

# Legendárium Nagyappó: Augmented Reality-based Audiobook Application

Zsolt Döngölő\*, Kinga Kovács\*\*\*, Károly Simon\*\*\*, Zsolt Szécsi\*\*

\*Babeş-Bolyai University, Cluj-Napoca, Romania

\*\*Codespring LLC, Cluj-Napoca, Romania

\*\*\*Codespring LLC, Babeş-Bolyai University, Cluj-Napoca, Romania

zsoltdongolo@yahoo.com

kovacs.kinga@codespring.ro

simon.karoly@codespring.ro

szecsi.zsolt@codespring.ro

**Abstract**—The article presents the structure and the functioning of the Nagyappó Android mobile application and its implementation background. The purpose of the project is to create an application that is able to automatically identify legends by image recognition from the *Székelyföldi Legendárium* book and “read” them. To make the audio playback even more interesting, Augmented Reality (AR) elements are integrated into the application. The legends are “read” by the well-known grandfather character from the Legendárium cartoon series. Grandpa (in Hungarian Nagyapó) walks in into the camera view and sitting down on the page of the book tells the story of the legend to which the phone’s camera is directed. The application is mainly made for small children. Using the software, they can become acquainted with Transylvania’s legends even before they can read. If someone does not have the *Székelyföldi Legendárium* book, he/she can still listen to the available content: using the *Search* functionality, it is possible to search among the available audio books. The media materials (animations, audio books, images) which are used within the application are provided by the *Székelyföldi Legendárium* team.

## I. INTRODUCTION

*Székelyföldi Legendárium* [1] is a project launched in 2008 aiming to collect and popularize Transylvanian legends. Within the framework of the initiative 156 legends were collected so far. Maps, books, audiobooks, coloring books, puzzles, social games were published, documentary films and 3D animation series were also released.

There are many little children who are fans of these legends, but they cannot read yet. The idea emerged to develop an interactive application for them, which “reads” the pages of the book. Looking at the storybook through the camera of the Augmented Reality-based Android mobile application, [2] the Grandpa character known from the Legendárium cartoon series walks in and sitting down on the book tells the legend on which the camera is directed.

The application can be divided into two major parts. The first one is responsible for image recognition and animation playback. It is implemented by using the Vuforia framework and the Unity development platform. The second part includes the mobile application’s user interface and additional features. It is created by using the Android Software Development Kit.

The main feature of the mobile application is the “*Reading*”, which requires image recognition based on the *Székelyföldi Legendárium* book and animation playback. Another important feature is the *Search* functionality, which allows the user to view the available content and listen to the audiobooks without the printed storybook. The user can get more information about the application selecting the *About* menu, from where the online *Székelyföldi Legendárium* shop is also accessible.

## II. THE LEGENDÁRIUM NAGYAPPÓ APPLICATION

### A. Basic functionalities

The **Legendárium Nagyappó** mobile application has a user friendly graphical interface and provides the following main features:

- recognizes the “*Székelyföldi Legendárium*” book’s pages with the camera of the device;
- plays the audiobook associated to the recognized page;
- when the recognized legend starts, it renders a 3D object by augmenting the camera view with the Grandpa’s model. The model is animated, Grandpa is “telling the story”;
- makes it possible to listen to the legends without having the printed version of the “*Székelyföldi Legendárium*” book by providing a search functionality based on legend titles or identifiers.

### B. Architecture

The application can be separated into two main parts. The first part is the Unity module, which is responsible for the 3D model rendering and animation. The second part is the Android module, which takes care of the audio playback synchronously with the animation. The two parts communicate with each other through interfaces, using a callback mechanism (Figure 1).

## III. TECHNOLOGIES

### A. Vuforia framework

*Vuforia* [3] is an AR development platform, which supports mobile phones and tablets with Android or iOS operating system. Vuforia makes it possible to develop unique AR

