

MOBILE EXPLORING OF BULGARIAN CULTURAL AND SCIENTIFIC ASSETS

Zsolt László Márkus, Gábor Kaposi, György Szántó, Tibor Szkaliczki,
Miklós Veres, Zsolt Weisz, Detelin Luchev, Desislava Paneva-Marinova,
Radoslav Pavlov, Lilia Pavlova

ABSTRACT. The paper introduces an ecosystem of digital libraries and mobile applications for presenting Bulgarian cultural and science assets. The digital libraries concerned constitute valuable sources of cultural heritage and related scientific results. They include the Bulgarian Iconographical Digital Library (BIDL), the BellKnow multimedia archive on bells and the web site of the International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage (DIPP). These digital libraries can be accessed online through a Web interface. Due to the spread of mobile devices, there is a need to present the contents through mobile platforms as well. The GUIDE@HAND application family was integrated with the digital libraries for presenting

ACM Computing Classification System (1998): H.2.4, H.2.8, H.3.5, H.3.7, H.5.1, J.5.

Key words: mobile applications, digital library, Bulgarian iconography, cultural heritage, interactive multimedia, GUIDE@HAND Veliko Tarnovo, BOOK@HAND BIDL, INFO@HAND DIPP, BOOK@HAND Bells, interactive games.

the cultural and scientific assets offline in mobile applications. Interactive multimedia components (e. g., games, panorama pictures, maps etc.) make the presentation more attractive. The developed mobile applications facilitate learning, presentation and preservation of cultural and scientific objects.

1. Introduction. More and more new tools are provided currently by information and communications technologies. They have proved to be useful for bringing the cultural and scientific assets closer to the people, for presenting the heritage values in an impressive way, for overcoming cultural and linguistic barriers in acquiring new knowledge and for reaching a broader audience than ever. Mobile devices offer new types of interaction and user experience. Smartphones and tablets provide ubiquitous access to information on cultural and scientific assets, increasing their visibility, assisting the presentation, preservation and exchange of information. This is very important for the presentation of the cultural and historical national wealth, which in its role as an informal educational and educative method has always been open to the latest technological developments as they can interactively enhance interest and facilitate the understanding, evaluation and preservation of this wealth.

The paper presents the joint research and development work of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (IMI—BAS) and the Institute for Computer Science and Control of the Hungarian Academy of Sciences (MTA SZTAKI) for presenting Bulgarian cultural and scientific assets. IMI—BAS is experienced in the development of digital libraries (e. g., Bulgarian Iconographical Digital Library (BIDL), Bulgarian Bells Web-based Archive, etc.). MTA SZTAKI has experience in development of mobile applications. The paper presents the joint efforts of the institutes, integration of the digital libraries with mobile applications, interactive multimedia components applied to present cultural and scientific assets and the mobile applications (GUIDE@HAND Veliko Tarnovo, BOOK@HAND BIDL, INFO@HAND DIPP, BOOK@HAND Bells, etc.) created within the framework of the cooperation.

Several mobile applications are available in application stores for presenting Bulgarian cultural heritage [1]. The main novelty of our work is that the digital libraries and the mobile applications form an ecosystem for

presenting Bulgarian cultural and scientific assets. The presented cultural assets include cultural sights, icons and bells. We also created a scientific knowledge base on cultural and scientific heritage from conference materials.

2. Preliminaries.

2.1. The GUIDE@HAND application family. The eLearning Department of MTA SZTAKI started mobile-based software development in 2005. As a result of this activity, a new mobile application family was created with the brand name of GUIDE@HAND. It consists of more than 50 multilingual offline applications running on smartphones and tablets for providing thematic services [2, 3]. The applications are available on the most widely used mobile platforms (iOS and Android). A permission-based content management system supports the management and publishing of the multimedia contents of the applications. The application offers a variety of services to smart mobile device owners on iOS and Android platforms. The application family serves a wide variety of application areas:

- Tourist guide. GUIDE@HAND is a GPS-based multimedia tourist guide. It is developed so that users can view the new and already known sights, objects and motifs with a fresh perspective during their walks and discover the past and present neighbourhood in an entertaining and adventurous way.
- Event guide. EVENT@HAND provides a unified interface for events (professional, cultural, sport, etc.) on mobile devices in order to inform the participants on the event (event calendar, locations, presenters, etc.).
- Municipality guide. CITY@HAND provides municipal information including the sessions of the local government, the public services, local organisations etc. besides general information and interactive map of the town or village.
- Musician guide. MUSIC@HAND introduces the presenter or the band (text, image, audio and video). It provides an interactive map on the locations of the concerts, recommends events and presents albums, music pieces and lyrics, etc.

- University guide. UNI@HAND is a multilingual complex mobile information service for managing and displaying up-to-date information (teachers, courses, events, etc.) related to the life of students.
- Conference guide. INFO@HAND is an offline mobile application which primarily targets conference participants and scientists interested in the scope and topics of conference series.
- Sport guide. SPORT@HAND introduces sport teams. It provides general information on the team, description of the sportsmen playing in the team, time table containing the schedule of upcoming matches, results, news, etc.
- Book guide. BOOK@HAND presents the content of a book in an electronic form by using maps, image galleries, multimedia content, etc.

Content developers can prepare the content of the applications through a Web-based interface. The content can be synchronised with data bases of web portals for keeping the contents of the applications up-to-date.

The eLearning Department of MTA SZTAKI developed several smartphone applications within the framework of the cooperation with IMI—BAS to present Bulgarian Cultural and Scientific Assets. Detailed description of the applications can be found in Section 7 Applications.

2.2. Digital libraries maintained by IMI—BAS.

2.2.1. Bulgarian Iconographical Digital Library (BIDL). The Bulgarian Iconographical Digital Library (BIDL, available at <http://bidl.math.bas.bg>) was developed by IMI—BAS. The development started more than ten years ago during the national project *Digital Libraries with Multimedia Content and its Application in Bulgarian Cultural Heritage* of IMI—BAS [4] and was supported by several international and national projects. A complete description of the rich BIDL functionality is available in [5, 6, 7, 8].

BIDL is a Web-based environment—a place where iconographical objects of different kinds and origins have been documented, classified and “exhibited” for a wide audience, in particular—for professional researchers and education purposes. The icons included in BIDL are made in the period from

the end of the 12th to the beginning of the 20th century. BIDL presents painted icons and icons built with mosaics from the Bansko–Razlog iconographic art school, Triavna iconographic school, Samokov iconographic school, as well as icons from Veliko Tarnovo, Sozopol, Rila Monastery, Arbanasi, and other places and regions of Bulgaria. They are located in museums, churches, monasteries, and private collections.

Registration, access and exploration services are provided in BIDL for inclusion of a practically unlimited amount of Orthodox iconographical artefacts and knowledge. Interactive preview, complex object search, selection, and grouping supports users dealing with the rich knowledge database. BIDL follows the recommendations of the international group of museum experts of East-Christian Art (UNESCO/I.DB.I) and the standards of CIDOC/MICMO in organisation of media databases, in representation and description of digital objects, and the classification of artefacts. Special meta-descriptions are created for each object and collection and include data: “title”, “artist”, “period” in years and centuries, “iconographic school”, “dimensions”—width/height/thickness, “technique”, “base material”—type of wood, ground coat, etc., “category”, “location”, “author”—biographic data, “comments”—features of the icons such as state, previous restorations, signatures, etc. BIDL explores this information as well as the keywords, links between digital objects and collections, etc. for semantic annotation and indexing of digital objects and for facilitation of their locating during search requests and presentation on the web-based platform. According to their topics, as results of searching, grouping, etc. the users can make, keep and share the digital objects into thematic collections made by themselves [9, 10].

In order to make information on Bulgarian icons accessible in off-line mode on mobile devices, BIDL was integrated first with the GUIDE@HAND Veliko Tarnovo mobile application [10, 11] developed by MTA SZTAKI. Later, a standalone BOOK@HAND BIDL mobile application was created for presenting BIDL.

