Reconstruction of everyday life in 19th century Nicosia

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Abstract. This paper presents the first stages of a larger project concerning the study and realization of a 3D interactive environment of everyday life in 19th century Nicosia. The presented study involves the recreation of the built urban environment (i.e. the architecture of the city) based on historic and archival information taken from the first Land Registry documentations taking place on the island at the end of the Ottoman era by British engineers.

Keywords: built environment, urban, architecture, land registry, procedural modeling, 3D reconstruction

1 Introduction

This paper involves the initial stages of a broader study that aims to present a unique insight to the everyday life of the city of Nicosia; and which will concern both the socio-economic identity of its people and the spatial organization of its buildings within the walls, during the turn of the 19th century. The paper will focus on presenting the process by which the spatial organization of the buildings within the city is realized and on the historic representation of the different architectural building types of constructions found at the time.

The core of the information is drawn from the title deeds archives of the Land Registry Department in Nicosia and the first ever land survey conducted in the city and headed by Lord Kitchener in the 1880's. These documents in their whole have not been researched or published before and are now in neglect. The title deeds data are complemented by a meticulous study of the available surviving maps (Fig. 1a, 3c and 3d) in order to create a 2D map reflecting the location and structure of each property on the ground at the time of the property registration (Fig. 1b). In addition to the footprint of each building, we hold information as to the usage of each of the rooms (living space, kitchen, store room, chicken coop etc), the existence of other features (well, trees, outside oven), as well as the ethnicity and profession of the owner.

Based on the information gathered above, as well as the knowledge of architecture of 19th century, a set of rules and 3D components are created and

Fig. 1. (a) Kitchener's Map from 1880 represents an outline of built volumes found in the city at the time (b) 2D map of a city sector; the Taht el Kale mahalla [4] containing the detailed architectural ground elevation of each building with reference to the Land Registry index and information.

passed to a procedural modeling system to generate the 3D city model. This 3D model will represent the urban organizational pattern of the walled city. By using this approach we will be able not only to preserve the title deeds' information but most importantly to spatially allocate all the buildings within the urban context of a 3D interactive model of the city and, at a later stage, present a unique insight to the everyday life of the city as an urban environment and its inhabitants.

At its completion, the tool presented here will aim to stand as an educational platform for students so as to learn through interactive walkthroughs and role playing games within the 3D environment of the city and it's everyday activities at the period. At the same time the 3D representation of the city and exact 3D recreation of landmark buildings and sites will offer a useful tool to professionals (architects, archaeologists, historians, urban planners) concerned with the old city of Nicosia. In time this 3D model will be able to be enriched and expanded by the input of further research done in the field of history and architecture of the city of Nicosia. In this paper we present the results of our study as it materializes for one certain area in the city, the Taht el Kale mahalla which is shown in Fig. 1b.

A series of scientific objectives are to be implemented as part of the project. Some of them are presented in this paper:

1. The data from the Land Registry will be transferred into digital form, aiming for the database's preservation.
2. A digital footprint of the city of Nicosia during the last half of the 19th century will be created.
3. A procedurally generated 3D model of the city and the buildings which will be as accurate as possible, taking into account all the gathered information.

2 Previous Work

The walled city of Nicosia presents an exceptional urban layout which remained unaltered during the Ottoman era, where many different religious denominations

inhabited different mahallas within the walls, before the 20th century's redevelopment altered the image of the city forever. This work will be the first attempt to recreate an urban locale in its totality from the contents of title deeds as existing similar studies (e.g. Geniza Documents on Fustat/Cairo, title deeds studies for Renaissance Venice) are limited in just the social analysis of the deeds.

