# OVERVIEW OF OPEN SOURCE AUGMENTED REALITY TOOLKIT

*Mohd Nihra Haruzuan Mohamad Said, [1]Norazlina binti Ismail*
Universiti Teknologi Malaysia
Johor Darul Ta'zim
nihra@utm.my
[1] azlina@fs.utm.my

## ABSTRACT

Augmented reality or also known as AR is not a new technology. The technology has existed for almost 40 years ago after Ivan Sutherland introduced the first virtual reality (VR) application. At that time, works and research were mainly concerned to establish the hardware aspects of the technology. The head-mounted display (HMD) or some might called head-worn display is the result of augmented reality research and also one of the fundamental equipment for accessing the technology. As time goes by, the augmented reality technology has begin to mature to a point where the hardware cost and capabilities have collided to deliver a more feasible AR thus enable the rapid development of AR applications in many fields including education. To create a non-commercial AR application specifically for education, the ARToolkit can be taken into consideration. ARToolkit is the product of AR community and it is registered under the GNU General Public License. The user is provided with basic source code that lets the user easily develop Augmented Reality applications. Despite the fact that AR is not a new technology, people may unaware or unfamiliar with its existence. Therefore this paper is intended to (1) give an overview of augmented reality; and provides (2) solution to the technical problems that one's will face in setting up open-source augmented reality toolkit.

**Keywords**: *Augmented-Reality, ARToolkit, Virtual Reality, Education*

## INTRODUCTION

Augmented reality or also known as AR is not a new technology. The technology has existed for almost 40 years ago after Ivan Sutherland introduced the first virtual reality (VR) application. At that time, works and research were mainly concerned to establish the hardware aspects of the technology. The head-mounted display (HMD) or some might called head-worn display is the result of augmented reality research and also one of the fundamental equipment for accessing the technology. As time goes by, the augmented reality technology has begin to mature to a point where the hardware cost and capabilities have collided to deliver a more feasible AR thus enable the rapid development of AR applications in many fields including education.

Currently, literature shows more and more research have started to investigate the potential use of AR in education. AR can be found to be applied in the teaching of geometry, spatial relationships between planets and molecule structures (see Kaufman, 2004; and Shelton, 2003; and Chen, 2006). These research tried to utilize the advantage of AR to help visualize the abstract concept in more intuitive way which is believe could lead to an improvement in student's comprehension. In addition, interactivity is added to support the learning process, thus making learning more enjoyable and interesting.

Even though AR is not a new technology, the writer felt that many people especially teachers or lecturers still may unaware or unfamiliar with the technology existence. The technology itself is still 'new' to education mainstream compared with other information and communication technologies. Therefore this paper is written with the intention to (1) give an overview of augmented reality and introduce open-source AR toolkit; and provides (2) solution to the technical problems that one's will face in setting up open-source augmented reality toolkit.

## WHAT IS AUGMENTED REALITY?

The terms Augmented Reality or also know as AR has become more popular in recent year due to its relation to Virtual Reality. Many people or researchers have come forward with their working definition so that other can understood and differentiate between AR and VR. This paper is not intended to make any formal definition of AR, but instead highlight or provide the reader with some definitions and explanations from the literature.

Most definitions of AR in literature were focusing on HMD (Head-Mounted Display) as display technology. It can be obviously found in Miller et. al (1994). Miller defined AR as a special form of VR, where the user head-mounted display is transparent which allowed view of virtual object in real world. But a definition with specific reference to display technology (in this case HMD), allow for a broader interpretation. This motivates Azuma (2001) in his article entitled "Recent Advances in Augmented Reality" to confine AR definition to the following properties:

- It combines real and virtual objects in a real environment
- It runs interactively and in real-time
- It registers real and virtual objects with each other

A more general AR explanation can be found in O. Bimber and R. Raskar (2005), as it explained AR is opposed to VR where real environment is not completely suppressed but play a dominant role. Rather than replacing a real object into a virtual object, AR attempts to supplements the real environment with virtual information.

## AUGMENTED REALITY TECHNOLOGY

As stated previously, many AR research were dependent to display technology to deliver visualization. But basically there more other aspects that constitute AR technology such as tracking, registration and calibration. And these aspects are still in continuing improvement.