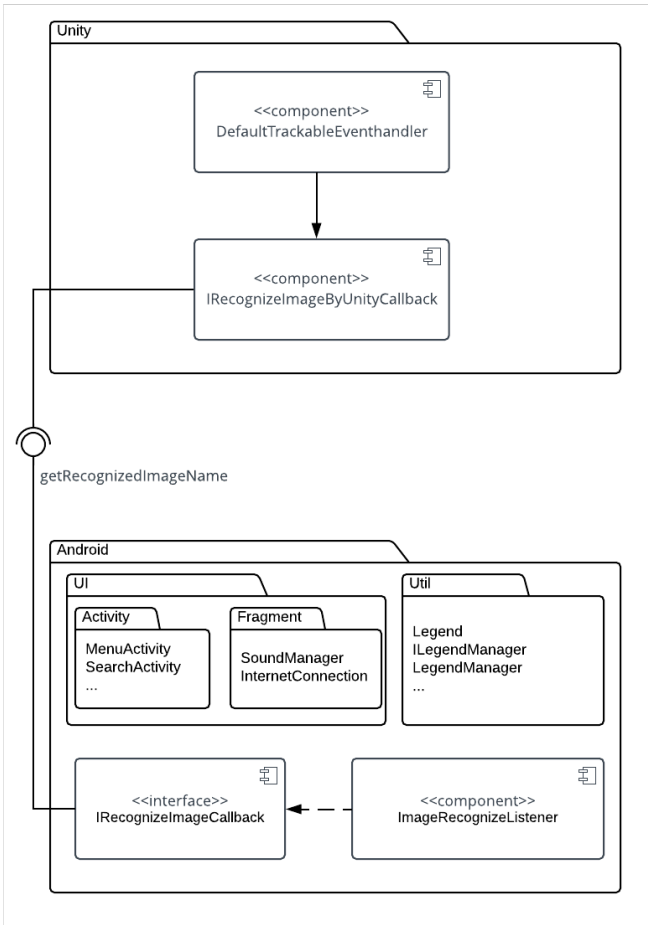


Fig. 1: UML component diagram - Communication between the Unity and the Android module

applications by recognizing images and rendering 3D objects. The platform uses *Natural Feature Tracking Algorithm* [4] (Figure 2.) for image recognition based on feature points. The algorithm contains three main steps:

- natural feature (points and regions) detection and selection;
- multi-stage motion estimation integrating point and region tracking;
- evaluation feedback for stabilized detection and tracking.

### B. Unity development platform

Unity [6] is one of the most popular game development platforms, used to create high quality 2D, 3D, VR (Virtual Reality) and AR (Augmented Reality) games. Unity was used for AR mobile game development in the past too. [7] These games can be deployed to multiple platforms, including mobile devices, home entertainment systems, game consoles, personal computers, embedded systems, etc. Unity has a powerful graphical engine and a fully-featured editor called *Unity Editor* that combines visual and artistic tools with code development [8]. The graphical content for the visual part can be created using this editor, where 2D and 3D models can be added or

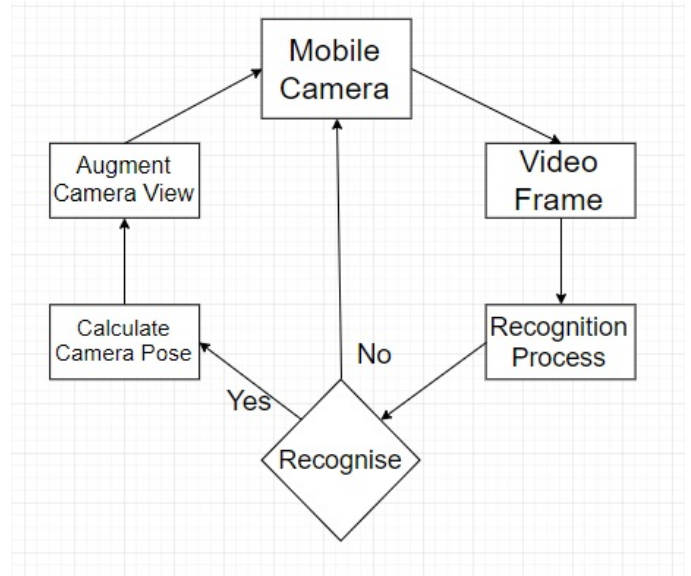


Fig. 2: Image recognition cycle [5]

created, and animated. *C#* scripts can be assigned to the visual elements, and in this way it is possible to control the operations at code level (for example, controlling animations).

### C. Android SDK

*Android SDK* provides libraries and developer tools for creating Android applications. The kit provides an emulator, API libraries, debugger, sample source code, tutorials for the Android operating system and documentation for the Android API.

### D. Butterknife

*Butterknife* is a viewbinding library for Android, which brings annotations to eliminate the necessity of writing boilerplate code. It helps the programmer to avoid the usage of multiple *findViewById* method calls or inner classes, by binding fields with `@OnClick` and `@BindView` annotations. It makes the code more clear, reusable and allows to use the MVC pattern.

```
@OnClick(R.id.search)
public void search() {
    Intent intent =
        new Intent(MenuActivity.this,
            SearchActivity.class);
    startActivity(intent);
}
```

Code snippet 1: Avoiding to write inner classes by using the `@OnClick` annotation

## IV. IMPLEMENTATION DETAILS

### A. Image recognition and animations

The recognition of the pages from the *Székegyföldi Legendárium* book is implemented using the *Vuforia* framework. As a first step, the pages of the book have been saved

as images to the Vuforia database. After preprocessing, the content of the database was downloaded in a *.unitypackage* format, corresponding to the Unity development platform. The package was imported into the Unity project.

