Augmented Reality-based historical guide for classes and tourists

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Abstract. In this paper, development of historical guide based on Augmented Reality (AR) technology is considered. The developed guide application it targeted to be used in different scenarios, in particular, during history learning classes, for guidance of the tourists to exhibits both indoor and outdoor. Common features of all these scenarios are generalized and according to them main information and objects model for forming scene are identified. This part is followed by detailed description of objects and scene representation, markers usage, employment of additional services, etc. Finally, the developed historical guide application has been introduced. It harnesses A-Frame library for processing of models and their representation. The application is able to work with different markers so that it can be extended easily. In addition, one of the main benefits of the developed application is support of multiple platforms because it works from web-browser and does not require installation of additional software. The developed application can be effectively used for all provided scenarios and has potential for further extension.

Keywords: augmented reality, historical guide, class, model, application, information.

1 Introduction

Augmented Reality (AR) technology has managed to become mainstream technology in a short period. Many of new devices on the market are powerful enough to support the technology. There are also huge demands and expectations from this technology at the customers' side. One of the most promising fields of use for AR is educational technology. Possibilities to enrich learning experience with AR seem to be almost unlimited. It relates to all age categories and all fields of knowledge. The major attractive point of AR is high level of interactivity that allows communicating with AR-objects.

The great advantage of AR is a huge visual experience for users. It is especially effective for the subjects with massive amount of visual data for presentation. From the student's point of view, visual data is much more involving and comprehensible than other types of information. Moreover, AR allows student to participate actively in the educational process.

One of the good candidates for application of AR is historical content and all historical-related activities. It can be learning history at university, automated guide over historical places, interactive application for museums, etc.

2 Overview of scientific sources and AR-tools

It can be alleged that AR has a huge potential in educational sphere [20]. Modern researches emphasize development of complex learning environment based on AR [10]. However, another approach supposes that each learning subject has its own peculiarities and they should be treated in context of the subject. This is the reason why specialized tools appear for learning chemistry [12; 13], physics [8] etc. In fact, they are easier from the design point of view because they do not require to cover multiple learning scenarios and can limit student to usage of only a few tools within educational framework [6; 9; 11; 14; 15; 16; 17; 19; 22]. It has advantage for both students and lectures as clearly identifies activities that include AR. Hence, in the proposed work we design AR-application for historical education with precise cases for its usage.

Many new libraries for AR-development has appeared in the recent time. Let us analyze most popular among them.

ARKit [2] is an AR-platform designed specifically for Apple devices. It procures great user experience for AR-applications. ARKit support various objects for tracking (posters, images, etc.) which means that requirements for the marker view is much softer. However, the obvious drawback is that ARKit available only on vendor's devices and cannot be used on other platforms.

At the other side, ARCore [5] and Vuforia [23] software development kits (SDKs) are much more flexible and support deployment on most popular mobile platforms. They are a great choice for developers who are going to implement application for multiple platforms. In terms of services, Vuforia is advanced SDK as it has integration with cloud. However, Vuforia inserts watermarks in the content if you use it for free and has limitation on performed requests, while ARCore is an open-source and provides free license.

All previously mentioned libraries have one feature in common. Their work is based on some native application programming interface (API). Therefore, application for one platform cannot be installed directly on the other one. More universal approach leverages capabilities of web-browsers installed in all platforms. Code executed in the browser is instantly available to any device. Developer needs to guarantee correct deployment on the server and qualitative implementation of client-side functions.

A-Frame [1] is an open-source library for Virtual Reality (VR) and AR (by including side-project library). This is a JavaScript library and it works out of the browser. Thus, A-Frame is not bound to the specific platform and can be launched on almost any device that has necessary computational ability. Because A-Frame is open-source and requires no fee payment from developers, it is a perfect choice for educational projects that leverage AR in their functionality.

So, originally, A-Frame is supposed to work with VR-facilities. To map functionality of the library to AR, it is necessary to include one additional library available from [4]. It enables markers, processing image from camera, and other basic features of AR.

