AR툴킷에 의한 AR 트래픽 북(Traffic Book) : 매력적인 사항들에 대한 재검토

AR Traffic Book by ARToolkit: A Review of Some Selected Challenging Issues

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요약 증강 현실(Augmented reality)은 실세계와 가상현실을 연결한다. AR 시스템의 가장 근본적인 목적은 보조 기구를 통하여 실세계에 3D 가상물이 동시에 존재하도록 하여 사용자의 두 세계 사이의 인지력을 개선시키는데 있다. AR 툴킷은 AR 어플리케이션 개발에 널리 이용되고 있다. 그러나 아직 많은 해결해야 할 문제들과 제약 조건들이 있다. 이 논문에서는 AR 툴킷을 이용하여 시스템을 개발할 때 생기는 몇 가지 문제에 대하여 전반적으로 검토 하고자 한다. 그리고 이러한 문제들과 관련된 3D 가상물과 소리를 가지고 있는 AR 트래픽 북이라는 실제 증강 텍스트 북을 소개한다. 이 논문에서는, 우선 가상물체, 렌더링, 카메라교정, 추적 같은 가장 일반적인 문제들에 접근한다.

Abstract Augmented reality makes the relationship between real world and virtual world. The basic goal of an AR system is to enhance the user's perception of and interaction with the real world through supplementing the real world with 3D virtual objects that appear to coexist in the same space as the real world. ARToolkit is widely used toolkit to develop any AR application. However, to do so, a lot of researcher faced many challenges and limitations. In this paper we comprehensively review some selected challenging issues using ARToolkit to develop AR system. And then, we implement a real application for augmented text book with sounds and 3D virtual objects which we called here AR Traffic Book concerning these challenging issues by ARToolkit. In this paper our foremost approaches on the most common challenging issues such as virtual object rendering, camera calibration and tracking.

핵심어: Augmented Reality, ARToolkit, Rendering, Calibration, Tracking.

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1. Introduction

The basic technologies required to build augmented reality (AR) systems are tracking, registration and display. Similar to virtual environment (VE), the most commonly used tracking technique technologies are magnetic, optical, acoustic, inertial and vision based [5]. Tracking information is used to register (align) virtual objects with real objects or locations. The common AR display technologies are see-through HMDs, which can be either optical or video see-through. Optical see-through displays place optical combinations in front of the user' s eyes. On the other hand video see-through displays work by streaming real-time video from head-mounted cameras to the graphics subsystem that is HHD (Hand Held Display). Virtual environment user interface design, the design of AR interfaces is often limited and defined by the properties and limitations of AR display, tracking and registration technologies. To build ideal AR technologies or to achieve ideal AR environment is not possible properly cause of our current existing technologies, and that' s why we always have to do some compromise.

Lately, many researchers try to give us some high level tools for creating AR applications. By merging virtual and physical elements AR interfaces wholly redefine the way that software applications are developed. In the present situations, we can sort three existing toolkits for creating AR applications [6] such as, low level libraries/toolkits, high level frameworks/middleware or rapid-prototyping and design applications. A low level toolkit (based on C programming language) provides a high degree of flexibility but has a long development time for complex applications as for example MXRToolKit [14], ARToolkit [11]. A high level framework generally integrates a large number of services, has better probability, and can be easily extended to creating new AR applications, such as ARTHUR [4]. Rapid prototyping tools which are manly GUI and scripting based can be a way for non programmers to create simple AR applications, such as AMIRE [7], DART [12].

But in this paper we give our concentration on low level toolkit, more specifically on ARToolkit. Because many augmented and mixed reality applications are based on two libraries: OpenGL is used for rendering and ARToolkit is used for marker recognition. The ARToolkit library is great for rapid prototyping of AR/MR applications. This library is very easy to use and it hides the complexity of marker recognition. So ARToolkit library is a widely used toolkit to develop any AR application. But working with ARToolkit many researchers faced some challenges to build up efficient AR based system. The most common challenges are virtual object rendering efficiently, camera calibration and tracking. This paper provides a through review of these three selected challenges and issues using ARToolkit. And finally, we employ ARToolkit to develop an AR book: traffic education with AR in relation to these challenging issues.

The rest of the paper is organized as follows: section 2 describes overview of AR, section 3 presents the main features of ARToolkit. The reviewed challenges and issues are discussed in section 4. Section 5 describes about the final attainment consequence of AR Traffic Book with ARToolkit. Conclusive remarks are addressed at the end of this paper.

