Applications of Augmented Reality

5th lab of Smart City Laboratory

Smart City secondary specialization, Electrical Engineering MSc,

BME Department of Telecommunications and Media Informatics

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February 18, 2020

1. History and applications of augmented reality

1.1. Definitions and history of augmented reality

The idea of Augmented Reality (AR) dates back to the 1930's, when the first computing devices were built. In practice, the history of AR started in the 1960's and 1970's, when the large companies began to use augmented reality for visualization. The first head-mounted display was built in 1966, which can be considered as the ancestor of today's smart glasses [1]. The 'Augmented Reality' phrase was first used in 1992 by **Tom Caudell**, who built educational applications for the employees of the Boeing company. However, the technology applied at Boeing was not cost effective enough to reach the everyday users for a long time.

Augmented reality, in simple words, is the stacking of digital information and real environment (or a video from the real environment) onto each other. We can find this technology for example in sport broadcasts, when some additional information is drawn onto the football field in television broadcasts (see Fig. 1).

Figure 1: Sport broadcast and augmented reality [2].

One of the definitions of augmented reality was created by **Ronald Azuma** in 1997. According to this, the augmented reality has layers which consist of the real world and virtual reality, and the layering is done with the help of digital devices. For example, an AR user can wear a transparent glass containing a screen – this way the user can see both the real world (one layer) and the pictures coming from the computer (another

layer) [3]. According to this, the main point of augmented reality is that it contains elements both from the real and virtual worlds; and real-time interaction can be done between these elements. The virtual objects can be constant or time-varying. As an example, the added content from the virtual world can help to understand the structure of real world objects. Users can interact with the virtual objects within augmented reality using sensors and screens of the real world.
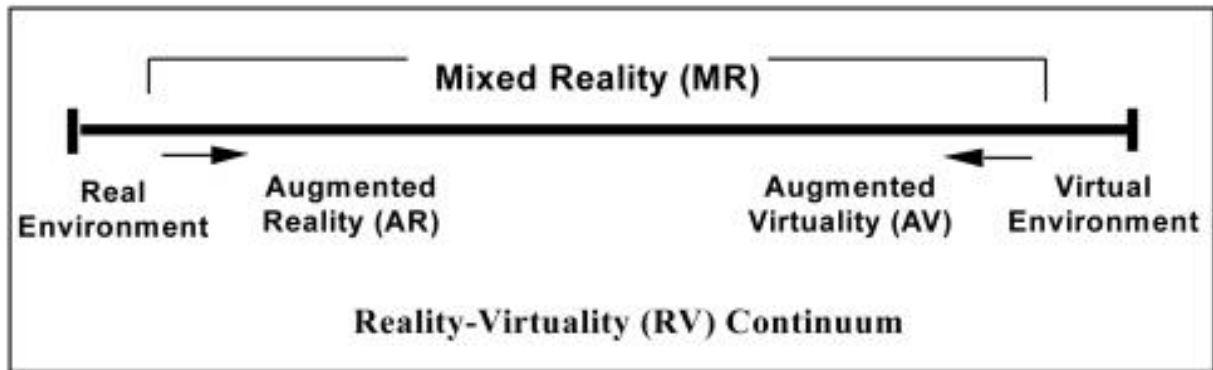

Figure 2: Milgram's Reality-Virtuality Continuum [4].

Another definition of augmented reality was proposed by **Paul Milgram** and **Fumio Kishino**, which is called Milgram's Reality-Virtuality Continuum [4]. The left side of Figure 1 shows the real environment, while the right side shows the virtual environment. The fully real environment is simply the real world. The fully virtual environment is a computer-driven environment, which can simulate a real or imagined world – for example, Second Life, which was started in 2003 [5]. Between these two extremes the Mixed Reality can be found, which contains the middle part of the continuum, including Augmented Reality and Augmented Virtuality.