2.2.2. Bulgarian bells web-based archive. The web-based archive of Bulgarian bells (BellKnow archive) was developed by IMI—BAS within the framework of the project “Research and Identification of Valuable Bells of the

Historic and Culture Heritage of Bulgaria and Development of Audio and Video Archive with Advanced Technologies” (BELL). Studying and identifying several dozens of the most valuable bells in Bulgarian churches and monasteries, and developing an audio archive (based on advanced technologies) for their analysis, reservation and audio data protection, was the aim of this project. As a result, Bulgarian bells are analysed, documented, selected and exhibited (over 3,000 digital resources—photos, video clips, audio recordings, diagrams etc.) in a Web-based environment [12, 13, 14].

The Bulgarian bells digital archive contains: the bells’ characteristics: type, form, material, geometric size, weight, design, state, characteristics of chime, decorative and artistic scheme, estimation of the historical value, data about the producer and owner of the bell; video recordings and digital photos of the ringing bells; bells frequency spectrum during a stroke and after transitive process; charts representing acoustic characteristics: sound stream, sound fade by time, sound pressure; etc.

Based on the ontological-based knowledge on the bell object, functionality modules are created for: metadata and semantic descriptions of digital resources; optimization and automation of their input; search optimization in semantic descriptions of digital resources and metadata content; digital resources comparison collating the records of different media types; presentation of digital resources and objects with their semantic and meta descriptions. The embedded functionality includes basic activities such as creating, presenting, searching and grouping objects and information content. A supplement of glossary of terms in the specific subject area is created and it overlaps the ontological substructure and uses its semantic annotations.

The Bulgarian web-based archive of bells includes: name of object (Title); name of subject who digitised it (Creator); additional data (Description); date of creation (Date); type of media (Type); file format and parameters (Format); geographic coordinates (Identifier); owner of property rights (Rights), etc. The prepared passport of a bell summarizes all the information gathered about the object (technical data, historical reference, photographs, charts and research done in the electronic version of the passport, multimedia files, etc.) [15].

2.3. Joint projects. IMI—BAS and MTA SZTAKI have had an intensive co-operation for many decades as academic institutions. A joint bilateral academic cooperation project of IMI—BAS and MTA SZTAKI entitled “Development of Software Systems for Multimedia and Language Technologies” was performed within the integration framework. Some applications were created within the GUIDE@HAND family as a result of the cooperation: the tourist guide GUIDE@HAND Veliko Tarnovo (contains a demo guided tour in the village of Arbanasi), GUIDE@HAND DIPP 2013 and 2014, INFO@HAND DIPP 2015 and 2016, etc. The Bulgarian Iconographical Digital Library (BIDL) tourist guide has been integrated with the GUIDE@HAND mobile application. This integration made it possible to explore the digital iconographical collections marked with QR codes on mobile devices using the GUIDE@HAND tourist guide.

3. Integrating the digital libraries of IMI—BAS with GUIDE@HAND application family. QR codes are one of the most commonly used techniques for quick content download to mobile devices. Extended QR code services for exploring and learning of art are maintained by the GUIDE@HAND mobile application. The integration opened new ways to present the information of IMI—BAS digital libraries for cultural and scientific heritage through the GUIDE@HAND mobile application. QR codes are used in the Bulgarian Iconographical Digital Library (BIDL)—GUIDE@HAND integration for marking digital iconographical collections stored in BIDL and for sharing them as virtual exhibitions on mobile devices.

Several issues were considered and appropriate services were created during the BIDL-GUIDE@HAND integration. The BIDL content editor tool allows users to create personalised collections of selected iconographical objects and to save, edit, or delete these collections. Each collection gets a unique QR code, which can be used to generate an export package. The generated zip file is stored on the BIDL server and can be read by the GUIDE@HAND mobile application. This QR code can be read by GUIDE@HAND and it is recognized as a BIDL QR code. The mobile application downloads the zip file. The downloaded collections are stored and managed locally and the downloaded

icons and the related descriptions can be presented in GUIDE@HAND mobile application (see [16] for more information on the integration).

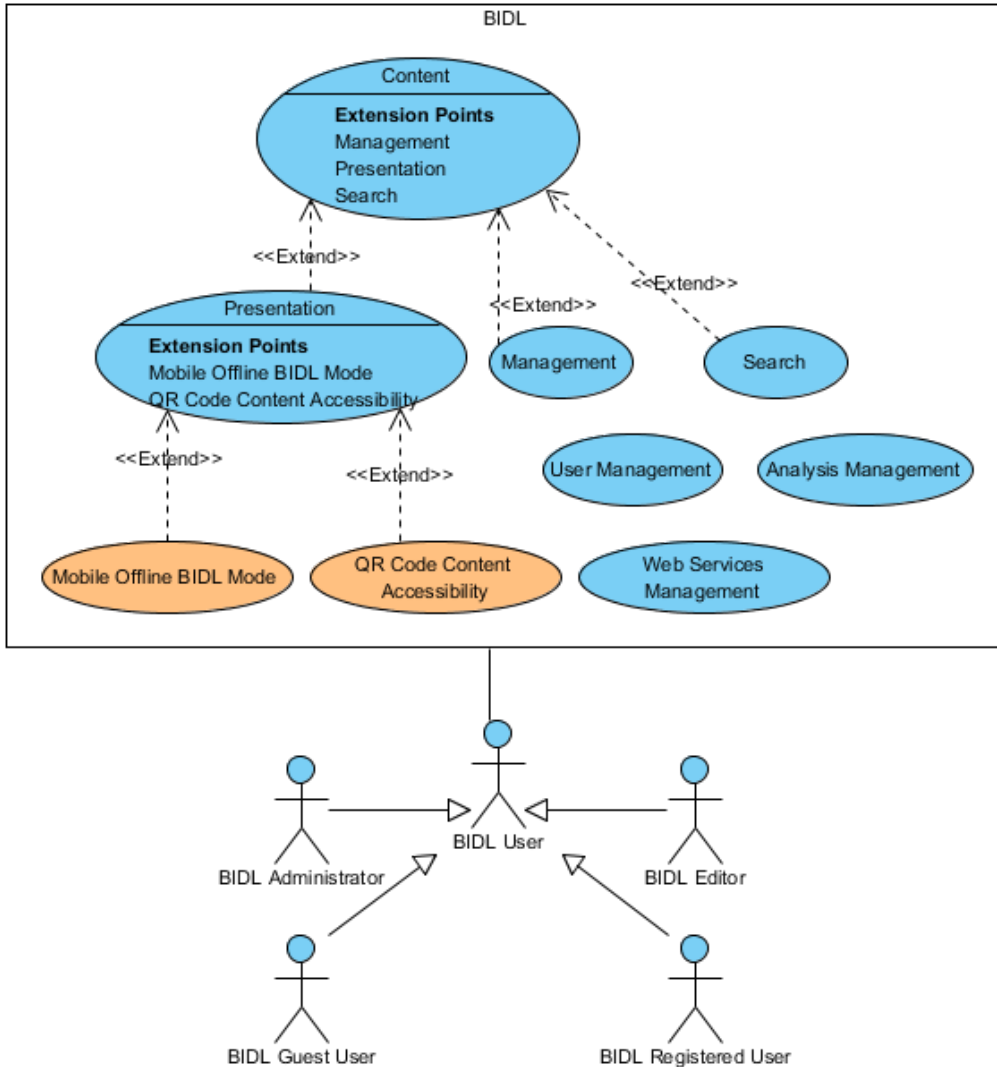


Fig. 1. UML Use Case Diagram

Fig. 1 depicts a UML Use Case Diagram of new services and new functionalities for QR code maintenance and mobile offline BIDL Mode that are created. Two new extension points for the presentation layer of BIDL were

defined: offline mobile mode for BIDL collections and content accessibility trough QR codes for all the BIDL collections. The following main features are implemented: QR code generation, which implements the content accessibility trough QR codes, and generation of offline archives (according to the GUIDE@HAND specifications), implementing the offline mobile mode for BIDL collections. The BIDL presentation layer was extended with two new mobile templates and functionality for automatic bulk creation of web content, based on the mobile templates and the collections data. The mobile templates – one as master page for a collection, and the other as a detailed view of a certain object – have been created.