One more library works behind the curtain of A-Frame. three.js [21] library serves as a basic software for A-Frame. three.js is fully-featured library in terms of VR-operations. However, it heavily relies on scripting and requires that all functions have to be declared and implemented in code. That detail can make code developed with three.js cumbersome and demands more time to implement all tasks from specification. In comparison with three.js, A-Frame provides many new components (in form of html-tags) that greatly simplify development process and allow organizing all elements on the scene in a structural way. Therefore, A-Frame can be considered as a wrapper around basic library but it greatly extends initial version in various terms. It clearly decouples declaration of element from implementation of its actions. Additionally, it binds default functionality set to the object even when developer wrote no script code for actions.

In this work, we develop AR-application that can be used as a tool in learning history and as a tourist guide. We identify differences for these cases in context of application usage and AR-involvement. A-Frame library has been chosen as a base platform for application implementation due to its free license, automatic support of multiple platforms, and rich set of components and functions that speed up and simplify development process.

3 Results and discussion

It can be assumed that application under development has three categories of users:

1. Students of historical classes.
2. Tourists who visit indoor exhibitions (e.g. in museums).
3. Tourists who visit outdoor locations and exhibits possibly located on a notable distance from each other.

All these groups should be treated differently by application in terms of content presentation, location tracking, and selection of models to form the scene, etc. Students are going to work in group while tourist will use application individually in most cases. Estimated time that student spends with application is bigger than tourist does. Consequently, we suggest that for classes' purposes scene should contain more activities and provide more factual information.

In general, models of objects should be close to the outer view of the original objects. However, approaches for content presentation are quite different. For the historical classes, historical facts must be emphasized and established for learning. Two remaining options may contain some entertaining content to seize attention of the user to the current item or maybe to the other items from the list. But it does not prohibit entertaining entities (e.g. animated character) to be present in the educational content as long as they support it and enrich user experience.

For the first group, they always stay within the same classroom. In the second case, application users move from one room to another. Thus, indoor navigation will be sufficient for this task. The last group of users can be tracked via the means of Global Positioning System (GPS).

AR-based historical guide performs the following functions:

1. Provides visual representation of historical object, dynamic scenes, etc.
2. Reaction to user input actions and provides dynamic behavior of the object.
3. Facilitates additional information about the presented entity to the user.
4. Switching between different objects in catalogue.
5. Location of the object in the museum, park, etc. on a map or by other means (optional).
6. Animation of the object in context of one or several scenes (optional).
7. Guides user to the object in interactive manner (optional).

The function list implies permanent presence or temporarily appearance of the following object types in the scene:

- historical object itself;
- textual description of the object;
- graphical information about object location.

As A-Frame library requires markers for its work, it is necessary to provide markers and bring them into the scene. Historical guide is able to display different objects; therefore, two options can be used. The first one is to provide multiple markers and switch among them manually. Booklet with set of markers seems a feasible solution for this case because it is compact but still provides information to the application. The second option is to implement switching directly in the application. It implies presence of additional object in the application, menu. The user can select object he or she is interested in and processing engine will treat marker as a starting point for different object.

For the development of complex scenes, presence of multiple markers is required. They must be captured and tracked simultaneously to provide better user experience. Hence, placement of the markers on the surface and scenario for user actions should be worked through carefully. Multiple objects on the scene make it more dynamic. However, in context of learning history, those objects have to relate to each other, have some comparable feature to analyze, so the overall scene will have sense and represent part of historical knowledge.

Textual information that accompanies the object on the scene has an aim to provide brief description about object shown. Its location on the screen depends on the current point of view selected by the user. It should stay readable regardless of user actions specifically connected with object rotation. From the implementation perspective, such textual model can be represented as text object in the A-Frame library. It is also a good practice to give user choice to turn off visibility of the description object.