Nowadays most virtual and augmented reality applications are functioning without glasses. The AR applications are now highly portable, and can be accessed by everyone for example using the camera of a smartphone. It also helps the spread of AR that the users are surrounded by smart devices (smartphone, tablet, game console, smartwatch, smartglass, etc.), which are fully integrated to the everyday life. These devices usually have broadband internet access; have numerous sensors (e.g. camera, GPS, accelerometer, gyroscope); and contain high-resolution displays, thus are suitable for creating experiences and adventures of virtual and augmented reality. Today augmented reality is mainly used for marketing and amusement, but it is more and more popular for education purposes. Besides, today it is not unimaginable that the user, while pointing the smartphone camera to a friend, runs a face recognition application, and visualizes real-time the newest posts of his friend from the Facebook, Google+, Twitter, etc. profiles. This way, the users can start interaction with other people both in the real world and in the digital environment [6].

Augmented reality is highly device dependent, by which we mean that with naked eye, the user cannot see or perceive the virtual contents of the augmented space – for this, digital devices are a requirement. An important aspect is that these digital displays

are already integrated in the everyday life, and it is not necessary to learn new knowledge for using them.

The future of AR depends on the spread of augmented reality contents (i.e. whether content richness or content poorness can be expected). The technology is already accessible by anyone, but with the spread of smart glasses, further increase is expected in the everyday application of AR tools [6].

1.2. Augmented reality - functions

The binding of the virtual contents to the real world can be done with two types of solutions.

Absolute position

The main point of absolute position based AR (also known as 'geotagging') is that for a given location the virtual contents (e.g. videos, text information, audio, or other user-generated content) can be assigned based on the GPS coordinates (being the absolute position). This content can be accessed by other users only at the same location. For example, today's smartphones and modern cameras save as metadata the location and date of the picture, like a Geotag. If we navigate in Google Earth, in the virtual world we can see the real-world pictures taken by other users at the location of the Geotags. Besides, there are absolute position based smartphone applications which put the virtual contents onto the real world – here the recognition of the actual position can be based on Geotag [1].

Relative position

For showing the augmented reality contents, often markers are used. Such a marker is a special identification code which can be recognized by sensors, and based on this the human-machine interaction can be started on a suitable display. This way, AR can work without borders and it is not bound to a given location [6]. Thus, markers assign the virtual contents to relative positions.

There are two main types of markers (see Figure 3). One type of markers is the QR code, which is a 2-dimensional barcode. This cannot be interpreted for the human, but it is easy to recognize for the machine. The other type of marker can be a simple picture or a symbol – this way the user can recognize the content by the human eye, but for the recognition with the machine, the processing of the picture is necessary.

Figure 3: Marker types: QR code and simple picture with a frame.

1.3. Augmented reality applications

Layar

One of the first augmented reality applications for smartphones was the Layar, having the first version in 2009 in the Netherlands. Within Layar, the augmented reality content can be found in various layers, and the user can choose what to display. For example, if the user points the camera to a building, there can be a layer about the history of the building, another from the restaurants in the nearby, and a third layer about the menu card of the restaurant in the current building. One of the most common applications of Layar is the 'time travel': within the layers of virtual contents, one can see how the Berlin wall looked like or how San Francisco was before the 1906 earthquake [7].

Figure 4: Example for Layar [7].

Wikitude

Wikitude World Browser is also an augmented reality based smartphone application [8]. With the browser users can get information about their neighborhood, nearby terrain features, interesting places – and these all are displayed on the smartphone screen. The Wikitude app uses a markerless, geotagging based technology.

Figure 5: Example for Wikitude [8].

Google Goggles

Google Goggles is another smartphone app, which can recognize locations, logos, pictures, persons with the help of the search engine database. This way it replaces text based search, instead of which image processing algorithms are running in the background. For example the Goggles app can be used in the Metropolitan Museum of Art in New York while watching the paintings [9].

Games – Pokémon Go

Among the several augmented reality games, Pokémon Go is a clear success as it reached a huge number of users [10]. It was one of the most used and profitable mobile apps in 2016, having been downloaded more than 500 million times worldwide. In the game, players use a smartphone's GPS to locate, capture, battle, and train virtual creatures, who appear on the screen as if they were in the same real-world location as the player [11].

Museums

The effect of the augmented reality technology is that the galleries, museums, exhibitions are changing. For example in the British Museum the first augmented reality based exhibition opened in 2011: marker based AR was used to enable getting more information about the objects of the museum [12]. Besides, the ancient objects can be virtually reconstructed, and certain objects come to life in the museum, e.g. by pointing to a skeleton or a sculpture.