Fig. 2 shows the current BIDL design architecture extension (classes in orange present the new features). There is:

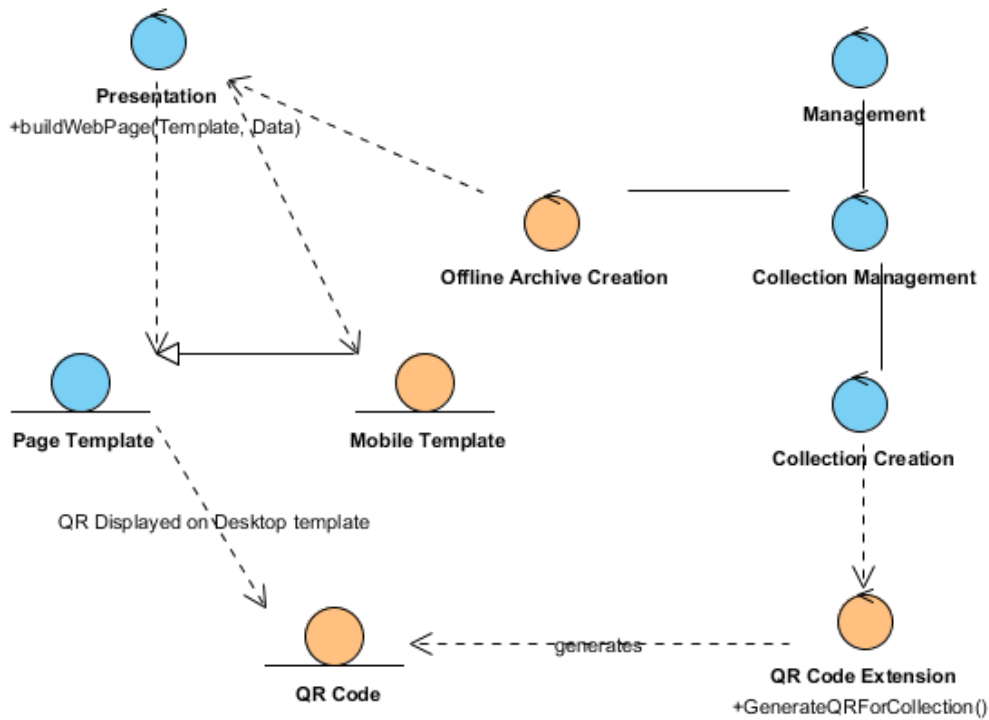


Fig. 2. Design Class Diagram

- a controller responsible for the offline archive creation extending the Collection Management and Presentation services;

- a controller for generation of QR codes (which extends the Collection creation service).

The main newly developed entities are the mobile templates and the generated QR codes.

The following picture (Fig. 3) depicts the QR code accessibility point from the BIDL desktop mode web page (an example of an icon collection from the Regional History Museum in Veliko Tarnovo).

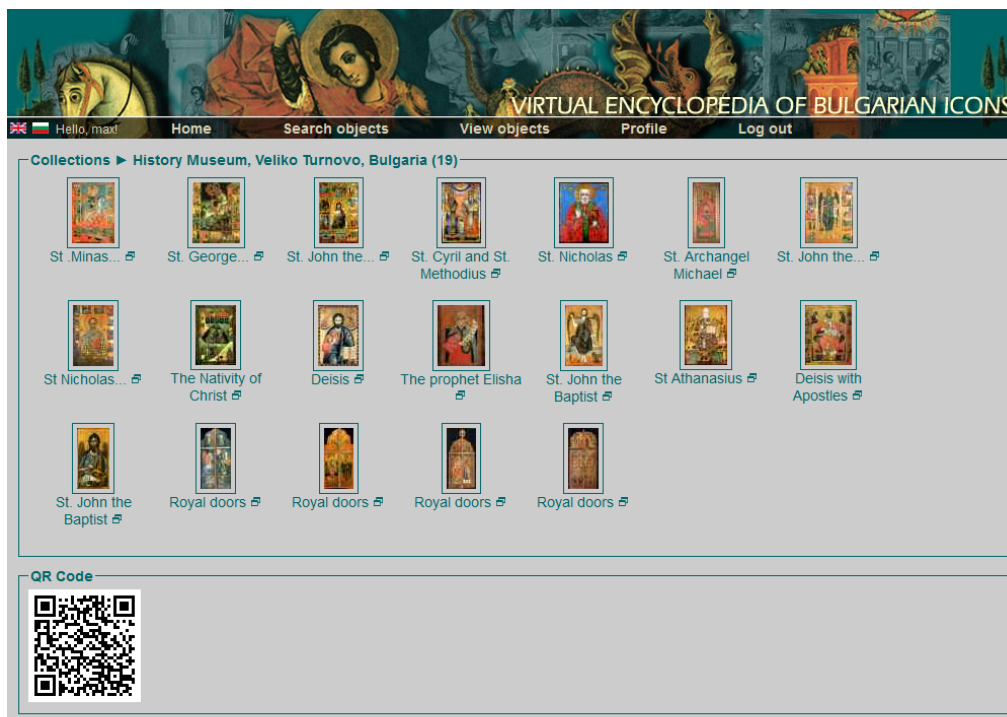


Fig. 3. Collection of icons from Regional History Museum in Veliko Tarnovo

For supporting the creation of QR codes for the existing collections in BIDL, a migration process was developed. The creation of offline archives was developed as a real-time process. In this process, the collection archive is built every time a mobile request is made with the help of the QR code. The purpose of this real-time archive creation is to preserve the content dynamics,

because the BIDL collections are not static and do not depend on the sets of selected objects, but on the characteristics of objects.

The created archives have the following structure:

- index.html (the master page for a collection)
- collection_name.txt (metadata for the collection, currently contains only the name of the collection)
- bidl.css (cascading style sheet for the presentation of the mobile page)
- bidl.js (custom JavaScript code)
- jquery.js (jQuery code for reusing common JavaScript functionality)
- page_1.html (detailed view of an object)
- page_2.html
- page_....html
- Images/ (folder containing the objects images; the images are watermarked)
- Images/1-view.jpg (the big one for the detailed view of the object)
- Images/1-thumb.jpg (and the smallest for the master page of the collection)
- Images/2-view.jpg
- Images/2-thumb.jpg
- Images/...-view.jpg
- Images/...-thumb.jpg

The functionality for creating QR codes immediately after creating a collection is implemented in the QR Code Extension.

4. Interactive multimedia.

4.1. Panorama pictures. Interactive panorama pictures can be used to present both indoor and outdoor sights. They can be created not only from photos of a real sight but in a virtual environment as well. MTA SZTAKI applied virtual panorama pictures to present collections of Bulgarian icons on mobile devices. The virtual panorama displays the icons of the collection positioned around a virtual exhibition room (Fig. 4). The screen displays only a segment of the virtual room while the user looks around in the virtual room. The icons in the panorama view can be zoomed and selected. After selection, detailed information about the icons is presented.



Fig. 4. Panorama view in landscape mode

The virtual panorama is generated on the device from the collection of icons and the background. There is no theoretical limit on the number of icons presented. There are two methods for presenting virtual panoramas in the application:

- Automatic mode. The view on the panorama can be moved by using the mobile device's motion sensors (Fig. 5a). The visible segment in the virtual room is shifted when you turn the smartphone. The automatic mode provides a realistic impression. Our experience is that the speed of the movement of the icons on the screen can be too low or too high as the user turns around if the number of presented icons goes below 6 or above 12, respectively.
- Manual mode. The view on the panorama can be directly moved by hand (Fig. 5b). This is the only option if the mobile device has no motion sensors.