### Display technologies

Display technologies are the fundamental equipment for accessing the technology visually. User needs display technologies in order to see the virtual information. The information can be formed are either planar or curved, depending on the used optics. The process of information-forming can take place anywhere on the optical path between the eyes of the observer and the physical object. The common display technologies are mounted on the head of the user, called head-mounted display. But as described by Azuma (2001), AR is not necessarily limited to a certain type of display technology. It can be projected by other display devices such as PDA, normal web cam or LCD projector. Bowman et. al (2005) categorized display technologies as

- monitors
- surround-screen displays
- workbenches
- hemispherical displays
- head-mounted displays
- arm-mounted displays
- vitual retina displays
- autosteroscopic displays

### Tracking and Registration

In many AR applications, tracking is one of the problematic factors that contribute to the ineffective AR presentation. For AR system to be able to provide the user with the correct information of real and virtual images, it needs to know the user location virtually. In this case, AR system requires the user's head position and orientation. It is not only important to provide correct registration when the user is in a fixed position, but it also when the user move around or walking. Ineffective AR system may result to user's negative experience, in some cases may disastrous (for example in surgical training). Bowman et. al (2005) described three common tracking devices as motion trackers, eye trackers and data gloves.

**Calibration**

Tracking is used for providing the input needed for the correct registration of virtual objects with respect to the real world. But before these two connected processes can be carried out, another issue which is related to both needs to be handled. That is, the parameters of used display components in the AR system need to be determined. The complete set of procedures to estimate these parameters is called calibration. The purpose of calibration is to establish the viewing projection of the used camera. From the process of calibration, correct transformations for projecting virtual objects on the real world can be established. These transformations are meant to copy the intrinsic and extrinsic parameters of the virtual camera. It is necessary to have the parameters of the real camera and the virtual camera to match both real and virtual objects projection.

**Interaction**

AR system must be able provide user with the opportunity to interact with the AR environments. There are four interactions in AR environments, each offering different interaction levels.

***3D Data browsing***

The basic AR data browsing was to use it for superimposing virtual objects on the real world. The overlaid information can be three-dimensional, but can also in textual, voice or video annotation. The interaction between the user and the AR environment is limited to navigation within the overlaid information space. Although 3D data browsing can be supported by several display devices, many of the AR applications that are guided by this interaction style use an HMD in combination with 6 DOF (degree of freedom) optical or magnetic tracking.

***3D AR interfaces***

To offer the user the possibilities of interaction within AR environments, the 6 DOF input devices can be used. These devices are able to support natural interaction by tracking their position and orientation. This allows seamless spatial interaction, that user can interact with virtual objects anywhere in environment. Another shortcoming of this interaction style is the lack of sufficient tactile feedback, which is a stringent requirement for many real world applications.

**Augmented surfaces**

In this interaction, virtual objects are only registered to selected work surfaces that allow user to interact with them through the use of tools, such as a pen or any designed physical handles. This is the way used for accessing both the virtual and the real world. Compared to the 3D AR interfaces interaction is significantly eased, but it introduces a spatial reduction in interaction. Full interaction in three dimensions is nearly impossible, and is limited to the 2D augmented surface.

***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. A paddle and paper object with an attached marker could be used. This provides a transparent interface for two-handed 3D interaction with both the virtual and real objects in the environment. Also this interaction can take place anywhere in the physical environment.

**Augmented Reality Toolkit**

ARToolKit is a software library written in the C programming language for creating AR applications. It is distributed free for non-comercial or research applications. It has been primarily developed by Dr. Hirokazu Kato of Osake University, Japan, and is supported by the HIT Lab at the University of Washington and the HIT Lab NZ at the University of Canterbury, New Zealand. Distributions for SGI Iris, Linux, MacOS and Windows OS are available, and are distributed with complete source code.

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. 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 algorithm.

For developing and running AR applications with ARToolKit the minimum hardware requirements are a computer with a camera connected to it. It also can be used with HMDs and handheld displays. Both the use of video see-through and optical see-through HMDs are supported. The computer should at least have 500 MHz processor and a graphics accelerator card. For the Windows platform USB cameras, FireWire cameras and composite video cameras connected to a frame grabber can be used, as long as they have DirectX drivers.