Figure 6: Augmented reality int he British Museum [12].

In the MTVA museum an augmented reality based exhibition opened in 2015 in Budapest [13]. The exhibition is using relative position based AR. Within this, the user (actually the smartphone or tablet) can sense the proximity of the museum objects using iBeacon technology, and the interaction is started automatically when the user is close enough to the beacon.

<u>Others</u>

Besides the above samples, one can find augmented reality based applications in numerous fields: AR books and magazines, modeling tools, logistics, games, furniture stores, education, sports, military devices, etc. Within the laboratory measurement, we will not deal with these topics.

1.4. Augmented Reality As Fast As Possible

Figure 7: Video about augmented reality [14].
https://www.youtube.com/watch?v=otIgj8F7XmI

1.5. References

[1] Hamilton K. E., Augmented Reality in Education, https://augmented-reality-in-education.wikispaces.com/home

[2] Ball Tracking and Augmented Reality, http://thinkactreflectrepeat.blogspot.hu/2014/05/ball-tracking-and-augmented-reality.html

[3] Azuma, R., A Survey of Augmented Reality, *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, 1997, pp. 355–385.

[4] Milgram P., Takemura H., Utsumi A., Kishino F., Augmented Reality: A class of displays on the reality-virtuality continuum, ATR Communication Systems Research Laboratories, Kyoto, 1994.

[5] Second Life: The largest-ever 3D virtual world created entirely by its users, http://secondlife.com/

[6] Szűts Zoltán, Yoo Jinil, A kiterjesztett valóság térhódítása [The spread of augmented reality, in Hungarian], Információs társadalom [Information Society], vol. 13., no. 2., 2013, pp. 58-67.

[7] Layar history, https://www.layar.com/news/blog/tags/history

[8] Wikitude App, http://www.wikitude.com/app/

[9] Google Goggles in MET, http://www.metmuseum.org/about-the-museum/now-at-the-met/from-the-director/2011/google-goggles

[10] Pokémon Go, http://www.pokemongo.com

[11] Pokémon Go, https://en.wikipedia.org/wiki/Pokémon_Go

[12] British Museum - Augmented Reality: Beyond the Hype, http://www.museum-id.com/idea-detail.asp?id=336

[13] MTVA Rádió- és Televíziótörténeti Kiállítóhely [MTVA Radio and Television History Exhibition, in Hungarian], http://www.mtva.hu/hu/radio-es-televiziotoerteneti-kiallitohely

[14] Techquickie, Augmented Reality As Fast As Possible, https://www.youtube.com/watch?v=otIgj8F7XmI

[15] LARA – Augmented Reality, http://www.laraapp.com/en

Last check of links: February 1, 2017.

2. Control questions

1) What definitions do you know for the 'augmented reality'?

2) Who / which company used first the 'augmented reality' phrase?

3) What is the definition of augmented reality according to Ronald Azuma?

4) What is Mixed Reality?

5) What is the difference between Augmented Reality (AR) and Virtual Reality (VR)?

6) Which applications do you know that are using augmented reality?

7) What is the Layar application suitable for?

8) What is the Pokémon Go application?

9) What is the LARA application suitable for?

10) Which devices are necessary for showing augmented reality contents?

11) What is the difference between markerless and marker based augmented reality?

12) What kind of markers can be used in augmented reality applications?

13) How would you test an augmented reality application with potential users in a museum environment?

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3. Laboratory measurement instructions

3.1. Introduction

The MTVA Radio and Television History Exhibition reopened in 2015 at the Pollack Mihály square in Budapest [1]. The visitors of the museum can watch the augmented reality contents during the visit of the exhibition with an Android tablet. Near the exhibited objects there is a QR code or an iBeacon, based on which the application on the tablet can recognize the location or the actual object. After the recognition, related contents (audio and recordings) can be seen. Besides, the visitors can look into the interior of an old radio, using augmented reality. At the end of the exhibition, visitors can take pictures about themselves together with a virtual TV teddy bear and with Süsü the dragon. During the laboratory measurement, your task will be to create an augmented reality application that could be used in a similar museum environment.