4.2. Gamification. Because of integration in the web-based digital libraries and mobile application, several interactive games are developed to deepen the users' knowledge for Bulgarian icons. Each game has a question pool of all the BIDL objects and can be maintained by the Game Administrator. During the game, some of the questions/answers are randomly selected from the pool.

The application contains the following games:

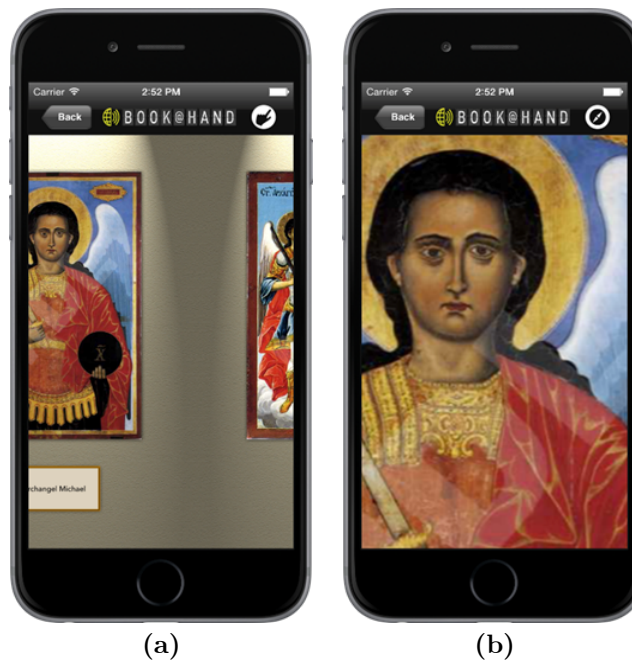


Fig. 5. Panorama views in Automatic and Manual mode

- Ordering — In the beginning, the names and locations of some icons are presented in random order. The gamer must arrange them in chronological order (Fig. 6).
- Blind map — The provinces of Bulgaria are presented on a blind map without their names. The user must find the source location of a series of selected icons (Fig. 7).
- Memory game — Twelve cards, half of them containing the pictures of icons and the other half their titles, are located in a grid. At the beginning of the game, the cards are face down. The gamer can flip face up two cards in each turn. The objective of the game is to find and remember the places of matching pictures and titles and turn over pairs (Fig. 8).

