3D-Model as a Basis for the Discussion on the Reconstruction of the Aleppo Bazaar

ANNE MOLLENHAUER, German Archaeological Institute (DAI), Germany
TUTKU TOPAL, Ostbayerische Technische Hochschule Regensburg, Germany

In 1989 the old city of Aleppo was declared world heritage. Since 2011 Aleppo became one of the hotspots of the armed conflict in Syria and a great number of historical buildings were damaged or destroyed. The project presented here is part of the project network “Stunde Null - a future for the time after the crisis”, an initiative of the Archaeological Heritage Network (ArcHerNet), a network of German Institutions, concerned with the preservation of archaeological heritage. It aims at creating a scientifically based 3D-model of the bazaar in its condition before the destructions since 2012. The model will be delivered to the very heterogeneous groups of actors involved in decision-making and planning of rehabilitation measures as an instrument that illustrates the historical monuments of the bazaar and conveys the complexity of its structures.

The construction of the 3D-model is carried out in a number of successive working steps. After dividing the bazaar into twelve areas, a pilot area was chosen to begin working on. First, a survey on available data (plans, photographs, scientific research, etc.) was carried out. This data was collected and integrated in a systematic folder structure that allows fast and easy access to the data.

The virtual 3D-model is developed on the basis of the plans and photos collected from several sources. Appearing differences are equalized manually. The 3D-model is intended to serve not only as a tool for visualizing and documenting the bazaar but also as an instrument which enables through its development process an exact verification of the available data on individual building areas and their reliability for the reconstruction. Another important goal of the project is capacity building. The creation of the 3D-model is combined with the training of Syrian experts and young researchers and the establishment of a network of persons and institutions working on the bazaar.

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INTRODUCTION

The project “3D-model of the Aleppo-bazaar” is designed as a cooperation project between the German Archaeological Institute (DAI) and the Ostbayerische Technische Hochschule (OTH) Regensburg. It is part of the project network “Stunde Null - a Future for the Time after the Crisis” under the umbrella of the Archaeological Heritage Network (ArcHerNet) and generously funded by the Gerda Henkel Foundation.

Author’s address: Dr. Anne Mollenhauer, Leonhardstr. 7, 14057 Berlin, email: mollenhauer@em.uni-frankfurt.de; Tutku Topal, Faculty of Architecture, OTH Regensburg, Prüfeninger Str. 58, 93049 Regensburg, email: tutku1.topal@oth-regensburg.de

1 https://www.dainst.org/documents/10180/15360/Flyer+Project+Stunde+Null+%28english+version%29+7ec8f3-e595-49ba-a411-b094b047d19
3 https://www.gerda-henkel-stiftung.de/foundation
The localization of the project-team at two institutions reflects the research design and its workflow: The Berlin team is responsible for the collection and evaluation of available scientific data, from this the Regensburg-team is processing the 3D-Model. Both, the Berlin and the Regensburg teams comprise students – Syrians and Germans – since capacity building is one of the major targets of the project. This refers in particular to the establishment of a network of persons and institutions working on the monuments and rehabilitation of the bazaar, with a special focus on close exchange with Syrian universities, especially in Aleppo.

The city of Aleppo

Aleppo is the second largest city in Syria after Damascus and is considered as one of the oldest constantly inhabited cities in the region [Burns 2017]. The skyline is dominated by the citadel hill, which is surrounded by historic residential quarters, governmental buildings as well as the vast Bazaar area.

Strategically located between the Mediterranean Sea and the Euphrates, the city was an important trade centre already in its early history, in the time of the Hittites from Anatolia, the Hurri-Mittani of Upper Mesopotamia and the Egyptians as well as Greek and Romans. From early on, the city was a centre of the weather god Hadad, one of the most important deities of Ancient Near East [Gonnella et.al. 2005; Kohlmeyer 2009].

