Reviving Nicosia of the XIXth Century

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1 Introduction

In this paper we describe our on-going work on the virtual reconstruction and population of XIXth Century Nicosia. The project involves the development of a semi-automatic pipeline that will take as input maps and land-registry deeds and will give as a result a 3D model of the urban space inhabited by animated virtual characters, guided by the historic information. The aim is to present a unique insight to the everyday life of a bygone era. In the city, now divided by a wall into Muslim north and Christian south, a population of Muslims coexisted with the Christian-Orthodox population as well as with other minorities, in an interesting intertwine of culture and religion located in the dense built environment within the city walls.

The core of the historic data is drawn from the 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 had not been researched or published before and are now in neglect. The archive information is processed by a software tool that matches the records and pieces together the urban structure, to create an annotated footprint of Nicosia. This annotated footprint will include the map of Nicosia at the time, together with the real inhabitants' names and particulars, plus information about the buildings.

The buildings at the time were designed based on structured rules that we have encoded in the required form. A procedural system will be fed with these rules, the annotated land maps and 3D models of the basic features of the city (buildings, inhabitants, livestock and everyday objects), to produce the final models. A small number of handcrafted landmarks will also be included.

One of the most ambitious parts of this project is the integration of intelligent autonomous virtual characters behaving in a realistic manner. These characters will be dressed according to their faith denomination, their occupation and social status, again derived from the land-registry deeds. By integrating realistic characters, the dynamics of urban life will be accurately portrayed historically; the city will be enriched with life giving it an even more realistic appearance and feel.

To conclude, through a meticulous study of the available historic information we aim to construct a 3D interactive model, which will represent the urban organizational pattern of the walled city. In that way we will be able not only to preserve the title deeds' information but most importantly to spatially allocate all the findings within the urban context of a 3D interactive model of the city and finally present a unique insight to the everyday life of the city and its inhabitants.

2 Setting the background for reviving an urban locale

2.1 Historical information and data collection; a context

Historical data that are found in archival collections such as the ones from which our research draws upon, often present an immense opportunity for digitalised analysis.

The study and quantitative analysis of probate inventories has been a key feature in the development of material culture studies within the newly emerging discipline of historical archaeology (Hicks and Beaudry 2006, Hall and Silliman 2006). Such inventories have been used by many historians in an effort to analyse changing patterns of consumption and their related social rituals in an effort to better understand early modern society. More over though, than the mere analysis of movable objects the study of immovable property provides us with solid clues of life in the past. French social theorist Henry Lefebvre notes that the city represents a projection of society on the ground whether bad or good (Koffman and Lebas 1986: 83) where the ground encompasses the notion of topography which is in all definitions of cities and landscapes crucial. The digitalised analysis of such data stands above any effort of a mere quantitative analysis of data as it produces a 3D living environment. This interactive model provides us with the unique opportunity to not only represent a three dimensional built environment but also to furnish this setting with all aspects of social expression recreating a historical everyday- life environment in its totality.

Many of these documents present official records of documenting various aspects of everyday life and material culture in historical times. Such records maybe notary documents, property registries for tax purposes, inheritance inventories and so on. As they represent official documents ruled by legislative or other norms set by the consequent responsible authorities, these documents are drafted according to rules. Most of the time their form follows a set pattern of sections to be filled, as it is in the case of the Land Registry documents of XIXth century Nicosia. This patterned form of these documents allows the digital analysis of the information they include using a set form of rules as the documents are already written following rules.