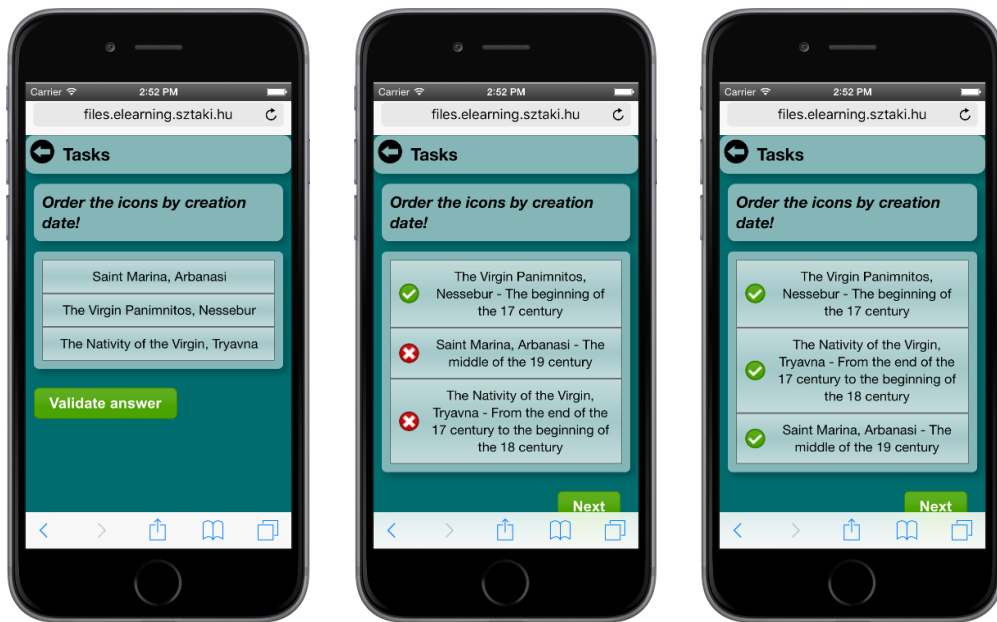


Fig. 6. Ordering game

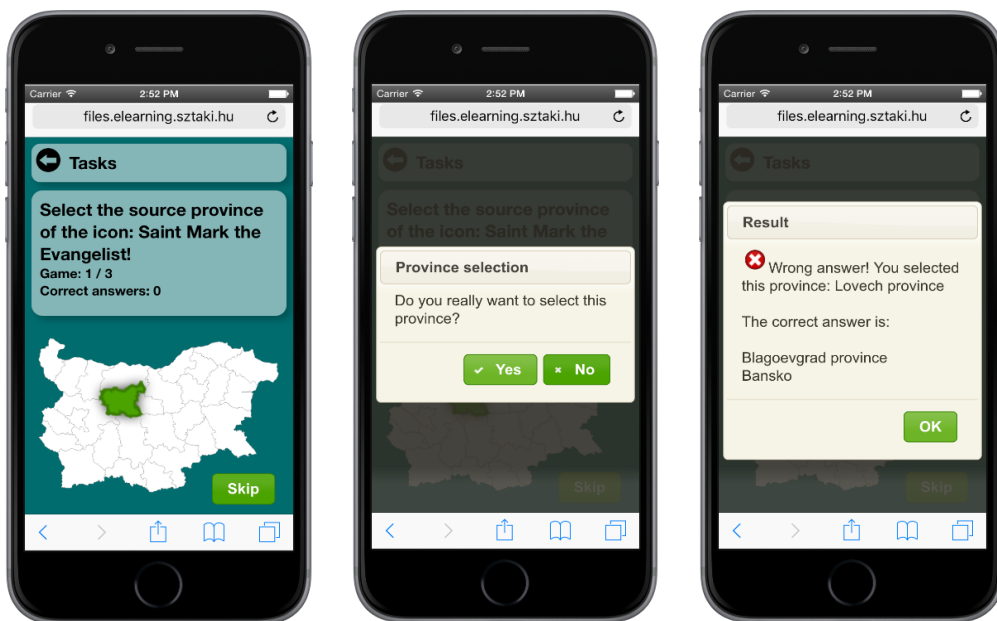


Fig. 7. Blind map

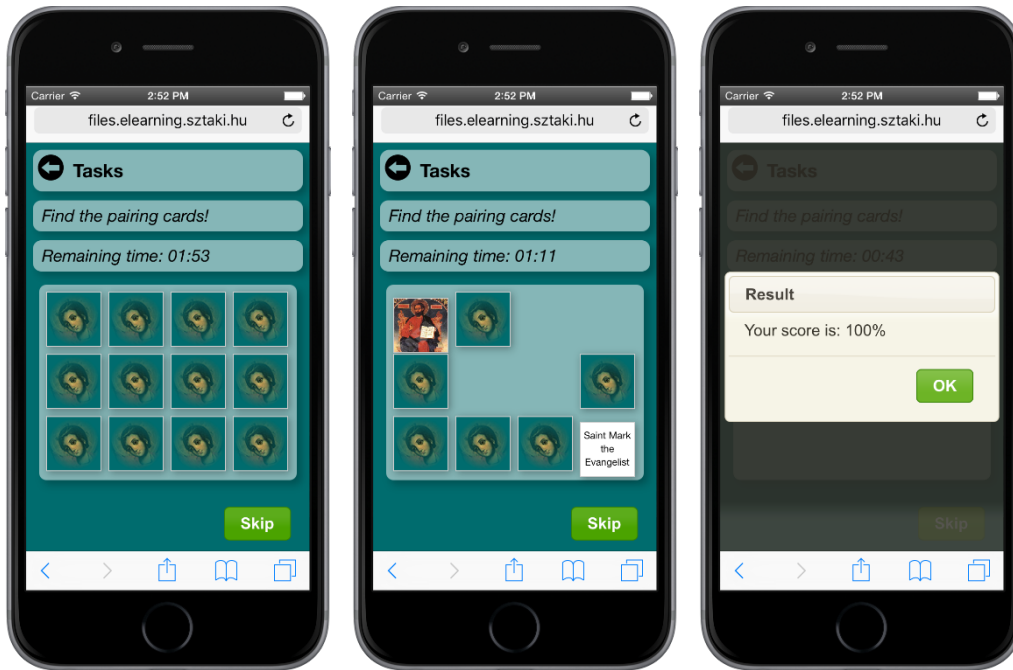


Fig. 8. Memory game

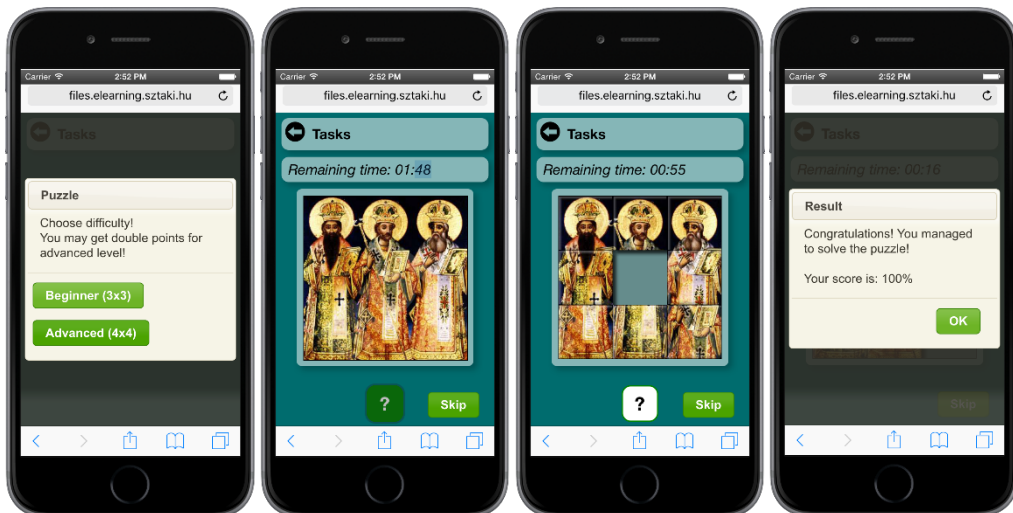


Fig. 9. 3x3 sliding puzzle

- Sliding puzzle — The image of an icon is divided into square tiles. Initially, the tiles are arranged in random order and there is one empty place. The user can move a tile to an adjacent empty place. The user wins the game if the tiles are moved to their original position and the picture is restored. The two difficulty levels of the puzzle contain 3×3 and 4×4 tiles (Fig. 9).

The interactive games can run on the Web or offline on mobile platforms (Android, iOS). MTA SZTAKI has been applying Flash technology under Web and Android platforms for many years. However, the iOS platform does not support the application of the technology at all. For this reason, MTA SZTAKI replaced Flash with HTML5 in all eLearning and smartphone developments [17, 18]. HTML5 together with CSS3 technology was successfully applied in multiplatform game development.

5. Applications. This section introduces the mobile applications developed in cooperation between IMI—BAS and MTA SZTAKI. The applications present valuable Bulgarian cultural and scientific assets. Four mobile applications were developed within the framework of the cooperation:

- GUIDE@HAND Veliko Tarnovo;
- BOOK@HAND BIDL (Bulgarian Iconographical Digital Library);
- INFO@HAND DIPP (International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage);
- BOOK@HAND Bells.

5.1. GUIDE@HAND Veliko Tarnovo. Veliko Tarnovo is one of the most significant towns in the history of Bulgaria. It served as capital of medieval Bulgaria for more than two centuries and the first National Assembly of Bulgaria convened there after the end of Ottoman rule. The GUIDE@HAND Veliko Tarnovo mobile application helps tourists discover the city with an interactive offline map, detailed description of sights, guided tours, event recommender, audio narration, etc. (Fig. 10). The application is available in Bulgarian and English.



Fig. 10. Screenshots from GUIDE@HAND Veliko Tarnovo

GUIDE@HAND Veliko Tarnovo contains the following main menu items:

- The *Taster* function presents some selected Points of Interest (POIs) (Church of the Nativity, Konstantsaliev's House and an introduction of the town itself) in order to provide a first impression about the application and the content.
- The *Walks* function contains a demo guided tour in the National architectural Reserve Arbanasi. The walk helps tourists discover Arbanasi with turn-by-turn navigation, guiding them from one interesting sight to the next. The tourists are provided with the relevant information (detailed description, pictures and audio records, etc.) at the right place.
- The *Places* function present some famous sights in the city.

- The *Moments* function can be used by users to record experiences. The program can automatically track the route of the user. At any point, visitors can grab and store an experience by taking a picture, recording a voice memo or taking a note.
- The *How to use* function explains the use of the mobile application by using voice explanations illustrated with a sequence of screenshots.
- The *Explore* function can be used by visitors for exploring the sights alone: whenever the tourists approach a point of interest their device will automatically provide them with basic relevant information.
- The *Events* function can be used for recommending events to tourists in the town.
- The *More* function contains general setting options such as selecting language, updating, map manager, scanning QR codes, etc.

5.2. BOOK@HAND BIDL. The aim of the BOOK@HAND DIPP mobile application is to provide the content of the Bulgarian Iconographical Digital Library offline on smartphones and tablets (Fig. 11) [16, 19, 20]. It can be used to present user-generated collections in a list form or as virtual panorama pictures. The application is available in two languages (Bulgarian and English).

BOOK@HAND BIDL contains the following main menu items:

- The *BIDL* function provides a general description of the digital library.
- The *Icons* function presents icons from the digital library.
- The *Download* function can be used to download collections from the BIDL Web page by using QR codes.
- The downloaded collections can be presented by using the *Collection* function.

The *Settings* function contains general setting options such as selecting language, updating the application and the content, etc.

The *BIDL* functions contain an introduction to the Bulgarian Iconographical Digital Library (Fig. 12) and a link to the home page of BIDL.