Location information in the AR-historical guide depends on what institution actually uses it. If it is application for tourists, it shows path to attractions via card service (e.g. Google Maps). On the other side, application for museum does not need such functionality and in-building navigation is preferable in this case. User can select exhibit he/she interested in and make use of markers placed inside the museum. Depending on the selected item, arrows that show direction or next step on the route will be shown. Thus, route to the exhibit is constructed dynamically and guides user to the necessary location inside the building. Finally, for the history classes at school or university, routing to the object is not necessary and brief static information about object location is enough. The location block should be placed beside the main object on the scene. However, we can employ different approach to represent place of the object by using interchangeable surrounding assets. For instance, if object is located in snow region, the object itself is surrounded by snow. In opposite, if object relates to the warm region, it might be demonstrated in the scene with desert environment and appropriate landscape.

One of the most indispensable features of AR-application is active participation of the user and ability to respond to user actions. In general, we can suppose that device with deployed program contains touch screen and sensors to react on user's movements and gestures. By default, the user observes front side of the object. The user is able to change perspective in two ways:

1. By gestures sensed by inertial sensors (accelerometer, gyroscope).
2. By gestures received from touch screen.

Both of them can be considered as primary actions to control the scene.

A-Frame supports several formats of object models. glTF format is recommended by A-Frame documentation as format for WebVR. Nonetheless, during development of historical guide application, it is possible to convert format of the file to the required one using modeling environments such as Blender. The main issue concerned with models is to obtain models of historical objects. Complex models may contain as much as several hundred thousand vertices and go with multiple textures. Design of precise copies of objects is very time-consuming task that will take much more time than application development. Therefore, it would be a better choice to find freely available models on services like Sketchfab [18] or order models from designer. Downloading models from the specialized websites puts additional constraints because you may not find the object you are looking for and will include some similar object or have to refuse from the demonstration of the object.

In general, A-Frame proposes traditional web-site architecture for the purposes of AR-application. User sends request to retrieve corresponding resource from server and works with it. It is preferably to direct user to single page and do not switch from this page as it requires more time. It is obligatory for the user to grant access for camera usage for the page. When page receives this access level, it can act. The next step to do for the user is to provide marker(s) into the scene and direct camera at the marker(s). After that moment, all previously mentioned scenarios and tools take place to demonstrate scene.

The following part of the page markup is used in description of the scene:

```
<a-scene embedded arjs="sourceType: webcam; ">
      <a-assets>
        <a-asset-item
          id="scene-1"
          src="/models/scene-1/scene.gltf"
        ></a-asset-item>
        ...
      </a-assets>
      <a-marker
        type="pattern"
        url="./chnu-marker.patt"
        emitevents="true"
        registerevents>
        <a-entity> </a-entity>
      </a-marker>
      <a-entity camera></a-entity>
</a-scene>
```

The outer element defines the scene and sets support for AR-capabilities via web-camera-support. Inner elements of the scene are list of assets (only the first one is shown while the rest are omitted), marker, and camera. The models are stored in the models directory and for performance reasons models in glTF-format are applied for demonstration application.

Let us provide demonstration of software developed according to the proposed model background and functional requirements for history learning AR-environment. For demonstration purposes, the application has been deployed on the local machine. In Fig. 1, starting scene with no selected model is shown.

The menu appears over top of the image captured from camera and is always available to change the model. As one of the option from the list is selected, corresponding model appears at the marker place. In this case, the first model corresponds to pearl monument as well as second model is represented by castle object as demonstrated in Fig. 2.

Besides presence of the model, textual description for the model is provided (in this case, text does not contain information about the model, it just performs placeholder function).

Once again, this fictional model does not correspond to any known architectural form. However, it proves that even such large-scale buildings like castles are suitable for demonstration in AR-guide even on mobile device.

