

A DIGITAL MONUMENT ARCHIVE (DMA): THE CASE STUDY OF THE KHOJA ZAINUDDIN MOSQUE IN THE OLD CITY OF BUKHARA (UZBEKISTAN)

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Abstract

The historic centre of Bukhara (Uzbekistan) is one of the most important historical urban fabrics in Central Asia. In 1993, UNESCO declared the old city, comprised of 462 architectural monuments that vary between different types of religious and domestic architecture, a World Cultural Heritage Site. Many of these buildings are documented in numerous written sources as well as in historical photographs, sketches and architectural drawings. However, it is often difficult to access this information as it has never been systematically filed. Yet the Digital Monument Archive (DMA) provides the opportunity to gather and save the different types of data, using a plan-based inventory system in combination with various search options. The Khoja Zainuddin Mosque, the subject of a German-Uzbek joint research project, presents a challenging example of a project that addresses new problems and asks for specific requirements in its DMA, due to its cultural context. The adapted version of the DMA allows the building to be located within its urban context as well as the possibility to zoom into details as small as a particular stone in the building. In addition, the combination of textual and visual identification options facilitates queries as it helps avoiding any emerging problems related to the different involved languages or disciplines. The translation of the DMA software into Russian further enables transfer and exchange of information on a larger scale.

Keywords: World Cultural Heritage, Bukhara, Khoja Zainuddin Mosque, Database, Digital Monument Archive (DMA)

1. The Research Project “Monuments within their Context in Bukhara (Uzbekistan)”

1.1 The Historic Centre of Bukhara

The historic city of Bukhara has played a significant role over two millennia as one of the most important trading centres on the Silk Road. The road network in the old city still shows the courses of the early medieval streets crossing the centre and many buildings have resisted modern modifications. Today it presents one of the rare examples of a mostly intact historic urban fabric. In 1993, its extraordinary state of preservation was honoured by the UNESCO and the old city centre, comprising an area of 450 ha, was inscribed on the World Heritage list [1]. The registered ensemble is made up of 462 monuments, 257 of them apartment houses. The other 205 monuments are public buildings, including mosques, madrasas (colleges for higher studies in Islamic sciences), caravanserais, khanqahs (Sufi convents), hammams, cemeteries and water basins (fig. 1).

It is not only the amount of existing monuments but also the outstanding state of preservation of these buildings that makes Bukhara a very special case study. Even though several restoration campaigns may have modified some of these historical sites, there are still many buildings with extraordinary and unique construction types, mosaics or wall paintings. One of the most interesting examples is the Khoja Zainuddin Mosque, which was chosen to be the main subject of a German-Uzbek joint research project, supported by the German Research Foundation (DFG).