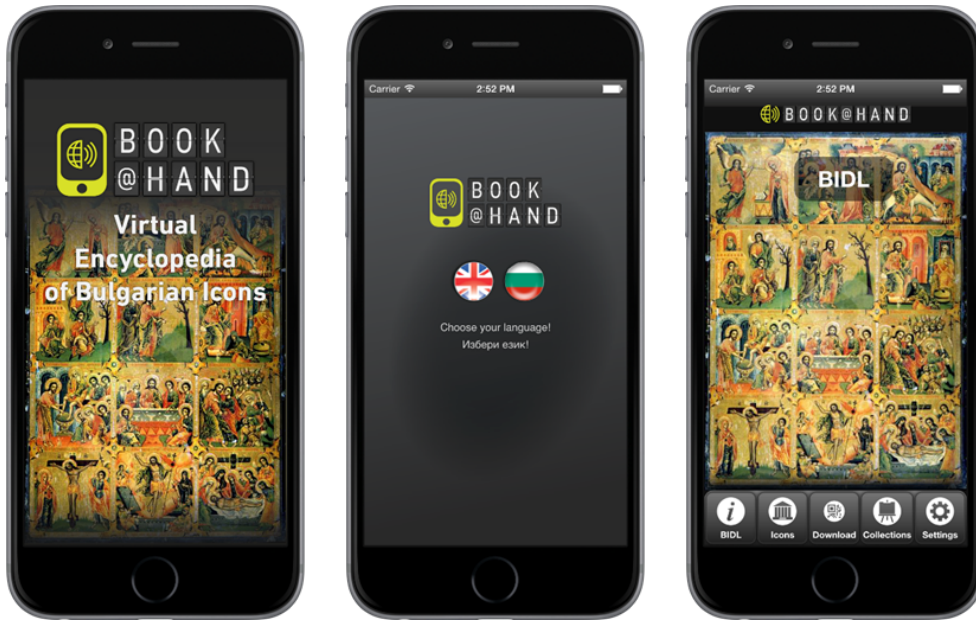


Fig. 11. Opening screenshots from BOOK@HAND BIDL

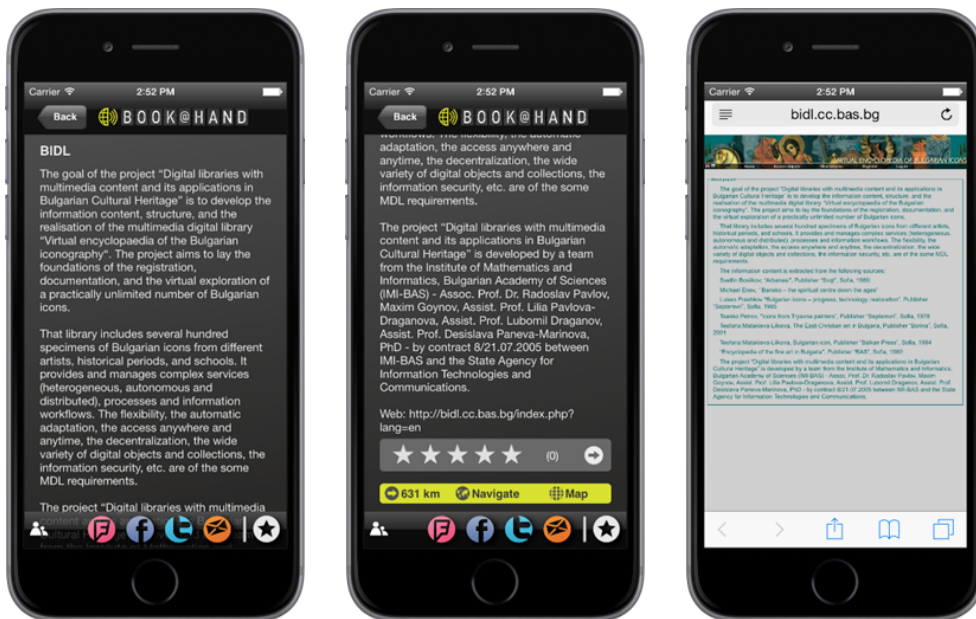


Fig. 12. Screenshots from function BIDL and the BIDL Web site



Fig. 13. Screenshots from the function Icons



Fig. 14. Screenshot from the function Download

If the device is online the Web site can be opened in an external browser by clicking on the link.

The *Icons* function presents some sample icons from BIDL (Fig. 13). The list of the icons contains title, type and thumbnail. The page of a selected icon consists of the picture of the icon, type, period of the origin, name of the author, dimensions, current location, source location, iconographical technique, etc. Interactive games related to the icons (see Section 4.2) can be accessed from this function.

The user can download own collections consisting of icons from BIDL by using the *Download* function (Fig. 14). Details on creating collections on the BIDL Web page can be found in Section 3.

The application uses a built-in QR code reader to scan the QR code of the selected collection on the Web site. The QR code contains a URL pointing to the package consisting of the icons in the collection. After scanning the code, the content package is downloaded from the BIDL web server and becomes available under the Icons function.

The user can find the downloaded collections offline under the *Collection* function (Fig. 15). The function lists the titles of collections. The icons in a selected collection can be presented to the user in list view and panorama view. For panorama view, see Section 4.1.

The list view displays a list containing thumbnails and titles of the icons belonging to the collection (Fig. 16). When an icon is selected from the list, its picture and detailed data sheet are presented to the user.

The *Settings* function contains general setting options such as changing language, updating the application and the content, connecting to a 3G network, displaying an *About* screen containing general information on the application, etc. (Fig. 17).

5.3. INFO@HAND DIPP. The International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage (DiPP) has been organised annually since 2011 by IMI—BAS under the patronage of UNESCO. The INFO@HAND DIPP mobile application provides information for participants about the DiPP conference series [21, 22] (Fig. 18).