The study by Iliadou [4], serves as a guidance to our research since it attempted a 2D recreation of one of Nicosia's neighborhoods from the same information we investigate and represent in this current study. However, in [4], the result was a set of 2D annotated maps. The information was not used for extracting information on the type of each building and reconstructing them in 3D. Based on the methodology implemented in [4], the urban environment is derived from the written accounts on each property taken from the first ever land registration and also draws on studies made on the topography [6], architecture of the city [4,5,6,7,11,12,14] photographic itineraries/ drawings [1] and traveler's accounts [2,9]. Regarding the social history aspect, the registry archives which will be the main source of information on which the city will be rebuilt, also include details on the occupations, family relations and religious beliefs of the owners and occupants as well as details on livestock kept, workshops, shops, bathhouses, hans/ hostels and so on. All these information are preserved, analyzed and for the first time will be presented in conjunction to scholarly research on the field [3,8]; recreating the urban locale of a late 19th Mediterranean city.

Digital modeling of old cities has been a long part of active research in Computer Science. A number of methods have been developed for this purpose. One approach is the use of photogrammetric methods [18], where photographs from the area are used to create the models of the buildings and the environment. Satellite images are also used so that maps of the area are created and analyzed to study the architecture of the city. A very popular approach is to procedurally generate a model of the city using a set of architectural rules [17]. This approach was employed for the digital modeling of Pompeii. The process was based on archaeological data and ancient Pompeii life is simulated in real time [16].

3 Reconstruction Methodology

To create the 3D model of the city, we start from a collection of data (Fig. 2): printed maps such as Lord Kitchener's map (Fig. 1a), data from the land registry done by the British during the period and a series of photos, drawings and paintings of different buildings, people, events etc. taken by travelers or people that used to live in the city at the time.

All the maps are scanned and digitized, and all the building limits are identified and marked generating in the process a 2D vector map with road and building limits. A software tool is being developed so that all the land registry data will be entered and processed accordingly; this data consist of high level description of buildings and neighborhoods such as "Costas lives next to Yannis, has two children and his wife's name is Maroulla, his house has two bedrooms, one bathroom, a backyard and a well". This software will try and identify the

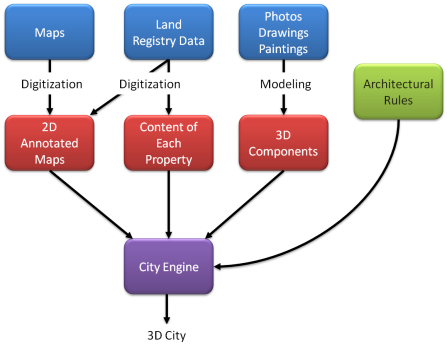

Fig. 2. The reconstruction process. A series of printed data such as maps, the land registry data, photos, etc. are digitized and used by modelers so that a set of 2D annotated maps and 3D building components are made. All these data, alongside a series of architectural rules are fed into CityEngine [19] and a 3D model of the city is procedurally generated.

real positions of the buildings in the digitized maps and annotate the maps with this information. Since this approach will most probably not be 100% accurate, some post processing will be done from the research team. Information about each house will also be gathered so that the 3D representation of the house will be as accurate as possible.

Using photographs of the buildings and the streets, alongside drawings and paintings drawn by travellers or inhabitants of the city, a series of basic 3D building blocks such as walls, doors, windows, wells, etc. are created. These simple building blocks will be combined to create the 3D model for each house using a series of architectural rules, defined manually by a member of our team, specialist on the architecture of 19th century Nicosia.

3.1 Data gathering and preprocessing

The collection, study and analysis of the historical data and evidence needed to create a realistic 3D model of the walled city will result in the generation of an annotated footprint of the area of Taht el Kale in Nicosia at the time and information about the inhabitants. This area has recently been renovated and been awarded a Europa Nostra award as a historic urban regeneration project.

In order to achieve this, work along two different avenues is performed in parallel: maps,drawings, paintings and photos are analyzed and processed and the Land Registry data conducted by Lord Kitchener are used to enhance the maps and identify properties.

On one side the data of the period is collected, analyzed and pieced together. These data form the basis for the virtual models, both of the city and the people inhabiting it.