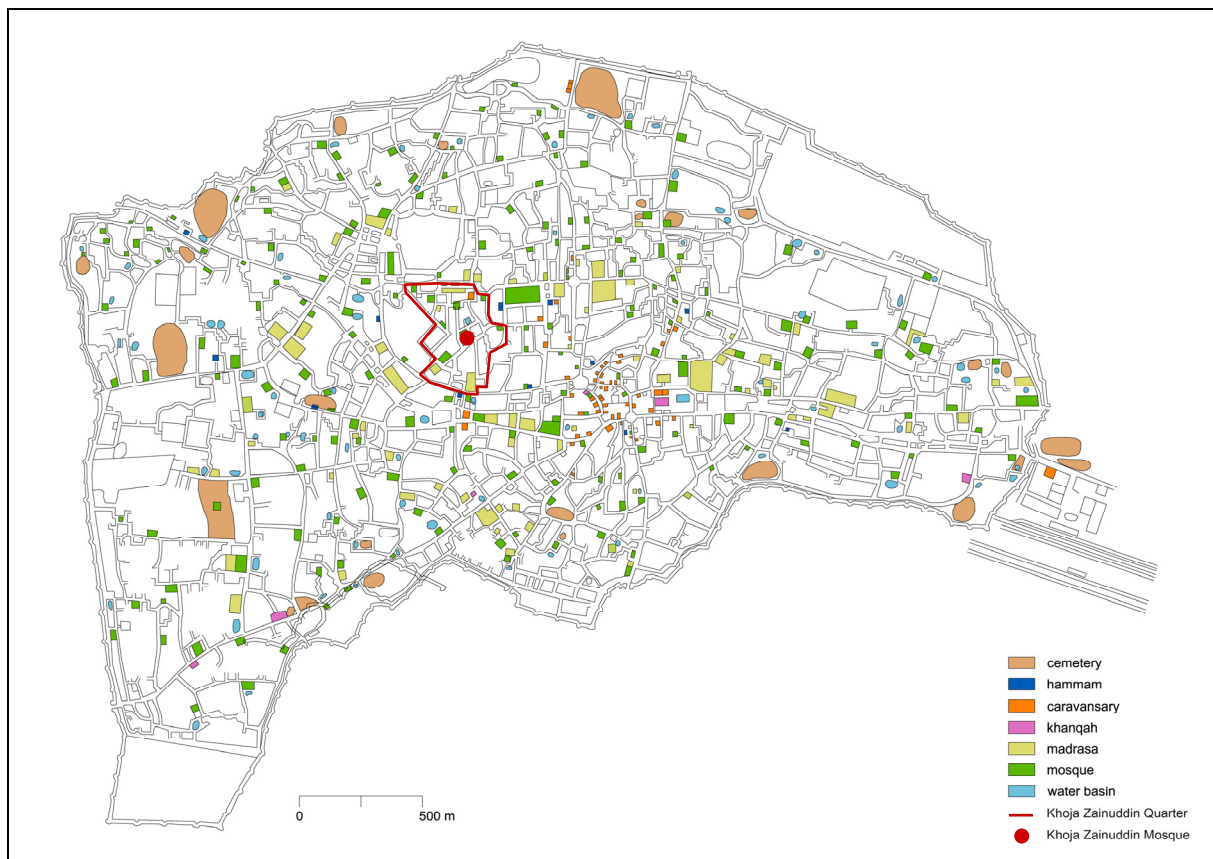


Fig. 1: Plan of the historical city centre of Bukhara indicating the listed historic buildings. Navigation map from the Digital Monument Archive (DMA) of the research project “Monuments within their context in Bukhara (Uzbekistan)”.

1.2. Subject and Approach of the Project

The research project “Monuments within their context in Bukhara (Uzbekistan)” is conducted by the Otto Friedrich University Bamberg (Department of Islamic Art History and Archaeology and Department of Building Preservation Sciences), the Technical University Munich (Department of Building History, Building Archaeology and Heritage Conservation) and the Austrian Academy of Sciences (Institute of Iranian Studies) on the European side and the General Office for Scientific Production for Preservation and Utilization of Objects of Cultural Heritage and the Bukhara State Museum on the Uzbek side. The project mainly deals with the historic quarter of Khoja Zainuddin (currently named the Imom al-Bukhoriy Quarter) and the mosque at its centre (fig. 1) [2]. This project is subdivided into three main units. The historical background and base for this project is being provided by the historians and art historians. Aside from the detailed analysis of the Khoja Zainuddin Mosque and the determination of its role within the art history of the region, a general survey of Abu'l-Khayrid buildings (1500-1599) [3] is also being conducted. At the same time, a complete documentation of the mosque is being carried out by architects and restoration specialists. In order to generate accurate drawings of the building, a three-dimensional scan was completed and details were measured by hand. Further sketches as well as photographic documentation additionally contribute to a better understanding of the construction history. For the examination of the building materials, e.g. mortars, plasters and painting layers as well as glazes of the different tiles, scientific analyses are being conducted. The third unit studies the wooden constructions of the mosque and other relevant historic public and private buildings. The results of the research project are being entered into a digital monument archive (DMA), specially modified to suit the demands of the project.