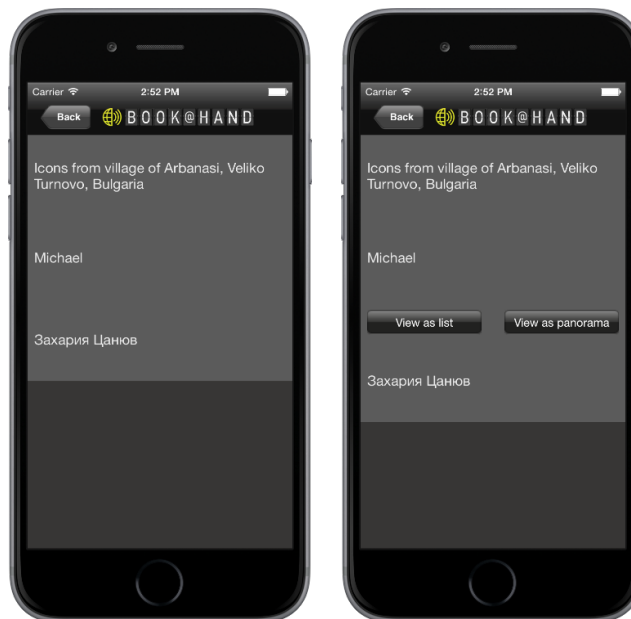


Fig. 15. Screenshots from the function Collection

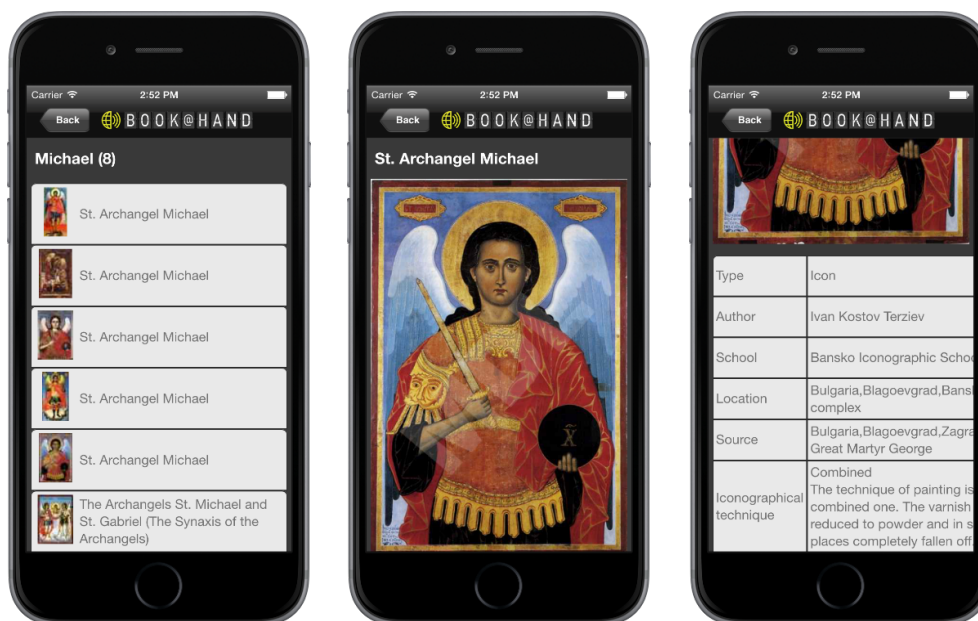


Fig. 16. List view and detailed description of an icon

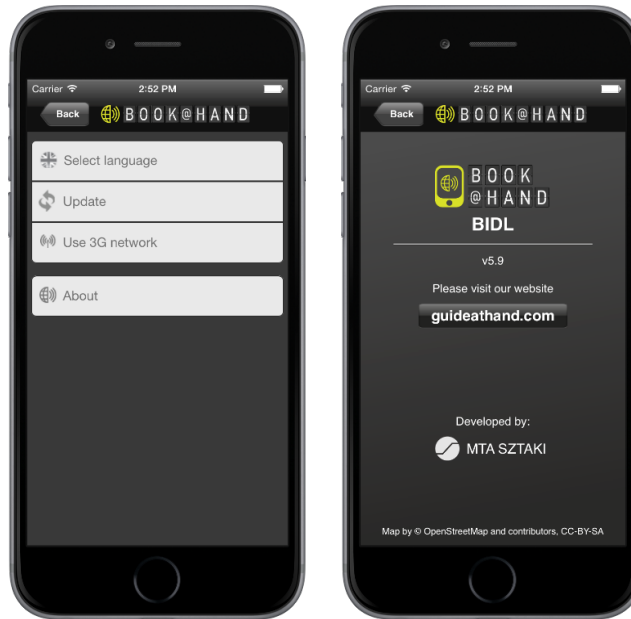


Fig. 17. Screenshots from the function Settings



Fig. 18. Screenshots from INFO@HAND DIPP

The INFO@HAND offline mobile applications primarily target conference participants and scientists interested in the scope and topics of conference series. The offline application is more than a conference guide because it can also present the conference materials (papers and information on presenters) of the preceding years, thus constituting a scientific knowledge base. The main features of the application include:

- The *Organizers* function introduces the conference organisers, including the organising institutions, sponsors, committees, etc.
- The *Presenters* function provides detailed information (name, picture, affiliation, job title, biography, contact information, etc.) of the speakers of the latest and the preceding conferences.
- The *Program* function shows the important dates and events related to the conference and the conference schedule.
- The *Map* function presents an interactive map of the conference venue.
- The *DIPP* function presents general information on the conferences.
- The *Papers* function presents the abstracts of all papers and links to the final versions of the papers. If the device is online the full papers can be downloaded by using the link to the mobile device from the Central and Eastern European Online Library (CEEOL) [23] after their publication.
- The *Places* function presents locations related to the latest conference.
- The *More* function contains general setting options such as changing language, selecting online or offline map, update, etc.

5.4. BOOK@HAND Bells. BOOK@HAND Bells presents offline the information in the BellKnow archive (Fig. 19). The application is available in Bulgarian and English. It is the most recent development and has not been published yet.

BOOK@HAND Bells contains the following main menu items:

- The *Places* function presents the locations (churches, monasteries and museums) of the bells.



Fig. 19. Opening screenshot from BOOK@HAND Bells

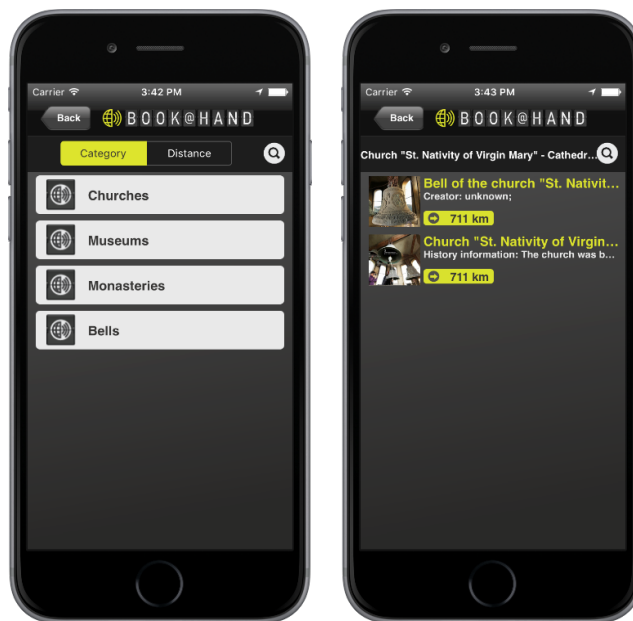


Fig. 20. Screenshot from the function Places

- The *Bells* function introduces the bells themselves. The detailed information on the bells includes description, data sheet, photos, acoustic characteristics, etc.
- The *Explore* function presents an interactive map with the locations of the bells.
- The *More* function contains general setting options such as changing language, selecting online or offline map, update, etc.
- The *Places* function contains a list of locations where the bells are found (Fig. 20). The places are grouped into categories (churches, monasteries, museums) and the list of the places can be sorted by their distance from the current location of the user. A list belongs to each place where the first item contains general information on it and the further items refer to the bells located there. The general information includes the description, photos and an introduction to the history of the place. The place can be presented on an interactive map as well and the route from the current location of the user to the place can be planned.

The *Bells* function contains the searchable list of all bells (Fig. 21). The list contains the thumbnails of the pictures of the bells, their IDs, locations and distances from the current location. After selecting a bell from the list, detailed multimedia information is presented to the user including a textual description, photos, videos, sound, diagrams on acoustic characteristics, data sheet including type, material, weight, height, diameter, location, date of creation, creator, etc. Six types of acoustic diagrams can be shown: waveform, spectral plot, spectrogram, 3D spectrogram, partials and pitches.

The *Explore* function shows an interactive map with the locations of the bells. Either online or offline maps can be presented. Offline maps save Internet access costs. If an online map is used, less storage is used on the mobile device. The interactive map shows the current location of the user and the places of the bells. The pictogram denoting the location of a bell can be selected. After selection, a panel is displayed on the map with the name and short description of the bell. The panel can be selected also. In this case, detailed full screen information is presented.

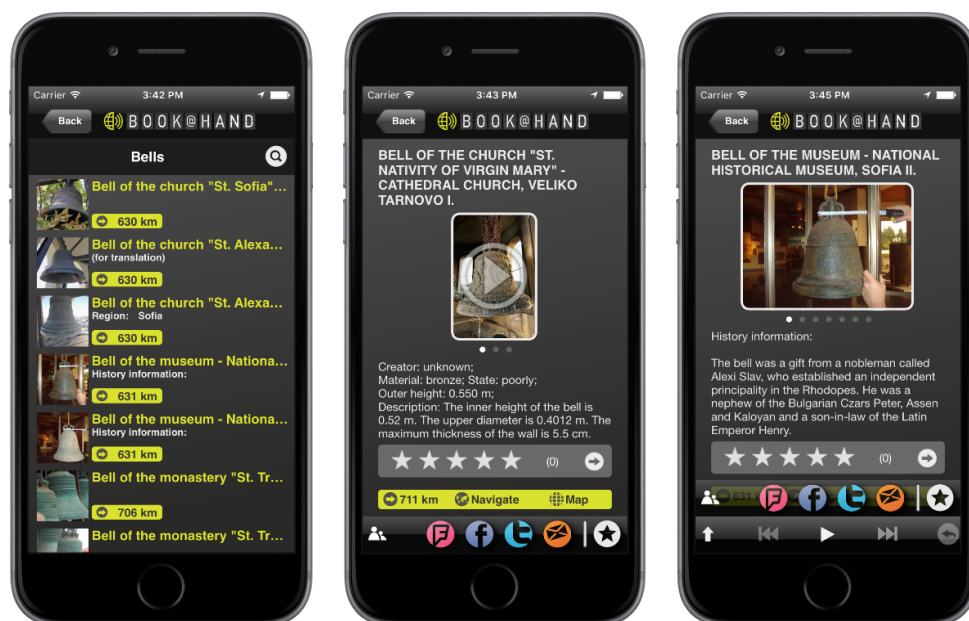


Fig. 21. Screenshots from the function Bells

The *Settings* function provides similar general tasks as the same function in other applications (language, update, switch between online and offline maps, connect to 3G network, About screen, etc.)

