ALAPP – Advanced Limes Applications for Smartphones

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On the basis of the development of smartphone applications in Bavaria the ALAPP project was granted funding from Creative Europe to create a new version to enhance visitor experience at the Antonine Wall in Central Scotland and on the Raetian Limes in Bavaria. The ALAPP project is using the existing technological framework from Bavaria to develop a smartphone platform for the Frontiers of the Roman Empire World Heritage Site. In the future, ALAPP may be used by other cultural and archaeological sites to provide visitors with the latest technology. The main focus of the project is to enhance the existing framework with the latest technologies. Therefore, Augmented Reality (AR) is the most important topic of the project. However, the technology to integrate AR in an app project is complicated and raises many issues. The project tries to address these issues and show possibilities as well as best practice examples. An important aim of the project is to enable different cultural organizations to use smartphone technology. The idea is to share information and save costs for those projects.

The ALAPP platform will be available for Android and iOS. The Creative Europe project started in 2016 and will be finished in 2019.

INTRODUCTION

In 2016 the ALAPP project received grant funding from Creative Europe. Its aim is to develop cutting-edge technology to enhance visitor experience at the Antonine Wall in Central Scotland (UK) and on the Raetian Limes in Bavaria (Germany).

Based on earlier developments of smartphone applications in Bavaria, created for archaeological monuments and museums (Mainlimes App and Limes Middle Franconia App), the ALAPP project is using and extending these existing technological frameworks to develop a smartphone platform for the Frontiers of the Roman Empire World Heritage Site. State of the art technology will be integrated and an ease of use for both, content managers and users, will be provided. The ALAPP project is aiming to enhance the capabilities of the existing platform. For users, new types of content will be introduced and coverage will be extended to include museums as well as sites in the landscape.

ENHANCING THE VISITOR'S EXPERIENCES

Modern smartphones are powerful computer devices. They are able to display any kind of information in variable ways. The existing platform, based on the applications from Bavaria, already shows a wide variety of content such

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as videos, audios and texts with pictures [Dobat et al. 2011]. Furthermore, GPS navigation provided by smartphones will alert the user when approaching a Point of Interest (POI) in the landscape (Fig. 1). The application displays content offline, so an internet connection is not mandatory. This is especially important for remote regions (which is the case for significant sections of the Lower Bavarian Limes and the Antonine Wall in Scotland) and also for users visiting from different countries. High quality content requires data volume – therefore the choice to provide offline content is very important. But it is important to communicate the offline functionalities to the audience as they should download content before visiting the archaeological sites.

The ALAPP project is now aiming to enhance the capabilities of the existing platform. For users, in addition to images, videos, audio and text, new types of content will be introduced:

- Rotatable 3D objects and 3D reconstructions of sites

- 360 degree views of the reconstructed landscape

- Augmented reality

The focus of these new content technologies will be on reuniting the artefacts and the sites [Dobat et al. 2013]. This means bringing the finds back to the provenance digitally, showing the visitors on site which objects were found there and how these enable understanding, interpretation and reconstruction of the site. Finds are displayed as rotatable 3D objects (Fig. 2a). It is always difficult to work with 3D objects on mobile devices. The rendering power is limited (especially on older devices). It was important to create software solutions for both platforms (Android and iOS) and they have to accept the same data provided by the CMS (see below). We finally were able to establish a workflow that displays good 3D results even on older portable devices. With the 3D objects integrated into the ALApp platform the users have the archaeological finds at their fingertips. Very important has been the workflow of scanning objects in a very high resolution. We used techniques such as laser scanning, structure from motion and photogrammetry to achieve the best results currently possible. In doing so the objects that are used as content for the ALApp platform are documented digitally as well. For the future the data can therefore be used for scientific purposes, for high end displays as well as on mobile platforms.

