Teaching Augmented Reality in Practice: Tools, Workshops and Students' Projects

Marcin Wichrowski

Department of Multimedia

Polish-Japanese Institute of

Information Technology

Warsaw, Poland

mati@pjwstk.edu.pl

Abstract

Increasing popularity of Augmented Reality (AR) and easy access to new software for creating projects using this technology leads to considerations how to integrate it with the students' assignments/projects and encourages us to check potential of it in the academic world. The first part of this paper gives a brief description of the AR technology, requirements needed for using AR, and the preparation process. The second part presents various editors, applications, tools and developing environments for teaching AR, useful in IT and art areas. It focuses on projects prepared by the students of Computer Science and New Media Art in the Polish-Japanese Information Technology, and also on projects created during AR workshops. The main goal of this paper is to present ideas and suggestions concerning applying AR technology to students' works based on the experience of the author, and final results are also shown.

Author Keywords

Augmented Reality, Virtual Reality, Education

ACM Classification Keywords

H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities

General Terms

Design

1. The usage of AR

Augmented Reality technology allows merging a view of real-world environment with computer generated elements. Digital content is applied to real-time video and embedded in 3D space on the screen, resulting in a feeling of co-existence of the real environment with the virtual world. It offers a lot of scenarios of use, starting from simple commercials/advertising, entertainment, games, websites, social services and art installations, and ending with advanced educational applications, supporting medical solutions, new navigation ideas etc. Moreover, the rapid development of smart phones and tablets equipped with better computing power, HD cameras and faster internet connection causes that the popularity of mobile AR technology is definitely increasing. This influences the e-marketing, accessing to data, distribution of information, interaction in public places, entertainment, architecture, travel and development of new digital services. In the case of education, AR provides an opportunity of ubiquitous access to knowledge related to the surrounding reality and complements it perfectly.

Figure 1. presents the evolution of AR technology over the last 15 years across different platforms. Nowadays, we are entering the era of mobile and web AR solutions, which means an even higher availability of this technology practically anytime, anywhere. The ability to check its potential for use in education, in particular how it affects the ingenuity and creativity of students, brings promising observations.
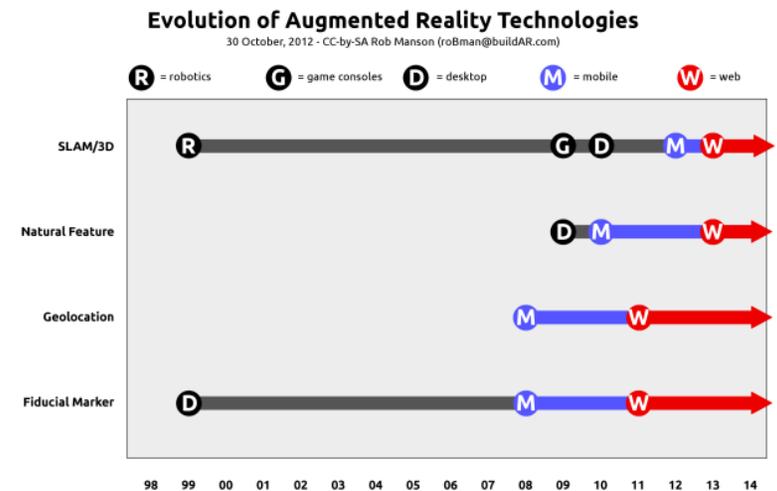
Figure 1. AR technology evolution (source: http://www.w3.org/community/ar/demos-and-projects/)

Figure 2. Project "Meta" by PJIIT student Bogna Kowalska at European Culture Congress 2011

2. Inspiring students

The experience of the author shows that many students have little knowledge about AR regardless of the faculty they represent (Computer Science or New Media Art). In many cases students cannot imagine practical examples for implementing AR nor the wide range of possible usage of this technology. Usually the first students' associations concern only advertisement and entertainment. That is why it is so important to show worldwide AR projects concerning different areas and explain what kind of benefits it may offer. The presentation of available software/SDK solutions and explaining their possibilities and limits serves as a good introduction to planning AR projects. Brainstorm session considering potential usage and analyzing pros and cons of AR may also be very helpful for better understanding of this technology.