After the Arab expansion in the 7th century, the city retained its role as a political, cultural and economic centre with supra-regional connections. Aleppo was a transport hub of transregional importance on the major caravan routes connecting the Mediterranean east to Mesopotamia, Persia and India and the Anatolian Highlands and the Caucasus to Arabia. With the incorporation into the Ottoman Empire from 1516 Aleppo experienced an economic heyday that has left impressive monuments [Gaube and Wirth 1984; Watenpaugh 2004]. During the Ottoman Empire, goods from India, Iran and Europe were handled in Aleppo. Spices, Indigo and Persian raw silk contributed to the wealth of the city and also the local trade in wool and agricultural products played a big role. The climate of cosmopolitanism and exchange resulting from these conditions gave the city its character. The three square kilometres large covered bazaar area of Aleppo, with its grid of vaulted streets, flanked by small shops, is one of the most beautiful in the Islamic world and testifies to this supra-regional trade (fig. 1) [Kasmo 2014 and Kasmo 2018].

Within the area numerous monumental caravanserais for the hosting of traders and their goods, impressive mosques, public baths and small workshops form an exceptional variety of architectural heritage. In 1986, the old town of Aleppo was declared a UNESCO World Heritage Site. Since 1993, in cooperation with the GTZ (now GIZ), the Agha Khan Trust for Culture and the Arab Fund for Social and Economic Development have carried out a comprehensive project for the rehabilitation and development of the Old Town, which included the bazaar as well [GTZ 2006; Fansa 2018].

Since the escalation of protests in the wake of the "Arab Spring" in early 2011, Aleppo became one of the hotspots of armed conflict in 2012. Until then the bazaar had been exceptionally well preserved. The first attack against Aleppo started in late July 2012, and in September a major fire destroyed large parts of the historic bazaar. Since then, the fighting and the associated displacement of the civilian population and the destruction of infrastructure and buildings have increased dramatically. A great number of historic buildings were damaged or destroyed. During the last five years the old city has seriously been damaged, since parts of the front line between the two conflict parties ran between the south western foot of the citadel and the historic residential areas as well as entrance to the bazaar.

OBJECTIVES

The project presented here aims at creating a scientifically based 3D-model of the bazaar in its condition before the destructions since 2012. The 3D model shall serve as a tool for the discussion of the future reconstruction of the Bazaar. The model shall help the very heterogeneous groups of actors involved in decision-making and planning processes of rehabilitation measures to set up guidelines for the future rehabilitation of the bazaar: governmental decision-makers and planners as well as merchants and shopkeepers and, last but not least, scientists, all actors involved in the future rehabilitation of the bazaar. It shall illustrate the historical monuments of the bazaar and convey the complexity of its structures. Available data (plans of buildings, photos, aerial photographs, written documents) are evaluated concerning their reliability towards the localization as well as dimensions and shapes of individual monuments. It is a main target to visualize in a generally understandable form that the creation of a 3D-model is always based on a series of individual decisions, some of which may be arbitrary, esp. if the amount of available reliable data is low. It is our intention that the 3D model of the bazaar conveys these uncertainties in a transparent way: Those areas with a high quantity of reliable data (i.e. the area around the Great Mosque) will be shown in more detail than those with few reliable information on shape and dimensions- i.e. a large number of bazaar alleys and the adjacent small shops (see also below). This should help decision makers to develop sustainable
guidelines for the rehabilitation and facilitate decisions on the establishment of areas of high monument value and those of lesser importance.

METHODOLOGY

The construction of the virtual 3D-model is carried out in a number of successive working steps. After dividing the bazaar into sectors, a pilot area was chosen to test the workflow between Berlin and Regensburg (Fig. 2). First, a survey on available data was undertaken. It became apparent very soon that the level of detail (LOD) of the available material is very different, ranging from precise building research on specific monuments to non-professional photographic documents, lacking any kind of dimensions as for example for the major parts of the km-wide bazaar lanes. The most important data sources are the Syrian Heritage Archive Project (SHAP), who is collecting so far unknown archives of researchers who have been working in Syria during the last decades (i.e. the collections of Jean-Claude David (France), Julia Gonnella (Germany), Michael Meinecke (Germany) and Eugen Wirth (Germany).

Another source is unpublished material which was kindly provided by the University of Aleppo (Survey of the University of Aleppo). Furthermore, a survey of published plans, photographs and scientific researches on the buildings of the bazaar is conducted (i.e. Jean Sauvaget, Aleppo, Jean Claude David …), the material evaluated, sorted and integrated in a systematic folder structure by the team based at the DAI in Berlin, that allows fast and easy access to the data by the team of the OTH Regensburg.