Besides generating 3D scans from artefacts it is also very important for the project to integrate 3D reconstructions from different sites along the Antonine Wall as well as from Limes in Bavaria. 3D models will be mainly used in video sequences. Additionally we are currently investigating the possibility of displaying 3D sites as turnable objects as well. Here the rendering power of mobile devices is the limiting factor and only further research will show if this is a feasible option. The 3D models of the sites will also find their way into the AR module of the application (see below, p. 3). Using high quality 3D reconstructions as content is also a philosophical matter. With the possibility of photorealism there are many obstacles. The final version of a 3D site is the result of many discussions between the media producers and the archaeologists. Decisions have to be taken on the available evidence, but the problem is the documentation. When choosing the most appropriate reconstruction to be used, the final decision is usually made by archaeologists. For recipients (end users or professionals) this process involved is not obvious and therefore the detailed virtual reconstruction may lead to deception [Dobat 2015]. Therefore, we are discussing ethical issues concerning virtual reconstructions in the ALApp project as well. In Bavaria we are going to reconstruct a Roman temple area on the Weinberg near Eining. We are planning to make the process visible and clear for the audience. To achieve this, we are trying to incorporate the principles of the *London Charter* [London Charter 2009] and the *The Principles of Seville* [Lopez-Menchero and Grande 2011]. The *London Charter* and the *Principles of Seville* provide a toolkit for 3D models that incorporate ethical standards and therefore enhance the benefit of the virtual reality. The key is documentation. For the Bavarian site we are planning to create a documentation of the process the will lead to the final output of the 3D reconstruction. This will include information on: Aims and Objectives, Sources (excavations, epigraphy, historical sources, etc.), Inferences (based on the observations and interpretation of the sources), Visualisation decisions / Visualisation team, Modelling. Basically the process aims to integrate a clear process to understand the decisions that taken by the project team during the creation of the app. This will be valuable for the scientific community as it will be possible to track the different modelling choices. For the average user this is different again as she or he usually only consumes the available information. Therefore it is inevitable to clarify that reconstructions are only possibilities. We are trying to make this visible by either two different versions of the reconstruction or by commenting on a single reconstruction to clarify that it is only a possibility reflecting the current status of research on the topic. With proper documentation of generated content, and maybe by publishing and marking the software programs involved within the archaeological process, 3D models can be much more than just nice pictures from the past for a public audience. They can even help to enhance our scientific knowledge about the past, as well as reminding us of the limits of our knowledge.

The 360° degree views of the reconstructed landscape offer a breath taking experience where users dive into the historical past with the help of smartphones in situ. While surrounded by today's landscape, the application on the smartphone is able to show visitors how these locations might have looked in historical times (Fig .2b). The content is a 360° picture generated from a 3D software such as Blender or 3DS MAX. The smartphone provides information from its GPS location, the compass and its gyroscope. Thanks to these geo-locative features, it is possible to display the proper view according to the smartphones location. Our research enabled us to find open source libraries for both iOS and Android. From the technical perspective it required some adaptations as both systems have to work with the same content data that is provided by the content management system (see below, p. 4).

Augmented reality is used to engage users with a site or monument [Wilson et al. 2017]. The live camera view of the smartphone is enriched with information about a certain location. The landscape or an artefact are used as target markers. The smartphone searches its database and once it recognizes certain structures in the camera live view it will display the provided information. It is possible to use any type of media as an overlay in the camera picture. We are using transparent videos and 3D objects to enrich the camera perspective with information (Fig. 2c). Augmented Reality (AR) is a difficult type of media to cover. Therefore, we started to experiment first with 360° degree views (see above) as they provide a basic feeling of AR. But we are in the process to go beyond these capabilities. Augmented reality is considered to be the most important type of content within the smartphone industry in the coming years. This is reflected by the integration of AR libraries in the SDK environments of iOS and Android. Apple published iOS 11 in September 2017 and integrated the so called ARKit. Google instead has recently published ARCore for the Android platform. But there are several obstacles that need to be addressed. Both toolkits require the latest hardware to run. This means that users with older hardware would not be able to enjoy the benefits of AR content. For Android this could represent a problem since more than 90% of their users do not have the required hardware. Also for iOS there could be issues because only the smartphones built after 2016 can run the ARKit. Furthermore, the required data structure for the content is different in ARKit and ARCore. This is a challenge as we are using a content management system (CMS) to provide the content data. For the two different versions we would have to find a complicated solution within the CMS with the good chance that two different dataset have to be hosted. This requires additional efforts for the content manager of a smartphone application.