4. Conclusions and future work. The paper described the joint research and development work of IMI—BAS and MTA SZTAKI for presenting Bulgarian cultural and scientific assets. As a main result of our work, an ecosystem of digital libraries and mobile applications was created. Several mobile applications were produced which can present information available in digital libraries. Users can get personalised information through their smartphones or tablets at any time and any place. The content can be presented offline, i. e., the user can view the content on a mobile device even without Internet connection. Mobile applications serve as new tools to reach a broader audience. The joint work is based on the experience gained by MTA SZTAKI in the development of mobile application and by IMI—BAS in digital libraries. Our hope is that our knowledge can be successfully exploited in presentation of other cultural and scientific collections as well. Interactive

multimedia components such as panorama view, games and personalised collections proved to be useful tools to deepen the users' knowledge about highly valuable pieces of cultural heritage.

Acknowledgements. This work is partly funded by the Bulgarian NSF under the research project No DN02/06/15.12.2016 *Concepts and Models for Innovation Ecosystems of Digital Cultural Assets*.

REFERENCES

- [1] STEFANOV T., M. STEFANOVA. Mobile Applications for Cultural and Historical Places. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, Bulgaria, 2013, 227–234.
- [2] MÁRKUS ZS. L., B. WAGNER. GUIDE@HAND: Digital GPS Based Audio Guide that Brings the Past to Life. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, 2011, 15–25.
- [3] GUIDE@HAND. <http://guideathand.com/en/index>, 16 June 2017.
- [4] PAVLOVA-DRAGANOVA L., D. PANEVA, L. DRAGANOV. Knowledge Technologies for Description of the Semantics of the Bulgarian Iconographical Artefacts. In: Proc. Fifth HUBUSKA Open Workshop “Knowledge Technologies and Applications”, 2007, Kosice, Slovakia, 41–46.
- [5] PAVLOV R., D. PANEVA-MARINOVA, M. GOYNOV, L. PAVLOVA-DRAGANOVA. Services for Content Creation and Presentation in an Iconographical Digital Library. *Serdica Journal of Computing*, **3** (2010), No 4, 279–292.

- [6] PAVLOVA-DRAGANOVA L., V. GEORGIEV, L. DRAGANOV. Virtual Encyclopaedia of Bulgarian Iconography. *Information Technologies & Knowledge*, **1** (2007), No 3, 267–271.
- [7] PAVLOVA-DRAGANOVA L., D. PANEVA-MARINOVA, R. PAVLOV, M. GOYNOV. On the Wider Accessibility of the Valuable Phenomena of Orthodox Iconography through Digital Library. In: Proc. 3rd Intern. Conf. dedicated on Digital Heritage (EuroMed 2010), Lymassol, Cyprus, 2010, 173–178.
- [8] PAVLOVA-DRAGANOVA L., D. PANEVA-MARINOVA, L. DRAGANOV. A Use Case Scenario for Technology-Enhanced Learning through Semantic Web Services. *Information Technologies & Knowledge*, **3** (2009), No 3, 257–268.
- [9] PANEVA D., L. PAVLOVA-DRAGANOVA, L. DRAGANOV. Digital Libraries for Presentation and Preservation of East-Christian Heritage. In: Proc. HUBUSKA Second Open Workshop “Generic Issues of Knowledge Technologies”, Budapest, Hungary, 2005, 75–83.
- [10] PANEVA-MARINOVA D., D. LUCHEV, ZS. L. MÁRKUS, T. SZKALICZKI. Mobile Access to Specimens of Bulgarian Iconography through QR Code in a GPS-Based Information System. In: Proc. 43rd Spring Conference of the Union of Bulgarian Mathematicians, Borovetz, Bulgaria, 2014, 180–185.
- [11] KAPOSI G., T. SZKALICZKI, ZS. L. MÁRKUS, D. LUCHEV, M. GOYNOV, D. PANEVA-MARINOVA. Mobile Exploring of the Bulgarian Iconography through QR Codes in the GUIDE@HAND Tourist Guide Application. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, Bulgaria, 2013, 44–52.
- [12] BOGDANOVA G., T. TODOROV, N. NOEV. Semantic Model of Digital Resources of Bulgarian Bells. *Mathematica Balkanica*, **25** (2011), Fasc. 5, 483–490.

- [13] NOEV N. Organization and Security of the Audio and Video Archive for Unique Bulgarian Bells. *Mathematica Balkanica*, **24** (2010), Fasc. 3–4, 285–291.
- [14] NOEV N. Approaches and Methodologies of Creating, Storing, Presentation and Protection of Digital Resources in the Field of Cultural and Historical Heritage via Technologies Based on Knowledge. In: D. Luchev (ed.). Proc. Workshop Innovation and Culture—Regional Problems and Solutions. Veliko Tarnovo, Bulgaria, 2015, 19–28.
- [15] TRIFONOV T., G. DIMKOV, G. BOGDANOVA. Study and passporting of unique bells of historical and cultural heritage of Bulgaria and creating audio and video archive with the help of modern technology. In: Proc. VI Nat. Conf. Libraries – Reading – Communications, Veliko Tarnovo, 2007 (in Bulgarian).
- [16] KAPOSÍ G., T. SZKALICZKI, ZS. L. MÁRKUS, D. LUCHEV, M. GOYNOV, D. PANEVA-MARINOVA. Mobile Exploring of the Bulgarian Iconography through QR Codes in the GUIDE@HAND Tourist Guide Application. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, Bulgaria, 2013, 44–52.
- [17] Tattami adventure game. <http://guideathand.com/en/walk/tattami-adventure-game>, 15 August 2017.
- [18] Application 6ásos mérnök—Mobilis. <http://guideathand.com/en/downloads/6asos-mernok-mobilis>, 15 August 2017.
- [19] MÁRKUS ZS. L., G. KAPOSÍ, T. SZKALICZKI, D. LUCHEV, R. PAVLOV. BOOK@HAND BIDL: Mobile Exploring of the Bulgarian Iconography by Using Panorama Pictures. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, Bulgaria, 2015, 109–120.

- [20] LUCHEV D., D. PANEVA-MARINOVA, R. PAVLOV, G. KAPOSI, ZS. L. MÁRKUS, G. SZÁNTÓ, T. SZKALICZKI, M. VERES. Game-based Learning of Bulgarian Iconographical Art on Smartphone Application. In: Proc. Intern. Conf. on e-Learning'16, Bratislava, Slovakia, 2016, 195–200.
- [21] MÁRKUS ZS. L., G. KAPOSI, G. SZÁNTÓ, T. SZKALICZKI, ZS. WEISZ, W. ROUTSALAINEN, D. LUCHEV, R. PAVLOV. INFO@HAND: Mobile Application for Conference Series. In: Proc. Intern. Conf. Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, Bulgaria, 2015, 219–226.
- [22] INFO@HAND DIPP. <http://guideathand.com/en/content/dipp>, 15 August 2017.
- [23] Central and Eastern European Online Library (CEEOL). <http://www.ceeol.com>, 15 August 2017.

Zsolt László Márkus

e-mail: markus.zsolt@sztaki.mta.hu

Gábor Kaposi

e-mail: kaposi.gabor@sztaki.mta.hu

György Szántó

e-mail: szanto.gyorgy@sztaki.mta.hu

Tibor Szkaliczki

e-mail: szkaliczki.tibor@sztaki.mta.hu

Miklós Veres

e-mail: veres.miklos@sztaki.mta.hu

Zsolt Weisz

e-mail: weisz.zsolt@sztaki.mta.hu

eLearning Department

Institute for Computer Science and Control

Hungarian Academy of Sciences

H-1111 Budapest, Hungary

Detelin Luchev

e-mail: dml@math.bas.bg

Desislava Paneva-Marinova

e-mail: dessi@cc.bas.bg

Radoslav Pavlov

e-mail: radko@cc.bas.bg

Institute of Mathematics and Informatics

Bulgarian Academy of Sciences

Acad. G. Bonchev Str., Bl. 8

1113 Sofia, Bulgaria

Lilia Pavlova

Department of Informatics

New Bulgarian University

21, Montevideo Str.

1618 Sofia, Bulgaria

e-mail: pavlova.lilia@gmail.com

Received May 25, 2017

Final Accepted June 13, 2017