Towards an Integral Solution for Application of Information Technologies in Representation of Medieval Fortresses

Radomir S. Stanković[1], Dušan Tatić[1][0000-0002-9228-6020],
Detelin Luchev[2][0000-0003-0926-5796]

[1] Mathematical Institute of SASA, Kneza Mihaila 36, Belgrade, Serbia
[2] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
8, G. Bonchev Str., Sofia, Bulgaria
Radomir.Stankovi@gmail.com, dule_tatic@yahoo.com,
dml@math.bas.bg

Abstract. In Serbia, there are many fortresses from the period 12th to 18th century, most of them in ruins, but a few being reconstructed and open to the public. This paper proposes an integral solution for application of information technologies in providing relatively detailed, visually attractive, and immersive presentation of the historic heritage related to these fortresses.

Keywords: Medieval Fortresses, Information Technologies, Electronic Guides, Visual Projection Systems.

1   Introduction

In the Middle Age, under the rule of the dynasty Nemanjić and its successors, there existed a strong state on the territory of present state of Serbia. From that time and later, under the Ottoman occupation, there are remains of many fortresses and old towns. Research on the project *Visual representation of fortresses and old towns on the territory of Serbia*, that started in 2018 by Svetlana Dingarac, see (Dingarac, 2018), enlisted 126 medieval fortresses and ancient towns besides 94 from the Roman and Early Byzantine times, (Dingarac, 2018).

In this current project, many of fortresses are well illustrated by professionally made photographs and well described. In that respect, for more detailed description see, also (Deroko, 1950).

Most of the medieval fortresses and old towns are in ruins, but a few being reconstructed and open to the public. Further, there are relatively well-preserved remains of fortresses from the period of Ottoman occupation of Serbia, and a couple of them are also reconstructed. Among examples that can be mentioned are Kalemegdan in Belgrade, Fortress of Nis, both on foundations and reminds of fortresses from the Roman

times, and relatively recently reconstructed fortresses in Bač, Golubac, Ram, and the fortress Fetislam in Kladovo.

Typically, the historical data and background of the fortresses are well known to historians and experts in these and other related fields, and properly presented in many books each of them usually devoted to a particular fortress or a group of them, (Bosnić, 2021; Deroko, 1950; Djidić, 2009; Stojkovski, 2019; Vuković et al., 2017).

Besides in printed form, data about fortresses are often presented as collections of files on CDs or other memory devices. In some cases, there are websites with textual description, galleries of photograph or video record and possibly other similar ways of presenting a fortress. This information, however, usually remains in rather small and relatively closed circles of professional and specialised experts or possibly individuals with specific interest in this subject, and it is hardly offered and made easily accessible to the general public.

Moreover, these ways of descriptions and presentation of fortresses are very valuable from a professional point of view, however, they are not very practical and convenient for a visitor to use on the site while visiting a fortress. At the same time, a visually more attractive and immersive presentation is usually expected. Therefore, in this paper, we propose a wider and more thorough application of information technologies in presenting historical heritage related to concrete fortresses.

We propose a solution which we consider as integral in the twofold sense. First it aims at a rather complete audio-visual presentation, and second, it can be applied to different particular cases and can be adapted to the levels of preservation of fortresses, and various possible situations on the site.

The proposed solution is based on the following two main components.

1. An application for mobile devices (smartphones and Tablet PCs) for presentation of a fortress (electronic guide, short e-guide),

2. A few types of audio and video projection installations in the fortress by using different projection approaches and systems.

Development of an e-guide is possible in every case, however, other ways of using information technologies requires some prerequisites to be provided.

Which of the proposed solution elements will be applied in a concrete case, depends on many factors, but the choice of the most adequate and appropriate solution is essentially related to the conditions and situation on the site and available physical resources, but it is also dependent on the historical and other contents to be presented.

2   Prerequisites

Application of information technologies in presenting a fortress certainly depends on the condition of the fortress, how well it is preserved or possibly reconstructed, entirely or up to some measure, as well as on the available resources, primarily electricity sources, and existence of suitable spaces for projections, as light conditions for instance, and protection of the installed hardware.

In that respect we distinguish fortresses:

1. In ruins, without rooms with a roof or some other possible way to protect projection devices and related technical equipment from atmospheric conditions (Class 1).

2. With available necessary facilities for installation and protection of projection devices. It is assumed that there is connection to the electro-energetic network or that a system of solar panels for electricity is provided at the site (Class 2).