In the case of a historical urban built setting the researcher seeking to virtually recreate such environment goes far beyond the simple quantitative analysis of data provided in archive documents. The written information found in relative sources may go as far a setting an urban environment on the ground but further knowledge is needed to feed in the process to create a three dimensional environment. Building regulations and legislative clauses are included in many governing rules drafted in the past centuries. These rules may not be found under the anticipated name of ‘building regulations’ as we are used to them today but are sometimes hidden within other clauses such as the ones regarding ‘public decency’, ‘fire protection’, ‘privacy’ and so on. The Byzantine rules of urban regulative norms for the city of Constantinople are mostly descriptive in making a case of how people ought to built or rather regulate their built property in respect of their neighbours (Harmenopoulos 1930, Laiou and Simon 1994). The Assizes of the Latin Kingdom of Jerusalem and Cyprus, the regulative system set before the XIVth century also provides us with similar clues (Nader 2006). This kind of clues that refer to the way an urban historical locale was built and regulated become more obvious in the early modern period where urban rebuilding following the industrial revolution demanded the founding of a strict set of rules. In the case of XIXth century Nicosia the Ottoman Land Code provides our research with such a background of rules that coordinated the built environment (Iliadou 2011) at the time. As such, these restrictions and rules aimed to ordinate how different buildings where set on ground and these exact clues provide our research with another set of fundamental ‘3D building’ information in the realisation of this historic urban site.

Also as the era that concerns us is the end of the XIXth century since which great parts of the locality of the walled city may still stand in a great degree unaltered. This is due to contemporary protective legislative development and enables our research to draw also from on- site evaluations of the case- study area. Our research employs at certain points 'standing-building' archaeology, drawing from on- site studies of standing buildings (Danilo 1997, Iliadou 2008) and the cross- reference of their built form with the information included in the relevant archive documents.

In conclusion the virtual historical city that will be the outcome of our study draws from a threefold of historical data and methodological approaches, the above mentioned that all feed in the creation of the 3D interactive environment of the city of Nicosia. An analysis such as the one traced in this paper aims to create trans- disciplinary scholarship disabling conservative boundary- maintaining devices within historical research (Hicks and Baudry 2006: 197).

2.2 Virtual reconstructions

Digital modelling 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 (Y. Takase 2003), 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 (P. Birch 2001). This approach was employed by some researchers for the digital modelling of Pompeii; the process is based on archaeological data and ancient Pompeii life is simulated in real time (J. Maim 2007). In this paper, the approach that we are employing is based on procedural modelling: through the archaeological evidence for the region, rules are defined and using a specialized procedural city modelling software (Esri CityEngine 2011), a 3D model of the city is created.

2.3 Crowd Simulation

Computer generated crowds are now becoming common in films, computer games and other virtual world applications and simulations. Although methods for animating a single human character have advanced considerably, automatically animating a believable crowd remains a challenge. A lot of algorithms and techniques have been developed that fall into two categories: rule based (C.W. Reynolds 1987, C.W. Reynolds 1999, D. Thalmann 2007) and data driven (Lerner 2007, Lee 2007). Relatively few of these systems take into account character interactions, and those that do, model the behavior of small groups of interacting agents with some simplifying assumptions. In this work, we will create a system that combines both rule based and data driven algorithms. A related project to the one proposed here, was the work done by (Maim 2007), where the ancient city of Pompeii was procedurally generated and populated with crowds of virtual Romans but having only limited steering behavior.

3 Previous Reconstructions of XIXth Century Nicosia

There has been some previous work relating to the 3D reconstruction of parts of the old City of Nicosia. Dikaiakou et al. (2003) developed a rule based procedural system, similar in principle to the system we present here. In their system they recreated parts of the Chrysaliniotissa Quarter as it stands now. That specific quarter is particular in that it has

retained its character and many of the buildings date back to the first half of the XXth century and some even older.

Based on the study of Danilo (1997), they assumed that the houses can be classified into four categories: Original Courtyard-House, Minimal Courtyard-House, Planned Serial-House and New Courtyard-House. They take as input the detailed, current, maps from the Land Registry Department that contain the outline of each house to a scale of 1:500. From the outline they place each house into one of the four categories, with each one having different rules and features for the 3D reconstruction. Out of the four categories only the first two are relevant for the XIXth Century. The two latter are styles adopted during the British rule of the island (1878-1960 ad). But even houses falling into the first two categories look very different in their current form than they would have looked in the XIXth Century. They have different styles in their various features such as doors and windows. Due to the simplistic approach for identifying the house type and components, the final result was not very satisfying. In addition, no characters were added and with the exception of the Chrysalliniotissa church, only residential buildings were modelled.

