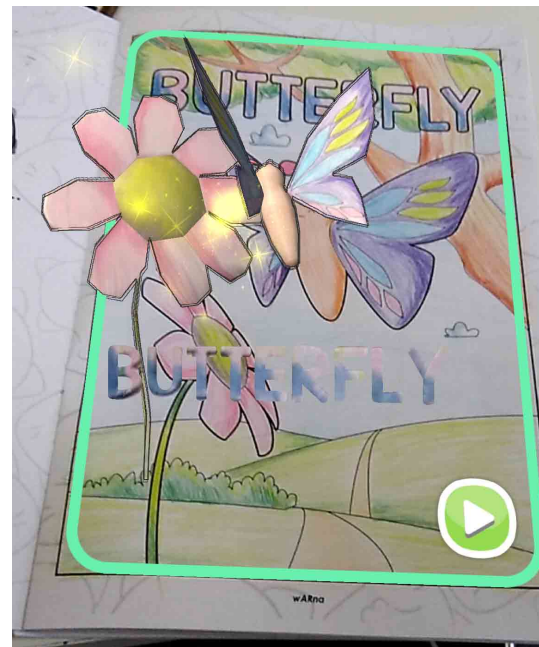

Fig. 8. 3D object of butterfly pop-up painted with colored page.

the use of deep learning to improve detection of colored marker.

Even though, conventional technique in teaching cannot total be removed by technologies. By maintaining conventional method and integrating with technology is good movement to empower children to be more creative and help their brain development. For software developer, this product is local product that can penetrate market not only in Malaysia but worldwide. Limitation of local content for kids in market is bad for us. Hopefully these products encourage more local digital content in the market, which parallel with mission and vision of Malaysian government.

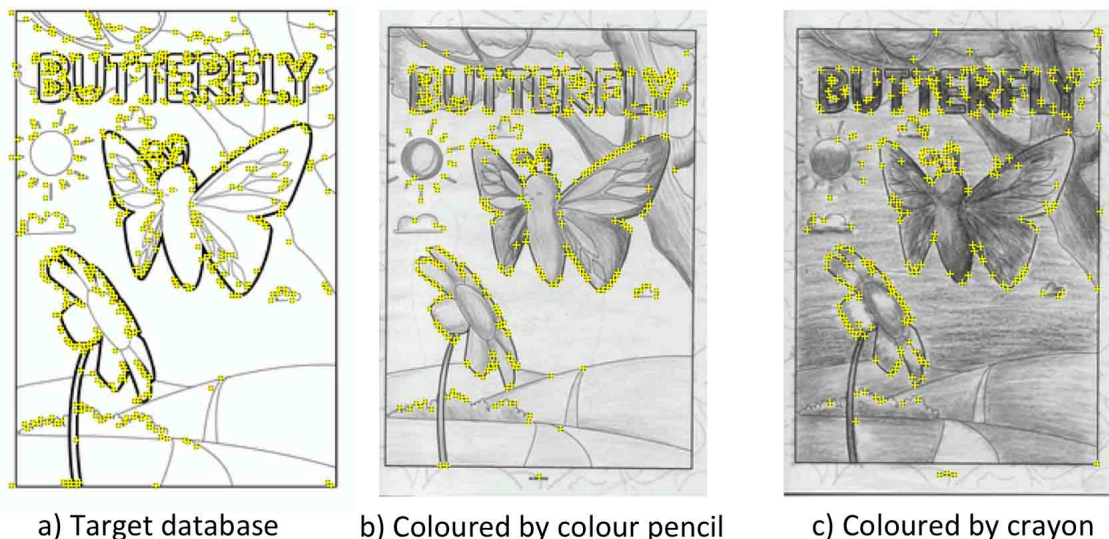a) Target database   b) Coloured by colour pencil   c) Coloured by crayon

Fig. 9. Natural features distribution for three types of image.

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