As part of this preliminary study, 2D designs and maps (Fig. 1b) of one neighbourhood, the Taht el Kale Mahalla in Nicosia were recreated from the same

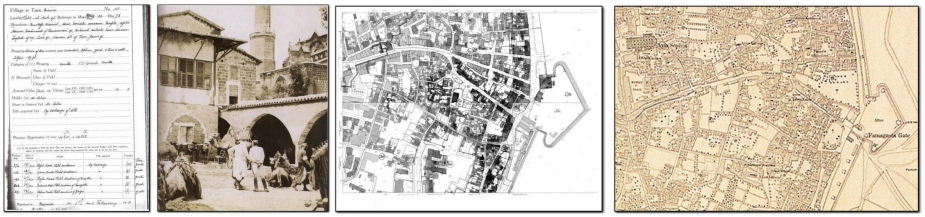

Fig. 3. (a) Original Registration document [4] (b)Detailed photographic images from the time, assisting on the 3D recreation of elements. (c)(d)Land Registry Maps (from the 1880s and 1920s respectively) that were used for the production of the 2D outline of the properties in Fig.1b. They are the only two existing maps that can be consulted to produce results on the urban built development at the end of the 19th century as they show how the image of the city was altered in a period of 40 years.

archive material, the Land Registry documents (Fig. 3). This experience proved valuable in the form of guiding the researches through the bulk of information provided in the archives by following an already tested analysis of these certain data and also avoiding any time consuming reconnaissance procedures of the relevant documents.

This 2D representation of each property on the ground (Fig. 1b) used here for the 3D environment recreation of the Taht el Kale area is an outcome of synthesis of two surviving maps of the area, one predating the archival data and one postdating (Fig. 3c and 3d). The scholarly synthesis of the two was accompanied by field studies where the elements of the maps were cross referenced to architectural remains on the ground. During this process the set outline of the built structures of the 1880's map was tested upon the borders of the properties in the later map (1920's) and superimposed upon ancient remains on the ground as seen today. This process produced the outline of properties on the ground but still without the exact reference of which property was which in relation to the information of the land registry data since any maps referring to the land registration are not preserved today at the Land Registry archive. Also the properties in the registration documents are mentioned without any street names or numbers so one could identify them in space easily. The peculiarity of this case arises as properties included at the registry are numbered and described by bordering properties (name of owner) and not by street names and numbers along one street. A meticulous calculation then has to take place putting each property side by side on the ground relating borders (names of owners) to one another to produce clusters of neighbouring properties. A dedicated software is being developed by the research team so that all the information is gathered and processed with as little human intervention as possible. When these two patterns are combined the 2D outline of buildings can be numbered and matched to the written registry information to produce the final map (Fig. 1b) with each built property set in its rightful place.

On the other hand the Land Registry documents (Fig. 3) include a richness of information regarding the built elements of each property, number of rooms

and function of each space on the ground. These pieces of information are already organised in tables (Table. 1) taken from [4] research for this certain area the serves as the case-study of this paper. Based on this the spaces and further architectural characteristics of each building could be recreated in the later produced 3D model of the environment.

The process of giving form to each facade that was generated from the ground will be described later on as it was a building investigated as part of this current study.

Table 1. Analysis Tables - Building Property elements

Properties															
Registry Number	Elements making up each property(number)												Valued at (thousand piastre)		
	Shop	Ground Floor Room	Room On Upper Floor	Kitchen	Yard	Toilet	Bath	Well	Stable	Store Room	Verandah	Other	-5	5-10	10-15	15+
29		1	2	X	X	X					2			X		
30	Space for Shop													X		
31	Shop													X		
32	Shop											X				
33		1	2		X						3			X		
34	House & Shop	1	1								2					
35		2		X	X	X					2			X		

3.2 3D Reconstruction

The digitized, vectorized maps of Nicosia are imported into CityEngine [19], a procedural city modeling tool. After studying the architecture of the houses, a set of rules that describe them are defined. A set of different building types were identified: one floor house, two floor house, store etc. Each of these has similar appearance (similar materials, doors, walls, etc.) but requires different rules for its construction.

For the appearance of windows, doors, arches, etc., models were designed using a 3D modeling package and then imported into CityEngine to have a more realistic result. We note here that the major landmarks will need be created by the artist directly since those are unique; a significant number of them have already been created. Different textures and dirt-maps were created to enhance the appearance and variability of the models. Each building of the test map (Taht El Kale) was identified and built using the appropriate rules as was previously described in Section 3.1.