For the Unity project, the first step was to create a scene called *Nagyappo*, and an *ARCamera* (needed for image recognition) was assigned to this scene. Then an *ImageTarget* panel was created, which can be configured under the *Inspector* tab, where several properties can also be customized (e.g. component's position and rotation, associated scripts and other components, etc.).

One of the most important settings for the panel is the definition of the content, which in the current case is a page from the book containing the legends. To access the downloaded Vuforia database a setup procedure is required via the *Vuforia Configuration* interface.

The *ImageTarget* panel was created in as many copies as required for image recognition, which means that all of the pages of the *Székelyföldi Legendárium* book are considered *ImageTargets*. 3D models have been assigned to the created *ImageTargets*, and animations have been associated with these models.

The functioning of the application is realized by various *C#* scripts. The animation control is implemented within the *DefaultTrackableEventHandler.cs* script that is assigned to all *ImageTargets*. The image recognition is also implemented in this *DefaultTrackableEventHandler* class, and here is the specific link between the Unity and Android projects, based on a *callback* mechanism. The animation control is related to the image recognition. First, an animation controller called *NagyappoAnimController* was created in *Unity Editor*, which includes animation clips and transitions between these clips. The functioning of this animation controller is shown in Figure 3.

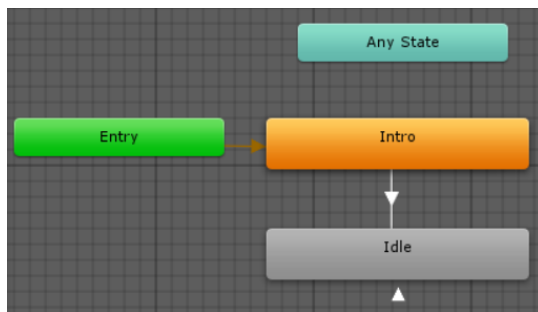


Fig. 3: NagyappoAnimController - includes animation clips and transitions between these clips

An animation clip called *Intro* will be played first: Grandpa is entering into the camera view. This animation is played when the camera is focused on a page from the storybook and the image recognition is performed. The following animation clip is the *Idle*, which plays the "reading" process: Grandpa is telling the story. The arrow between *Intro* and *Idle* represents the transition between the two animations. The self-returning arrow under *Idle* indicates that the animation clip is played

repeatedly. This playback loop is finished when it is closed at code level or when it is necessary to restart the animation controller (when a new legend is recognized). The animation controller is restarted using the *Rebind()* method call (see code snippet 2).

```

animator = GetComponent<Animator>();

if (!imageTarget.Equals
    (mTrackableBehaviour.TrackableName))
{
    if (prevAnimator != null)
    {
        prevAnimator.gameObject
            .SetActive(false);
    }

    animator.gameObject.SetActive(true);
    animator.Rebind();
}

imageTarget = mTrackableBehaviour.TrackableName;
prevAnimator = animator;
  
```

Code snippet 2: Restarting the animation controller using the *Rebind()* method call

After successfully building the components for the image recognition, model rendering and animation playback functionalities with the Unity Editor, an Android application is exported from the Unity project, allowing the development of the additional features using the Android SDK.

### B. The Android mobile application

After an image is recognized, the *DefaultTrackableEventHandler* class sends a message to the Android module containing the identifier of the respective image. Each legend is stored in a JSON file with their title, subtitle, identifier, an audio stream URL and the identifiers of the associated images. This JSON object makes it possible to identify the recognized legend by associating the received image name with an image identifier from the json file (3. code snippet).

```

String imageName =
callback.getRecognizedImageName();
Log.d("PluginClass",
    "Returned value: " + imageName);
legendUrl =
lgndManager.getLegendByImageName(imageName);
  
```

Code snippet 3: Processing the message received from the Unity side and selecting the corresponding legend

Finally, when the legend associated to the recognized image is selected, the *mediaplayer* is launched with the corresponding stream url from a third party server (<http://www.indiesound.com>), and the audio playback is started.

The application has another important functionality, the search feature, which gives the possibility for listening legends without having the printed version of the storybook.

Internet connection is required for using the above mentioned features, and it is checked before launching the application.

