

Creating learning activities using Augmented Reality tools

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Abstract—There is an increasing number of students using smartphones and tablets in schools. Mobile devices gained popularity as an educational tool and there are many schools that used them frequently in educational activities to improve learning. There are many augmented reality (AR) applications available that can be used to create educational contents for these mobile devices. This paper surveys the most popular augmented reality applications. Our goal is to select AR eco-systems, for educational purposes, that are user friendly, that do not require programming skills and are free, so that they can be used in daily teaching activities. We also present teaching activities created with these tools that use different augmented reality technologies for creating animations, 3D models and other information to be shown on top of interactive documents. The examples presented are used in educational activities in kindergarten and to improve the learning of music and orthographic views in elementary and secondary schools.

Keywords—Augmented reality, Electronic learning, Educational technology

I. INTRODUCTION

The increased availability of smartphones and tablets with Internet connectivity and increasing power computing makes possible the use of augmented reality (AR) applications in these mobile devices.

With the introduction of Apple iPhone in 2007 and the Android mobile platform in 2008, the use of smartphones became prevalent. By February 2012, about half (49.7%) of U.S. mobile subscribers used smartphones [1].

Furthermore, smartphones and tablets are becoming less expensive and many students already bring them to classes.

In the near future, eventually everyone has a smartphone or a tablet that is capable of displaying augmented information. This makes it possible for a teacher to develop educational activities that can take advantage of the augmented reality technologies for improving learning activities. According to Fernandes and Ferreira [2], the use of information technology made many changes in the way of teaching and learning. We believe that the use of augmented reality will change significantly the teaching activities by enabling the addition of supplementary information that is seen on a mobile device.

In this paper, we present several educational activities created using free augmented reality tools that do not require programming knowledge to be used by any teacher.

There are currently many augmented reality applications. We looked to the most popular augmented-reality eco-systems. Our purpose was to find AR systems that can be used in daily learning activities. For this reason, they must be user friendly, since they are going to be used by teachers that in general do not have programming knowledge. Additionally, we were interested in using augmented reality applications that are open source or free, without any type of water marks.

This paper describes educational activities using several types of augmented reality applications. We cover the marker and marker less based augmented reality technologies to show how we can create learning activities to visualize augmented information like animations and 3D objects that help students understand the educational content.

This paper is organized as follows. Section II surveys the most common augmented reality eco-systems. Section III describes an activity that can be used in a kindergarten that is based on marker less AR technology. In section IV we present activities supported on marker based augmented reality for teaching music. It is also presented in section V a marker based example for improving the learning of orthographic views by showing the 3D model in an augmented reality application. Finally conclusions are presented in Section VI.

II. AUGMENTED REALITY

Augmented Reality applications combine 3-D virtual objects with a 3-D real environment in real time. Virtual and real objects appear together in a real time system in a way that the user sees the real world and the virtual objects superimposed with the real objects. The user's perception of the real world is enhanced and the user interacts in a more natural way. The virtual objects can be used to display additional information about the real world that are not directly perceived.

Paul Milgram and Fumio Kishino [3] introduced the concept of a *Virtuality Continuum* (fig. 1) classifying the different ways that virtual and real objects can be realized. In this taxonomy scheme Augmented Reality is closer to the real world.

Ronald Azuma [4] defines augmented reality systems as those that have three characteristics: 1) combines real and virtual; 2) interactive in real time; 3) registered in 3-D.

In general, augmented reality applications fall in two categories: *geo*-base and *computer vision* based.

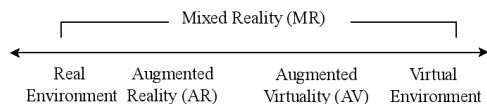


Fig. 1. The Virtuality continuum [3].

Geo-based applications use the mobile’s GPS, accelerometer, gyroscope, and other technology to determine the location, heading, and direction of the mobile device. The user can see 3D objects that are superimposed to the world in the direction he is looking at. However, this technology has some problems. The major problem is imprecise location which makes difficult for example the creation of photo overlays.

Computer vision based applications use image recognition capabilities to recognize images and overlay information on top of this image. These can be based on *markers*, such as QR (Quick Response), Microsoft tags or LLA (latitude/longitude/altitude), or *marker less* that recognize an image that triggers the overlay data.

There are currently many augmented reality applications and development systems for Android and iOS (iPhone Operating System) smartphones and tablets.

The most popular ones are: Wikitude¹, Layar², Metaio³, Aurasma⁴ and Augment⁵.