4 Architecture

The process of giving form to each facade that was generated from the ground was an important research part of this current study. Nevertheless it was based on previously done analysis of the architectural typology of the historic architecture of Nicosia. The historic typology of buildings refers to both a typology of spaces- organised on the ground (floor- plan typologies) and typology of facades (windows and doors organisation upon a facade). A typology and a morphology of buildings refers thus in a set of rules formulated in years of constructing within an urban environment. These rules spur from both regulatory norms of building legislation as well as functional needs that are related to sun orientation, privacy and access towards the street.

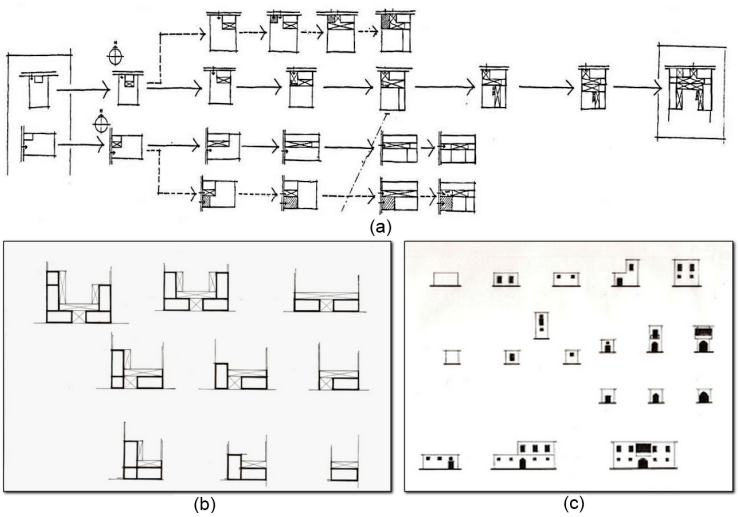

Fig. 4. (a) Floor plan typologies for Nicosia by D. Demi represent the floorplans of different building types found in Nicosia. They present typical plots of land and the way volumes where built in the plot around the open space of a garden. (b) Floor plan typologies for Nicosia from [4]. These diagrams represent a simplified form of the floorplans presented by D. Demi.These diagrams show the way built volumes where organised along the street. (c) Facade typologies.

Italian scholar Danilo Demi [11] drafted an elaborate floorplan typology study of Nicosia (Fig.4a) one that is simplified by Iliadou in her study (Fig.4b) setting such the rules by which built volumes are set on ground within a certain land-plot. These rules serve later as a guiding line for the 3D recreation of each building within a plot. The main rule upon which built volumes are set on the ground is that structures were first created upon the street line were all the main living spaces were found taking one floor or two depending on the case. Secondary uses as store rooms, animal sheds, kitchens etc are found to be taking up the back inner spaces of each plot. The entrance to each property is usually through a semi-open but covered space that leads from the street to the inner courtyard. In all the cases of buildings except in the cases of shops all built structures are organised around an inner open yard where local fruit trees are found. The built volumes of each property are organised organically upon the boundaries of each plot and open up towards the inner yard.

When we come to the stage of formulating the facades, meaning drawing windows and doors the main guiding line to dictate the form these will take is the function of the building and the rooms in question. This information is derived for each structure from the title deeds which name each property's use. According to each use and relating the information that comes from photographic itineraries and written accounts of the time, the architectural morphology/ design of each facade element is suggested to be digitally generated. A useful tool to the organ-

isation of the design of the facades is the typology chart by which walls/ facades are divided in types of different openings/windows doors categories (Fig.4c).

