

MAPPING OF BUILDINGS FACADES' AT THE HISTORICAL CENTRE OF NICOSIA, CYPRUS AND CREATING A PRESERVATION INFORMATION SYSTEM

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Abstract:

In order to restore buildings of cultural importance, the Municipality of Nicosia and its Master Plan needed the 2D drawings of buildings' façades in different areas inside –and close to- the historical centre of Nicosia. At this paper we present the mapping of these buildings' façades. The scope of this project was the creation of such 2D drawings and rectified images of cultural buildings' façades. Additionally, a survey of the general area of the buildings was also performed for the production of local survey maps. The project covered an area with approximately 488 different buildings. In order to create the façade's models we used both traditional surveying and single image Photogrammetry. For each building façade a number of control points and points of interest (balconies, architectural details, and roofs) were measured. For each façade we produced one or more rectified images, depending on the number of dominant planes in each façade. The rectified images were used to create facades' drawings, which were complemented with the surveying measurements. Furthermore, the façades were geo-referenced, to produce detailed series facades of building along the street. In this paper we present the work plan we followed, starting from the field work, the processing procedure and concluding on the production of the final drawings. In addition, we present a proposal for a preservation information system. The preservation information system includes historical information about each building, information concerning the current building condition (construction materials, damages, etc.), the proposed restoration works and materials. The system will be designed in a way that allows the online monitoring of the preservation works, so that the user will have an overall perception of restoration process.

1. INTRODUCTION

The restoration of historical buildings and monuments is a crucial process for the preservation of our cultural heritage. The first step in the restoration process is the creation of accurate monument models. Numerous techniques have been developed over the last years that allow the accurate modelling of buildings and monuments [1,2]. The municipality of Nicosia and its Master Plan decided to proceed in the restoration of several buildings (mainly their facades) in different areas inside – and close to- the historical centre of

Nicosia (figure 1). The project was spanning in four different neighbourhoods and included 30 different streets. The main goal of the project was the mapping and the creation of 2-D drawings of the buildings' facades' along those streets. The creation of accurate 2-D drawings is a task that can be addressed with many different approaches. The mapping of a building facade can be performed by traditional surveying techniques, Photogrammetry both single image and multiple image approaches, and laser scanning [3,4,5]. Choosing the optimum mapping technique is a process that takes into account a lot of variables, regarding the shape of the object, its complexity, the required accuracy etc.[6] In our case due to the volume of the work, the limited time constraints and the nature of the building we decided to use single image photogrammetry combined with traditional surveying measurements for the creation of the 2-D drawings. Traditional surveying techniques require time consuming field work, and a detailed sketch for each facade, while laser scanning would require a considerable time spend in the field and also a lot of processing time in the office. On the other hand photogrammetry offers a way to create 2-D drawing with less effort compared to the other approaches while retaining the same accuracy in the results. In our case we choose to process our data using single image photogrammetry because of the nature and shape of the buildings' facades. In figure 2 we can see a sample of the processed images. It is obvious that in most of the cases the building facades are flat, thus making them suitable for mapping using single image photogrammetry (single image rectification).