AR toolkit can be downloaded at *http://www.hitl.washington.edu/artoolkit/download/*. The following drivers need to be installed in the working computer before one can run the AR toolkit. The drivers are

- OpenGL Driver
- The GLUT library
- Microsoft's Direct X

**Setting-up Augmented Reality Toolkit**
AR toolkit source code can be edited and compiled using Microsoft Visual Studio or Visual C++ version 6.0. User guide for setting up the AR toolkit is available at http://www.hitl.washington.edu/artoolkit/documentation/usersetup.htm. The step by step instructions are easy to follow. The camera and marker pattern files must be included in the working folder.

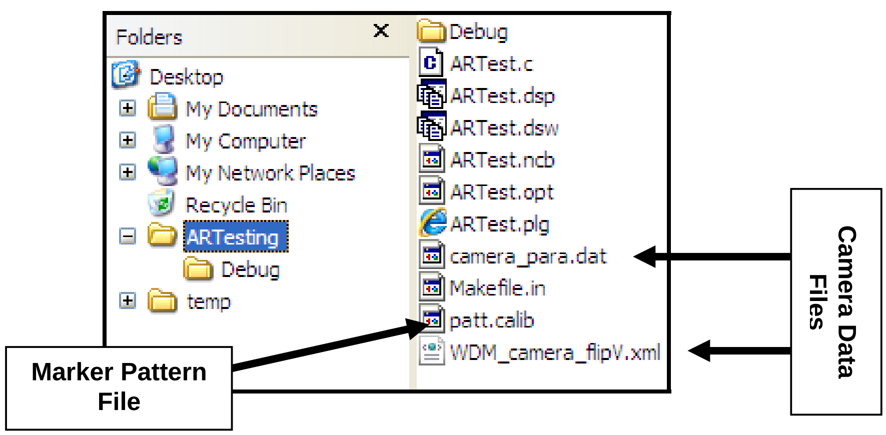


**Figure 1:** AR Working Folder

Also the three drivers (js32.dll, libARvideo.dll and DSVL.dll) should be placed in debug working folder (as shown in figure 1).

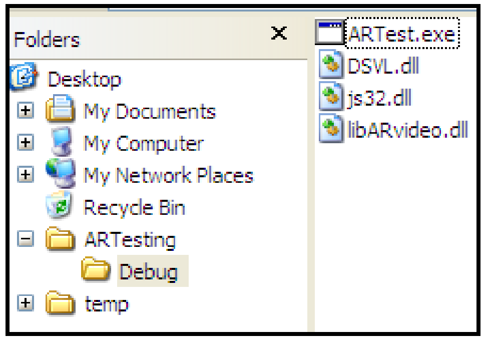


**Figure 2:** AR Debug Working Folder

User can modify the file source code to include different object. As figured in figure 3, a blue teapot appeared on the top of the marker.

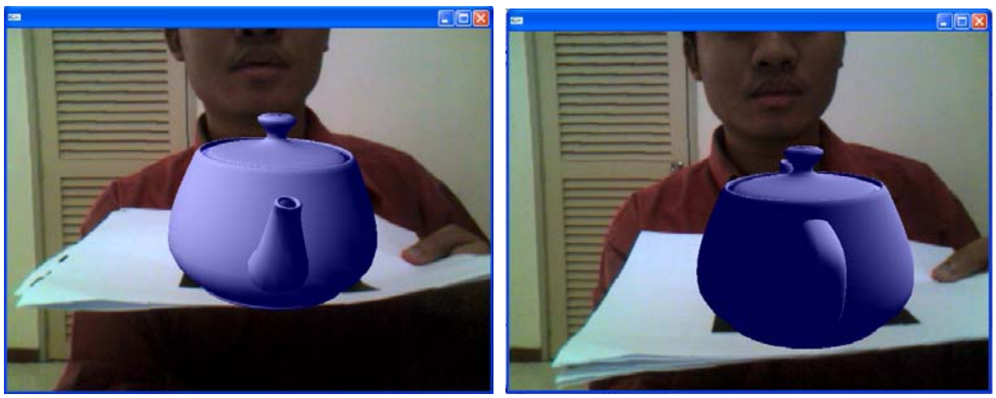

**Figure 3:** AR simple test 1

```
/* load the camera transformation matrix */
argConvGlpara(patt_trans, gl_para);
glMatrixMode(GL_MODELVIEW);
glLoadMatrixd( gl_para );

glEnable(GL_LIGHTING);
glEnable(GL_LIGHT0);
glLightfv(GL_LIGHT0, GL_POSITION, light_position);
glLightfv(GL_LIGHT0, GL_AMBIENT, ambi);
glLightfv(GL_LIGHT0, GL_DIFFUSE, lightZeroColor);
glMaterialfv(GL_FRONT, GL_SPECULAR, mat_flash);
glMaterialfv(GL_FRONT, GL_SHININESS, mat_flash_shiny);
glMaterialfv(GL_FRONT, GL_AMBIENT, mat_ambient);
glMatrixMode(GL_MODELVIEW);
glTranslated( 0.0, 0.0, 25.0 );
glRotated(90,10.0,0.0,0.0);

glutSolidTeapot(50.0);

glDisable( GL_LIGHTING );

glDisable( GL_DEPTH_TEST );
```