The main rule of formulating facades is actually a social one relating to privacy norms prevailing at the time in question. According to that most first floors bear smaller windows usually found high above the ground in an effort to guard interiors from intruders and to obscure any view from the outside. Following the same notion from the outside the volumes are usually closed with the outer walls of each plot boundary to be above human hight at around 2m and over.Doorways are arched and are centrally set usually in each main facade upon the street. Upper floors and inner walls are set withe bigger rectangular windows. The rooftops may be included or flat depending the built volume they cover. Smaller buildings are usually covered by flat roofs and where inclined roofs are found they are of small angle. Flat roofs where made by earth/ soil that was pressed to become hard over a wooden thatched flat structure that made up the ceiling of each building. In the case of inclined roofs a wooden inclined structured was covered with tiles in the outter surface. The inner courtyards as well as the streets are not paved with the palm trees, vine trees and cypress being the main green feature found in public spaces.

5 Results

As part of the early work in this project, a section of Nicosia, the Taht El Kale was selected for 3D modeling (see Fig.6). The source maps were digitized and the properties were identified manually, since the automatic annotation tool is in development. By defining a set of primitive objects such as doors, walls, windows, wells, etc., (Fig.5) and a set of architectural rules and the data from the land registry a 3D model of the block is generated. We can observe in Fig.6 that the houses belong in two categories; one or two floor buildings, some of them have backyards with household animals and the overall structure of the reconstructed area is similar to the source map. It should be noted here that the 3D rendering of the buildings and the area is not that accurate since these pictures were taken from the CityEngine renderer which is just enough for previewing capabilities. Once these models are integrated in our dedicated 3D Urban simulation framework with advanced rendering capabilities, the appearance will be much more realistic.

Fig. 5. A series of components such as windows, doors, livestock and trees were used as building blocks.

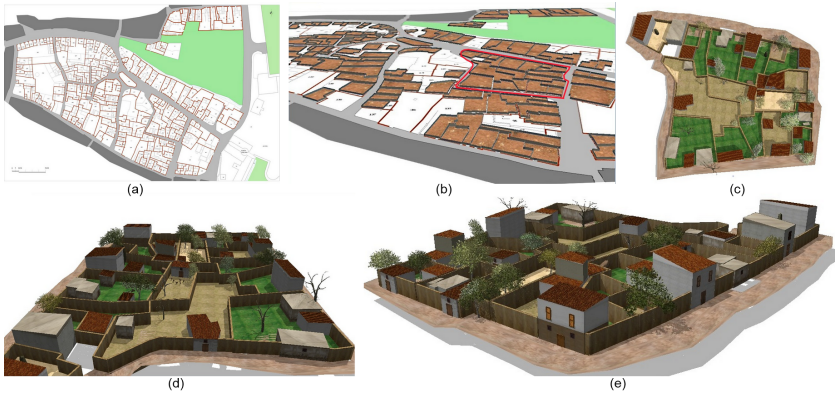

Fig. 6. (a)Source digitized maps, (b) 3D view of the map in CityEngine: the shaded areas indicate buildings and the red outline indicates the testing region, (c) top down view of the procedurally generated 3D view (d)(f) 3D views of the selected area.

6 Future Work

We plan on using this model in a variety of applications, most of them being educational. The learning experience will be enhanced by the interactive manipulation of the city model. It will be integrated in varius virtual reality games that will help students and visitors of museums to learn more about Nicosia, its people and their customs during the period. Social games can also be developed, where the users will be able to collaborate to solve fun and clever puzzles, explore the city and learn about important monuments and buildings.

Currently, a software tool is being developed to process all the Land Registry information so that all the real life inhabitants of the city at the time are assigned to their original houses. Information in the land registry documents are a little bit vague: houses did not have any address information and information is described in relation to the neighbors. This tool will group together neighbors and people and will try to find their houses in the maps.

One of our main targets is to add lifelike virtual characters into the 3D simulation of the city. These characters will enhance the immersion felt by the users; these characters will act and look like the people from the era. Information from images of the era and real clothes will be used to model the appearance of the characters whereas information about the people's social behavior and moving behaviors will be gathered from documents of the time. To do so, a combination of rule based and data driven crowd simulation algorithms will be developed and employed. Rules will be used mainly for the high level social behavior patterns of the people, whereas data driven algorithms will be used for the low level steering/collision avoidance behavior.

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