Wikitude delivers the Wikitude World Browser for free, which is an augmented reality web browser application, and the Wikitude SDK (software development kit) for developers which is free for educational projects. However, the educational version of the wikitude SDK always displays a splash screen and the wikitude logo.

The wikitude browser presents users with data about their points of interest, which can be the surroundings, nearby landmarks or target images, and overlays information on the real-time camera view of a mobile device.

Augmented reality learning activities can be realized with the wikitude SDK. The wikitude SDK can be used to display a simple radar that shows radar-points related to the location based objects. It is also possible to recognize target images and superimpose 2D or 3D information on top of them. The developer can also combine image recognition and geo-based augmented reality. However, the building of these capabilities using the wikitude SDK requires programming knowledge.

Layar has the Layar App, an augmented reality web browser, and the Layar Creator, which is a tool for creating interactive printing documents. With the Layar Creator it is very easy to make an interactive document for a teaching activity. There is no need to do any programming and, in this way, it does not require any developers with programming skills. The teacher can easily upload the trigger page to which he wants to associate augmented information. Marker less image recognition techniques are used and with the Layar Creator interface the teacher can easily associate a video, for

example. Later, with the Layar App, the student can view, on the camera of his mobile device, the overlaid information associated to the page. These applications are both free. However, every trigger image published within the Layar’s publishing environment is paid. For this reason, it is not affordable for developing interactive printing documents for teaching. Geo-location based augmented reality information is free of charge.

Metaio delivers the junaio, metaio Creator and a development SDK. Junaio is the metaio’s free augmented reality browser and is free. The metaio Creator is an augmented reality tool to create and publish augmented reality scenarios and experiences within minutes. With the metaio Creator the teacher can connect 3-D content, videos, audio, and webpages to any form of printed medium or 3D map (object-based or environment-based). However this tool is paid. If a user wants to develop augmented reality applications for iOS or Android, the developer can use the metaio SDK. However, this development SDK is also paid.

Aurasma delivers the Aurasma App and the Aurasma Studio.

The Aurasma App is available for Android and iOS and uses advanced image recognition techniques to augment the real-world with interactive content such as videos, 3D objects or animations associated to trigger images or geo-based information.

The Aurasma Studio is an online platform that lets the teacher create and publish their own augmented reality information in an intuitive and user friendly environment. It is not required any programming knowledge and very teacher can easily upload trigger images that can be associated to videos, images, 3D objects or other information.

The Aurasma eco-system delivers these application for free.

Augment is a free application for Android and iOS that uses augmented reality to visualize 3D models triggered by QR codes. After registering at the augment website, the teacher can easily upload a 3D model that is triggered by a QR code.

In this way, as our concern is to find augmented reality eco-systems that do not require programming, that are free and easy to use for learning activities. For this reason, in the following sections of this paper we use *Aurasma* and *Augment* systems which are free, do not require programming and teachers can prepare activities in an easy way.

III. CREATING LEARNING ACTIVITY USING MARKER LESS AR TECHNOLOGIES FOR KINDERGARTEN

In this section, we introduce the augmented reality technologies that we found more appropriate to create a learning activity that is based on an image that triggers an animation that can be used for example in a kindergarten.

In a kindergarten a childhood educator frequently reads a story to children and then make an activity about it. In this section, it is shown a form of a puzzle (fig. 2) that is shown to children after the childhood educator reads to them the story of the “Frog and Duck”. The children have to choose the appropriate character (fig. 3) to the question formulated by the

¹<http://www.wikitude.com/>
²<http://www.layar.com/>
³<http://www.metaio.com/>
⁴<http://www.aurasma.com/>
⁵<http://augmentedev.com/>

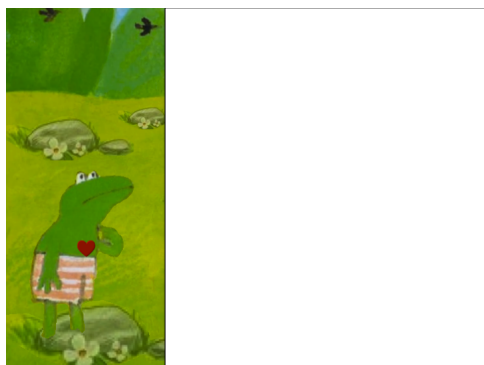


Fig. 2. Puzzle.



Fig. 3. Two of the possible characters that children have to choose.



Fig. 4. Trigger image that is used to start the animation.

childhood educator to place in the puzzle (fig. 2). Once they choose the right character, the trigger image (fig. 4) activates the associated animation that was generated with Microsoft Power Point.