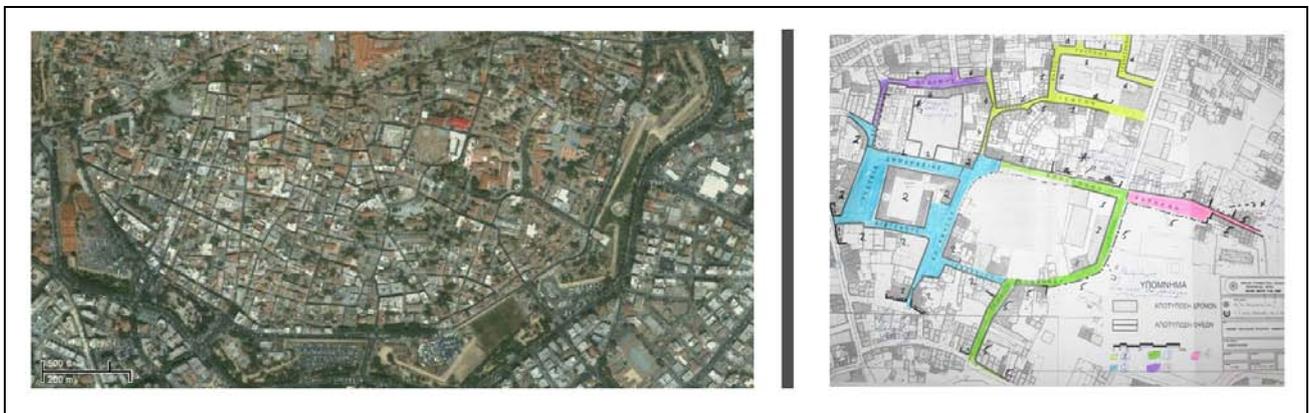


Figure 1: Aerial View of Nicosia's Historical Centre. Detail of a project's area.



Figure 2: Sample images of Building facades.

The 2-D drawings were produced using the rectified images of building facades, in combination with survey measurements of architectural details in specific cases. Furthermore the drawings were geo-referenced using a survey of the 4 different neighborhoods in order to produce detailed series facades of streets. Another aspect of our presentation is the creation of preservation information system. Novel techniques and advancements in both software and hardware [7] provide the means for the creation of cultural heritage tools

regarding documentation and monitoring of preservation works. Several methods and tools have been developed for the creation of information systems for cultural heritage [8,9]. Based on these examples and case studies we propose a custom design regarding building facades. The structure of the paper is the following in the first section we present the photogrammetric survey for the production of the rectified images, in the second section we present the creation of the and geo-reference of the 2-D drawings, in section three we present a proposal for a preservation information system, and we conclude in section four with some remarks regarding the project and future work.

2. THE PHOTOGRAMMETRIC SURVEY

The photogrammetric survey was organized based on the topography of the buildings and was divided in two sections, field work and data processing in the office. Due to the large volume of buildings that had to be mapped and the time constraints regarding the project, different teams working simultaneously were organized.

2.1 Data acquisition

The main task of the field work was the acquisition of facades images, the collection of control points and the general surveying of the project's area. As we mentioned above the project's area was spanning in four neighborhoods, along 30 streets containing approximately 300 building facades. The field work was organized along each neighborhood. The first step was image acquisition. This task was performed the first two days of the project. During the data acquisition stage the most difficult problem that we had to cope with was the narrow streets and alleys (figure 3). As a result we have to cover a building façade with multiple images, find vantage points in opposite buildings floors and use a wide angle lens.

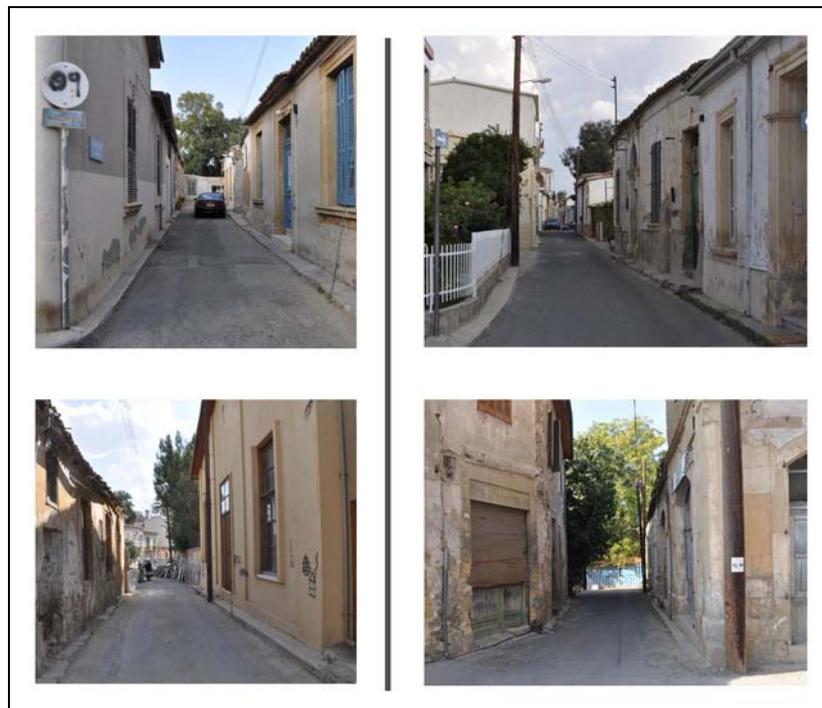


Figure 3: Example of narrow streets and alleys.