2. Augmented Reality

AR can be defined as a real world environment that is enhanced (augmented) with synthetic objects or information. Augmented reality (AR) is a variation of Virtual Environments (VE), or virtual reality as it is more called. According [1] AR is system which has the following characteristics:

1) Combines real and virtual

2) Interactive in real time

3) Registered in 3-D

AR enhances a user' s perception of and interaction with the real world. The virtual objects display information that the user cannot directly detect with his own senses. The information conveyed by the virtual objects helps a user perform real-world tasks.

According to [5], there are four interaction techniques in AR to make interfaces between real and virtual world. These are given below:

AR interfaces as 3D data browsers: AR data browsing was one of the every first vision for AR interfaces. The technology was used to superimpose virtual 3D objects on the real world so that the user could see both. The goal was to create an illusion of virtual objects just as real as physical objects.

3D AR interfaces: To offer the user possibilities for interaction within AR environments 6 DOF input devices can be used. These devices are able to support natural and familiar interaction metaphors.

Augmented surfaces: This interaction style is related to the before describe spatial display technique. Virtual 3D objects are only registered to selected work surfaces that allow user to interact with them through familiar and traditional tools, such as a pen.

Tangible AR: Tangible AR tries to combine the advantages of 3D AR interfaces and augmented surfaces; it offers a way of undisturbed spatial interaction using only one input modality. Usually a video see-through HMD is used for implementing this interaction style, combined with optical registration. Virtual objects are registered to markers, physical objects that contain a known pattern. Interaction with the virtual objects is done through manipulating the physical, tangible interface elements.

The most likely problem faced in AR applications is the registration problem [1]. There are two types of error source that can cause registration problems: static and dynamic. Static errors are the ones that cause registration errors when both the user's viewpoint and the object in the environment remain still. Dynamic errors are the ones that cause registration errors when either the viewpoint or the objects begin to move. According to [15], the calibration procedure should be an autonomous process, meeting certain accuracy requirements, reasonably efficient and versatile. One way to minimize the registration errors is by having a robust camera calibration. In order to achieve this, certain criteria must be met.

3. ARToolKit

The ARToolKit is an open-source vision tracking library written in C that can detect a cameras position and orientation relative to special physical markers. ARToolKit can be used for the easy development of a wide range of AR applications. As discussed earlier, one of the key difficulties in developing AR applications is the problem of tracking the user ′ s viewpoint. ARToolKit uses computer vision algorithms to solve this problem by calculating the real camera position and orientation relative to physical markers in real time [10]. Also the other two elements of AR, registration and calibration, are contained within ARToolKit. Registration is done by overlaying virtual objects on the recognized physical markers; either created in VRML or OpenGL. Calibration is provided by ARToolKit in the form of an easy camera calibration algoritm. Three types of AR display that can be used with the ARToolKit including monitor based, video see-through and optical see-through displays. Different kinds of displays require different kinds of calibration routines. Our present implementation used HHD/HMD for AR Traffic Book.

4. AR Development Process: The Challenging Issues

For developing and running AR applications with ARToolKit the minimum hardware requirements are a computer with a camera connected to it. Tracking rectangular fiducial markers is today one of the most widely used tracking solutions for video see-through Augmented Reality applications. Our present application in this paper is relevant to the same approach. It needs to add more texts and 2D illustrations and remove the number of markers to diminish the complexity caused by the number of markers. The most challenging issues to develop AR system using ARToolkit are, first, to find out best high level graphics API together with ARToolkit for virtual object rendering, Second, the camera calibration problem and third, the tracking problem.

4.1 The virtual object rendering

As we know the most of the AR applications are based on two libraries: OpenGL is used for rendering and ARToolkit is used for marker recognition. But the problem is to make very efficient AR system we have to give more concentration on graphics. Many researchers try to combine ARToolkit with different types of graphics libraries. They are trying to find which library should be used for rendering. Can they use a high -level graphics API together with ARToolkit? Which graphic library would be the best for further AR/MR applications? There are so many graphics API library such as, Direct 3D, OpenGL Performer, OpenSG, or OpenSceneGraph etc. So our main problem: how difficult is the usage of ARToolkit, originally based on OpenGL, in combination with a high-level graphics API like OpenSG?