Therefore we had a closer look at different software libraries that provide augmentations for iOS and Android [Hücker 2012]. Several different AR solutions are available and they provide different possibilities. We had a closer look at four different toolkits. The table below shows an overview:

Table 1. Augmented Reality Libraries

	Wikitude	**Vuforia**	**EasyAR (open source)**	**ARToolKit (open source)**	**ARKit (iOS)**	**ARCore (Android)**
2D Recognition	√	√	√	√	√	√
3D Recognition	√	√	-	-	√	√
Geolocation	√	-	-	-	√	√
Cloud recognition	√	√	-	-	√	√

After examining the open source versions we decided that it would not be possible to develop the required features such as Geolocation and 3D recognition within the projects budget. The open source versions provide a framework to integrate AR in a project, but developing new features on our own (such as Geolocation) is not feasible within the limits of the ALApp project. The decision therefore was made between (both commercial) Wikitude and Vuforia. The main task – object recognition – is well integrated in both platforms. The Wikitude SDK is a little more

comfortable to work with and it features Geolocation which is a big benefit for archaeological sites in the landscape. The SDK of Wikitude may be integrated in iOS and Android. Given that the content data in our content management database is consistent and we only need one file set for the two operating systems. Hence we decided to use the Wikitude SDK for our project. Another advantage of the Wikitude SDK is that it supports older smartphones devices on iOS and on Android in comparison with the AR solutions provided by Apple and Google. The latest version of the Wikitude SDK even let you explore the native ARKit and ARCore: the smartphone uses the native software of iOS or Android if possible. Otherwise for older smartphones the Wikitude engine is used. Thus the audience for AR content is much bigger, but also the best user experience is guaranteed. We are now also able to integrate AR content anywhere in the ALApp application (Fig. 2c).

An important part of the ALAPP project is to integrate museum tours as well. Indeed the Hunterian Museum in Glasgow will be integrated as a best-practice example. The ground plan of the exhibition will be available in the app and it is going to provide multimedia information. Again there will be a focus on AR utilization.

The application will be especially user-friendly. Currently visitor research is being carried out in Bavaria as well as in Scotland. The results will be examined and transferred to the user interface of the application. ALAPP provides high quality information on the World Heritage Sites in Bavaria and Scotland. To reduce data requirements of the application the user may choose between different offline packages (usually representing a site). As the Roman frontiers are huge monuments with many archaeological sites the visitor can actually select only sites that are of interest at the moment.

TECHNICAL SOLUTIONS FOR CONTENT PROVIDERS

For content providers, the platform will feature a content management system (CMS) that enables information to be kept up-to-date without the need to upload a new version of the application to the app stores every time. The content management system is one of the main modules to be developed within the ALAPP project. The CMS enables museum staff and site managers to feed new data into the system. At start-up the application checks back, if there is any new information available and integrates the new POIs into the data set of the application. This ensures a flexible and constantly improving app system – the content is always up-to-date. Here again we had to check which of the available content management system is best suited for our project. After research we decided to use Django CMS as the communication between the CMS and the operating system works well with Android and iOS. The CMS is also user-friendly and clear in its handling. This enables the museums' staff, site managers and other content providers to get familiar with the system in a short period of time. However, including a CMS also means that technical maintenance is necessary here too. So one may save money on updates for upload to the App Stores, but the infrastructure of CMS needs work as well. Using a CMS certainly implies additional work when setting up the project, but over the lifetime of an application it starts saving money and the content may be always up-to-date. So any museum or organization using a CMS like this needs to know about regular costs for maintenance and security updates – the decision for or against should be carefully taken.