For the lab measurement, the 'AR Media Player' application [2] will be used for showing the augmented reality contents. The preparation / design of the AR contents will be done using Trimble SketchUp [3]. While you are doing the tasks of the lab, please write of a full measurement report that includes screenshots (and source codes, if any) about the solutions every subtask.

3.2. Lab report

You should write a detailed lab report (with screenshots, description and source codes) about the tasks you have made. You will find a sample for this on the website.

At the end of the lab, you should upload this report as a <NEPTUN1>-<NEPTUN2>-OV05.ZIP file through this website:

http://smartlab.tmit.bme.hu/education-OV-upload_login

3.3. Main tasks

1) Playing an armedia file

Open the ARplayer application and choose an .armedia file from the demo folder. From the printed papers, select the AR-media marker and point the webcamera to this.

Move the object / building around, check the animation (if there is any). You can test the other .armedia files as well.

Help: the menu of ARplayer can be displayed with the 'H' button; you can get out from full screen mode with 'F'. With the left/right/up/down keyboard buttons you can mirror the screen.

2) <u>**Text and simple objects on a predefined marker**</u>

Open the SketchUp application. If not visible, the ARPlugin can be found in View / Toolbars.

Try to create simple objects (e.g. cube, circular column, text title) with the SketchUp toolbar. If the full scene is ready, you can run and test it in ARPlayer using the first button (View) of ARPlugin.

3) <u>**Complex objects from 3D Warehouse**</u>

Open the 3D Warehouse (https://3dwarehouse.sketchup.com) in a browser (login might be required, e.g. use Google authentication). Search for a BME building, download it in SketchUp 2014/2015 format, and add it to the actual scene. Test it in ARPlayer.

4) <u>**Embedded video**</u>

Add a video to the actual scene (Create a custom object that will display the chosen video file…) within the Objects toolbox of ARPlugin. Add a .mov file to the scene from the 'video' directory. Test it in ARPlayer.

5) <u>**Embedded audio**</u>

Add an audio to the actual scene (Create a custom object that will display the chosen audio file…) within the Objects toolbox of ARPlugin. Add a .wav file to the scene from the 'audio' directory. Test it in ARPlayer.

6) <u>**Using several markers**</u>

In the previous tasks, all objects appeared at the same time in ARPlayer when the marker was recognized. In the next, you will create a multi-marker scene. This means that only part of the objects (e.g. a building with a related video) will be displayed for a given marker.

First, open the 'Setup' part of ARPlugin.
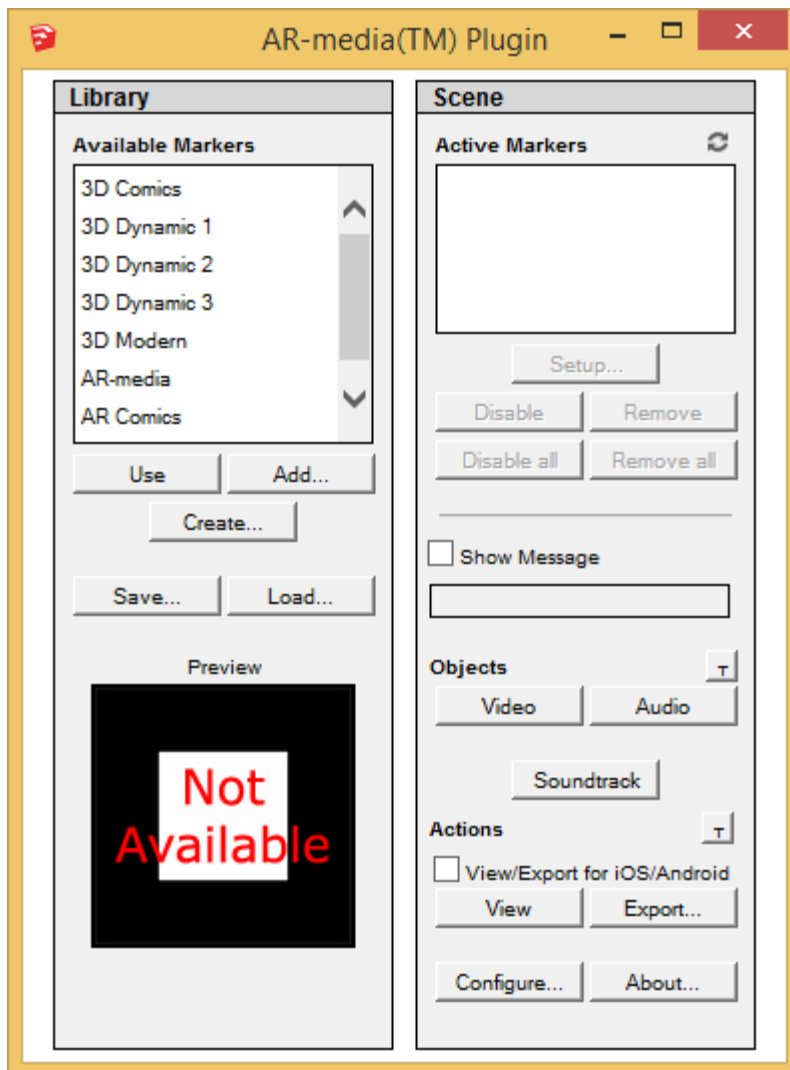
From the 'Available markers' you can choose which marker to use within the current scene. Add at least two markers to the current scene with the 'Use' button. From the 'Active Markers' window you can choose the added markers, and with the 'Setup' button, you can set which objects are assigned to the given marker. Try to assign the previous complex object and the audio to the 1st marker and the simple object and video to the 2nd marker.