The images were captured using the Canon EOS 400D digital SLR camera using a 10-20mm wide angle lens. The images had a resolution of 3888 x 2592 pixels (10 MP), and were captured with an average distance of 2-3 meters resulting in ground pixel resolution of 3-4 mm. The acquired images were grouped per neighborhood, street, street side, and building. For each building some images were chosen to serve as a sketch for control point collection while some were picked for the rectification. Four 2 person teams were

used for the collection of control points and surveying measurements in figure 4 we can see a sample control point sketch, and images picked for the rectification.

For each façade an average of 10-15 control and check points was measured, depending on the number of dominant planes per façade. The control points were measured using reflectorless total stations with an accuracy of 5 mm. The control points measurements lasted for a week, while the topographic measurements of the area lasted for a month and were performed by two measurement teams.



Figure 4: Sample control point sketch and acquired image.

2.2 Single Image Photogrammetric Processing

The single image processing consisted of three different stages. The first stage was the processing of the control points measurements, the second stage was the creation of the rectified images and the third stage was quality and accuracy control, and creation of mosaics where necessary. Control points were measured in an arbitrary coordinate system for each building façade. At the first stage the system had to be rotated so that the X axis was parallel to the building façade, the Y axis was parallel to building height and Z axis was the distance from the camera, meaning that we have to apply an 90° angle rotation and a κ angle rotation equal to the direction of the building facade. For the rotation of the coordinate system we used the following approach. At first all the control points of the dominant facade plane were selected, and a line fitting algorithm was applied. As a result the plane direction was calculated. The line's direction was used to calculate the κ rotation angle and to perform the rotation of the measured control points. The result was the projection of the control points to the façade's plane. In figure 5 we can see all the above steps, starting from the top view of a building consisting of 1 dominant plane with the best fitted line displayed, the rectified image and the digitized façade.

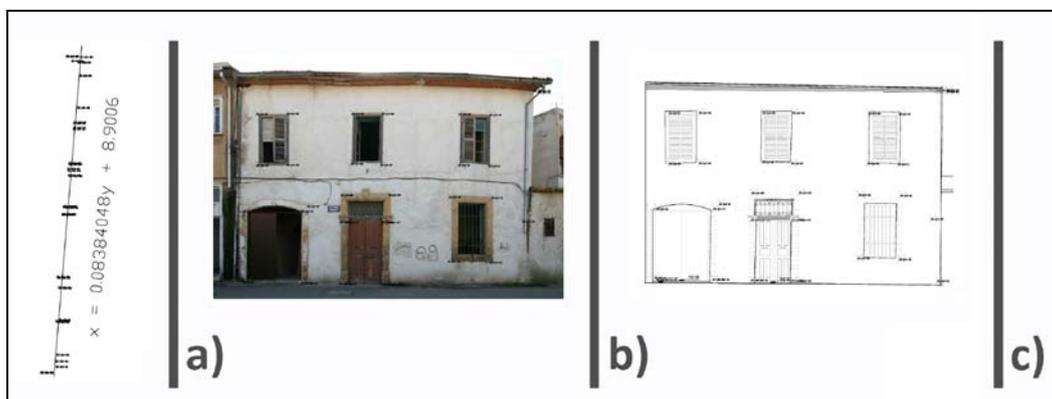


Figure 5: Control point projections and rectified generated from the arbitrary coordinate system a) Best fitted line b) Rectified façade c) Digitized façade.

For image rectification we used the Z/I IRAS/C software. We used at least 8-10 control points and 3-5 check points for each image rectification. In the majority of the cases the projective transformation had an accuracy of 1-2 cm. The accuracy was calculated using the coordinates of the check points. The produced rectified images had a resolution of 0.5 cm (figure 6). In the cases that more than one image were required to cover the building façade a mosaic was created using the IRAS/C software. In that case a seam line was digitized and the image mosaic was created along the seam lines.

