Telling Stories: Historical Narratives in Virtual Reality

Roger L. Martínez-Dávila
Universidad Carlos III de Madrid and *University of Colorado-Colorado Springs*
Paddington Hodza
University of Wyoming-Laramie
Mubbasir Kapadia
Rutgers University
Sean T. Perrone
Saint Anselm College
Christoph Hölscher
Chair of Cognitive Science, ETH-Zurich
Victor R. Schinazi
Chair of Cognitive Science, ETH-Zurich

Introduction

Telling stories is as old as humanity. It was Herodotus (484-425 BCE), the Greek scholar often known as the "father of history", who proclaimed in *The Histories* both our collective reasons and worries about preserving stories. He wrote:

> This is the display of the inquiry of Herodotus of Halicarnassus, so that things done by man not be forgotten in time, and that great and marvelous deeds, some displayed by the Hellenes, some by the barbarians, not lose their glory, including among others what was the cause of their waging war on each other.[1]

We tell stories to save the past. Most of these stories today are experienced through reading texts, and we consequently are denied the visceral experience of the past even though we strive to recapture and animate lost worlds through our distinct senses. Virtual Plasencia is our highly realistic and interactive model of the Spanish medieval city of Plasencia. Virtual Plasencia offers dynamic new ways of storytelling via visual and auditory senses. By navigating the three-dimensional city simulation, users begin to experience the sights and sounds of daily life in a medieval city, meander its cobbled streets and contemplate its principal structures and residences, and observe human interactions from different (e.g., religious, personal, communal) points of view. Inside Virtual Plasencia, users encounter people and places that cannot usually

[1] Herodotus, *The Histories*, Book 1, Chapter 1.

be achieved through traditional written narratives. The opportunity to observe historical events *in loco* represents a valuable new form of representation of the past.[2]

This chapter examines one specific digital story titled, "'La Mota': A Christian Assumes Ownership over Jewish Homes, circa 1416," for which we have developed historically-accurate avatars, that move beyond text and provide users a more comprehensive approach for learning by experiencing a tangible period of medieval history. The story recounts why and how a Jewish neighborhood came into existence, what transpired during its less than one hundred year presence, and why it was displaced. This 3D avatar-inhabited narrative consequently tells a more complex story of interreligious relations during a time of increasing anti-Jewish/Muslim animosity in Castile that culminated in the expulsions of Jews (1492) and Muslims (1502). This narrative was developed as part of a larger interdisciplinary project titled, "The Revealing Cooperation and Conflict Project: An Integrated Geovisual and Transcription Project for Plasencia, Spain," or RCCP.[3]

As we expand Virtual Plasencia, we will map and document other neighborhoods within the city and anticipate that some users will use the environment and documented histories as a starting place to undertake their own research on interfaith relations within this world. By employing Virtual Plasencia's search and geodatabase tools, which are under development, users will be able to conduct their own research and prepare new digital histories.

We sought to employ virtual reality because it offers users the chance both to engage the past through role-playing simulations and to gaze at particular events in different time periods from a variety of perspectives (e.g., nobles, commoners, religious minorities). For comparison, consider the role-playing model Valley of Sim that allows users to take on the persona of a Civil War era resident from Augusta County, Virginia or Franklin County, Pennsylvania.[4] Once users have studied their persona's letters, diaries, and other documents, they can engage in informed arguments for and against slavery, secession, emancipation among other topics. Another example, the Virtual Paul's Cross Project, explores a specific sermon (e.g. John Donne's sermon for Gunpowder Day in 1622) and uses it to create a real time experience of an early

---

[2] It is worth noting that virtual reality projects are feasible even with modest budgets. The prototype of Virtual Plasencia and the present narrative were created over four noncontiguous months with a limited budget (under $15,000 USD). We are grateful to the Global Middle Ages (MappiMundi) at University of Texas-Austin and University of Colorado President's Fund for the Humanities for their generous subventions that made this work possible.

[3] More information on the project can be found at our website, http://revealingcooperationandconflict.org.

[4] Hope College, "ValleySim: Social Computing Meets Inspired Learning," accessed June 1, 2016, http://valley.cs.hope.edu/template/home.php; Christian Spielvogel and Laura Ginsberg Spielvogel, "Speaking the Language of Digital Natives: Role-Playing Simulations in the Communication Classroom," *Electronic Journal of Communication* 20, 1&2 (2010): no page number. http://www.cios.org/EJCPUBLIC/020/1/020123.html. Accessed June 1, 2016.

modern sermon and recreate multiple models to open our eyes to new interpretations.[5] Our project blends the role-playing and flexibility aspects of virtual reality with the ability to witness an event unfold.

Virtual reality extends the user's experience because it help them develop empathy with individuals living through challenging time periods and events. That virtual reality serves an educational function should not surprise us because many 3D animations are at the most basic level dioramas (albeit interactive dioramas). Dioramas are used in museums and classrooms to recreate actual places and events. Educators use dioramas to give people a sense of how a battle unfolded or what life was like in a medieval village. Dioramas help people to immerse themselves in a distant time and place and allow them to visualize how life must have been like in the past. Consequently, dioramas allow people to utilize visual cognitive skills to compare past and present. Viewing an event unfold (such as property transfers in a medieval city of Plasencia) allows users to organize and process information differently and develop new insights about the past that text alone cannot convey. These insights should in time generate new research and make clear the importance of observation along with textual analysis for humanists.

In this article, we first establish the rationale for interdisciplinary collaboration in the digital humanities as a means to explore unique problems of historical analysis. We then provide a sample narrative in virtual reality. Finally, we outline the steps used to create our virtual narrative so that others can prepare their own narratives. The La Mota narrative represents the outcome of our efforts to move beyond text and to provide the public and scholars a more comprehensive approach for "experiencing" history.

Part 1: Interdisciplinarity Enhances Historical Understanding

The digital humanities offer novel ways for historians to collaborate with geographers, computer scientists, and visualization specialists to research medieval interreligious relationships. Historical documents can provide detailed textual content and serve as the basis of historical geography and geovisualization.[6] Using digital tools, scholars can generate multi-sensory experiences to evaluate nuanced human interactions that are often omitted or underrepresented in traditional historical narratives or 2D maps in geographic studies. Compared to conventional narrative approaches, the ability to experience and interact with events and people through

[5] John N. Wall, "Virtual Paul's Cross Project: A Digital Re-Creation of John Donne's Gunpowder Day Sermon," accessed July 3, 2016, https://vpcp.chass.ncsu.edu; For a virtual walk through of a simiar project, see: Bernard Frischer, "Digital Roman Forum," accessed June 3, 2016, http://dlib.etc.ucla.edu/projects/Forum.

[6] F. Driver, "Research in historical geography and in the history and philosophy of geography in the UK, 2001–2011: an overview," *Journal of Historical Geography*, 42 (October 2013): 203-211;
J. Dykes, MacEachren, A. M., and Kraak, M.-J, *Exploring Geovisualization* (Amsterdam: Elsevier, 2005).

realistic 3D visualizations allows for a more intellectually robust analysis of manuscripts, maps, and texts.