Test it in ARPlayer: move the camera to the markers and check which objects appear.

7) Adding locations

Check the coordinates of a location that you like through http://www.gps-coordinates.net or other website – your objects will appear here. Within SketchUp, you will find it here: Window / Model Info / Geo-location / Set Manual location….

After this, export the scene to .KMZ format. Open Google Earth on the computer and test your objects and scene on the world map. (help1: do not use special characters

in the filename or path; help2: you can press the 'Preview model in Google Earth' button).

Alternative solution: Select the 'Add location' button from SketchUp menu, and choose a location on the map.

8) **Interactive multimedia**

Design and develop an interactive video player embedded in a television device, in which a button in the scene can start / stop video playback. For this, the connection between the TV and the video can be mapped using XML based interaction description of ARmedia toolbox. Always test the subtasks in ARPlayer!

a) Download a television device from 3D Warehouse (similar to task 3).

b) Add an embedded video (similar to task 4) and rename it to 'Video_A'.

c) Rotate the video and move it to fit to the TV screen (Move, Scale, Rotate).

d) Add a higher cylinder which will be the 'off' state of the button. Rename it to 'Button_UP'. (help: it might help to create a component from the cylinder object, using right mouse click and 'Make Component').

e) Add a lower cylinder which will be the 'on' state of the button. Rename it to 'Button_DOWN'.

f) Rotate the button and put them onto each other and on the TV.