## V. DEVELOPMENT TOOLS AND METHODS

The development of the *Legendárium Nagyappó* application was based on Agile principles, with daily Scrum meetings, planning, demo and retrospective sessions, using Continuous Integration (CI) methods.

*Git* was used as distributed version control system. *GitKraken* is a graphical user interface for Git, which provided operations related to version tracking and repository management. *GitLab* facilitated the management of the central repository and it was also used for issue tracking and continuous integration.

An automated build system was created using *Docker*, the build process is automatically launched and executed after the push operations.

The functioning of the application is tracked by *Fabric*, in this way the performance and accuracy of the application was evaluated across all development stages.

*Visual Studio* was used to develop *C#* scripts for the Unity platform, while *Android Studio* was used to develop Java code for the Android application. Android Studio uses *Gradle* as automated build and dependency management system.

## VI. USING THE LEGENDÁRIUM NAGYAPPÓ APPLICATION

After launching the *Nagyappó* application, the home screen appears containing the main menu (Figure 4.).



Fig. 4: The home screen of the application

The main functionality of the application can be accessed by clicking the *Felolvasás* (Reading) button, which launches the Unity module and turns on the camera. If the camera is focused on a page from the *Székelyföldi Legendárium* book, the image is recognized by the *Vuforia* framework, and Grandpa appears as a part of the Augmented Reality, who walks in the camera view and sitting down on the page "tells" the story of the legend. The device can be rotated around the 3D model. If the camera loses focus during the storytelling (e.g. the camera is not permanently directed to the selected legend), the audio playback will be continued

without suspension. The image recognition is only needed once for "reading" a legend. However, Grandpa is visible only when the camera is directed to the page. If the user directs the camera to another legend, the animation is restarted, Grandpa reenters the stage, and the audio playback is switched to the newly selected legend. Figure 5. illustrates how Grandpa enters into the camera view, while in Figure 6. he is "telling" the story.



Fig. 5: Grandpa enters into the camera view



Fig. 6: Grandpa is "telling" a story

The search feature of the application can be accessed by clicking on the *Keresés* (Search) button. The corresponding screen is shown in Figure 7.

The search is executed based on the title or on the identifier of the legend. The first legend has the title *Medve-tó* (Bear Lake), below it the identifier (*m 01*) appears. These identifiers are also used within the printed storybook, appearing in the upper corner of the pages. Legends are divided into regions (*Marosszék, Csíkszék, Udvarhelyszék, Gyergyószék*, etc.). The first character of the identifier is the first letter of the region's name, and the number indicates the position of the legend in the storybook. Therefore the identifier *m 01* means, that *Medve-tó* is the first legend in the *Marosszék* chapter. By clicking on the button below the title of the legend, the audio playback is started. A paging feature is also included: legends can be switched by swiping left or right on the search screen.



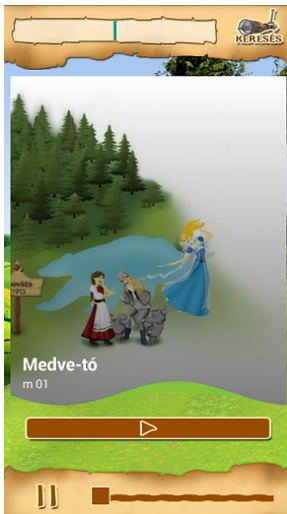


Fig. 7: Searching for legends and starting the audio playback manually

Clicking on the *Az alkalmazásról* (About) button displays the content shown in Figure 8. The *Rate it on Google Play Store* item will be available after the release of the application. By selecting the *License* item the list of the integrated frameworks appears together with related license information (see Figure 9). By selecting the *Legendárium termékek* (Legendarium products) item the user will be redirected to the online shop of the *Székelgyödi Legendárium* project (see Figure 10).

By clicking on the *Kilépés* (Exit) button, the application will be closed.



Fig. 8: The *About* screen

presented at several conferences in Seklerland. After some further development tasks and improvements, the application will be published and available in the *Google Play Store*.

The planned development tasks are: creating a central server for storing and streaming the audiobooks (currently a third party server is used), embedding in-app purchase possibility (some audiobooks could be purchased from the application), displaying more legend-specific 3D elements (besides Grandpa other models could be rendered as a part of the AR) and including multiple animations (e.g. different Grandpa animations for different legends).

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[illegible]

Fig. 9: List of external dependencies and libraries used during development



Fig. 10: Székelyföldi Legendarium webshop

## VII. CONCLUSIONS AND FURTHER DEVELOPMENT

In its current state the *Legendárium Nagyappó* application is an operational prototype, but it was already successfully