In Virtual Plasencia we visually explain how the La Mota Jewish neighborhood was shaped by prior events and dynamically interacted with contemporaneous circumstances. By utilizing avatars, or computer-generated actors, and different camera perspectives, we contextualize local events within the broader historical arena. In the case of the foundation of the La Mota neighborhood, we detail how developments at the end of the fourteenth century made this physically-separated city zone a necessity for survival of Jewish community.

La Mota was created in the late 1300s as Christian Spain convulsed from the disastrous outcomes of plague, civil war, and massive religious and cultural change. From 1347 to 1350, approximately 25 percent of Europe's population died from the Black Death.[7] Across Europe, Jewish communities were implicated as the cause of the illness.[8] Thus, Jews built enclosed neighborhoods like La Mota for their own self-protection from mob and vigilante attacks. It was a safe haven for Plasencia's Jews who largely escaped the worst physical and religious attacks that culminated at 1390s. Simultaneously, from 1350 to 1369, a politically and culturally destabilizing civil war raged in the Spanish Kingdom of Castile and Leon.[9] At end of this century, prominent new elites like the Mendoza, Ponce de Leon, and Estúñiga families became the "New Nobility" of Castile.[10] The power and authority of the Estúñiga clan subsequently seeped into Plasencia and the family would be instrumental in the dislocation of Jewish residents from La Mota neighborhood.[11] Virtual Plasencia's digital storytelling, with its avatars re-enacting historical events, showcases the machinations of Count Pedro de Estúñiga's shadowy entry into the city and his efforts to conceal his purchase of the homes in La Mota.

In this respect, Virtual Plasencia allows us to move beyond traditional narrative analysis and evaluate "spiritual geographies", or those physical areas where distinct religious communities interacted. In Plasencia, the centers of Christian, Jewish, and Muslim religious authority (e.g., the cathedral, parish churches, the synagogue, and the mosque) were relatively close to one another. Our analysis reveals the Jewish synagogue of Plasencia, located in the heart of La

---

[7] Ricardo A. Olea and George Christakos, "Duration of Urban Mortality for the Fourteenth-Century Black Death Epidemic," *Human Biology* 77, no. 3 (June 2005): 291.

[8] Samuel M. Cohn Jr, "The Black Death and the Burning of Jews," *Past and Present*, no. 196 (August 2007): 4.

[9] Cayetano Rosell, C*ronicas de los reyes de Castilla desde Don Alfonso el Sabio hasta los Catolicos Don Fernando y Doña Isabel. Tomo primero* (Madrid: Biblioteca de Autores Españolas, 1953), 390; Rosell, C*ronicas*, 592.

[10] Bartolome Clavero, *Mayorazgo: Propiedad feudal en Castilla 1369–1836* (Madrid: Siglo XXI de España Editores, 1974), 28; AHNSN Osuna, Caja 124, doc. 2.

[11] The La Mota narrative relates to a larger conflict between Estúñiga family and local converso leaders in the Cathedral of Plasencia and the city council. For more on the Estúñiga's efforts and local efforts to restrain them, see Martinez-Davila''s manuscript, *Blood, Faith, and Fate: Jews, Conversos, and Old Christians in Early Modern Spain* (forthcoming)."

Mota, was less than 75 meters from the second oldest Christian structure, the thirteenth century Church of St. Nicolas.[12] (Figure 1 presents a geographic information systems map of medieval Plasencia. See the southwestern section of the city for the location of the synagogue and Church of St. Nicolas.) This was a closely connected community of multiple faiths.

Figure 1: GIS Map of Late 14th-Early 15th Century Plasencia (Spain)

See Telling Stories: Figures, Tables, and Images

As such, mapping and modelling the movement of Jews, Muslims, and Christians through the city's streets and footpaths, offers a novel approach to understanding the intensity of Christian-Jewish-Muslim interaction. Using information about the residence of the principal Jewish, Christian, and Muslim families sets a starting point in the analysis of the type and frequency of the relationships and social interactions between these groups. Here, 2D and 3D visualizations inside Virtual Plasencia allow for the recreation and reenactment of the regular pedestrian traffic in these areas.

Users are able to have the sensory experience of cathedral canons, rabbis and residents regularly passing each other in specific plazas (like the Plaza de San Nicolas), streets (like Calle de Zapateria/Rua), and footpaths. (In Figure 1, Calle de Zapateria/Rua is depicted as a green line in the southwestern zone of the city.) In addition, the accurate modelling of these spaces allows us to calculate different activity patterns. This includes the distribution across space and time of religious events at specific footpaths, streets, and plazas. It also provides details about the time (e.g. holidays, days of week, hours of the day) when these activities occurred and the actors involved. Presently, we have surprising anecdotal evidence derived from archival sources that indicate the Plaza of St. Nicolas, in the heart of the Jewish quarter of the city, was the most dynamic and intermixed space.

The Church of St. Nicolas was an important venue because interfaith disputes were literally resolved at its front doors.[13] In "extraordinary circumstances," a Jewish judge and a Christian judge heard and adjudicated cases on the church's steps that involved conflicts between individuals of these different faiths.[14] However, it is not until we collect more historical data and fully develop *Virtual Plasencia* that can we evaluate our initial archival evidence as well as identify other places of noteworthy interaction. We are particularly intrigued by fifteenth century life in the main city square (Plaza Mayor) where Christian knights, Jewish merchants, and Muslim purveyors of silk, all resided as neighbors. In addition, Calle de Talavera, which served as the de facto border between the Christian ecclesiastical neighborhood to the southeast and the Muslim quarter to the northeast, appeared to hold a unusual concentration of local church leaders like Cardinal Juan de Carvajal (a voracious preacher of crusade against the Ottoman

[12] Jose Benavides Checa, *El Fuero de Plasencia* (Rome: Tipografia de M. Lobesi, 1896), 106.
[13] Jose Benavides Checa, *Prelados Placentinos* (P*la*sencia: Excmo Ayuntamiento de Plasencia, 1999), 139.
[14] Ibid.

Turks during the mid-1400s) and Abdalla Bejarano, a wealthy Muslim merchant that rented the largest stables within the walled city.[15] These residential zones are all highly compact and it begs the question of how residents viewed themselves as a multi-religious community during such religiously-charged times.

Such maps grant us the opportunity to evaluate whether interfaith neighborhoods heightened or lessened conflict between religious communities. Further, if religious animosity had little to do with actual physical living patterns and instead was related to deep-seated religious hostility. Therefore, this research raises important new questions about how urban residential living patterns affected interfaith cooperation and conflict.