The images presented in figures 2 to 4 were created from an original image from the story and edited using GIMP⁶ (GNU Image Manipulation Program). Although GIMP is an advanced application, it was easy to use and very useful for: i) extracting the characters with transparency from the original image and to ii) fulfill the background after removing the duck. For this purpose, we used the GIMP *Foreground Select Tool* and *Heal Selection* which are very easy to use and yet very powerful.

After making the trigger image and the animation, it is time to use an augmented reality eco-system so that when using a mobile device it can recognize the trigger image and activate the animation.

⁶<http://www.gimp.org/>

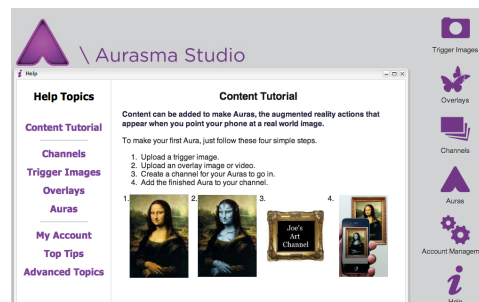


Fig. 5. Aurasma Studio.

For the recognition of marker less images we used the Aurasma eco-system which is free, does not require programming knowledge and is easy to use.

After registering to Aurasma we can access to the Aurasma Studio that begins with the step by step tutorial (fig. 5).

It is very simple in Aurasma Studio for a teacher to setup his augmented reality contents.

First, the teacher creates a *channel*. It is like a YouTube Channel or TV Channel, except that this is the teacher augmented reality channel and, there is no limit, the teacher can create multiple channels. In this case, we created an *education* channel that can be followed using the following link to subscribe <http://auras.ma/s/tBkQ0>. This is created once and the teacher can add multiple augmented reality contents into the same channel.

The second step is to upload the *trigger* image of figure 4. The trigger image is a still image that will trigger the augmented reality contents. It is a JPEG or PNG file that in the Aurasma Studio has less than 500,000 pixels. The one used in this example has 720 x 540 pixels which makes the total of 388,800 pixels. The teacher only has to give a name to the trigger image, select the file to upload and save it.

The third step is to upload the *overlay* content that will replace the trigger image. Overlays can include videos, images, 3D scenes or web pages. This step is also straightforward. The teacher only has to give a name to the overlay content, select the file to upload and save it. It is recommended the use of MP4 video format files up to 100MB.

The final step is the *aura* creation. Auras are augmented reality actions - images, videos or 3D animations that appear when the mobile device is pointed to a real world image or object. The auras associate the trigger image to the overlay animation and stores it to the channel created before. This information is stored in Aurasma Central. Whenever the Aurasma application is running on a mobile device it connects to Aurasma Central to download auras that the user is subscribing in a channel.

The process is simple as it was described. Compared to other augmented reality authoring tools available, this one is definitely the simplest one and is free.

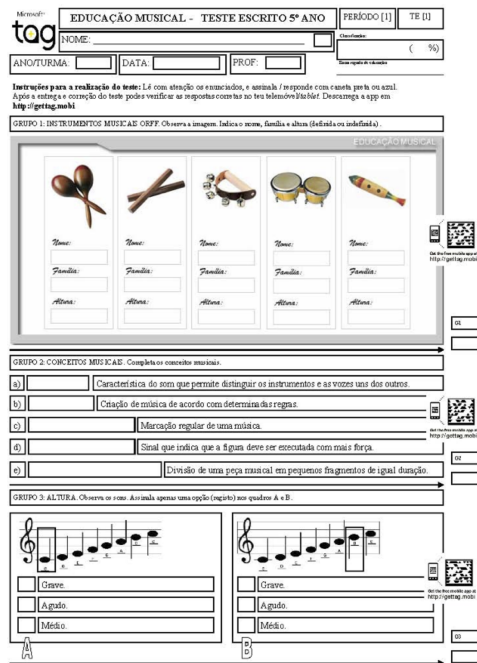


Fig. 6. Music test with Microsoft tags codes.

IV. CREATING LEARNING ACTIVITIES USING MARKER BASED AR TECHNOLOGIES TO TEACH MUSIC

In this section, we use marker based augmented reality technologies to create teaching activities for improving music learning for students for the 5th grade.

Using marker based codes for presenting additional information in a mobile device is very simple to use and straightforward. The teacher can use simple QR (Quick Response) two dimensional codes for associating information such as text, URL or any other data. Quick response codes are much more popular than the other code formats and there are several sites where the teacher can easily create such codes.

We decided to use the Microsoft tags because for the example presented in figure 6 we want to use smaller codes that become less intrusive. Reading smaller Microsoft tags are more reliable than the equivalent QR codes.