As part of the stocktaking of the available data, one of the first tasks was to examine the existing plan fundamentals that might serve as the basis for the construction of the 3D-model. As a basis, two plans were chosen: the cadastral plan created in 1928-1930, which is available in digitized form as a CAD plan and was provided by the SHAP, and the figure ground plan, which was provided to the project by the BTU Cottbus. However, these plans do not contain any usable information about the relief. This information is indispensable for the first step of model making, the installation of the floor slab.

In close consultation with Prof. Teichert of the HTW Dresden, Faculty of Geoinformation, various options were discussed, regarding the most suitable method for height evaluation, both the terrain heights, and the building heights. As a result, a high-resolution satellite image was ordered (Pleiades-1A / B PSM 4-band Tri-Stereo archive data from 28.08.2015 Area: 25 km2), from which GAF AG, on behalf of the working group, generated a Digital Terrain Model (DTM) and a Digital Surface Model (DSM), which are now available for further work.

The hard surface model is based on the above mentioned plans and photos. In order to determine the location of the buildings, the above mentioned cadastral plan and figure ground plan are used to build a gapless model of the whole area.

Both plans, however, only show the ground floor zone and to complicate matters, they are sometimes outdated, incomplete or customized. This difficulty was partly overcome by using groundplans and sections prepared by the University of Aleppo and other archive material which allowed us to complete details and upper floors. The process of decision making induced by inconsistencies and contradictory information from past research will be visualized in the model.

It turned out that the heights of the Digital Surface Model are too inaccurate for reconstructing the building height. So the heights were calculated using sections and facades, mainly drawn by students of the Aleppo University. In case there are no drawings available, the heights were reconstructed on the basis of photos.

Example

A photo that shows the pre-war state is in general the most reliable source for clarifying these inconsistencies. If there is no sufficient photo documentation, missing information will be supplemented in a meaningful way and without invention of structural shapes. If there is no information about the shape of a lintel for example, it will be modelled in the simplest way, in this case a straight lintel type, unless several factors reinforce the assumption that it is most probably an arch lintel. In both ways of modelling the information about the decision will be retrievable by the end user via info point.

4 https://project.syrian-heritage.org/en/
5 https://www.gaf.de/
TECHNICAL GOALS

Next to the above mentioned content-related goals, we also focus on a number of technical goals in the implementation of the project.

The tool will be controlled exploratory, which allows the user to move freely in the model and use it intuitively. Using the unreal engine the output should be customizable on different devices. The result is supposed to be an executable file without special software requirements. It can be used as a web-based application on the smartphone, a computer or VR glasses. The stored files will be retrieved from a server. Furthermore, we want to present the scientific results in understandable form and by using graphical possibilities. So we created interactive info points to explain certain contents.

MODELING

Many buildings of the bazaar look well documented at first glance. But during modelling it soon became clear that many data sources are contradictory. For that reason it was decided to document the indeed level of knowledge about the buildings in a scale from certain to uncertain, which will be visualized in a colour range using different LODs, Fig. 3.

The hard surface models of the buildings are all man-made with common CAD software such as ArchiCAD and SketchUp. Each building is modelled in up to four LODs. The model will switch automatically between these zoom levels, depending on the viewer's distance to the model and the density of available data. It is important that all LODs are modelled manually and not generated automatically by software. So we have the opportunity to control what to represent in which way and to make individual decisions. The different levels also give the possibility to load a more or less detailed version of the model to save memory and power necessary for real-time rendering of complex 3D scenes.

The lower LODs are also intended to allow the output of larger sections of the model on devices with low performance. The level of detail serves to emphasize certain content such as the urban context of the bazaar for example. They also can be carriers of different representations of the metadata. This, considering current developments in Aleppo it is becoming increasingly important to have an overview of current activities. For this end another level of metadata might be introduced which refers to “state of post war activities”.

LEVEL OF DETAIL (LOD) 1

The LOD 1 is a simple volume model that looks like a city model in the area. It will serve to have a bird’s eye view at the model and provide information about the complex structure of the bazaar. For this purpose, the buildings are shown without any openings, projections or recesses in the facade. Only the simplified volume and the roof shape are built to convey the character of the building from a long distance.