1.3. The Khoja Zainuddin Mosque

The Khoja Zainuddin Mosque is situated in the west of the old city, in close proximity of the *Ark* (citadel) and the *Masjid-i Kalan*, the Friday mosque of Bukhara. It is part of a complex comprising the mosque and a water basin located to the northeast of the mosque, which is also named after the saint Khoja Zainuddin. The mosque itself consists of a central square-shaped prayer hall that is surrounded by an L-shaped portico in the north and east and by several small adjoining rooms and a niche with the saint's (Khoja Zainuddin) tomb in the west.



Fig. 2: View over the Khoja Zainuddin Quarter and the mosque in the centre.

The dome, covering the prayer hall, emerges between the one- or two-storey dwellings so that it is quite noticeable in the panorama of the old city (fig. 2), along with the famous Kalan minaret of the Friday mosque or the domes of the Mir-i Arab Madrasa. In the north, a courtyard opens towards the water basin which was probably also used for ablution. The mosque is composed of one level, except for the small rooms in the western part of the building that are divided into two storeys. A spiral staircase leads to the roof, which can be climbed to the base of the dome. In the portico, eight elaborate wooden columns support the eight bays of the wooden ceiling. The designs of the bays vary between fields of panelled ceilings and flat ceilings with central star ornaments. Traces of paintings can be seen on both the ceiling and the columns. As for the prayer hall, it is remarkable that the dado is nearly entirely covered by mosaic panels with geometric (*giri*) and vegetal (*isl*) ornaments. On the walls above the dados, at least three historic painting layers can be determined that are partly carried out in different techniques. The most impressive painting is carried out in *kundal* technique, in which raised ornaments are gilded on a blue background [4].

As for the dating of the mosque, it is generally assumed that the building was constructed in the sixteenth century. According to the current state of research this dating can be approved except for the portico, where radiocarbon analysis provided results pointing to the middle of the seventeenth century. A stylistic analysis of the last historical painting layer could rather be dated to this later period as well. However written sources first mention a building with the name Khoja Zainuddin in the second quarter of the sixteenth century, a dating that could also be supported by the tile decoration in the prayer hall [5].

1.4. Sources about the Historic City of Bukhara

Aside from the data gathered within the current research project, a significant amount of historical sources exist about the city of Bukhara and its history. From earlier periods, most written sources, i.e. documents and inscriptions, are in Persian; in later times mostly in Uzbek Turkish. Some relevant sources as well as Quranic inscriptions on the monuments themselves are in Arabic.

Among the modern literature dealing with Bukhara and its history, many Russian publications can be found. Only in the last twenty years have a number of articles and monographs been published in western European languages, mainly in English, French and German.

In order to reconstruct the recent development in the city, oral history plays a role that is not to be underestimated. The challenge therefore is the ability to communicate in at least three languages: Russian, Uzbek and Tajik.

Architectural drawings and sketches play a key role in the examination of the historic monuments. The majority of these documents are stored in the Uzbek Archive (Uzbek Archive of the General Office for

Scientific Production for Preservation and Utilization of Objects of the Cultural Heritage) in Tashkent. Unfortunately the oldest drawings often only date to the beginning of the twentieth century. Despite this fact they are of great importance as a significant number of these monuments have disappeared due to decay, demolition or natural disasters (i.e. the earthquake sequence of 1976). Historical photographs, also preserved in the Uzbek Archive and dating from the late 1920s onwards, document the state of many buildings before restoration.

2. The Digital Monument Archive (DMA)

The DMA is a digital filing system that provides the opportunity to save large amounts of various data on historical buildings. The idea of the DMA was developed within a research project (MonArch), supported by the German Research Foundation (DFG), and carried out by the University of Passau (Information Management Department) and the Otto Friedrich University Bamberg (Department of Computing in the Cultural Sciences and Department of Building Preservation Sciences) as well as different teams of architects and historians working in the field of heritage conservation. The interactions of these different specialisations take various aspects related to databases of historical objects into consideration, so as to generate a scientifically established and applied system [6].