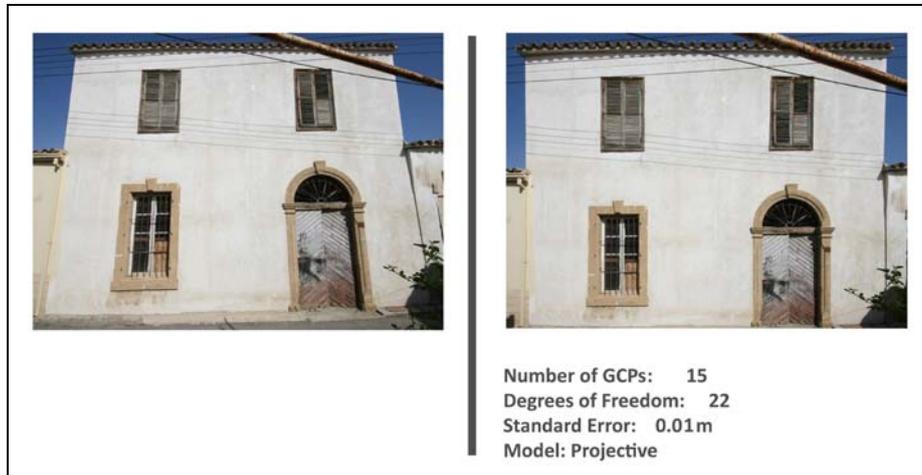


Figure 6: Rectification Example.

3. 2-D DRAWINGS CREATION AND GEO-REFERENCE

The next step was the digitization of rectified images. The images were imported in AUTOCAD, and a team of architects designed the 2-dimensional drawings of the building facades. Different layers were used for the mapping of facades keeping in mind the needs of the preservation information system. An example of the used layers is shown in table 1. Architectural elements that could not be digitized by the rectified images were measured with traditional surveying methods and were designed using these measurements. Such elements include non flat surfaces, information about the building’s roof, etc.

Digitization Layers
Facade walls
Pathology
Roof Tile type
Roofs
Door and window frames
Architectural details (stones, hashes, bricks, gutter pipes, etc.)

Table 1: Digitization Layers

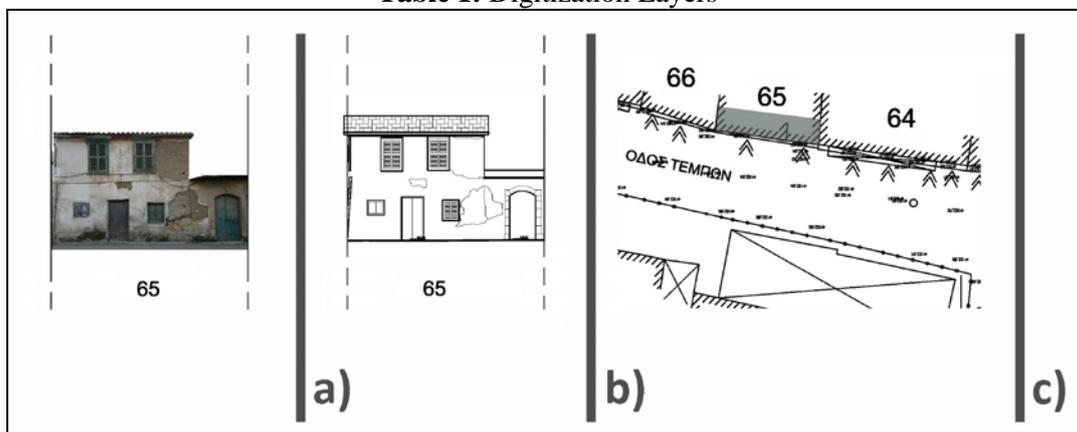


Figure 7: Building façade mapping procedure a) Rectified image b)2-D Drawing c)Georeferenced façade.

Following the façade digitization was the geo referencing of the facades. Survey maps of the 4 different neighborhoods were used as reference. For each building façade 3-4 interest points were measured in the field and as tie points for the georeference procedure. The final drawings were comprised from all the facades along a street face. In figure 7 such an example is displayed, including the vector form of the facades and the rectified images used for the production of the geo referenced part. While in figure 8 a façade series along a street part is displayed.