3. Determining project requirements and functionality

The first step in implementing AR is to determine project requirements in relation to this technology. It is important to choose the right application/developer solution for achieving the best results. Students are required to make a research concerning various technologies and prepare the plan of the project, taking into account pros and cons of each solution. Several aspects should be considered:

- expected functionality of AR technology in the project, especially concerning what kind of interaction is needed,
- way of embedding digital objects in the real world (simplified/photo-realistic/object based markers, geo-location data),

- devices/equipment needed to display AR contents (desktop computer, laptop or mobile device, webcam, AR glasses etc.),
- detailed technical requirements (supported mobile operating systems, is there a need to connect to the internet etc.)
- method of publishing/viewing AR scene (via a web browser or through a dedicated application/service),
- supported authoring platforms and dedicated programming languages,
- co-operation with related technologies/libraries and equipment such as AR glasses,
- limitations of the software (supported 3D animation formats, the level of complexity of the objects, video resolution, maximum number of objects, performance issues, available forms of interaction etc.)
- limitations of demo versions to test the capabilities of software,
- students' technical skills level (programmers/artists).

Examples/scenarios of use are integral part of the planning process and students prepare it in various forms (short written descriptions, storyboards, simple animations/videos).

4. Preparing prototypes and basic tests

Students should make basic prototypes using a chosen solution and run tests in various conditions. It allows full understanding and the prediction of potential problems, as well as evaluation of important issues like lighting, reaction time, the level of recognition of

Figure 3. Project "What's the youth of today like?" by PJIIT students at Culture 2.0 Conference 2011

makers (size of the printed marker/precision of scanned 3D object), the distance of the viewer from the camera, etc. In the case of projects for mobile devices, more complex prototypes are needed, taking into considerations the range of devices, screen resolutions, mobile features (gestures, geo-location, accelerometer etc.) and performance.

5. Teaching AR methodology

Author's observations shows that teaching AR varies strongly depending on the faculty and gives different but very interesting results in each case.

5.1. AR for New Media Art students

Among art students there is very strong belief that implementing AR is difficult. Choosing and presenting proper tools which are adequate to their computer skills level is a key to make them interested. Simple practical demos with automated AR editors like BuildAR Pro [1] (Windows/MacOS) and Metaio Creator [2] usually convince students to make first steps and encourage them to start thinking about functionality they want to achieve.

BuildAR Pro is a very simple AR editor for desktop computers. A webcam is needed and BuildAR Viewer to check the created scene. The program offers recognizing ARToolKit markers (having the appearance of black and white shapes in a square frame) and image based markers. It is possible to load images, text, videos/animations with alpha channel, primitives, animated 3D models and sounds. Unfortunately, it is not possible to add interaction with objects (like clicking, dragging etc.).

Metaio Creator is another automated AR editor dedicated to creating simple scenes for desktops and mobile devices. It is an integrated environment which consists of:

- Creator (Windows/MacOS) - authoring tool for building AR experiences,
- Junaio AR Browser [3] - free mobile application (Android/iOS) for loading AR channels,
- Metaio Cloud - online host service for users' projects stored in channels with unique ID.

With its ultra-easy configuration and minimalistic workspace, even students who have never used the AR technology are able to create first working scenes in a few minutes. It gives a possibility to use three tracking technologies: image, object and environment based. Creator allows embedding different types of objects such as images, text, videos/animations with alpha channel, animated 3D models with interaction, sounds, calendar events, links to websites and buttons for integrating with social networks. To create one's own scene the user must first register as a Junaio developer. In the next step the tracking method must be selected. Using image based tracking is as simple as loading image file from a disk. If the user wants to use object or environment based tracking, he or she must first scan the desired object with free Metaio Toolbox [4] application using mobile device and send back the obtained data to the Creator. Precision in identifying the actual spatial objects is very good and it allows attaching additional digital content to real elements of the surrounding world. It is possible to add interaction, so the user may, for example, start different animation, change channel, or access social networks by clicking on objects in the scene.