The software was originally developed for European religious buildings like St Stephan's Cathedral in Passau, where it was perfectly applied. Members of the cathedral construction department use the archive in their daily work, therefore constantly enhancing the database's structure and content [7]. At present, the DMA is mainly applied and developed within projects dealing with religious monumental buildings in Germany, such as the St Sebaldus Church and St Lorenz Church, both in Nuremberg (fig. 3) [8]. As a large number of persons with different specialisations, e.g. historians, architects and craftsmen, work on these historic buildings, the archive has to meet the requirements of various user groups. It may serve as a spatial repository for the stencils of stonemasons as well as for architects, who are looking for historical maps for a building activity to be carried out.

As for the technological requirements, the DMA allows for processing and collection of archive material and sources regardless of their file format. Any type of digital data can be uploaded in the archive and later accessed by the user. Consequently, all documents regarding historical sites, e.g. analyses, plans, and historical sources, can be inventoried. The interdisciplinary collection of data thus contributes to the preservation and exemplary handling of cultural heritage. At the same time, the DMA also serves as a backup device for traditional archives as the documents are digitally recorded and saved to a definite location.

Most documents in existing traditional archives are stored in a chronological way or according to their document type. The DMA, however, is based on partonomy, a structure arranging the documents from the greatest to the smallest parts of a building. The partonomy is also linked with maps for optical navigation so as to enable visual spatial localisation and identification (fig. 3).

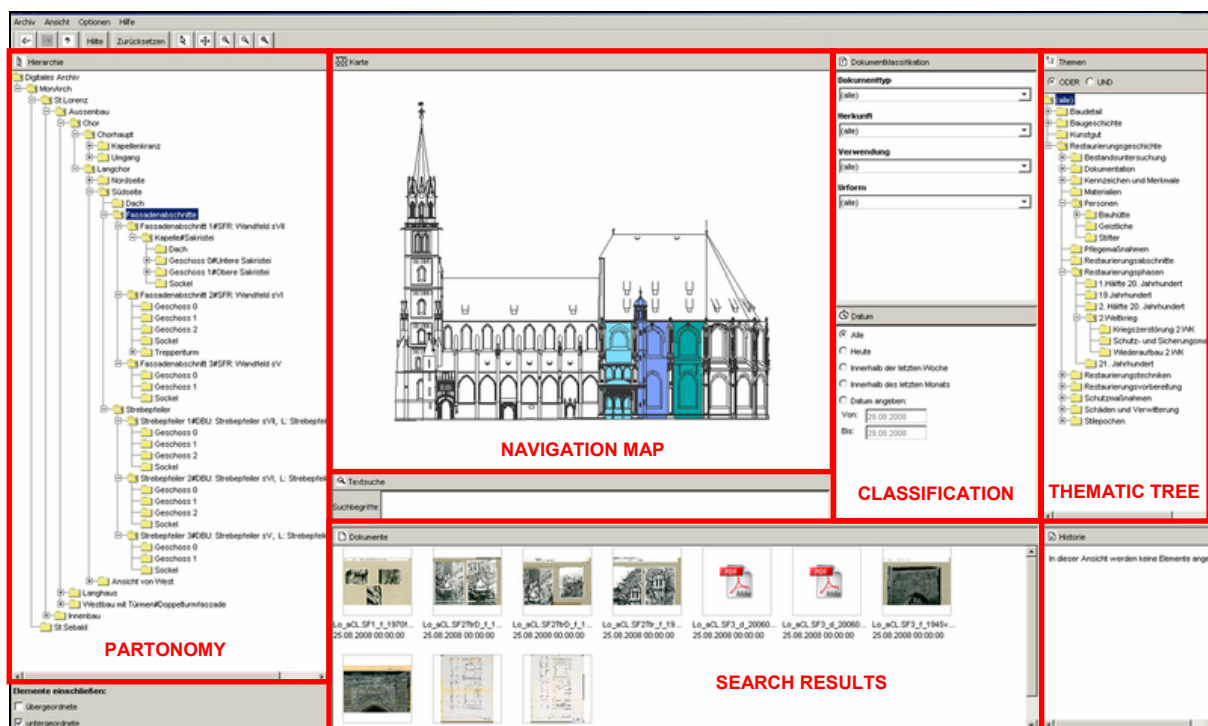


Fig. 3: Interface of the DMA of the St Lorenz Church in Nuremberg.