g) Add an own marker and assign to it the TV, video and the two buttons.
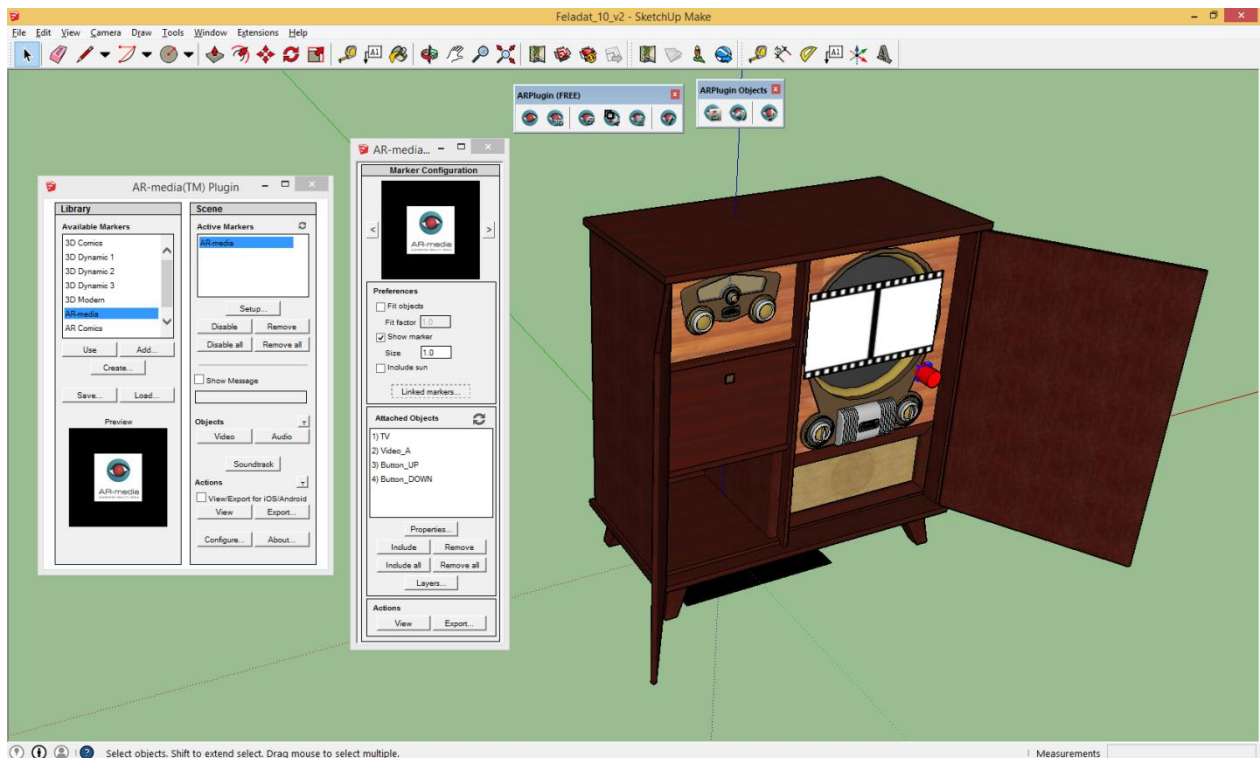
h) In the 'Attached Objects' part of the 'Marker Configuration' window select the 'Video_A' object and click on the 'Properties…' button. Within the 'Interactions' part, add a custom XML file, which will be similar to this (help: modify it to your actual task!) :

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<events name="video_events">
    <event name="on_init">
        <actions>
            <!-- choose to hide the video on startup -->
            <action source="_self_" target="_self_">
                <command>hide</command>
            </action>
            <!-- take the chance to set the loop mode -->
            <action source="_self_" target="_self_">
                <command>loop</command>
                <parameters>
                    <parameter name="loop">true</parameter>
                </parameters>
            </action>
        </actions>
    </event>
</events>
```

You can test the actual interactions in the 'Action' part of the 'Marker Configuration' window with the 'View' button.

i) In the 'Attached Objects' part of the 'Marker Configuration' window select the 'Button_UP' object and click on the 'Properties…' button. Within the 'Interactions' part, add a custom XML file, which will be similar to this (help: modify the TODO lines to your actual task!)

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<events name="button_up_events">
    <!-- possible events:
    on_left_mouse_click,        on_right_mouse_click,
    on_left_mouse_double_click, on_right_mouse_double_click,
    on_mouse_in, on_mouse_out,  on_hide,    on_show,
    on_init, on_marker_detected, on_marker_lost -->
    <!-- possible commands:
    hide, show, play, pause, toggle_pause, rewind, loop -->

    <!-- events for left mouse click -->
    <event name="on_left_mouse_click">
        <actions>
            <!-- hide this button -->
            <action source="_self_" target="_self_">
                <command>hide</command>
            </action>
            <!-- show the DOWN button -->
            <action source="_self_" target="Button_DOWN">
                <command>show</command>
            </action>
            <!-- show the video -->
            <!-- TODO -->
            <!-- play the video -->
            <!-- TODO -->
        </actions>
    </event>
    <!-- events for right mouse click -->
    <event name="on_left_mouse_click">
        <!-- TODO -->
    </event>
</events>
```

j) In the 'Attached Objects' part of the 'Marker Configuration' window select the 'Button_DOWN' object and create the interaction in XML (help: if the user presses the DOWN button, the DOWN button should be hidden, the UP button should be visible, the video should be stopped and hidden). The final result can be like this:

3.4. Further suggested tasks

9) QR code and marker in one piece

In this task you will create a QR code based marker. The QR code will contain a link that will start the downloading and starting of an .armedia object.

a) Create a link, from which the .armedia file can be downloaded. For this, you can use your own homepage, or this upload site:
http://smartlab.tmit.bme.hu/education-OV-upload-armedia_login

b) Using the link, create a QR code at http://goqr.me

c) Save the QR code as a 300x300 pixel image and create an own marker (similar to task 7).

d) Create some model in SketchUp and assign it to the new maker.

e) With the 'Export' feature of the ARplugin, export the scene to an .armedia file.

f) Upload the .armedia file to the previous upload site (10. a)

g) Open a QR code recognition app and test the QR code based marker.