Figure 4. Part of artistic diploma "wo/man" by PJIIT student Bogna Kowalska
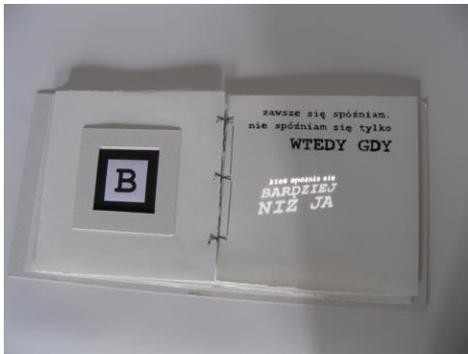
Figure 5. Project "Out of Context" by PJIIT student Bogna Kowalska

Both editors are really popular among art students and examples of their works are presented in next chapters.

5.1.1. Art installations and works

Art students put more effort in building visual aspects of their works and it usually takes form of installations and specially crafted real objects which are triggers for AR experience.

BuildAR Pro was used to present PJIIT students' works from Multimedia and Image Processing Lab (New Media Art) led by Anna Kliczmak and Marcin Wichrowski at the European Culture Congress 2011 [5] (project "Meta", see Figure 2.) and Culture 2.0 Conference 2011 [6] (project "What's the youth of today like?", see Figure 3.), both organized by the National Audiovisual Institute.

Project "Meta" by the PJIIT student Bogna Kowalska uses three big hanging cubes with image based typography markers on every side of all cubes. Markers trigger hidden animated words which can be observed using connected Vuzix AR glasses. The main goal of the project was to build sentences using real and virtual typography.

The next project, "What's the youth of today like?", is based on ARToolKit markers attached to t-shirts. In this case markers allow watching hidden graphics, movies and animations on a big TV screen. A Logitech HD webcam is used for acquiring video feed. The added elements are answers to the title question and viewers can see objects placed directly on t-shirts. Installations elicited very lively reaction of the viewers.

Both projects were very good tests of using the AR technology in public space for students. This experience showed how important it is to check the project in real environment and what could cause potential problems. Encountered issues mainly concerned changing lighting conditions during the day, weak recognition of typography as image based markers, performance problems with more than about 10 markers at a time and accidental covering of the markers by users. Infographic instructions are obligatory to explain principles of interaction with this installation. Moreover, Vuzix AR glasses turned out to be too heavy and uncomfortable for some participants because of many wires needed for connecting the glasses to the computer.

Another unusual usage of BuildAR Pro is a part of an artistic diploma "wo/man" by PJIIT student Bogna Kowalska. She designed a sophisticated book (with moving elements) combining AR makers recognition with projection on the book's pages, see Figure 4. Markers are used for checking which page of the book is opened, and a selected animated typography is projected accordingly on a sheet of paper, complementing the existing words. Before completing this project Bogna Kowalska prepared the implementation of a similar AR book, "Out of Context", which allowed to test the ideas presented above, see Figure 5.

Beside students' projects the author had the interesting possibility of testing BuildAR Pro during the preparation of an interactive installation "Become Whom? Him!" [7] for Burn Selector Festival 2012 (created with Jaśmina Wójcik and Kuba Wróblewski). This installation was

Figure 6. Interactive installation "Become Whom? Him!" at Burn Festival 2012

addressed to children and its main goal was to show funny animated animal faces instead of markers on a big LED screen, see Figure 6. The project attracted hundreds of visitors each day and aroused great interest.