To find the answer so many approaches were tried to implement. According [8][7], to make the integration of ARToolKit into high-level graphics frameworks as OpenSG and Open SceneGraph as easy as possible we have decided to create an object-oriented abstraction of video capturing and object tracking functionality. They have used this abstraction layer only to integrate the object tracking and overlaying of live video images into the high-level framework. But now, in our present application, how could draw the virtual objects? If we set the environment using any graphic API based on OpenGL, we can use any drawing tools like 3DMAX or MilkShape. MilkShape is very easy to use and to make simple virtual object. Many graphic API support MilkShape' s models. We just used MilkShape to build our virtual model and rendered it using OpneGL.

4.2 Camera Calibration

Camera calibration is one of the important tasks in AR systems. AR systems generally require extensive calibration to produce accurate registration. It establishes the projection from the 3D world co-ordinates to the 2D image co-ordinates. This can be achieved by finding the intrinsic and extrinsic camera parameters. The coordinate system of ARToolkit is shown in figure. Once the parameters are determined, 3D information can be inferred from 2D information and vice versa [2].

According [3] to calibrate a camera for monitor based display; the ARToolKit uses two different patterns. The first pattern is used to estimate the image centre point and lens distortion. The second pattern is used to estimate other camera parameters. They try to investigate the use of camera self-calibration for the ARToolKit, which has the advantage of simplicity of implementation. In order to improve its accuracy, a distortion model is also investigated. Their aim is to find parameters in the 3x3 calibration matrix in a monitor based AR display for the ARToolkit. Their proposed algorithm is not as robust as the existing algorithm in the ARToolKit, but this could be considered as a first step towards a more automatic calibration process without the needs for a particular pattern. Improvement can be made by accurately estimating the fundamental matrix which is largely related to the accuracy of point correspondence matching. Once this is achieved, it is easier to obtain a good estimation of camera parameters. In our case in this paper we used default camera parameter for Logitech webcam of ARToolKit.

4.3 Tracking

Accurate registration and positioning of virtual objects in the real environment requires accurate tracking of the user's head and sensing the locations of other objects in the environment. The biggest single obstacle to building effective Augmented Reality systems is the requirement of accurate, long-range sensors and trackers that report the locations of the user and the surrounding objects in the environment [1].

Tracking rectangular fiducial markers is today one of the most widely used tracking solutions for video see-through Augmented Reality applications. The ARToolKit libraries were developed to support the tracking of simple fiducial markers, allowing applications to appear to place 3D objects onto these markers, and then viewed on a display device

The In AR application, by ARToolkit, the distance between the user and the target is often quite small (less than a meter), and so many errors are not noticeable at larger distance. In our AR traffic book, we also feel that problems. Many researchers are trying to overcome this range problem. According [13], they show the results from an experiment which was performed to test the ARToolKit and the accuracy of its tracking over large distances of 1 to 3 metres. They used ARToolKit to extract the position of a camera pointed at a fiducial marker, and compared these values to physical measurements to quantify the accuracy of the tracking.

Very recently, ARToolkitPlus [16], a successor to the ARToolkit pose tracking library has been introduced. They manly focused on the "Robust Planar Pose Tracking" (RPP) algorithm provides improved pose estimation quality with less jitter and improved robustness.

5. AR Traffic Book

Our current implementation AR Traffic Book can be a good traffic system instructor for children. By reading this book, and manipulating several objects and characters they will feel fascinating to study better in augmented sense. In this part we will show the AR Traffic Book scenario and the list of 3D models and animation scenes that will be used to raise this education book. In the previous sections we already have analyzed and investigated some selected challenging issues and also examine what and how these issues affect to build our current system using ARToolKit. Now let' s see what type of ingredients exit in this AR Traffic Book.

5.1 Stroy

This is instruction book for traffic system education targeting children. It has 3 traffic situations. Each traffic situation consists of 2 pages that left page is explanations for elements of traffic education and right page is the animation of traffic situation for example. The scenario of story is in figure 1.

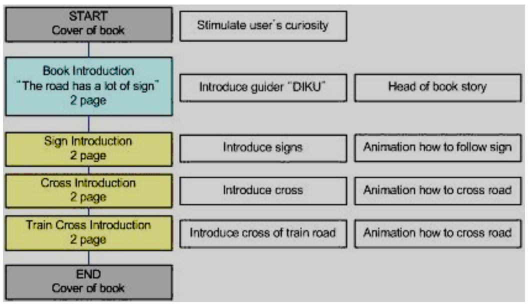

그림 1. The Scenario of the AR Traffic Book.