Another factor to be considered is the level of interest of visitors. In that respect, the visitors are categorised as those who:

1. Are ready to download and install the offered electronic guide on their mobile devices (Category 1)

2. Do not want or have some other restriction in installing the offered application but are interested in obtaining some information about the fortress or particular exhibits within it (Category 2).

A suitable way to provide information for visitors in Category 2, is a spread of QR-codes. The scanning of them leads to the corresponding links with prerecorded files related to objects to which the codes are assigned. Since QR-code readers are presently a part of standard software installations on mobile devices, the advantage of Category 2 visitors is that any preliminary software installation is required.

The advantage of Category 1 visitors is that when the application is download and installed, all the contents, except video records, remains at the mobile device and can be viewed at any time later. Video records are usually downloaded from a dedicated web link to reduce the size of the application. They can be watched at any time when a connection to the Internet is provided.

3 Elements of Installations

In this section, we briefly discuss elements of installations that are a part of the proposed integral solutions.

3.1 Electronic Guide

When addressing to visitors in Category 1, a prerequisite is existence of a multimedia and multilingual electronic guide (e-guide). This term refers to an application for mobile devices such as tablet PCs and smartphones. It can be viewed as an advanced version of the classical audio guides already offered for many years to visitors by many museums, galleries, archaeological sites, and other exhibition installations. The advent of e-guides is in offering besides audio records, various multimedia contents including video records, galleries of photographs, scrollable textual records, a navigation module based on the Google Maps application, and an augmented reality (AR) module enabling a direct interaction of a visitor with various artefacts at the exhibition installations.

3.2 Projection Systems

The main idea behind considering different projection systems is offering a possibility to select projection system that is the best suited for the contents to be presented and the situation at the location selected for the projections.

For the intended applications, we consider the following projection systems.

1. Projection pyramid which is primarily used for displaying 3D models.

Fig. 1 shows a projection pyramid projecting the 3D model of an ancient church.

Fig. 1. Projection pyramid of dimension 60x40x35, based on a 32" monitor powered by the Raspberry Pi 3 (Photo by R. S. Stanković).

2. Inclined plane projection device (IPPD), which enables projection in two planes. The horizontal plane is typically used for projection of geographical maps, terrain situations, floor plans, etc. The inclined projection plane is made of a purposely selected glass positioned under the angle of 45 degrees. Therefore, projection on it results in a kind of holographic effect since produces a three-dimensional visual impression. Fig. 2 shows an example of this device, that is a technical solution by the ARhiMedia group as a result of an earlier project performed by the ARhiMedia group at the Faculty of Electronic Engineering in Niš, Serbia.

Combining simultaneous projections on two planes, after providing a proper time synchronisation of the projection contents, produces a more immersive impression than the classical projections on a single plane. Further, an efficient manipulation with the holographic effect when projecting 3D models with a properly selected background image results in impressive experience for the visitor. For instance, assume that we are projecting on the horizontal plane a geographic map or an aerial image or video of a terrain.

Fig. 2. Inclined projection plane device (IPPD) with two projection planes (Photo by R S. Stanković).

At the inclined plane, we want to project 3D models of some buildings or other constructions. A proper adjusting of the distance between the horizontal plane and the bottom edge of the inclined plane, with a suitable spatial position of 3D models at the projection screen, results in an impression that 3D objects are positioned at the exact geographical locations. The visual effect is usually more impressive than any 2D projection.

From the technical point of view, this projection device is realised such that the projection starts when triggered by an observer. In practice, the observer should press a dedicated and clearly marked button, or step on a corresponding triggering device, or when the visitor approach to a certain predefined distance as determined by a sonar device built-in and powered by the projection system implemented in the IPPD.

3. The touch screen-projector system enables projection of various contents where a particular topic out of a few offered is selected on the touch screen by the desire of a visitor, depending on his personal interest, previous knowledge, available time for the visit, etc. Projection of the selected video content at the purposely positioned projection plane usually of large dimensions, or directly at the wall of the fortress, usually produces a visually impressive effect. Besides possibility of selecting various video records devoted to different subjects to be projected, another possibility is possibly particularly interesting for children and younger visitors. The idea is to project the basic contour or outline of the fortress, or certain object within it, and then allow the visitor to draw the remaining and missing parts as he imagines them, and then possibly colour. Some other interaction scenario is of course possible. The first to come in the context of fortresses is a computer game-like fight with imaginary invaders of the fortress.

4. Mesh screen projection enables producing large scale image with holographic effect resulting in an immersive experience. It assumes projection on a projection mesh by a relatively powerful projector.