Figure 8: Georeferenced Façade series along a street part a) Rectified images b) Architectural Drawings c) Survey Map.

4. PRESERVATION INFORMATION SYSTEM

Mapping the building facades was the first step for the preservation process. All the information needed for designing and scheduling the preservation action is depended on the existing 2-D drawings. Although the 2-D plans are suitable for the planning, there is a need for a system that will allow the monitoring of the works, along with the monitoring of the buildings' condition for the future. In this section we present a proposal for such a preservation information system. The first step is the design of the system's database. Taking into consideration our collected data, we design an information system specifically for the building facades along the surveyed streets, because we don't have any information regarding the building's interior or of facades

that haven't been mapped. The information needed for monitoring the condition of the building can be classified in the following categories:

- Historical data
- Cadastre data
- Building materials
- Building condition
- Previous restorations

More specifically in table 2 we analyze the data for each category.

HISTORICAL DATA	CADASTRE DATA	BUILDING MATERIALS	BUILDING CONDITION	PREVIOUS RESTORATIONS
Date of construction	Current owner	Structure Materials	Structure condition	Type of restoration
Ownership history	Building plot	Facade materials	Facade condition	Original Materials
Previous uses	Building data (number of floors, area, height, etc.)	Morphological Elements	Pathology	Restoration Materials
Construction phases	Current use	Roof	Erosion	Restoration date
		Wall paintings/ frescos	Corrosion	Analysis and Evaluation of previous restoration
		Balconies	Disintegration	
		Chimneys	Vegetation	
		Coatings		

Table 2: Preservation Information System Database design

The second critical part of such a system is the cartographic background; in our case are the 2 D drawings of the building facades organized in series along a street face. The projects goal was the mapping of the building facades along streets with cultural heritage significance. As a result for most of the building we haven't model all the building's facades, but only the ones that faced the specific streets. Consequently that is the reason we organize our preservation system based on the street series facades. Each facade is linked to the database entry regarding the specific building facade. Furthermore facade elements are linked to database entries regarding the materials, proposed restoration, and damages. More specifically information about architectural elements, such as doors, windows, morphological elements, roofs is linked to specific drawing elements for each facade. Facades areas that are erodes, corrodes or damaged are individually digitized for each facade and linked to database entries regarding the facade's condition. In addition information regarding cadastre data of each building is linked to the survey map of the area.

A monitoring system is present which allows to follow the restoration processes and changes made to each element. As a result all changes made during the restoration process can be recorded in the database and also in the 2-Dimensional drawing of the facade as a different design layer, giving the restoration experts the ability to monitor everything what is being done to the building, and create database entries with data regarding the restoration process and approach. Another aspect of the application would be tools that will allow the automatic creation of status reports regarding the preservations works progress.

5. CONCLUSIONS – FUTURE WORK

At the first part of this paper we presented the production of 2 dimensional drawing of building facades. In our approach we used single image photogrammetric techniques to map the facades. The final rectified images had an accuracy of less than a 2 cm and a resolution of 0.5 cm. The produced drawings had also an accuracy of less than 2 cm and were fully mapping the facades. All the architectural elements and façade corrosions, erosions and damages were fully recorded in the produced 2-D façade maps. Finally all the

facades were geo-referenced using traditional surveying technique to produce facades series along streets. The accuracy of the reference procedure was also less than 2 cm. Although it was a difficult task to produce the 2-D drawings in the time allocated, the work plan that we followed allowed us to keep the deadlines. The photogrammetric processing of the images lasted about two months, while the creation of the 2 D drawings lasted for 3 months and was done simultaneously with the photogrammetric processing. The georeference of the drawings was the last step and was finished in a week.

At the second part of this paper we presented a proposal for a preservation management system. Although preserving our cultural heritage is a critical task and technological advancements in both hardware and software allow to produce such systems, they are very rare or not at all used. We are currently at the stage of implementing the proposed information preservation system and creating all the additional tools that will allow the monitoring of preservation work. The next step is to test it in a small case scenario, involving 7-10 building facades and determine its weak and strong aspects. Taking into account the results of the test case we are going to improve the proposed system and test in a large scale scenario.

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