The emerging benefit of the 3D component of Virtual Plasencia is that it also provokes us to ask new questions about the particular "lines-of-sight" of each building. The Estúñiga's massive four-story, fortified Palacio de los Mirabeles provided them with 360-degree surveillance of this residential zone. That is, using the 3D model, we can visualize how these strategic properties enforced control over a neighborhood. The 3D model also provides the ability to represent the accurate architectural style of the city and how it changed over time. For example, users can walk through Virtual Plasencia before and after the creation of the Palacio de los Mirabeles. More importantly, the synagogue that no longer physically exists in contemporary twenty-first century Plasencia, resides in Virtual Plasencia as it did during the fifteenth century. Examining these changes from a first person perspective provides an additional layer of information to scholars interested in how religious, cultural, and political differences were physically expressed in the cityscape (e.g., the embossed coats of arms on the property of noblemen and mudejar architectural styles used in the adornment of the synagogue).

As we advance our efforts to fully develop Virtual Plasencia into the entire medieval footprint of the city, users will be able to walk the same streets and experience the same sights and events as the residents did during the fifteenth century. This ability to enter a digital diorama of the city offers profound new ways to understand life in a pluralistic city. As we shall see, the virtual model allows us to hypothesize and model events in the absence of adequate qualitative or quantitative data. That is, often the archival record is incomplete and we only know some of the elements of historical events. By employing avatars and using different camera-angle views, we can examine street scenes and events from different personal points-of-view (e.g., a nobleman's perspective versus a Jewish woman's view). This is accomplished by modeling multiple scenarios regarding violent attacks, like the anti-Jewish pogroms of the 1390s, peaceful Jewish festivals like Purim, or the civil transfer of property. Simulations, will provide users with new historical insights that take into account different perspectives regarding interreligious relations.

---

[15] RAH Colección Salazar y Castro, tomo C-12, 159v; RAH Manuscript L-5, 106v; ACP Legajo 7, doc. 10, fol. 1; Domingo Sánchez Loro, *Historias Placentinas Ineditas: Primera parte catalogus episcoporum ecclesiae Placentinae. Vol. B.* (Cáceres: Institución Cultural "El Brocense" Diputacion Provincial de Cáceres, 1983), 461–462.

Part 2: La Mota: A Prototype of a Virtual Narrative

The La Mota story is an initial effort at authoring a virtual narrative to recreate this crucial time in the lives of several Christian noblemen, a Jewish rabbi, local civic leaders, and Jewish families. Users who watch the visual story serve as witnesses to the events as they unfold. Further, the virtual narrative simulates the atmosphere (dress, streets, buildings) and offers visitors an experience that unfolds in real time.

The thirteen minute digital narrative "La Mota: A Christian Assumes Ownership over Jewish Homes, circa 1416," is viewable at: https://youtu.be/H5MwORpIb7U and http://revealingcooperationandconflict.com/digital-video-narrations/. What exactly occurred in Plasencia in the fifteenth century and why was it consequential to the history of interreligious relations? Our traditional textual narrative argues that within Plasencia, religious coexistence was degenerating during the fifteenth century. The textual narrative, which varies slightly from the actual text used in the digital narrative, uses a more formal writing style and academic notations. The digital narrative, where avatars portray the events, uses language that is more colloquial, shorter in length, and does not include citations.

The essence of the La Mota story is as follows:

> *Sometime before 1416, several Jewish families found it necessary to live in a fortified and gated collection of homes known as the Apartamiento de La Mota.*[16] *This enclosed section of homes was located across from the Church of St. Nicolás. Contemporaneous militant Christian evangelization of Jewish communities in the region during the early fifteenth century may have been the impetus for the creation of La Mota. In 1411, Vicente Ferrer preached in the cities of Zamora and Salamanca, which are located just north of Plasencia.*[17] *He went as far as preaching his message of conversion in these communities' synagogues.*[18]
>
> *In response to these Christian initiatives, Plasencia's Jewish community built the enclosed La Mota, which was secured with stone walls surrounding both homes and the synagogue.*[19] *The large wooden doors of La Mota were likely festooned with bronze or*

[16] AHNSN Osuna, Caja 298, doc. 3 (17); Marciano de Hervás, *Historia de los judios de Plasencia y su tierra. Vol. 1 of De los orígenes a la Inquisición siglos XII – XVII* (Sevilla: Objectivo 4, Medios Audiovisuales, Septiembre 2001): 38-50; Marciano de Hervás, *Hístoría de los judíos de Plasencía y su tíerra. Vol. 2 of Coleccíon Diplomática 1187–1823* (Sevilla: Objectivo 4, Medios Audiovisuales, 2001), 86–92, 100–102.
[17] José M. de Garganta and Vicente Forcada, *Biografía y escritos de San Vicente Ferrer* Madrid: (Biblioteca de Autores Cristianos, 1956), 172–173.
[18] Ibid; Benavides Checa, *Prelados Placentinos*, 154. While there is no explicit evidence describing Ferrer's travels within the Diocese of Plasencia, the Estúñiga family would later construct a monastery bearing his name in Plasencia's La Mota.
[19] AHNSN Osuna, Caja 298, doc. 3 (17), 42v.

steel hardware, and at night they could be closed and locked from within by a large metal bar (aldaba).[20] *In 1416, there were two zones within the apartamiento: one area contained the synagogue and multiple Jewish homes, and the other area included the dwellings of Tel Diaz de Vega, a local Christian city councilman.*

Why Tel Diaz was the sole Christian property owner inside La Mota is not clear, but it does suggest that he may have been a recent Jewish convert to Christianity. When the city council forced Tel Diaz to forfeit his properties inside of La Mota to Alvaro de Sande, due to unpaid debts, many details about the apartamiento and its inhabitants emerged.[21] *An accounting of properties conducted by Mayor Juan Sánchez and the scribe Fernándo Rodríguez revealed that Tel Diaz owned approximately five homes in the walled community.*[22] *Jewish families occupied all of Tel Diaz's properties; those families included Rabbi Abraham Deloya, Yucef Castaño, Symuel Abenabibe, Yuce Abencur, Cag Pardo, and Hayn and Symuel Daza.*[23]

In April 1416, the city council supervised the initial liquidation of Tel Diaz's holdings in order to settle Alvaro de Sande's petition. Fernándo de la Mota purchased all of these homes but allowed the families to continue to reside in them. In an interesting display of the process involved in taking possession of a house, the scribe recorded that:

> *Fernándo entered into the houses lived in by Yucef Castaño [and other Jewish residents]. These houses, the best of all of them, had been owned by Tel Diaz. [Fernándo] took possession of the homes by physically walking into them . . . and then he closed all of its doors. He then opened the doors and shook the hands of Ledicia and her husband, Symuel Abenabibe, and all of the other Jews living in these homes.*[24]

In this manner, Fernándo de la Mota proceeded to secure all of his houses in the apartamiento. Unfortunately for these families, less than eight months later the properties were sold again and purchased for 100,000 maravedis by Iñigo de Camudio, the shield bearer of Alonso de Sande.[25] *By 1426, less than a decade after taking possession of these homes, the new owner forced all of the Jewish clans from their homes.*[26] *Thus, Plasencia's Jewish community, and La Mota, returned to the traditional mixed-religious residential pattern previously characteristic of Plasencia.*

---

[20] Ibid.
[21] Ibid., 45-46v; Hervas, *Historia de judios, Vol. 1*, 42.
[22] AHNSN Osuna, Caja 298, doc. 3 (17), 77v.
[23] Ibid., fol. 78.
[24] Ibid., 90-90v.
[25] Ibid., fol. 91.
[26] AHNSN Osuna, Caja 298, docs. 3 (13) and 3 (14); Hervas, *Historia de judios, Vol. 2,* 100–102.