**The Object**

Figure 4 shows different objects have been appeared in the target marker when *glutSolidTeapot* has been changed to *glutSolidSphere* and *glutSolidCube*.

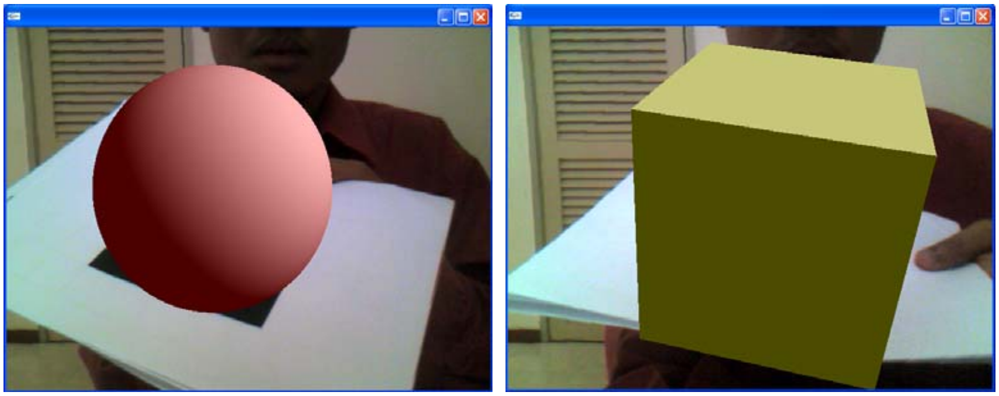

**Figure 4**: AR simple test 2

**CONCLUSION**

AR environments are able to deliver a different and unique set of experiences if it added in teaching. This is true based on the finding of other researchers (see Kaufman, 2004; and Shelton, 2003; and Chen, 2006). To establish AR system for education, it requires knowledge and skills. Therefore it is hope that this article can provide basic information for teachers, students or anyone who are intended to embrace AR. Finally, it is hope that more and more AR applications can be developed by local developers.

**REFERENCES**


Azuma, R., A Survey of Augmented Reality, Presence: Teleoperators and Virtual Environments, vol. 6, n. 4, August, pp. 355 – 385, 1997

Azuma, R., Baillot, Y., Behringer, R., Feiner, S. and MacIntyre, B. (2001), Recent advances in augmented reality. Computers & Graphics, IEEE, November/December, 21,6, 34-47.

Bowman, D.A. et. al (2005), 3D User Interfaces: Theory and Practice. Second Edition. Addison-Wesley, Boston.

Feiner, S.K. (2002), Augmented reality: a new way of seeing. Scientific American, 286, 4, 48-55.

Kaufmann. (2004). Augmented Reality with Geometry Education. Doctoral Thesis: Vienna University of Technology.

Kato, H., Billinghurst, M., Poupyrev, I.( 2000), ARToolKit 2.33 Documentation, http://www.hitl.washington.edu/artoolkit/documentation/usersetup.htm. http://www.hitl.washington.edu/artoolkit/download/

Milgram, P., Takemura, H., Utsumi, A., Kishino, F. (1994), Augmented Reality: A Class of Displays on the Reality-Virtuality Continuum, Proceedings of Telemanipulator and Telepresence Technologies, pp. 282-292.

O. Bimber and R. Raskar (2005), Spatial Augmented Reality: Merging The Real and Virtual Worlds. Wellesley, Massachusetts

Shelton, B.E. (2003). How Augmented Reality Helps Students Learn Dynamic Spatial Relationships. Doctoral Thesis: University of Washington.

Yu-Chien Chen (2006). A study of comparing the use of augmented reality and physical models in chemistry education. ACM International Conference on Virtual Reality Continuum and Its Applications.