Fig. 3 is a photo taken during a mesh-based projection in the castle in Saint-Germain-en-Laye, France.

Fig. 4 shows the position of mesh for projection and illustrates the level of light required.

Fig. 3. Example of visual effect produced by a mesh projection in the exhibition at the castle of Saint-Germain-en-Laye (Photo by R. S. Stanković).

Fig. 4. Illustration of the position of mesh for a mesh projection and lighting conditions required (Photo by R. S. Stanković).

4 Presentation Solutions

In this section, we present scenarios for presentation of historical heritage of fortresses in Classes 1 and 2. We assume that each of the considered fortresses is described as an item in the e-guide. In other words, this element of the proposed information technology-based solution is provided. Therefore, we present other aspects of the possible fortress presentation scenarios.

4.1 Fortresses in Class 1

In this case, the application of projection systems is rather restricted, since such fortresses are usually at distant and isolate places, without many possibilities to connection to the electrical power network. In this situation, we propose installation of an interactive info-table with selected contents. The interaction of the visitor with the table is performed by the e-guide. In the experience of ARhiMedia group, although limited, most convenient dimensions of the table are 200 x150 cm, mounted on the 100 cm support, so that the contents on the table can be easily accessed by the camera of the mobile device. Typically, the background of the table is the map of the terrain with the aero-photographic view to the fortress. Important objects are depicted and labelled by short titles or illustrated by pictograms resembling the purpose of the objects. For instance, main gate, visitor room, military barracks, fortification tower, cannon platform, arsenal for arms and weapons, etc.

Interaction with the table is enabled either by QR codes leading to the specified web pages for visitors in Category 2, or it is much wider through a purposely developed e-guide for visitors in Category 1. In this case, AR module is used to recognize predefined images and project the related information on the screen of the mobile device. Usually, particularly interesting are interactive 3D models reconstructing the missing parts of the fortress. Term interactive refers to the possibility to zoom the 3D model and rotate it so that the object can be observed from different angles.

The above presentation related to info-tables is illustrated by photos from the archaeological sites from the Roman times, since we do not have at our disposal corresponding photos related to medieval fortresses. In the best knowledge of authors, with possibly a few exceptions of which we are not informed, establishing such tables for medieval fortresses in Serbia is a task still to be realized.

Fig. 5. a) The interactive info-table at Timacum Minus in Ravna near Knjaževac, Serbia (photo by Ivan Ivanović), and **b)** The info-table and QR-codes at the archaeological site Timacum Minus in Ravna near Knjaževac, Serbia, providing details about a villa from Roman times.

Fig. 5. a) illustrates the proposed table on the example of an installation at the archaeological site Timacum Minus for the Museum of Knjaževac, Serbia. In this case, AR module is used to project the 3D model of this Roman fortification after recognizing its floor plan shown on the table.

Fig. 5. b) shows an interactive table providing information about a particular point of interest at the archaeological site Timacum Minus in Ravna near Knjaževac.

4.2 Fortresses in Class 2

In this case, the possibilities for application of information technologies-based solutions are much wider. For presenting a complete proposal, we assume that there are four spaces suitable for installation of projection devices. As a typical example, we point out the Fortress Momčilov grad in the city of Pirot, Serbia, consisting of four towers within the protection walls. A similar example is the Fortress in Golubac, Serbia, having 8 towers, with four of them relatively easily accessible for visitors. These fortresses were relatively recently reconstructed and completely opened to visitors. In the case of Golubac, there is in addition a visitor center offering plenty of possibilities for application of information technologies in presenting historical and cultural heritage of this fortress. Another example to be mentioned is the recently renovated Fortress of Ram.

By accepting such a configuration of a fortress to be presented, a possible solution can be realized as follows. It is assumed that the presentation consists of the information about

1. The main person that initiated building of the fortress,
2. Important events from history of the fortress, mainly battles, attacks, etc.,
3. Everyday life in the fortress,
4. Believes, legends, and myths related to the fortress.

Projections in four towers will be organized and devoted to presentation of these topics. To provide first and overall information about the fortress to the visitor, on the passage to the towers, a timeline will be placed on the wall as a printed table with significant events and the years of their occurrence written on it. The timeline is made as a horizontally placed board 30 cm high and long 2.5 - 3 m, or more, depending on the available space on the wall and the number of events that will be presented. The visitor can read about important events arranged and described chronologically along the timeline. For a more detailed information on some of the events, beyond this written at the timeline, two to four or more tablet PCs are attached to the board. At their screens, projected are dates and names of important historical events from the history of the Fortress. By choosing a year or an event, the visitor receives additional information about it on the screen of the tablet. The information is in the form of text, audio, and video recordings, and when it comes to construction objects or objects for everyday use, such as buildings and tools or weapons, furniture, kitchen utensils, clothes, etc., interactive 3D models are also displayed. Interaction refers to the ability to rotate the 3D model for viewing it from different angles, and the ability to zoom the image either continuously (pitch zoom) or discretely via marked symbols.