The dismantlement of La Mota was not necessarily part of any Christian plan to prevent Jewish families from separating from the rest of the city's population. Rather, their ejection from these domiciles appears to be the product of a brewing competition among the region's local knights, the Cathedral of Plasencia, and the Estúñiga family. After the mid-1420s, the Estúñiga clan would quickly consolidate their land holdings in this section of the Jewish quarter, which would in turn lead to a significant conflict with the Carvajal and Santa María confederation. The Carvajal-Santa María confederation controlled the local cathedral and the city council. The Estúñiga clan's efforts to secure properties in La Mota were only the beginning of more convoluted times for Plasencia's Jews, Old Christians, and conversos.

Unsettled by the forceful removal of the Jews of La Mota and their own eroding power base, local Christian leaders contested the count's growing control. In 1431, a tumultuous regional war would find Rabbi Abraham de Loya imprisoned and placed in shackles. Commoners of all faith groups were intimidated with the erection of hanging gallows in nearby towns. Two Placentino Jews -- Fartalo and his wife -- were murdered and their bodies pulled from a nearby river. This was the other side of Spain's convivencia -- violence.

In December of 1441, King Juan II gave Plasencia and "all rights over the city" to Pedro de Estúñiga in return for his political loyalty. The count moved quickly to build his Palace of the Mirabeles -- right in the heart of La Mota. Not only were Christian nobles to receive Pedro as their lord -- but the Jewish community became the property of the count. The palace would expand in size and the synagogue would be demolished. In a donation recorded on July 22, 1477, the Estúñiga family gave the Jewish neighborhood of La Mota and the synagogue to the Dominicans to construct a monastery.

The response of the Carvajal-Santa María family confederation was remarkable because they stood steadfast and ready to integrate the displaced Jews and synagogue in their immediate neighborhood in Plasencia. Within eight days of the count's actions, on July 30, 1477, Rodrigo de Carvajal sold "forever after" – rather than just leasing – a large complex of his homes on Calle de Zapateria to Saul Daza and Yuda Fidauque. Proving the strength of their conviction that Plasencia's Jewish community should have a proper synagogue, the Carvajal-Santa María family confederation sold multiple properties so that a new synagogue could be constructed on the Plaza de Don Marcos. Religious co-existence had not come to an end in Plasencia...but now it was entering its twilight.

From our perspective as scholars this recounting of events, while powerful in their own right as a text story, can be enhanced by presenting a 3D cinematic visual story. We believe that by using computer-assisted narration, we can give students and the public a better sense of all that transpired. Existing research supports our claim that visual communication and visual thinking can be enhanced through interactive 3D graphical representations. 3D terrain and building representations, in particular, mimic the real-world and facilitate depth perception making them

intuitive and more engaging than their 2D counterparts.[27] These graphical representations are more than visual flourishes; they increase our ability to evaluate complex problems.[28]

By viewing the digital narrative, for example, we are better able to consider symbolically significant gestures from handshakes to crossing the threshold of the home. Such physical gestures helped to establish the legitimate transfer of property from one individual to another. The documentation notes these actions but in a formal notarial way. Visualization helps us to view the practices through which people experienced daily life. It highlights the fact that symbolic actions and rituals were key to medieval life and these physical processes helped to establish a shared language in a largely illiterate society.[29]

Virtual Plasencia's physical textures, those cover buildings and avatars, also convey important details to users. While elements of the natural environment, such as oak trees and moss, are present in Virtual Plasencia, the overwhelming sense of the city is its hardscape of quarried stone used for buildings and streets. This section of the city was remarkable uniform in appearance. On the other hand, the selection of textiles for avatars reflects the religiously distinctive and at times colorful clothing of the Spanish Middle Ages.

Spatially, users of Virtual Plasencia and viewers of the 3D narration, can perceive the close proximity and actual distances in between homes, religious structures, and palaces. This is a vital component of both historical and geographical analysis. Broadly speaking, geographic studies inquire into people, places, and environments.[30] An important research goal is to investigate and communicate scientific information about the locations, conditions, patterns, relationships, trends and possible scenarios of these elements.[31] In the case of Plasencia, it was our goal to understand how closely Jewish families lived to one another, Jews proximity to their primary place of worship (the synagogue), and how close Jews were located from the nearest Christian structures (in this case, a church). Those distances communicate important clues about the tightly-knit nature of medieval city life inside of a walled city. Moreover, temporally, by witnessing events like the property transfers in La Mota, users can appreciation the duration of events. Simply put, for the mayor, Fernando de la Mota, and the Jewish

---

[27] P. Hodza, P, "Evaluating user experience of experiential GIS," *Transactions in GIS*, 13, 6 (2009): 503-525; ESRI, "3D urban mapping: From pretty pictures to 3D GIS: An ESRI White Paper," last modified December 2014, https://www.esri.com/library/whitepapers/pdfs/3d-urban-mapping.pdf.

[28] J. N. Van Driel, "Three dimensional display of geologic data," in *Digital Geologic and Geographic Information Systems*, edited by J. N. Van Driel and J. C. Davis (Washington, DC: American Geophysical Union, 1989): 57-62.

[29] Though dealing with different types of possession ceremonies, Patricia Seed's work remains essential to understand the symbolic nature of taking possession of lands/property. See Patricia Seed, *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640* (Cambridge: Cambridge University Press, 1995).

[30] C. T. Dahlman and W.H. Renwick, *Introduction to geography: People, places, and environment,* 6th ed (New York: Prentice Hall, 2013).

[31] D. W. Rhind, "Why GIS?," In *ARC News* 11, 3 (Summer 1989): 9-28.

residents of La Mota to visit each home on one afternoon must have required at least thirty to forty-five minutes.

Part 3: How to Build a Virtual Narrative

There are a number of steps involved in creating a virtual narrative. This basic process for developing Virtual Plasencia can be used by others to tell their own stories in virtual reality. This section outlines the steps and technologies that we used to create our narrative.

Step 1: Culling data from manuscripts

This step will be the most familiar to medievalists who regularly consult archives and rare books collections. The basic process of extracting data is the same, but to link data in geodatabases one needs to note more closely than we usually do the location of the event being described in the manuscripts. The key to performing this type of research and narrative development is interconnecting the manuscript accounts to the actual places that will be visualized.