5.1.2. AR art workshops

AR editors mentioned above have been successfully used also during AR workshops with students. One of them was TYPE=IMAGE/TYPE-EMOTION 2013 [8], the international study and research week organized by the Graphic Design Department of the Royal Academy of Fine Arts in Antwerp. The AR part of it (see Figure 7.) was conducted by Ewa Satalecka and Marcin Wichrowski. The goal of this cross-over project was to initiate, stimulate and support research in visual communication. The main idea behind the AR part of the workshops included in this event was to use automated editors by students to implement original ideas of merging this technology with visual communication and art. This experiment yielded interesting projects like augmented stamps, tickets, posters, buildings and public spaces. The students designed animated infographics, labels, 3D models and social interaction. Final works were presented during public exhibition as posters and working interactive projects available for everybody with Junaio AR Browser application installed on mobile devices. This exhibition got a positive reception from the visitors, and many participants were eager to take part in the AR experience.

Other workshops were organized by Ewa Satalecka and conducted by Marcin Wichrowski at the Academy of Fine Arts in Katowice. Exemplary tasks included in these workshops are listed below:

- AR Photo 3D – converting standard photos to "3D" versions. At the begging, specified elements are extracted and moved to different layers in Adobe Photoshop. Next, they are imported and positioned on z-axis at various heights. Viewing the photograph through a mobile phone gives impression of objects emerging from the paper.

- AR Puzzle - preparing spatial objects such as cubes with markers. Each side of a cube is connected to specially prepared artwork/animation/video. Placing cubes in various positions gives interesting overall results which can be checked on a computer's screen using webcam.

- AR Book - preparing a simple book in which pictures/typography/images are augmented by additional visual content. It builds new experiences during reading the book and allows adding many surprising elements. It is worth noting that Sony started to produce story telling games (Wonderbooks) based on book-like objects for Playstation 3 console last year where children can control characters and interact with game's world using the AR technology.

- AR Wall - preparing visualization presented on the wall with the projector; the visualization is activated by markers. Alternative versions of the project:

  - mapping objects using the projector where the user can change the appearance of the visualization by changing markers,

  - augmenting space by the recognition of existing objects and addition of previously designed animation/graphics/sounds to it.
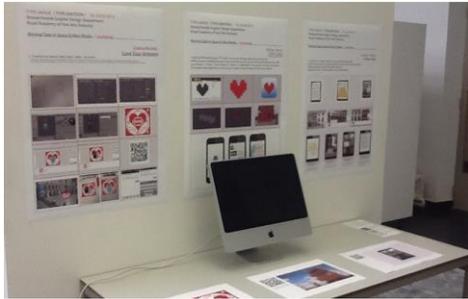
Figure 7. AR workshop at TYPE=IMAGE / TYPE-EMOTION 2013

AR Photo task turned out to be very good introductory exercise which gave students idea of how this technology works and resulted in new ideas about using it.

5.1.2. Regular art classes

AR technology is used as part of Interactive Multimedia classes in PJIIT (New Media Art) supervised by Marcin Wichrowski. Students carry out three projects which are similar to tasks from the workshops mentioned above, see Figure 8. The first one is based on Metaio Creator and it includes creating AR posters and leaflets, the second one requires using BuildAR Pro for designing AR books, and the third one involves the use of Adobe Flash Professional for implementing simple AR website. Usually AR Book task brings the most interesting results. Students demonstrate very high level of commitment and prepare visually attractive and eye catching works. For most of art students this usually is the first contact with the AR technology and they are surprised how easily they can convert ideas to working projects. Selected works are presented at the final exhibition on the PJIIT campus.

5.2. AR for Computer Science students

Computer Science students usually have much more experience with programming than New Media Art students. Therefore, their projects are more complex and bring custom interaction which offers richer AR experience.

5.2.1 Computer Science students' works implementing AR for the Web

Web based applications usually cannot offer very high graphic quality, but they do not require any additional software installation and are available world-wide through web browsers with Flash Player using a standard webcam. It is a great solution for education, entertainment and other areas where easy and fast access to AR is needed. The most widely used Flash-based marker tracking library is FLARToolKit [9] (based on NyARToolkit, Java ported version of ARToolKit). A lightweight framework called FLARManager [10] is recommended for robust and effective development of applications. This library is also compatible with other tracking libraries, supports many 3D frameworks (Alternativa3D, Away3D, Away3D Lite, Papervision3D, Sandy3D) and provides detection and management of multiple markers. Users can create their own markers for tracking but only of ARToolKit type (having the appearance of black and white shapes in a square frame).