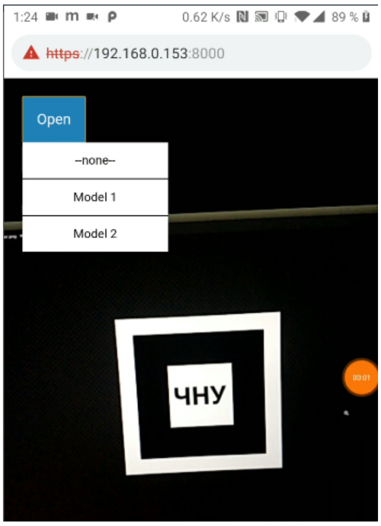

Fig. 1. Screen with open option menu and camera directed to the marker

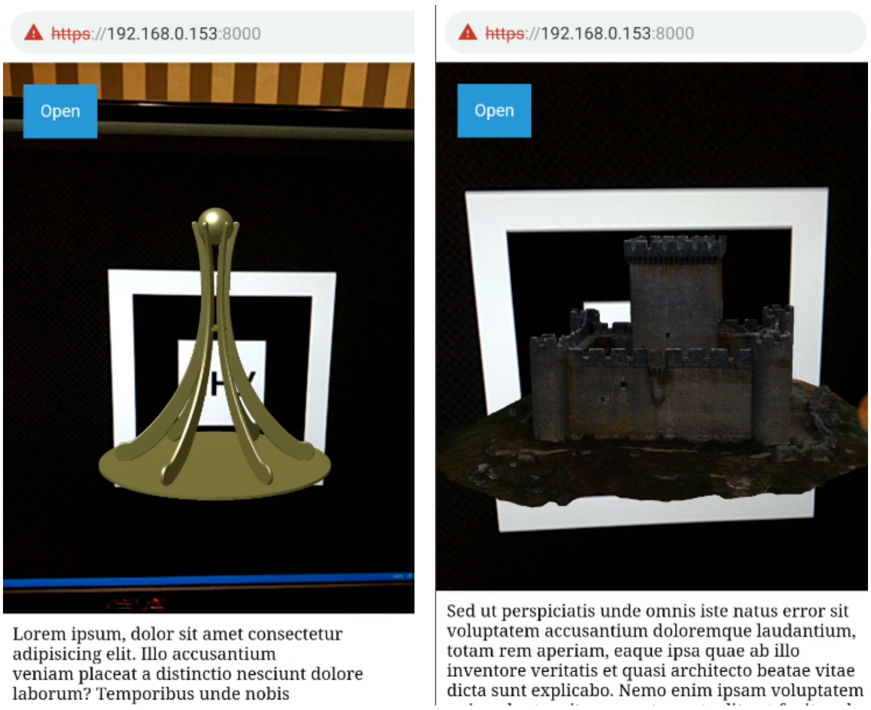

Fig. 2. Demonstration of the first model

Despite demonstration figures have been retrieved in the local infrastructure, the application code is available from Github repository [7]. It is also deployed at the github.io [3] for fast acquaintance with site and can be launched from every mobile device with camera that provides resolution sufficient for marker recognition and has internet access. We also make available for use and immediate testing marker for the application that is a Fig. 3.

Fig. 3. Marker for application

During the testing stage, several artifacts have been observed in the application work. First, it is required for the camera image provide distinguishable image of the marker. Otherwise, the model disappears. Secondly, the speed of processing for browser application even in the local network is lower than for native ones. We also experienced problems with launching site directly from the deployed location. Hence, possible solution for this problem is to pull source code from repository and run it from local environment.

The further development of the project is concerned with addition of new model into the application and improvements from the interactivity point of view.

4 Conclusions

In the presented paper, we established AR-based application that can be used in context of effective presentation of historical materials and history-related content. The application is meant to be used for historical classes and as a mobile tourist guide. We have provided detailed description of the system and all of its components. The entities used in application have been thoroughly inspected and functionality of each of them is identified. The developed application is based on the A-Frame JavaScript library that works from the browser. Hence, application is available to almost all device types that have web-browser installed and support capturing image from camera.

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