Step 2: Development of 2D Geographic Information Systems (GIS)

To ensure that Virtual Plasencia was constructed on a solid and accurate geographic foundation, and to verify that buildings and thoroughfares could be accurately placed, we first constructed a geodatabase. A geodatabase is a repository of geographically referenced data (e.g. streets and buildings) for predefined purposes, needs, and users. Our geodatabase of Plasencia serves two interconnected purposes. First, it provides the data layers necessary for creating a 2D base map of Plasencia. Second, it supports the various types of spatial analysis used to understand the interaction between Placentinos and their urban environment. We populated the geodatabase with both spatial and attribute data that capture not only the locations of features like buildings but also details about their occupants (See Table 1*).* This information was derived from several sources such as the OpenStreetMap web mapping service, photographs, and pre-existing analog and digital maps. The most important historical source was Luis del Toro's sixteenth century perspective view of the city, which accurately depicts the medieval city's layout and no longer existing structures (e.g., the castle) and sections of city walls and gates (e.g., the Puerta de Talavera).

Table 1: Data Layers for 2D map of Plasencia

See Telling Stories: Figures, Tables, and Images

To create the geodatabase we used ArcGIS, which is a Geographic Information System (GIS) software that provides users with a variety of visual and spatial analytical capabilities. We used GIS not only to model the physical structure but also to link this structure to the events that

transpired in Plasencia. As such, GIS provides a solid framework to explore the spatial interaction between different agents in fifteenth century Plasencia.

Using ArcGIS, we imported the multi-layered OpenStreetMap depiction of the city, extracted relevant thematic layers, and updated geographic feature attributes. For analog data sources, we scanned paper maps and imported them into ArcGIS. Once placed in the GIS software, the map was georeferenced and geographic features (e.g., point, line and polygon) were subsequently digitized and assigned attributes. Two assumptions were made for georeferencing: first, that there were no significant changes to the terrain since the fifteenth century; and second, certain features (e.g., streets and city blocks) in medieval and present-day Plasencia continued to correspond and remain stable. Known attributes such as building names and ownership titles were collected from the sources noted in Table 1, and attached to digitized features (i.e. city boundary, city blocks, city gates, streets, and river). In addition, digitized city blocks were subdivided into lots and these land parcels were then partitioned into individual buildings. All digitized and derived data layers and a recent five-meter resolution digital elevation model (DEM) of Plasencia were stored in the geodatabase.

One of our concerns as we built the geodatabase was to ensure our source data was reliable and robust. The quality of 2D worlds and the amount, variety, and depth of knowledge that can be drawn from such representations are directly related to the source data housed in the geodatabase. According to Worboys and Duckham, each feature depicted in a 2D world can be described by at least four dimensions.[32] These dimensions include (1) spatial (i.e., location such as street address or latitude/longitude coordinates); (2) geometry (i.e., point, line or polygon); (3) attributes (i.e., characteristics or properties); and (4) temporal (e.g. date when road was constructed). A fifth dimension, topology, is also important to describe the spatial relationships between features. Although the 2D world of medieval Plasencia created here represents only a snapshot of those features, it is constructed using the best sources available.

The end result of our efforts was the preparation of a historically-accurate GIS map, which was previously presented in Figure 1. By using an ArcGISOnline natural-color image basemap, we generated the building footprints for medieval Plasencia. These footprints were validated by matching Luis de Toro's sixteenth century perspective view of the city. In this way, modern buildings were eliminated from the Virtual Plasencia map and medieval buildings were reproduced as they appeared originally (mostly one- and two-story structures). Figure 2 shows how we overlaid our 2D geodatabase map over a contemporary natural color image of Plasencia from OpenStreetMap.

Figure 2: Medieval Plasencia Data Layers Overlaid Over Contemporary OSM Map

See Telling Stories: Figures, Tables, and Images

[32] Michael F. Worboys and Matt Duckham, *GIS: A Computing Perspective*, Second Edition (Boca Raton: CRC Press, 2004).

Creating the 2D world was essential to designing our 3D virtual world. 2D visualizations provide users with a bird's eye view of the environment free of occlusions often present in 3D visualizations. As such, 2D worlds tend to be well suited for the display and quantitative analysis of complex spatial interaction. When creating 3D virtual worlds, one normally starts with the 2D building footprints and then extrudes them to create 3D building models that are placed on to these footprints. However, in our case, the building footprints in the geodatabase are generalized into simple rectangles (due to scale issues) in some cases, as in the case of rows of residential houses. For the most important structures in Plasencia (e.g., the Cathedral of Plasencia, Palacio de los Marqueses de Mirabel), the 2D map of building footprints corresponds to the precise footprints of 3D buildings in Virtual Plasencia.

A key outcome of our work is that it demonstrates that historical GIS studies can be accomplished by integrating data collected during multiple time periods (medieval through modern). Further, by using a recent DEM of Plasencia and then draping fifteenth century layers on it, we can make realistic assumptions about the relative stability of the city's landscape and topography. In other words, our GIS datasets match the reliability of our historical data sources.

Step 3: Original Digital Artistry to Create the Virtual World

Among our principal concerns in generating Virtual Plasencia was manifesting a world where scholars and the public could be transported into a historical space void of modern artifacts such as power lines, vehicles, and signage. In order to achieve a high degree of realism, we collaborated with Mr. David Seidman, a graphic artist, to paint original digital work that captured the "essence" and "feel" of medieval Plasencia. This artistry, also known as concept art, depicted buildings as they existed in the fifteenth century. One of the challenges of recreating these buildings is that some structures, like the synagogue, no longer exist. To create historically accurate artistic visions, we reviewed existing historical sources and captured original photography of the Church of San Nicolas, Palacio de los Marqueses de Mirabel, the Plaza of San Nicolas, and other structures, to inform the architectural details used in Virtual Plasencia.[33] We also used existing scholarly works and imagery of other historic buildings that share the architectural style and features as those in Plasencia. These buildings included the synagogues of Toledo, Avila, and Cordoba.[34]

Seidman's contributions included a digital panoramic painting of the Plaza de St. Nicolas (a public space) that includes the detailed front facades of the Church of St. Nicolas, the Jewish synagogue, and the Palacio de los Marqueses de Mirabel (seignorial palace). (See Figure 3.) He also created three interchangeable, medieval building facades (backgrounds and non-descript buildings) that are used to "wallpaper" other buildings in 3D modeling.

[33] Pedro Codero Alvarado, *Plasencia: heraldica, historica y monumental* (Plasencia: Excmo. Ayuntamiento de Plasencia, 1997).
[34] Details for these other synagogues were gathered from Franciso Cantera Burgos, *Sinagogas de Toledo, Segovia, y Cordoba* (Madrid: CSIC, 1973).