A more recent project, funded by the Leventis Municipal Museum of Nicosia, involved the creation of an interactive system showing Nicosia in the XIXth Century (Michael 2010). The installation "Virtual Tour in Nicosia of the XIXth Century", uses a single wall, front-projection setup and it allows the visitor to get a glimpse of how the city might have looked like at the time. The scenario is built on the description given by an un-named English traveller who visited the island at the time and published his report in a British Magazine called "The Home Friend" (Anonymous, 1850).

The traveler entered the Old Town at one of the 3 gates, most likely Famagusta Gate, and crossed the city going through different neighborhoods, poor and rich, points of interest, bazaars, a hammam (Turkish Baths), administrative quarters etc. The specific application was placed in the museum where many visitors go through every day, therefore the total time spent by each visitor had to be restricted to less than 5 minutes and therefore only some most representative parts of the route are shown: after entering through the city gate, the visitor goes to a desolated street with houses in a bad state of destruction, only inhabited by donkeys and cows, if at all. Then it's the Serai, a rich nicely paved square hosting the administration buildings, mosques, coffee shops and big houses, followed by the Bazaar, or street market and the hammam (steam bath). After leaving the hammam, the visitor walks to the house of Kornesios, a rich local functionary, where he is hosted, and finally exists the city from the Famagusta Gate. Some images from the tour are shown in *Figure 1*.

Figure 1 *Images from the Leventis installation on Nicosia of the XIXth Century (Michael 2010), showing two computer rendered scenes with no characters (left and middle) and a populated scene filmed using conventional means (right).*

Certain parts of the route, were a challenge to recreate realistically using 3D graphics, so they were filmed using conventional methods. This was especially so for the areas where the presence of people was essential, such as the Bazaar which is always crowded with people (see Figure 1 right). In the current implementation shown at the museum, the video footage alternates with computer graphics. The users of the application are able to navigate interactively for the parts shown with 3D graphics while they just watch passively the video footage. At the parts of the route that are done using 3D graphics the users are allowed to change the viewing direction, the zoom, and navigation speed using touch buttons on the touch screen mounted next to the projection wall, however they are restricted to the pre-defined paths, within the areas that have been modelled.

Although the areas that have been reconstructed look a lot more realistic and faithful, as compared to (Dikaiakou 2003), the system as a whole falls, in many respects, short of the goals set in our current project. Since the models were manually built, they only cover a small area, in fact only a few scattered streets, through which the user is allowed to move. Even in these areas, attention was paid mostly to the facades. There was not much attempt to be precise in the representation of each specific building but the aim was more on given the right feel. The models are completely empty from virtual characters, and humans only appear in the pre-recorded video parts. However, several landmarks were modelled (such as the hamam, a mosque, the walls, the Hadjigiorgakis mansion) which we will re-use in our system since they cannot be built procedurally (see bottom row of *Figure 6*).

4 System Description - Nicosia as a case study

As part of this work, a system capable of rendering a complex 3D reconstruction of the city of Nicosia including a large number of virtual characters is going to be developed (see *Figure 2*). Data from various sources will be used to procedurally generate a 3D model of the city during the XIXth century (see section 4.1). At the same time, a crowd simulation system will be developed using information from textual and visual documents of the era alongside videos of real crowds (see section 4.2). These two components; the 3D model of Nicosia and the Crowd Simulator will be developed independently so that they can later be used in different platforms for different models and different purposes.