Uploaded documents are then assigned to the partonomy and the map and can be searched for both ways depending on the user's preference. The maps are created in AutoCAD, a common CAD program, and saved as dxf files. The drawings need to be turned into closed polylines on different layers so as to generate different fields that can be activated in the navigation map. The linkage between these fields and partonomy is simply accomplished by drag-and-drop.

The files can simply be entered into the archive by drag-and-drop, thus linking the document to the desired subsection of the partonomy. Subsequently a window opens where metadata is displayed and can be individually added. In addition, each document is automatically provided with an individual code, the automatic AKS (Allgemeines Kennzeichnungssystem, German for 'General Identification System'), which assigns the document to a precisely defined designation in a logical correlation. The AKS code follows the principle of partonomy and can be used for the archiving of the physical document as well.

Once the document is located in the archive it can be attached to various contextual subjects. This thematic classification is once again accomplished by drag-and-drop on the desired category of the thematic tree on the right side of the user interface. The tree is composed of a limited number of key subjects which are divided into different levels of subsections, following a hierarchy from the general term into very small details, i.e. the lower the position in the tree, the more precise the search option. Furthermore different search options are available and can be combined to limit and facilitate queries. After choosing a special query the selected documents are displayed at the bottom of the user interface. Formal search categories, such as the document type, the upload date and the classification (i.e. drawings, plans, or written sources) are shown in the field on the right side of the navigation map (fig. 3) [9]. By double-clicking on a document, the file is immediately opened, provided that a program supporting the chosen file type is installed on the computer. A simple right click opens a menu leading to the options of the document and containing the corresponding metadata.

For an optimal use of the DMA, three different user interfaces were developed. The first one is a server where the data is stored and saved and the second one is only a client, while the third one is a web client. The two latter types do not contain any data themselves but they can access the data from the server via an internet connection. While the web client can be directly used, for the activation of the second type of client the DMA software needs be installed first. The first web client was developed for the St Lorenz Church [10].

Another feature of the archive is the allocation of access rights. Four groups can be determined; they range from administrators, who have the unlimited right to change the partonomy or to enter data and documents, down to users, who can only utilise the different queries and open the documents. For copyright reasons there is also the possibility to release the documents only for specific groups of users that are to be determined by the administrator [11].

3. Case Study: The Digital Monument Archive for the Khoja Zainuddin Mosque

3.1. Special Requirements for the case study of the Khoja Zainuddin Mosque

The DMA for the Khoja Zainuddin Mosque is embedded within a larger archive developed for the entire old city of Bukhara. This archive provides the opportunity to document all listed historical buildings. As many street names were changed after the independence of Uzbekistan in 1991, a city map helps to localise the buildings regardless of their addresses.

Different spellings of the names of the buildings also complicate the search process. This problem is due to the numerous languages used in Uzbekistan both historically and at present. Even though Uzbek is nowadays the official language in Uzbekistan, a large number of Uzbek citizens still speak Russian. In addition, Tajik is widely spread in Bukhara and eastern parts of Uzbekistan, as the emirate of Bukhara covered large territories in what is Tajikistan today. As mentioned before, Arabic is sometimes used as well, predominantly in a religious context. Because of the use of these various languages and scripts (i.e. Latin, Cyrillic, Arabic/Persian), the transcription of names may differ. The tree structure of the DMA, divided according to the different building types, allows users to avoid to the use of a certain spelling and thus long search operations. Yet the user mask of the software needs to support several languages. This is not only important for the relatively limited use of the research group in Germany but also for the Uzbek partners and for external persons to whom the access to the archive should be provided in the future.