Figure 3: Plaza de St. Nicolas with Church of St. Nicolas (left), Synagogue (center), and Palacio de los Marqueses de Mirabel (right)

See Telling Stories: Figures, Tables, and Images

Step 4: 3D Spatial Modeling

Ultimately, our efforts to reanimate medieval Plasencia hinged on the expertise of visualization specialists who not only appreciated our collective interest in historical studies, but who could implement the latest technologies for 3D worlds. Modeling was conducted by the Chair of Cognitive Science at ETH Zurich and Zatun, a game developing company in India (Zatun). Outsourcing some of the most time-intensive tasks to Zatun allowed us to build Plasencia on a very limited budget (approximately $6,000 USD). As a first step, we gathered all references, images, and concept drawings (e.g., original artistry, digital photography, the *Actas Capitulares*, the Mss. 2.650) for the purpose of creating a detailed library (e.g., architectural details, textures) used to inform the design of each element (e.g., buildings, street furniture) in the virtual world. To build our structures, we used textured low polygon 3D models of the Church of St. Nicolas (Figure 4), the Plaza de St. Nicolas, the Jewish synagogue (Figure 5), the Palacio de los Marqueses de Mirabel (Figure 6). We also designed a several models of houses that were used to populate a portion of Calle/Rua de Zapateria (street). All the modeling work was created using 3D Studio Max.

Figure 4: 3D Model of the Church of San Nicolas

See Telling Stories: Figures, Tables, and Images

Figure 5: 3D Model of the Synagogue

See Telling Stories: Figures, Tables, and Images

Figure 6: 3D Model of the Palacio de los Marqueses de Mirabel

See Telling Stories: Figures, Tables, and Images

Subsequently, we situated the completed 3D models into an interactive virtual world. This was achieved by using the Unity 3D gaming engine (https://unity3d.com/). In Unity, we first generated the terrain including the background topography (e.g., mountains). Next, we imported a 2D map of Plasencia with the georeferenced location of streets and structures in the city (e.g., houses, church, palace and synagogue). This served as a template to place the 3D models. Figure 7 shows how we placed each individual structure inside of Virtual Plasencia and specified the location of each respect facade of row houses.

Figure 7: Final Placement of 3D Models in Virtual Plasencia

See Telling Stories: Figures, Tables, and Images

Once all the basic structures were in place, we added trees, a marketplace, and fountain located in the Plaza de St. Nicolas. We also included a series of period and location specific items (e.g., keys, books, armory) that were distributed around the city. Dynamic assets were also imported into the virtual model and these included birds, skyboxes (representing different times of the day) wind and water and were used to embellish the world and enhance the virtual experience.

In order to navigate the virtual world, we imported a prefabricated first person controller (FPC) from Unity-based assets. This controller allows visitors to use a keyboard and mouse (also joystick) in order to interact with the virtual world from a first-person perspective. We also created a variety of diegetic (part of the scene) and non-diegetic items and menus to guide the users around the virtual world (e.g., instruction screens, game speed, sound). (See Figure 8.)

Figure 8: Virtual Plasencia's Informational and Navigational Tools

See Telling Stories: Figures, Tables, and Images

These menus can be activated using the mouse and/or keyboard and are used to access specific items in the virtual world. For example, a diegetic menu around the fountain provides the user a brief history of the city of Plasencia. During navigation, users also have access to an interactive map that provides real-time information about their current location relative to the main structures of the city. The map is always visible on the top-left corner of the screen and can be maximized using a keyboard shortcut. Finally, we developed a time travel function that allows users to experience Virtual Plasencia during different time periods. Here, users can call up a menu consisting of a timeline with different marked eras (e.g., 1416, 1422). Selecting an epoch automatically transports the user to the specific date and updates the virtual world to the include period specific buildings and items. (See Figure 9: Virtual Plasencia's Time Travel Menu.)

Figure 9: Virtual Plasencia's Time Travel Menu

See Telling Stories: Figures, Tables, and Images

Step 5: Computer-Assisted Authoring of Digital Narratives

In Virtual Plasencia we are interested in creating narratives in highly authorable environments full of active and virtual humans. Just as in life, where stories worth telling can occur at any time and involve any number of actors, our goal is to give story authors, like historians, complete flexibility when communicating the behavior of a virtual populace. At the same time, however, we are limited in computational capacity and cannot afford to simulate every character always at the highest fidelity in real-time. Even regardless of computational cost, the sheer complexity of individual behavior authoring grows intractably from a conceptual standpoint; as the number of

virtual characters increases beyond even just a few dozen, those actors become more difficult to design, diversify, and debug.

The process of re-creating vibrant, living virtual environments is dependent on producing and managing the behavior of autonomous virtual characters in fully realized 3D worlds. Stories told and shown in busy spaces, such as those of a populous city, are dependent on an active backdrop of human characters performing a level of ambient activity to give life to the environment. These characters must exhibit intelligence not only in their individual routine, but in their interactions with one another and with the environment itself in order to present a realistic representation of expected human behavior. For instance, in Figure 10, Jewish residents autonomously meet as a group adjacent to the synagogue as they prepare to conduct a real estate transaction with the Christian mayor and Fernando de la Mota.

Figure 10: Jewish Communal Gathering

See Telling Stories: Figures, Tables, and Images

To bring the La Mota story to life, we use CANVAS, a graphical authoring tool for creating complex narratives in large, populated areas with crowds of virtual humans. This builds on top of ADAPT, an open-source software for authoring complex multi-actor character animations.[35] With an intuitive drag-and-drop interface, our system enables an author to assemble story arcs in terms of narrative events that seamlessly control either principal characters or choreographed heterogeneous crowds within the same conceptual structure. Another tool, Smart Crowds, allows groups of characters, such as our gathering Jewish and Christian individuals, to be dynamically assembled and scheduled with ambient activities. In addition, with Smart Crowds we can simultaneously select individual characters from the crowd and feature them more prominently as individuals in a story who display more sophisticated behavior. Our system runs in real-time at interactive rates with no pause or costly pre-computation step between creating a story and simulating it, making this approach ideal for storyboarding or pre-visualization of narrative sequences.

[35] Mubbasir Kapadia, Seth Frey, Alexander Shoulson, Robert W. Sumner, and Markus Gross, "CANVAS: Computer-Assisted Narrative Animation Synthesis" in *ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, July 11, 2016; Alexander Shoulson, Nathan Marshak, Mubbasir Kapadia, Norman I. Badler, "ADAPT: The Agent Development and Prototyping Testbed," in *ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, March 22-24, 2013; Alexander Shoulson, Nathan Marshak, Mubbasir Kapadia, Norman I. Badler, "ADAPT: The Agent Development and Prototyping Testbed" *IEEE Transactions on Visualization and Computer Graphics* 20, 7 (2014): 1035-1047.

CANVAS requires domain knowledge specified by experts in order to use automation for computer-assisted authoring. This includes annotating semantics that characterize the different ways in which objects and characters interact (Affordances), and how these affordances are utilized to create interactions of narrative significance (Events), which serve as the atoms of a story. In the case of Virtual Plasencia, this includes the primary cast of the La Mota narrative (e.g., Mayor Sanchez, Rabbi de Loya, Fernando de la Mota, Alonso de Sande) as well as other Christian and Muslim avatars who are walking through this section of the town.