After providing this introductory information about the Fortress, more detailed and visually attractive presentation is installed in the towers.

As there are four towers in the Fortress, one projection system would be installed in each of them. In order to achieve a more immersive impression, the best suited systems are chosen depending on the content that will be projected.

Tower 1. In one of the rooms of this tower, where there is a possibility of partial darkening, a projection mesh with a standard height of 2 *m* will be installed, and the length will be determined by the available space. An especially recorded video with an actor in the role of the first ruler of the Fortress, is projected on the mesh via a projector. The text spoken by the actor explaining the historical background and related issues would be appropriately written based on historical documents and adapted to the purpose by engaging a playwriter.

Tower 2. This tower would have a IPPD where on the horizontal plane it will be projected the geographical map of the terrain around the Fortress and the floorplan of it. A 3D model of the Fortress is projected on the inclined projection plane with a holographic effect. Time synchronization and arrangement of these two simultaneous projections contribute to a more complete and immersive impression of the viewer. The content of the projection and the choice of the 3D model is purposefully determined. The idea is to present the configuration of the Fortress and explain organization and purpose of each construction in it. It could be also explained the position and movement of guards in charge for defending the fortress.

Tower 3. A specially selected projection film for background projection will be installed in the tower. This film is glued to a transparent Plexiglas background secured with specially designed holders that allow precise adjustment of the board's position in portrait format, with dimensions of 150 x 200 cm. Around the foil, it will be prepared a wooden construction resembling the door frame, creating impressions that the visitor is viewing the interior of a room.

The foil will be placed in the corner of the room diagonally, so that the projector from which the video is projected is in the corner of the room behind the board with the foil. The video will be specially recorded with the involvement of actors and playwriters, and the content of the projection will be determined based on historical documents about the history of the Fortress.

Tower 4. A projection system consisting of a touch screen connected to a projector will be installed in this tower. The screen is placed in a specially designed stand in compliance with the ergonomic recommendations for positioning such devices. Several points are projected on the screen, in practice this means classic icons for computer applications, which are divided into two groups according to the content they refer to. The first group consists of points related to the history of the Fortress, while the second group refers to the myths and legends of this region. By choosing a certain point, the user starts the projection through the projector on the wall opposite to the position of the stand with the touch screen. The projection is of large dimensions, depending on the available space, and leaves a striking impression.

5   Conclusions

Medieval fortresses are a substantial part of national historical heritage of Serbia. A proper presentation of them highlighting historical backgrounds and explaining their importance in the time when fortresses were build is an important task, since it can considerably contribute to the present touristic offer.

Information technologies can be efficiently used in representation of historical heritage related to medieval fortresses. We propose a scenario for such applications based on a software application for mobile devices and various presentation installations by using different projection devices. The proposed scenario is based on a few distinct presentation modules and can be easily adapted to different circumstances and various situations at the fortresses to be presented, as well as diverse contents that can be offered to visitors.

Acknowledgements.

References

Bosnić, D. (2021). *Stari gradovi Srbije* [Old Towns of Serbia], IK Prometej. (in Serbian).

Deroko, A. (1950). *Srednjevekovni gradovi u Srbiji, Crnoj Gori i Makedoniji* [Medieval Cities in Serbia, Montenegro, and Macedonia]. Prosveta. (in Serbian).

Dingarac, S. (2018). *Project Fortresses of Serbia. Visual presentation of fortresses and old towns on the territory of Serbia*. https://tvrdjave.rs/mapa/

Djidić, P. (2009). *Tvrđave i ostaci utvrđenih gradova* [Fortresses and Remaining of Fortified Towns]. JP Beogradska tvrdjava. (in Serbian).

Stojkovski, B. (2019). *Tvrđave Srbije: fortifikacije, društvene i vojne strukture* [Fortresses of Serbia, Fortification, Social and Military Structures]. Data Status. (in Serbian).

Vuković, V., Pihler, V., Lazović, M., & Ercegan, S. (2017). *Fortresses on Danube* (2nd ed.). IK Prometej.