REACHING THE PROJECT'S GOALS

In order to evaluate the approach and the content the ALAPP project team is not only in close contact to other professionals but is also undertaking visitor research on a regular basis. This helps to improve the handling of the software. In the city of Glasgow in Scotland Historic Environment Scotland and the Centre for Digital Documentation and Visualization has invited a group of people to test the application. We received valuable feedback on how to enhance the graphical user interface and were able to correct some bugs. In Bavaria the University of Würzburg undertook an on-site survey of the Bavarian app framework on the Limes in Weißenburg in summer 2017. A group of school kids and adults were asked to test the application on site. From the technical perspective we received valuable information to enhance the platform within the ALApp project. The research with pupils showed that content should address the age of your target audience to keep it interesting. On the other hand the adults liked the application in general, but there seem to be obstacles that prevent usage. None of the testing users was aware of the application although it has been available in the App Stores since 2013. It is therefore very important to run a consistent marketing strategy so that people get the chance to know about the smartphone application.

An important aim of the project is that it can be used for other parts of the wider Frontiers of the Roman Empire World Heritage Site as well. The mobile application for the Antonine Wall World Heritage Site in Scotland represents the best practice tool to be transferred and tested at the Limes in Bavaria for further improvement. Then in the future it may be used for other sites as well without developing a new app and content management system from scratch. Additionally, the ALAPP team will also publish a toolset for other Heritage Sites to use the developments of the ALAPP project. An important focus will be to ensure sustainability of the application and the CMS in the future.

Public relations activities are an important part of the ALAPP project. Regularly news releases have been provided and both the ALAPP website and the ALAPP Facebook site provide up-to-date information on activities and developments.

RESULTS SO FAR – SUCCESSES, CHALLENGES AND CONCLUSIONS

At the end of 2017 we can report that we are very pleased that the transfer of technology goes seamlessly, as does the development of new content and modules, while the exchanging of data and ideas with other partners/experts has been inspiring, fruitful and successful in many ways (Fig 3).

What we have identified so far is how important the marketing of the application is, and will be, in order to inform visitors about this new tool and its possibilities. Well considered, and well targeted, marketing strategies are important for the success of an application in a world where so much information is being presented to users every day. We have also noted how important it is to keep both platform and content current (media updates, state-of-the-art technology, new modules, etc.); in order for the application to be successful in the long term and remain relevant to users.

For the usability, it will be important to customize the applications to the user's abilities. One major challenge is the use and availability of libraries for advanced technical solutions. The rapid technological advances force developers to work on applications in a regular timescale. Often functional modules (i.e. for AR) have to be replaced by newer developments. Libraries and SDKs help developers to keep their application up-to-date, but it needs regular maintenance.

There are lessons that have been learned and still have to be kept in mind every time when developing an application:

- always have the user in mind
- ensure continuous development
- sometimes less is more

The development of an application that can be used for other heritage sites is an inspiring and motivating task. The knowledge, creativity, imagination and innovation put into the ALAPP project is immense. The Frontiers of the Roman Empire World Heritage Site is an ideal monument on which to test the possibilities of modern technology. The Antonine Wall in Scotland in particular with its length of 56 km is a clearly defined monument. Several spectacular sites along its line provide the ideal playground to trial and experiment with new technological possibilities. The module developed for a small model region of the Limes in Bavaria will demonstrate the transfer to other regions.

In 2018 we will work on the enhancement of the AR module. The dissemination process of the ALApp platform for other heritage organizations will be developed and at the end of 2018 or beginning of 2019 the Limes in Bavaria (based on the ALApp platform) will be available in the app stores. Currently the Antonine Wall application (based on the ALApp platform) is available for Android and iOS.