The principal components of our computer-assisted authoring are: Smart Objects and Actors, State, Events, and Beats and Story Arcs. The virtual world consists of Smart Objects with embedded information about how an Actor can use the Smart Object. An Affordance is an advertised capability offered by a Smart Object that takes the owner of that Affordance and another Smart Object user (usually a Smart Actor), and manipulates their States. For example, a chair can advertise a “sit" affordance that controls a Smart Actor to sit on the chair. In Virtual Plasencia, our characters interact with each other as well as navigate around Smart Objects like fountains and buildings.

The State of a Smart Object comprises a set of attribute mappings and a collection of pairwise relationships with all other Smart Objects in the world. Attributes are used to identify immutable properties of a Smart Object such as its role, which never changes, or dynamic properties which may change during the story. Relationships are properties between Smart Objects, to indicate familial bonds, for example.

All Events are pre-defined context-specific interactions between any number of participating Smart Objects where each instance of an Event can have a vastly different outcome depending on the participating Smart Objects and their current State. Events serve as the building blocks for authoring complex narratives. An Event is formally defined using Parameterized Behavior Trees (PBT) and is an effective model for representing coordinated behaviors between multiple Smart Actors.[36] Preconditions on Events are used to check the validity of the States of each Smart Object. Event post conditions are used to set the States of participating Smart Objects upon successful completion of the Event.

A Beat is a collection of Event instances happening simultaneously at a particular point in the story. In Virtual Plasencia, this occurs when the main group of Smart Actors are conducting a property transfer outside a Jewish home and another collection of Smart Actors (Inigo de Camudio and Alonso de Sande) are on the steps of the Church of St. Nicolas. This sequence is viewable in the digital narrative between time markers 5:57[37] and 7:12[38]. A story arc is an

[36] Alexander Shoulson, Max Gilbert, Mubbasir Kapadia, Norman I. Badler, “An Event-Centric Planning Approach for Dynamic Real-Time Narrative,” in *ACM SIGGRAPH Motion in Games*, November 6-8, 2013.
[37] Roger Louis Martinez, Victor R. Schinazi, Katja Wolff, Paddington Hodza, Skye Swoboda-Colberg, Mubbasir Kapadia, Yuka Ichimura, and Ece G. Turnator, “'La Mota’: A Christian

ordered sequence of Beats representing a story, where Events can occur both sequentially and simultaneously throughout that story's execution.

Creating an entirely new story setting is split into three main task families, each requiring their own level of expertise -- world engineering, behavior authoring, and story design. This begins with world engineering. At the lowest level, a new scenario requires the programming and scripting of each Smart Object and its affordances, and still requires the direct writing of code, as well as the management of model, texture, and animation assets for the objects and the world environment itself. We have developed a graphical authoring interface for authoring story worlds, described here and shown in Figure 11.[39] For example, Figure 12 depicts one Event, when Fernando de la Mota, a Christian man, inspects the exterior of a residence and greets Yucef Castaño, a Jewish man.

Figure 11: A Simple Conversation Between Two Actors

See Telling Stories: Figures, Tables, and Images

Figure 12: Fernando de la Mota and Yucef Castaño Greeting Event

See Telling Stories: Figures, Tables, and Images

Next, we perform behavior authoring. The middle level of the scenario revolves around the construction of Parameterized Behavior Trees (PBTs), which are hierarchical, graphical representations of multi-actor behaviors. Lastly, we develop a story design. The story author places actors, crowds, and objects in the world and then uses a simple drag-and-drop authoring GUI to create Story Arcs using these world elements (See Figure 13).

Figure 13: A Simply Story Arc in our GUI

See Telling Stories: Figures, Tables, and Images

Lastly, we would like to highlight that to create authentic clothing and appearances for the avatars that re-enact the Story Arc, additional historical research was conducted on traditional, clothing for each respective religious group. Specifically, we consulted the textile collections of the Museo Sefardi of Toledo, Spain, and the Museo Etnografico Textil Pérez Enciso de Plasencia, Spain. By placing these traditional fabrics on our avatars, the entire visual environment was completed.

Assumes Ownership over Jewish Homes, circa 1416," filmed August 3, 2015, YouTube video, 12:52, posted August 3, 2015, time marker 5:57, https://youtu.be/H5MwORpIb7U?t=357.

[38] Martinez et. al., "'La Mota'", time marker 7:12, https://youtu.be/H5MwORpIb7U?t=432.

[39] S. Poulakos, M. Kapadia, A. Schüpfer, F. Zünd, *R. W. Sumner, and M. Gross, "Towards an Accessible Interface for StoryWorld Building," in AIIDE 2015 Workshop on Intelligent Narrative Technologies*, November 14-15, 2015.

Conclusion

Three-dimensional digital narrative provides a new way to convey historical understanding to the public and scholars. It transfers complex historical information into a more easily digestible visual format and gives users greater control over how they experience the past. The immediate benefits of our virtual world is much more than an animated 3D environment. It allows users to "experience" and "witness" events such as the cultural-significant shaking of hands during the Middle Ages. This is not simply a transactional affair, but as previously discussed, tangible evidence of the close personal contact that brought different faith groups together.

Moreover, textual ways of knowing can be cognitively demanding especially where investigators are interested in comprehending the complex spatial structure of places. The use of maps aids this understanding, but not as thoroughly as a 3D environment inhabited by properly-scaled human avatars. Virtual Plasencia, in this respect, enhances investigation because imposing structures like the Palacio de los Marqueses de Mirabel physically demonstrate political power.

Visualization also involves building mental models that are critical to developing new knowledge and understanding, and maps facilitate comprehensive mental modeling of spatiotemporal patterns and relationships.[40] Through visual exploration and interpretative analysis of these graphical representations, investigators can generate new scientific questions and theories for additional study. For example, to what event was the Jewish quarter of Plasencia considered a shared spiritual geography of Christians and Jews?

Analytical techniques like spatial autocorrelation (e.g. the distance between residences in Virtual Plasencia) and gravity models (e.g. the flow of people through the Plaza de St. Nicolas) help investigators better explain the nature and degree of interaction between people and places.[41] Put simply, was the location of Plasencia's Jewish quarter and its access to two major city gates (Puerta de Coria and Puerta de Trujillo) crucial to its economic vitality? Lastly, our scholarship argues that manipulatable 3D digital virtual worlds, like Virtual Plasencia's ability to showcase the city's environments during different eras, are more life-like and allow investigators to create multiple firsthand-like perspectives and thus more in-depth knowledge of real environments. Thus, integrating tools, concepts and techniques from history and information or scientific visualization into geography is important to better (re)construct, visualize, and explain the complexities of past, current, and future worlds.