Aside from the language requirements, cultural and religious specific factors should be taken into account as well. As the DMA software was developed for Christian churches in a European cultural context, this project presented a special challenge [12]. When dealing with an Islamic building in Central Asia, it is self-evident that different terms for building or construction elements must be integrated in the search options than in the case of a cathedral. Terms like 'mihrab' (prayer niche) or 'Timurid era', which would be completely unessential for a cathedral, must be added, replacing other – Christian – terms such as 'apse' or altar', which are indispensable in the Christian context.

The different cultural environment is also reflected in the décor and techniques used. A striking example is the famous *kundal* painting, an extraordinary painting technique that appeared at the end of the fourteenth century in Samarqand and was soon adapted by Bukharans. Even though underglaze and monochrome mosaic tiles can not only be found in Central Asia, the composition of the materials and the fabrication process may have differed according to the available natural resources. These differences should also be integrated into the thematic tree so as to offer optimal search options.

3.2 Realization of the DMA for the Khoja Zainuddin Mosque

The flexible structure of the archive can be perfectly adapted to the specific requirements of the Khoja Zainuddin Mosque. In this project, the centre of the user interface shows a general map of the old city centre of Bukhara as a first navigation map (fig. 5). Important historical places of interest are marked with different colours, according to their function, and can be activated by clicking on the fields. The corresponding building is then also highlighted in the partonomy. In addition to the option to navigate within the city map, the user also has the opportunity to choose the Khoja Zainuddin Quarter or Mosque directly from the partonomy. The city map was generated from a historical map drawn by Parfenov-Fenin in 1910 [13]. Hence, some of the historical buildings have already disappeared. However information about these objects can still be stored because their original location is still known and can be designated in the map. The plan of the Khoja Zainuddin Quarter is based on a Google Earth map. As for the plans of the mosque itself, they were generated within the research project where a three-dimensional survey was accomplished with a terrestrial laser scanner. The resulting point cloud served as a base for AutoCAD drawings (fig. 4). In order to facilitate the navigation within the maps, these plans had to be reduced to the main information. However, due to the high degree of details it is possible to navigate down to the smallest part of this historical building which is also reflected in the very distinctive partonomy.

The hierarchical tree for the thematic context is placed on the right side of the user interface (fig. 5). The specific project requirements for the thematic tree were developed and completed within the course of the project [14]. As the main focus of the project lies on art history, building archaeology and preservation sciences, the following six topics were chosen as main categories for the thematic tree: architecture, history, iconography, persons, rites and location (fig. 5). Each of these categories is then divided into various levels presenting even small details such as certain pigments in a layer of paint. At the same time, these criteria are associated with the historical context of the object or the document.

By activating a general term, all thematic links to this term will be displayed and can be selected. In order to search for details, only lower levels in one category can be activated. For instance, if the user wants to search for a mosaic panel in the prayer hall of the Khoja Zainuddin Mosque, the query should follow the thematic tree starting with the category 'architecture', then 'building details' and ending with 'tile panels'. By activating the superior button for architecture, all following terms and related documents on all tiles will be displayed at the bottom of the interface (fig. 5).

However, several search options can also be combined for even more precision. So, in order to view all documents concerning wood on the southern façade of the Khoja Zainuddin Mosque, a first selection can be made by choosing 'southern façade' in the partonomy or on the map. By clicking on the material 'wood' in the thematic tree, located under 'architecture' → 'building materials', all corresponding documents will be displayed. When further restricting the choice by determining the type of document, i.e. in this case photo and upload date, only a small number of hits will result.



Fig. 4: The three-dimensional model generated by the laser scanner, the AutoCAD drawing, and the DMA map of the Khoja Zainuddin Mosque.