4.1 3D Reconstruction

To create the 3D model of the city procedurally, we start from a collection of data (*Figure 2*): printed maps such as Lord Kitchener's map (*Figure 3a*), data from the land registry collected by the British at the time 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 (***Figure 4***).

All the maps are scanned and digitized, and all the building limits are identified and marked resulting in a 2D digitized map of Nicosia with road and building limits. A software tool is being developed so that all the land registry data will be entered and processed; the land registry data consist of high level description of buildings and neighbourhoods such as “Costas lives next to Yannis, has two children and his wife's name is Maria, his house has two bedrooms, one bathroom, one backyard and a well”. This software will try and identify the 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 due to incomplete and ambiguous data, the team will post process the results. Information about each house will also be gathered so that the 3D representation of the buildings will be as accurate as possible.

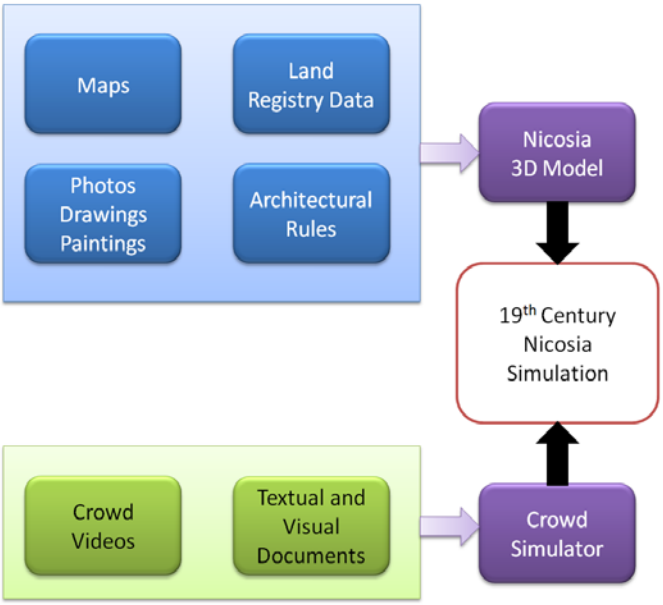

Figure 2 *System overview. A series of data like XIXth century maps, the land registry data, photos and some architectural rules are used to create procedurally the 3D model of XIXth century Nicosia. Using information from texts of the time a series of moving and behavior patterns of people are identified and used to control the high level behavior of people. Using videos of real life crowds (modern era), a data driven system for low level steering behaviors if created. The crowd simulator and the model of Nicosia are then combined to create the complete simulation of Life in XIXth century Nicosia.*

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 by the procedural engine to create a realistic 3D model for each house individually using a series of architectural rules. These rules are defined manually by the architecture specialist in our team and describe a small collection of rules governing the creation of houses during XIXth century Nicosia.

Figure 3 *(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 containing the detailed architectural ground elevation of each building with reference to the Land Registry index and information.*

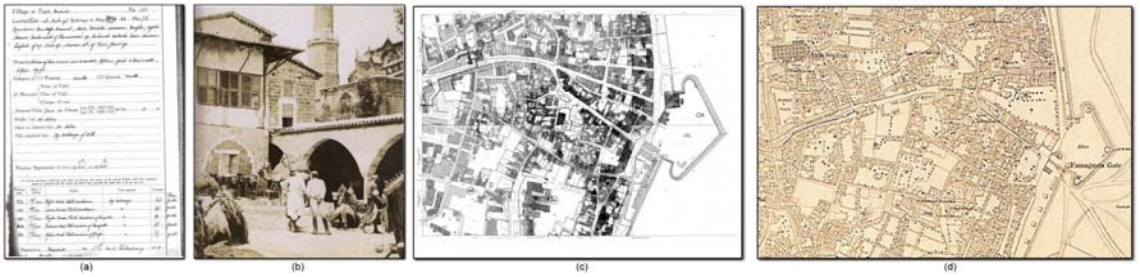

Figure 4 Historical documents used for the reconstruction of XIX century Nicosia. (a)Original Registration document (b) Detailed photographic images from the time, assisting on the 3D recreation of elements. (c)(d)Land Registry Maps (from the 1880s and 1920s respectively) that were used for the production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