Another popular solution for Flash is IN2AR [11]. It is an ActionScript3 and Adobe Native Extension library which allows building AR projects available for web browsers through Flash Player and as a mobile applications using Adobe AIR (Android/iOS). High level of recognition of image-based markers and integration with Unity3D promise creating unique games providing AR experience. Unfortunately, this solution does not offer preparing one's own images for tracking without buying license.

Below are shown examples of FLARToolKit usage in B.Sc. works made by Computer Science students supervised by Marcin Wichrowski in PJIIT. One of these projects, "Using FLAR technology in Adobe Flash for multimedia presentation of car manufacturer" [12], includes a specially designed complete website

Figure 8. Examples of PJIIT student's projects at Interactive Multimedia classes

presenting a car manufacturer. The AR technology added to this website allows viewing all cars available from this producer and even taking part in the race for 2 players directly on a printed marker, see Figure 9.

Another project, "Multimedia reconstruction of battle September 1939" [13], includes video production as the main part, and also incorporates an AR aspect in the additional printed album presenting models of weapon from that period. Animations of models can be started/paused by revealing/covering printed markers, see Figure 10.

5.2.2. Computer Science students' works implementing advanced AR experience

The best results in creating rich Augmented Reality experience can be achieved mainly by using dedicated SDKs which offer wide range of interaction possibilities and incorporate advanced techniques. Popular advanced solutions are Metaio SDK [14] and osgART [15].

First solution, Metaio SDK is advanced programming environment for delivering projects to Android/iOS mobile devices and creating stand-alone desktop applications. It offers image-based (2D) or object/environment (3D) tracking solutions and it comes with built in powerful 3-D rendering engine.

Second solution, osgART is a C++ development library which combines OpenSceneGraph (3D graphic library) with many computer vision based tracking libraries (e.g. ARToolKit). Thanks to OpenSceneGraph it is possible to achieve high quality rendering in real time; moreover, many 3D formats and community nodekits

are supported. Exemplary students' works supervised by prof. Krzysztof Marasek in PJIIT are shown below.

In the B.Sc. work „Augmented Reality – interactive story based on Julian Tuwim Glasses" [16] the osgART library is used to produce interactive experience which is presented on a paper cube. Markers attached to each side of the cube trigger 3D scenes and create an illusion that the story is taking place inside this paper object, see Figure 11. Turning the cube causes changing scenes and by doing this the user can control the camera angle and the point of view. This project gives very interesting AR experience which can be used in education and entertainment.

Another interesting work is a M.Sc. project "Immersive 3D game using natural interface and virtual reality glasses" [17], see Figure 12. It is a complex game system for the simulation of a disc fight based on the movie "Throne: Legacy". It uses Microsoft XBox Kinect, Vuzix VR920 IWear and Unreal Development Kit with NIUI API. The player sees the world of the game through the AR glasses and moves freely around the scene. Throwing a disc is implemented by swiping the hand. Kinect analyzes all moves of the user and the direction of the disc flight is calculated based on the orientation of the player's arm, elbow and hand at the moment of the throw. The current version of the project has great potential for using AR experience. Vuzix glasses gives opportunity to acquire video and put the player into real environment instead of virtual scenes.
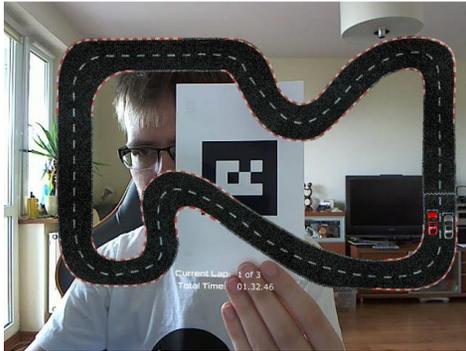
Figure 9. AR in PJIIT students' project "Using FLAR technology in Adobe Flash for multimedia presentation of car manufacturer"