Microsoft tags are also very easy to create, requiring only the registration at the site <http://tag.microsoft.com>.

The example of figure 6 uses the Microsoft tags to show the answers to the different questions. We created other augmented reality documents with music sheets and we noted that the students were more interactive in the classroom, improving the learning process [5].

V. AUGMENTED 3D MODELS TO IMPROVE ORTHOGRAPHIC VIEWS LEARNING

This section presents an example of using augmented reality to create an overlay with a 3D model that is used by the teacher to help students improve learning of orthographic views. Wu and Chiang [6] shows that applying 3D animations provided more enthusiasm for the learning activity, better

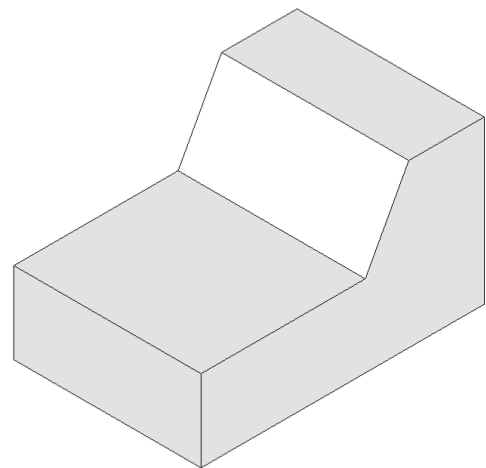


Fig. 7. The isometric drawing of the model created with SketchUp.

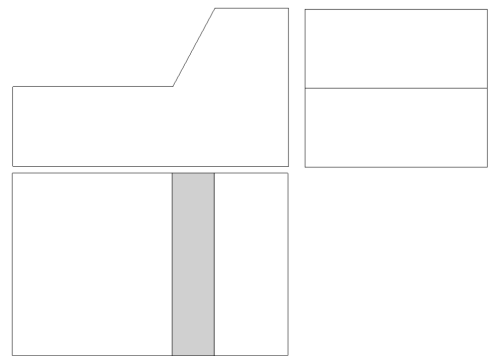


Fig. 8. The front, left and top views of a 3D model.

performance in understanding the appearances and features of objects and improve the spatial visualization capabilities.

For this purpose, the first thing the teacher needs is a 3D modeling tool.

We used SketchUp⁷ because it is simple to use, draws the orthographical views and is free. In this way, it was easy to create the 3D model that is represented in an isometric view in figure 7 and the corresponding front, left and top orthographic views in figure 8. If the teacher wants it is also possible to add textures to the model to make it look like a real object made of wood for example. This is very easy to do in SkecthUp, by importing a photo texture and add it to the model.

To help students visualize and understand this 3D model, we used Augment to render the 3D model in a mobile device triggered by a QR code. To upload a 3D model on Augment, from SketchUp we can export to a Collada file (DAE). This creates a .dae file and a directory containing the textures. Next, these files are compressed together into a zip file that is uploaded on Augment and then you are ready to share your model. This example can be tried after installing the Augment application in a mobile device and print the QR code available from <http://agmt.it/28855>. Figure 9 presents the visualization of the 3D model that the student can use to draw the isometric projection or the orthographic views.

⁷<http://www.sketchup.com/>

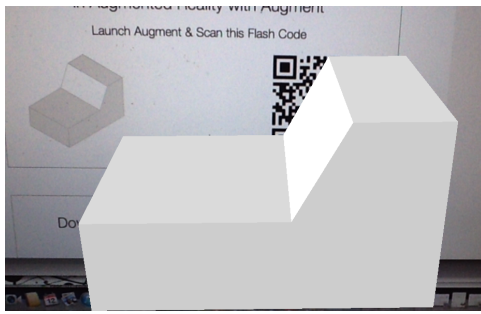


Fig. 9. Visualization of the 3D model with the Augment application.

VI. CONCLUSIONS

The increasing processing power of mobile devices, the increasing number of augmented reality applications and the increasing number of mobile devices, makes possible the use of augmented reality in the classroom.

In this paper we surveyed the most popular augmented reality applications available for mobile devices.

We were looking augmented reality applications that for educational purpose were user friendly and free, such that, every teacher can use them in everyday learning activities.

We created educational activities based on marker less images for kindergarten. For this purpose, we found out that the most appropriate tool is the Aurasma application. It is very easy to upload a trigger image and associate to it a video or an animation.

It was also presented an activity for music teaching using marker based codes. We used smaller Microsoft tags that are better recognized than the Quick Response codes.

Finally, we prefer to use the Augment application to show 3D models on top of a QR code. The example presented helps students to visualize the 3D model and draw the orthographic or the isometric views.

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