4.2 Historical data and reviving XIXth century Nicosia - a case study

As part of this preliminary study, 2D designs and maps (*Figure 3b*) of one neighbourhood, the Taht el Kale Mahalla in Nicosia were recreated from the same archive material, the Land Registry documents (*Figure 4*). This experience proved valuable in guiding the researches through the bulk of information provided in the archives as they were able to follow an already tested analysis of these certain data and so avoid any time consuming reconnaissance procedures of the relevant documents.

This 2D representation of each property on the ground (*Figure 3b*) 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 (*Figure 4c* and *Figure 4d*). 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 no maps referring to the land registration is preserved today at the Land Registry archive. Also the properties in the registration documents are mentioned without any street names or numbers so one is not able to 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. The dedicated software being developed by the research team will enable the information to be 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 (*Figure 3b*) with each built property set in its rightful place.

On the other hand the Land Registry documents (*Figure 4*) 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 taken from previous relevant research (Iliadou 2010) concerning the certain area which 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.

4.3 The historic built environment; architectural typology and morphology

The process of giving form to each facade that was generated from the ground was a stage in architectural history research investigated mainly as 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.

Italian scholar Danilo Demi (Danilo1997) drafted an elaborate floor plan typology study of Nicosia (*Figure 5*a) one that is simplified by Iliadou in her study (*Figure 5b*) setting in this way the rules by which built volumes are set on ground within a certain land-plot.

These rules serve 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. These spaces/ volumes were housing the main living spaces which depending the case are taking up one floor or two. 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 take up, 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 and followingly digitally generated. A useful tool to the organisation of the design of the facades is the typology chart made by Iliadou in her previous research by which walls/ facades are divided in types of different openings (window and door organisation on a facade) categories (*Figure 5*c).

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 rising above human height, 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 with bigger rectangular windows.

The rooftops may be inclined 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 outer 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.