The Creative Europe project started in 2016 and will be finished in April 2019.
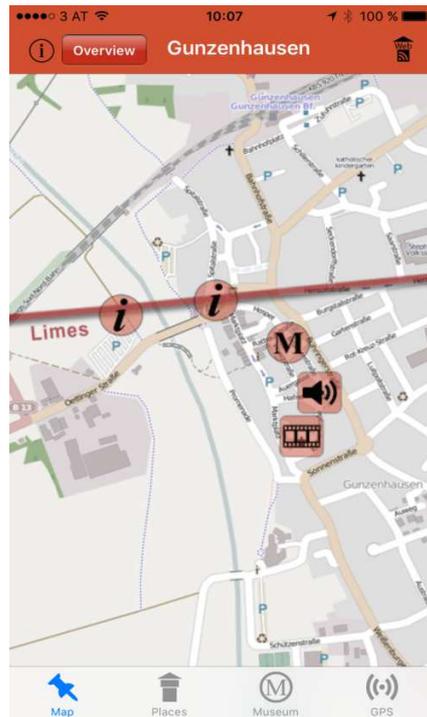
Fig. 1. Screenshot of the Limes Middle Franconia Application showing POIs in the city of Gunzenhausen.
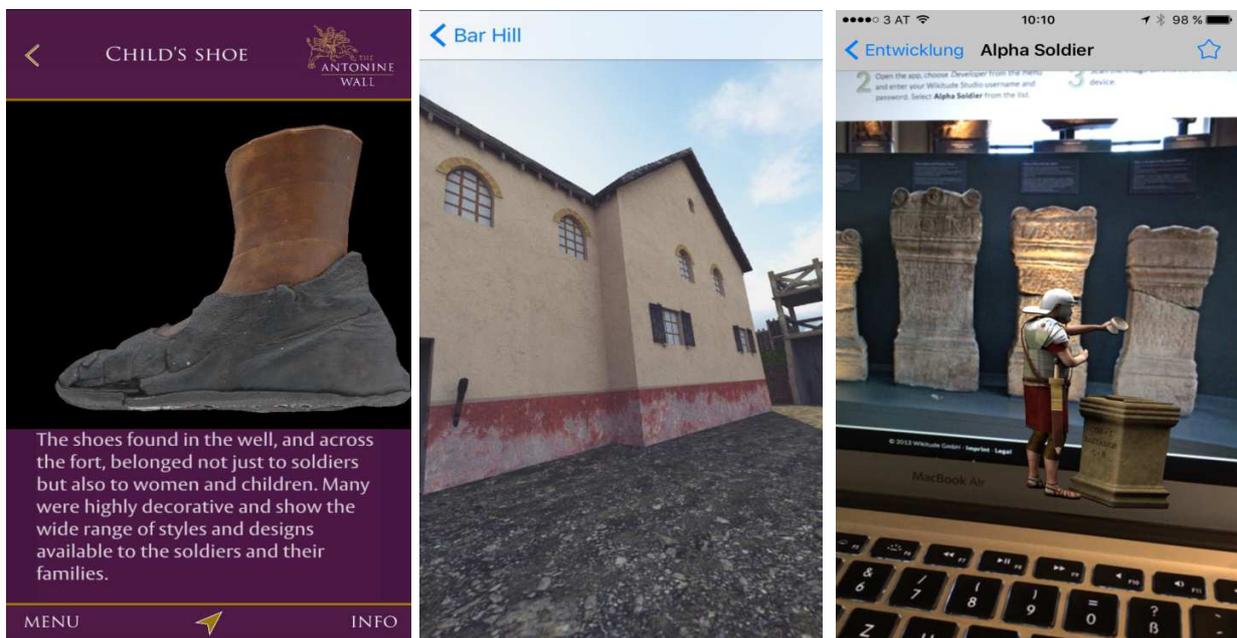

Fig. 2. Screenshots of the ALAPP Antonine Wall Application a) 3D object: shoe Bar Hill fort; b) 360° view Bar Hill fort; c) Augmented Reality video showing a Roman soldier in a temple.

Fig. 3. Testing and using the application in the landscape at Bar Hill Roman Fort.

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