LEVEL OF DETAIL (LOD) 2

The main objective of LOD 2 is the external appearance of the buildings. The user may see the position of facade openings, the subdivision of the facades through projections and recesses, oriel and recessed loggias. This LOD allows looking at a building from a shorter distance than LOD 1. It is not yet possible to look through the windows and see an interior, because the openings are only deepened in the outer walls without breaking trough.

LEVEL OF DETAIL (LOD) 3

The LOD 3 shows the interior of the building. In addition to the interiors, the exterior appearance is getting more detailed. Stairs are detailed by single steps instead of ramps and railings are becoming more and more fragmented. It is now possible to move through the bazaar lanes and rooms of a building and look around from the pedestrian perspective and experience everything more realistically. According to the available information, most of the buildings will probably be represented up to this third level of detail.
LEVEL OF DETAIL (LOD) 4

There will be an additional LOD 4 for selected exemplary buildings with a sound documentation, which allows to go further into questions of historical preservation. This LOD will be an almost realistic representation of a building with all architectural decorations. Everything except furnishings and technical building equipment will be represented.

INFO POINTS

To clarify the manual adjustments, which were undertaken to cope with the inconsistencies of the used data material info points are created in the model as objects and provided with index numbers. The explanation is given in a separate table. It notes the deviations between the plans, photos or other sources. This information from the table is linked to the associated info points by command in Unreal Engine. If the user clicks on the info point, the required information can be retrieved from the table and shown in a pop up window. Next, he may also document the explanation with additional pictures (Fig. 4).

UNREAL ENGINE

The visualization of the model is created with Unreal Engine developed by Epic Games. It is a suite of integrated tools for game developers to design and build games, simulations, and visualizations. The Unreal Engine is an open-source cross-platform software. With its code written in C++, it features a high degree of portability and also supports virtual and augmented reality.

Virtual reality (VR) is a computer-generated scenario that simulates a realistic experience. The immersive environment can be similar to the real world in order to create a lifelike experience grounded in reality or sci-fi. Augmented reality systems may also be considered a form of VR that layers virtual information over a live camera feed into a headset, or through a smartphone or tablet device.

User Interface

The user interface becomes a mix of graphical and text-based user interface type. The goal is to create a self-explanatory, efficient and enjoyable design. There will be a menu on one side, where the user can choose between the different metadata, fade the info points in and out or call up additional information or pictures. It will also be possible to look at the percentage distribution of the chosen metadata and other additional information which will pop up at the edges of the screen.

Design

The surface of the 3D model is textured with a slight grain which is only visible from a close distance. It serves to create a more natural surface that also leads to softer exposure and shadow edges. Further textures or colours have been omitted in the model to emphasize its scientific value.

CONCLUSION

The basic model will show the condition of the bazaar before the beginning of the war. As discussed above the main intention is to serve as tool for decision makers to decide about different aspects of the rehabilitation of the bazaar. Which areas are of major or lesser importance? For which areas is detailed knowledge available on the original shape of a building, which areas are well documented? Since the group of actors involved in rehabilitation process is a very heterogeneous one, the easy to understand 3D model should enhance the awareness about the necessity of a careful planning process to revitalize the bazaar – on one hand as a historic monument on the other hand as a vital area of economic exchange.

In addition to this, the model may serve as a basis for the following metadata:
- building state after the damage (Fig. 5)
- knowledge about the pre-war state
- state of post-war activities
- scientifically relevant information as i.e. historical building phases.
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REFERENCES


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Fig. 1. View of the bazaar area, seen from the citadel. To the left is the pilot area with the Adiliya mosque, to the right the minaret and courtyard of the Great Mosque can be seen. (© Adobe Stock Photos)

Fig. 2. Model of the pilot area. (© OTH Regensburg)
Fig. 3. Examples of the level of detail. (© OTH Regensburg)
Fig. 4. Example for the visual implementation of info points. (© OTH Regensburg)

Fig. 5. Building state before the damage. (© OTH Regensburg)

Fig. 6. Building state after the damage. (© OTH Regensburg)