When a user starts to read the AR Traffic Book with HHD or HMD, the cover shows the curios things. We made a lock in cover page then anyone can' t see the immersive virtuality that is augmented data. But users can read and understand the book. After a user unlocks the AR Traffic Book, DIKU guider will greet her. And she looks the book introduction and can know the book' s purpose and motive. And after head pages of the book she can enjoy the traffic education with the explanation and animation of each traffic situation. Those are the situations of how car follow the traffic sign to cross road interchange and how DIKU cross the car' s road and Show how DIKU cross the train' s road.

5.2 3D Models and Animations

After making scenario, we can find out each situation' s 3D models like DIKU, cars, signs, crosses and 3D animation. The below tables (1 & 2) have the list of 3D models and animation. Then we can make these models. The 3D models and animations are shown in figure 2.

표 1. 3D Models

Human	DIKU
Sign	Sign for Car, Sign for Man
Other Sign	Sign for Road and Train line cross
Car	Train, Red Car, Blue Car, Gray Car
Etc	Cross, Road and Train line

표 2. 3D Animations

Animation Type	Expression Result
Human	Hi, explaining, bye-bye
Sign scene	Show how car follow sign
Cross scene	Show how DIKU cross the car' s road
Train scene	Show how DIKU cross the train line

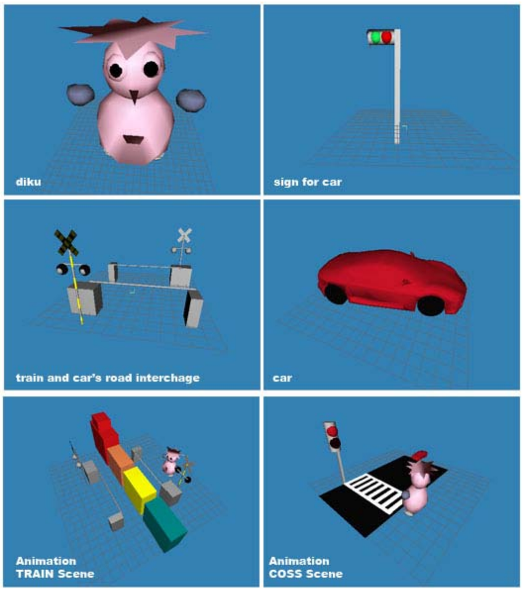

그림 2. 3D Models and Animations.

5.3 Development and Results

After developing 3D models and animations made by 3D design tool MilkShape 1.8.0 used in this paper, we can make the hard book cover and pages. It depends on story completion. The story easily can be added, modified or deleted. And the real book needs to have understandable texts without augmented information because sometime we can' t use computer and HHD, HMD related with AR devices. Figure 3 shows the basic arrangement with HMD to observe the AR Traffic Book. The first page is the cover and left page is explanation of traffic sign and the right page shows how car follow the sign to cross interchange with some virtual object animations. The figure 4 shows the result sequences of AR Traffic Book.

Figure 3. Basic Arrangements to watch AR Traffic Book with HMD

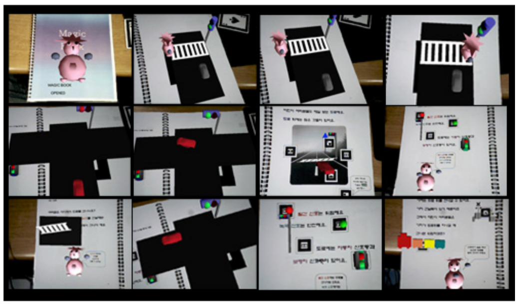

그림 4. AR Traffic Book sequences Scenes.

6. Conclusion

The ARToolkit is software libraries which are very useful in creating AR based applications. In this paper, we have presented a review of the most three challenges to develop AR based system with ARToolkit. This review allows the readers to be more careful to design AR system using ARToolkit. These all observations are carefully handled during our development process of AR Traffic Book. This paper also describes the possible solutions for different case study depends on diverse application by various researchers to face those challenges. But those clarification and solutions are not enough to build efficient AR system with ARToolkit. So this is awfully on going research in AR field. We hope for the best.

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