The final result can be like this:
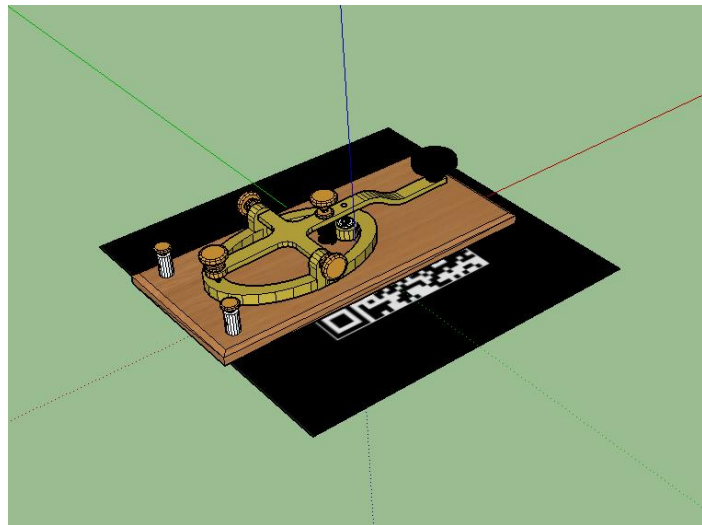
10) Augmented reality on a smartphone

In the ARplugin / Setup you can export special .armedia files for iOS / Android, if you select the 'View/Export for iOS/Android' option. You will need to install the ARPlayer application to your smartphone from the app store. After this you can test the augmented reality content on your smartphone.

3.5. References

[1] „Újra megnyílt a Rádió- és Televíziótörténeti Múzeum", [The Radio and Television History Museum has reopened, in Hungarian] http://www.hirado.hu/2015/01/15/ujra-megnyilt-a-radio-es-televiziotorteneti-muzeum/

[2] AR Media Player,
http://www.inglobetechnologies.com/en/new_products/arplayer/info.php

[3] Trimble SketchUp, https://www.sketchup.com/download

Lab report – sample

Smart city laboratory

OV_05: „Applications of augmented reality"

Measurement done by:

Group: xy.

Name: Student 1
Neptun code: STD123
Email: student1@bme.hu

Name: Student 2
Neptun code: STD456
Email: student2@bme.hu

Lab date: 2020. month day
 location: I.B.211.

Instructor: Tamás Gábor Csapó, csapot@tmit.bme.hu

Description: http://www.tmit.bme.hu/vitmmb04?language=en

Equipment used during the measurement:

- Logitech XYZ webcamera
- paper based markers

Software used during the measurement:

- Trimble SketchUp v.XY
- ARPlayer v.XY
- Logitech Webcam Software v.XY

Tasks and documentation

1) <u>Playing an armedia file</u>

Solution of the task (screenshot and short description):

2) <u>Text and simple objects on a predefined marker</u>

Solution of the task (screenshot and short description):

3) <u>Complex objects from 3D Warehouse</u>

Solution of the task (screenshot and short description):

4) <u>Embedded video</u>

Solution of the task (screenshot and short description):

5) <u>Embedded audio</u>

Solution of the task (screenshot and short description):

6) <u>Using several markers</u>

Solution of the task (screenshot and short description):

7) <u>Adding locations</u>

Solution of the task (screenshot and short description):

8) <u>Interactive multimedia</u>

Solution of the task (screenshot and short description):

9) <u>QR code and marker in one piece</u>

Solution of the task (screenshot and short description):

10) <u>Augmented reality on a smartphone</u>

Solution of the task (screenshot and short description):

Comments, subjective opinion related to the lab measurement:

- please write your comments here