Figure 10. AR experience in PJIIT students project "Multimedia reconstruction of battle September 1939" using Advanced SDK for AR

6. Observations and results

Art students require a lot of time and individual approach to each project. The most important thing is to get them acquainted with available solutions and convince that they are able to use this technology. Automatic AR scenes editors are very helpful in this case because students can quickly and easily create simple projects that do not require sophisticated interaction. It is especially valuable for beginners without programming skills and as prototyping tools for presenting AR ideas in more complex projects. Introductory lessons with this software using simple working projects encourage students to make own experiments and accelerate their imagination. Great part of art students work is dedicated to the preparation of visual assets (both digital and real) and proper fitting of all elements together. Typically, the final art works are very engaging for the audience, even though they are using simple AR solutions.

Computer Science students for obvious reasons are much more independent in using advanced AR solutions. It is important to accurately describe the principles of how the application should work and what are the key features. It provides a basis for selecting appropriate development environment and allows to determine project requirements and functionality. Building prototypes and early frequent testing give the ability to quickly find out software/hardware/ environment limits and constraints. In some cases support of graphic artist and user experience expert is needed and very valuable for building successful final product.

Summary

Nowadays creating AR projects is much easier and does not always require very specialized equipment or individually tailored applications. Wide range of new software and hardware solutions (editors, services, SDKs, high quality mobile devices) for AR, dedicated to users with different levels of skills, open great possibilities to applying this technology to students' works and teaching curriculum. Author's experience shows that both New Media Art and Computer Science students are interested in AR and this promises bright future for creating valuable projects merging art and IT world.

Furthermore, taking into account the perspective of launching Google Project Glass and similar devices, it seems to be a good idea to familiarize students with possibilities of the AR technology and introduce them to the process of creating their own working projects. It may become an essential skill needed in the future for designing/enhancing applications and activities related to the new world of digitally augmented reality.

References

[1] http://www.buildar.co.nz/

[2] http://www.metaio.com/products/creator/

[3] http://www.junaio.com/

[4] http://dev.metaio.com/toolbox/

[5] http://www.culturecongress.eu/event/czytelnia_modules

[6] http://www.nina.gov.pl/ninateka/wideoteka/detal/2012/10/25/Kultura_2_0_2011__Reportaz__Drugie_pietro

[7] http://selectorfestival.pl/en/Info/Multimedia-park

Figure 11. AR experience on cube in PJIIT students project „Augmented Reality – interactive story based on Julian Tuwim Glasses"

Figure 12. Gameplay from thePJIIT student's project "Immersive 3D game using natural interface and virtual reality glasses"

[8]   http://grafischevormgevers.be/projecten

[9]   http://www.libspark.org/wiki/saqoosha/FLARToolKit/en

[10] http://words.transmote.com/wp/flarmanager/

[11] http://in2ar.com/

[12] P. Burzyński, Ł. Wróbel, Zastosowanie technologii FLAR w aplikacji Flash dotyczącej niemieckiej marki samochodów [in Polish]. Warsaw, Poland: Polish-Japanese Institute of Information Technology, 2011 [B.Sc. thesis]

[13] Parol, T. Kołodziejak, Multimedialna rekonstrukcja bitwy z okresu kampanii wrześniowej 1939 roku [in Polish]. Warsaw, Poland: Polish-Japanese Institute of Information Technology, 2011 [B.Sc. thesis]

[14] http://www.metaio.com/products/sdk/

[15] http://osgart.org/

[16] M. Mikołajczyk, A. Szymański, Augmented Reality - rzeczywistość rozszerzona na podstawie wiersza Juliana Tuwima "Okulary" [in Polish]. Warsaw, Poland: Polish-Japanese Institute of Information Technology, 2010 [B.Sc. thesis]

[17] J. Laskowski, J. Garwacki, J. Szafrański, Immersyjna gra 3D z wykorzystaniem interfejsu naturalnego i okularów do rzeczywistości wirtualnej [in Polish]. Warsaw, Poland: Polish-Japanese Institute of Information Technology., 2012 [M.Sc. thesis]