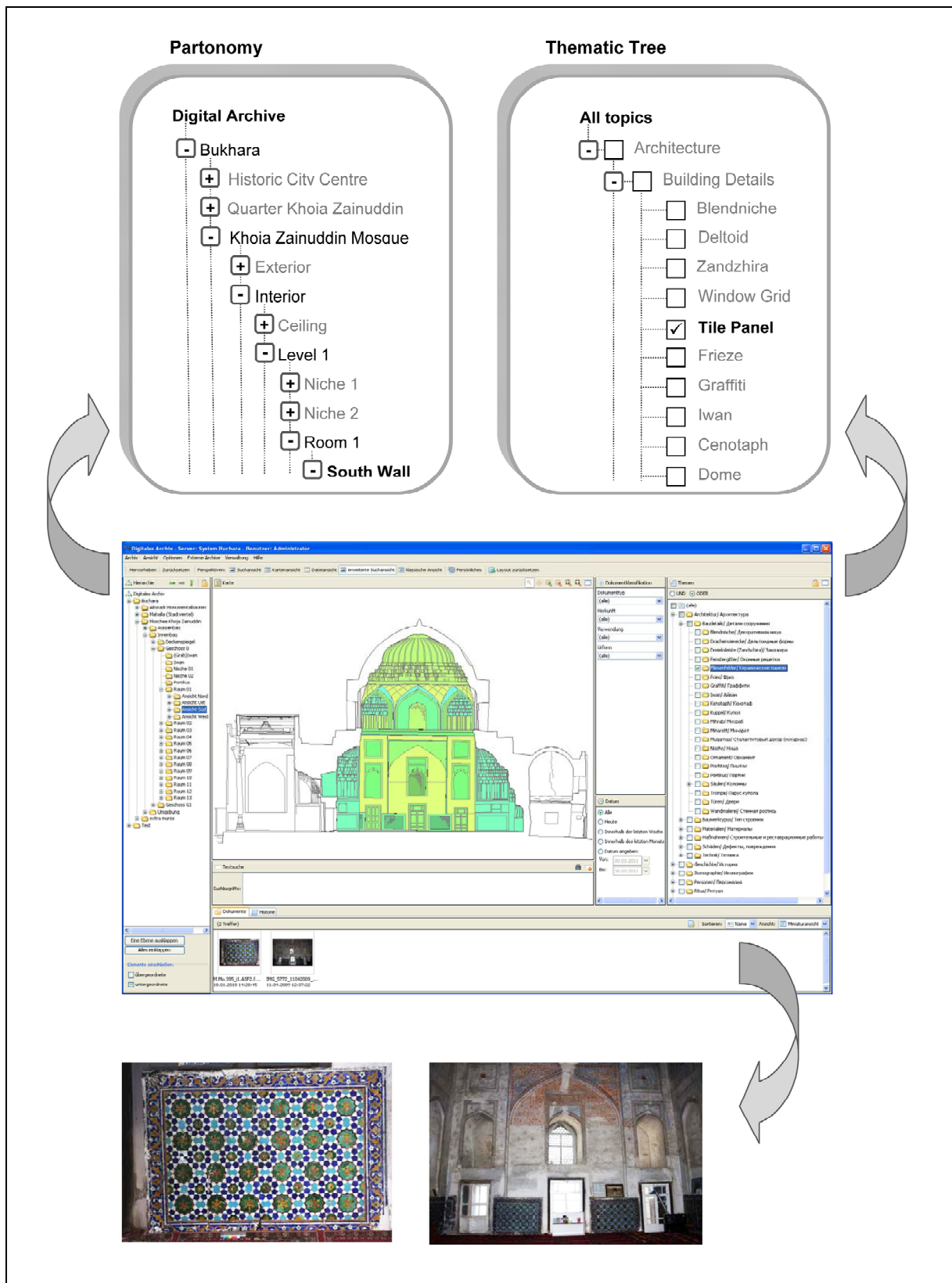


Fig. 5: Interface of the DMA of the Khoja Zainudin Mosque.