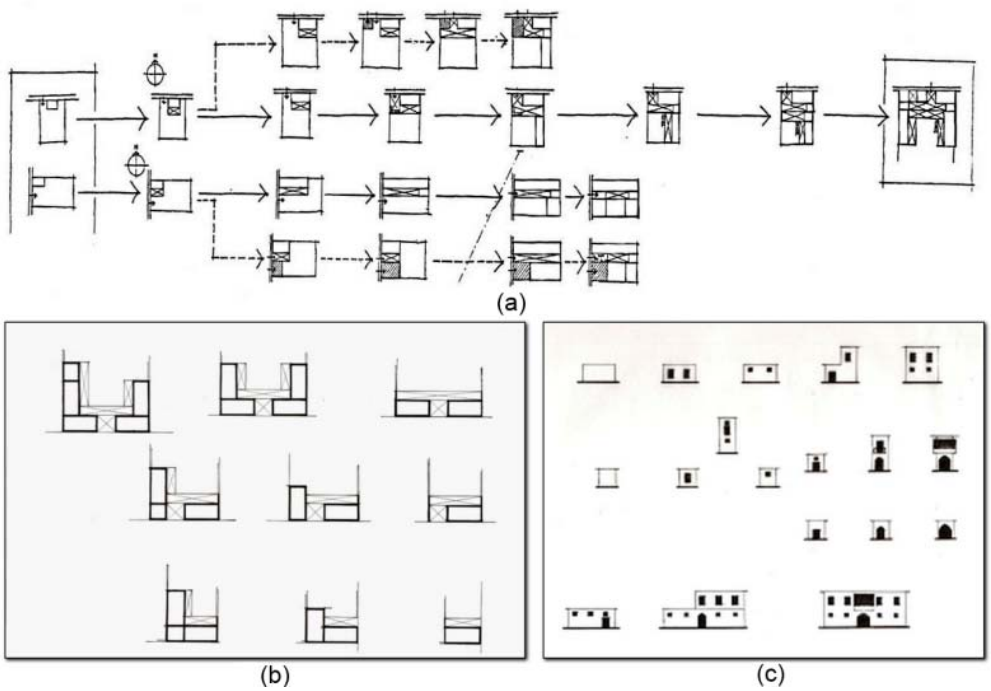

Figure 5 (a) Floor plan typologies for Nicosia by D. Danilo represent the floorplans of different building types found in Nicosia. They present typical plots of land and the way volumes were built in the plot around the open space of a garden. (b) Floor plan typologies for Nicosia from (Iliadou 2011). 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.

4.4 Crowd Simulation

One of the most ambitious parts of this project is the integration of intelligent autonomous virtual characters that will behave in a realistic manner. These characters will be accurately represented, drawing on archive information and old photographs; they will be dressed according to their faith denomination, their occupation and social status. By integrating realistic characters, the dynamics of urban life will be better portrayed historically; the city will be enriched with life giving it an even more realistic appearance and feel. Novel crowd simulation algorithms will need to be developed in order to take into account social behaviour patterns and customs of people as these were exhibited during the XIXth century within the walled city of Nicosia.

The crowd behavior subsystem is a collection of algorithms that are responsible for the simulation of the virtual characters behavior as part of a crowd: i.e. given the state of an agent (autonomous character) and its virtual surroundings, this system is responsible on deciding the best action the agent should take. Most of the currently systems under development currently use one out of two approaches: they either use a rule based system where various predetermined rules are defined or they use data driven (example based) algorithms where rules are implicitly extracted from some provided data such as videos or user sketches. Rule based systems are simple and straightforward to implement but to generate believable crowds, one should define a large number of finely tuned rules, which in most cases is cumbersome. In a data driven system on the other hand, given a large enough input dataset the results are

more realistic since these complex rules are defined implicitly by the data. The main issues with example based techniques are the collection of large enough input videos and the selection of appropriate influencing factors from the videos.

We will follow a hybrid approach: a combination of both data-driven and rule based techniques. We believe that this approach will provide the best of both worlds: the naturalness of data driven techniques alongside the simplicity of the rule based approach. At the same time we will avoid the need for very large input datasets that the data driven approach needs and also reduce the number of manually written rules. In our system we divide the possible behaviors in two categories: high and low level. Low level behaviors are basically reactive ones: steering behaviors like guiding an agent to walk towards a goal while at the same time avoiding collisions with other agents and various environment obstacles like walls, buildings etc. High level behaviors are more conscious ones: for example what should an agent do if he is thirsty or wants to buy something. A higher level system should be able to plan characters actions and decompose them into simpler ones.

At the lower level, data driven algorithms will be used since a video can provide us with very limited perception of a person's internal state and goals, but at the same time provides us with enough information for steering behaviors. It should be mentioned here, that even though we do not have any videos of crowds in the XIXth century Nicosia, a reasonable assumption can be made that at the lower level, the steering behavior of people didn't change much and therefore videos from sparse crowds in today's urban environments are adequate. Some fine tuning of the steering behaviors will be applied, using the collected information from the historical documents, such as the typical walking behavior of women and men (men are in front of the women, typical walking speeds), people and livestock (i.e. a horse should stay next to the owner), etc. Rules will also be defined for general purposes where no appropriate example situation is found in the videos.

At the higher level, rule based techniques will be used. Rules will be defined that will be responsible to guide the autonomous characters in the simulation, so that they accomplish some goals and fulfill desires, such as going to the market, meeting some friends, going and taking part in social gatherings, path planning etc. The rule based system will decompose complex tasks into simpler ones, such as move from point A to point B, wait for 5 seconds, talk, etc. The appropriate animations from motion capture data will be played according to the required actions. The motion capture data will come from two sources: a motion capture system owned by the team and free motion capture databases.