3.3 Advantages of the DMA for the Khoja Zainuddin Project

As previously mentioned (see 1.4.), the sources existing about the historic centre of Bukhara and the Khoja Zainuddin Mosque are distributed between various places. A great number of documents are stored in Tashkent (Uzbekistan), others in Bukhara while publications, apart from Russian ones, are mainly located in Europe. Unfortunately, all this information has never been gathered at one place, a fact that is surely not only due to cultural reasons but rather to the political situation over a long period

of time. The DMA allows the collection of all data at one single place while ensuring access for all involved persons regardless of their location. At the same time, the inventory, documentation and assessment of these documents is affected. The virtual linking of the documents to the different parts of the building enables the storage of the information in a logical and safe way. Moreover, the map helps to locate historical buildings in the city, therefore avoiding the problem of non-existent or changed addresses.

In order to adapt the archive to the use of the local partners in Uzbekistan, the research team elected to use a bilingual partonomy and thematic tree in German and Russian. This facilitates communication between the European research group and the Uzbek heritage conservation authority, a fact that is very essential for the success of such a research project. In addition, a Russian version of the client was created aside from the German and English version. For example, a project participant in Bamberg may enter data to the server with a German client via the internet. Due to the German-Russian thematic linkage, a search on a specific topic can be performed by an Uzbek participant via the Russian client. The various project stakeholders in different places all over the world can easily follow the work of other project members in the archive as well.

One common problem in numerous databases is the lack of standardised vocabulary. According to the cultural context or the involved disciplines, different terms may be used for the same part of building. In this case, the DMA provides the opportunity to avoid any misunderstandings through its defined partonomy and the visual option of the navigation map. This additionally solves the problem of varying spellings due to different applied transcription styles. Through the thematic mapping of the DMA, a restriction of the search parameters is also possible, regardless of different spellings or designation. Especially in consideration of the various involved languages, historical terms and project groups from different disciplines, this is an important advantage of this project.

3.4 Existing Problems and Current Approaches

Even though the DMA provides an efficient solution to many problems concerning data storage, there are still some deficiencies that need to be treated. A digital version of the documents is required in order to upload them into the archive. However, particularly historical sources are often not digitised yet. In this case, the adequate equipment and qualified persons for an elaborate digitalisation are needed, and this is not always available. This also applies to the required internet connection. In order to use the DMA from different locations, the internet connection needs to be stable and fast enough to provide the data transfer from the server to the client. The lack of such a connection may delay or inhibit the upload and display process of large documents.

Another problem is the question of long term assessment and saving of digital documents during the centuries to come. Solutions for this issue are currently being developed within the 'MonArch' research project [15].

The fact that the Khoja Zainuddin Mosque DMA was developed while basic research work was still carried out has resulted in various modifications of the structure of the archive, leading to additional work for the researchers. It is thus useful to establish only a basic structure at the beginning of a project and to adapt the archive to the requirements of the project as soon as its structure is determined and proved.

4. Summary and Perspectives

The DMA provides a basic tool for the archiving of data related to historical buildings or ensembles. Yet, the DMA is not only limited to architectural objects but could be used for archaeological sites or art collections in museums as well. Beside its function as a storage device it is an important means for the transfer of information and exchange within research networks. The user-friendly interface and the opportunity of a multi-lingual client as well as the internet-based access contribute to easy and flexible usage.

Even though the user is free to adapt the archive to the individual needs of his current object of research, the DMA maintains a certain common basic structure. Thus it allows for the linkage of different DMAs created for similar objects that can then be easily compared. The archive may not only represent a special research project with its different specialisations, but it may also be part of a large-scale database. The extension of knowledge transfer would be enormous. Measures, methods, and research results from similar objects could be compared, thus contributing to a better preservation concept for historical sites. This would be a great benefit, not only for scientific research but also for an intercultural understanding.

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