5 Conclusion

We presented our approach on reconstructing everyday life in the city of Nicosia during the XIXth century. A system for procedurally generating a 3D model of the city and inhabiting it with a multitude of virtual characters is being developed. Currently, we have created models of characters resembling people from the era and some models of the city using CityEngine (Figure 6 top row). Models of varius important buildings such as the walls of the city and the Agia Sophia monastery have been created by artists (Figure 6 bottom row). Also, a crowd simulation system is being developed that will be responsible for the virtual character's behavior. All of these components will be integrated into the system during the next few months providing an agile platform that will be used in a multitude of applications such as educational games where users can learn interactively, a research platform for crowd simulations, etc. Also, the rigorous study and collection of data by the members of the team can be used in future research work and as reference point since most of these data has never been collected before.

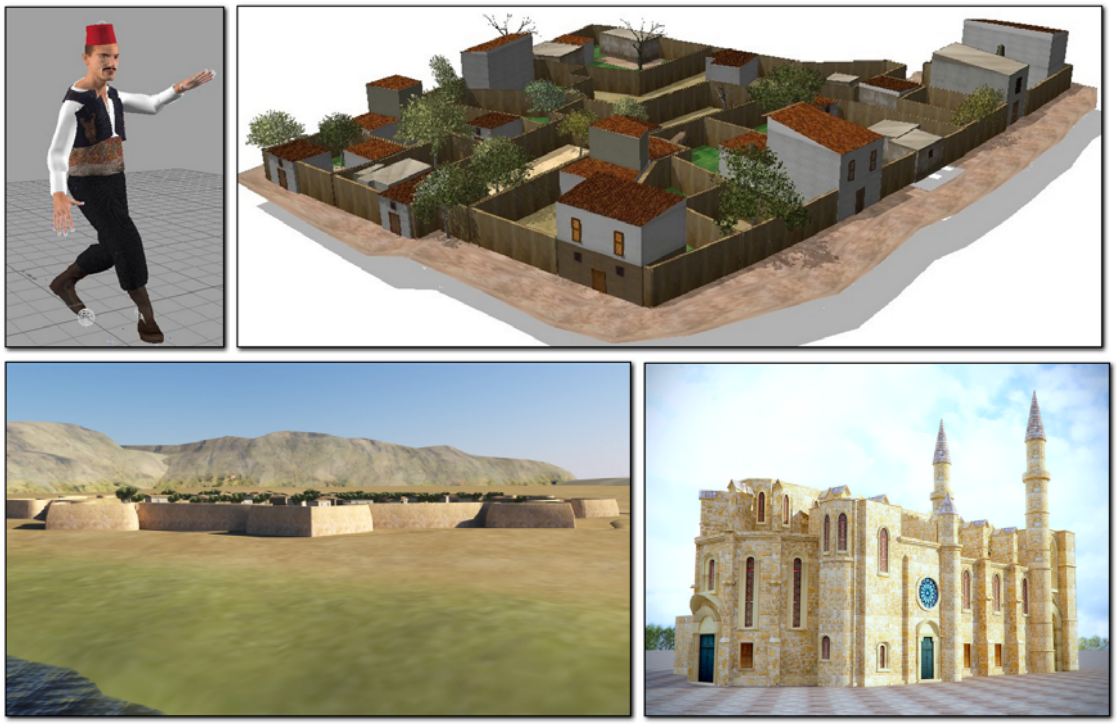

Figure 6 *Images from work so far. (top row) A 3D model of a Cypriot Dancer of the era dressed appropriately. A series of animations are also captured using our own Motion Capture system (b) First results from the procedurally generated system. This image represents a block from the city of Nicosia. Some important landmarks (bottom row) of the city that were created by 3D artists.*

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