Much still needs to be learned about how virtual worlds and digital narratives will change the way historical and humanistic arguments are made and how this knowledge is conveyed to

---

[40] A. M. MacEachren, M. Wachowicz, D. Haug, R. Edsall, R. and Masters, R, "*Constructing Knowledge from Multivariate Spatiotemporal Data: Integrating Geographic Visualization with Knowledge Discovery in Database Methods*", *International Journal of Geographic Information Science* 13 (1999): 311-334.

[41] M. Batty, *Spatial Interaction, Encyclopedia of Geographic Information Science* (Thousand Oaks: SAGE, 2007); W. R. Tobler, "On the First Law of Geography: A reply," *Annals of the Association of American Geographers* 94 (2004): 304-310.

others. We are still at the beginning of this new world, but as David Bodenhamer has pointed out, the digital humanities "stand alongside – but does not replace – traditional interpretative narratives, and it invites participation by the naïve and knowledgeable alike. We are not yet at this point, but someday we could be. It is a vision worth pursuing."[42] Our hope is that our project along with others will help make this vision a reality.

Bibliography

Archivo de la Catedral de Plasencia (Spain) (ACP). *Actas Capitulares, Libro 1 (1390-1453).*

———. Legajo 7, doc. 10.

Archivo Histórico Nacional–Sección Nobleza (Spain) (AHNSN). Osuna, Caja 124, doc. 2.

———. Osuna, Caja 298, doc. 3 (13).

———. Osuna, Caja 298, doc 3 (14).

———. Osuna, Caja 298, doc. 3 (17).

Batty, M. ed. *Spatial Interaction, Encyclopedia of Geographic Information Science*. Thousand Oaks: SAGE, 2007.

Benavides Checa, Jose. *El Fuero de Plasencia.* Rome: Tipografia de M. Lobesi, 1896.

———. *Prelados Placentinos.* Plasencia: Excmo Ayuntamiento de Plasencia, 1999.

Bodenhamer, David J. "The Potential of Spatial Humanities." In *The Spatial Humanities: GIS and the Future of Humanities Scholarship,* edited by David J. Bodenhamer, John Corrigan, and Trevor M. Harris (Bloomington: Indiana University Press, 2010).

Biblioteca de la Real Academia de la Historia (Spain) (BRAH). Colección Salazar y Castro, tomo C-12.

———. Manuscript L-5.

Biblioteca de la Universidad de Salamanca (Spain). MSS 2.650. Descripcion de la Ciudad y Obispado de Plasencia por Luis de Toro.

[42] David J. Bodenhamer, "The Potential of Spatial Humanities," in *The Spatial Humanities: GIS and the Future of Humanities Scholarship* ed. by David J. Bodenhamer, John Corrigan, and Trevor M. Harris (Bloomington: Indiana University Press, 2010), 29.

Cantera Burgos, Francisco. *Sinagogas de Toledo, Segovia, y Cordoba*. Madrid: CSIC, 1973.

Codero Alvarado, Pedro. *Plasencia: heraldica, historica y monumental.* Plasencia: Excmo. Ayuntamiento de Plasencia, 1997.

Cohn Jr, Samuel M. "The Black Death and the Burning of Jews." *Past and Present*, no. 196 (August 2007): 3–36.

Clavero, Bartolome. *Mayorazgo: Propiedad feudal en Castilla 1369–1836*. Madrid: Siglo XXI de España Editores, 1974.

Dahlman, C. T., and W.H. Renwick. *Introduction to geography: People, places, and environment.* 6th ed. New York: Prentice Hall, 2013.

Dominguez, Carlos, Yuya Ichimura, and Mubbasir Kapadia. "Automated interactive narrative synthesis using dramatic theory." *Proceedings of the 8th ACM SIGGRAPH Conference on Motion in Games* 15 (2015): 103-112.

Driver, F. "Research in historical geography and in the history and philosophy of geography in the UK, 2001–2011: an overview." *Journal of Historical Geography*, 42 (October 2013): 203-211.

Dykes, J., MacEachren, A. M., and Kraak, M.-J. *Exploring Geovisualization*. Amsterdam: Elsevier, 2005.

ESRI. "Telling stories with maps: A White Paper." Last modified February 2012. http://storymaps.esri.com/downloads/Telling%20Stories%20with%20Maps.pdf

———. "3D urban mapping: From pretty pictures to 3D GIS: An ESRI White Paper." Last modified December 2014. https://www.esri.com/library/whitepapers/pdfs/3d-urban-mapping.pdf.

Frischer, Bernard. "Digital Roman Forum." accessed June 3, 2016. http://dlib.etc.ucla.edu/projects/Forum.

Garganta, José M. de, and Vicente Forcada. *Biografía y escritos de San Vicente Ferrer.* Madrid: Biblioteca de Autores Cristianos, 1956.

Geraci, Fernando and Mubbasir Kapadia, "Authoring Background Character Responses to Foreground Characters." *Lecture Notes in Computer Science*, Vol. 9445 (2015): 130-141.

Herodotus. *The Histories*. Edited by A. D. Godley. Cambridge: Harvard University Press, 1920.

Hervás, Marciano de. *Historia de los judios de Plasencia y su tierra. Vol. 1 of De los orígenes a la Inquisición siglos XII – XVII.* Sevilla: Objectivo 4, Medios Audiovisuales, Septiembre 2001.

———. *Historía de los judíos de Plasencía y su tíerra. Vol. 2 of Coleccíon Diplomática 1187–1823.* Sevilla: Objectivo 4, Medios Audiovisuales, 2001.

Hodza, P. "Evaluating user experience of experiential GIS." *Transactions in GIS*, 13, 6 (2009): 503-525.

Hope College. "ValleySim: Social Computing Meets Inspired Learning," Accessed June 1, 2016. http://valley.cs.hope.edu/template/home.php.

Kapadia, Mubbasir, Shawn Singh, Glenn Reinman and Petros Faloutsos. "A Behavior Authoring Framework for Multiactor Simulations." *IEEE Computer Graphics and Applications*, Issue 6 (2011): 45-55.

Kapadia, Mubbasir, Fabio Zund, Jessica Falk, Marcel Marti, Robert W. Sumner, and Markus Gross. "Evaluating the Authoring Complexity of Interactive Narratives." In *Proceedings of Foundations of Digital Games (FDG)*, Pacific Grove, CA, June 22-25, 2015. Pacific Grove: FDG.

Kapadia, Mubbasir, Seth Frey, Alexander Shoulson, Robert W. Sumner, and Markus Gross. "CANVAS: Computer-Assisted Narrative Animation Synthesis" in *ACM SIGGRAPH/Eurographics Symposium on Computer Animation*, Zurich, Switzerland, July 11, 2016. Zurich: Eurographics.

Kapadia, Mubbasir, Jessica Falk, Fabio Zund, Marcel Marti, Robert W. Sumner, and Markus Gross. "Computer-Assisted Authoring of Interactive Narratives." In *Proceedings of the 19th Symposium on Interactive 3D Graphics and Games*, 2015, 85-92. New York: ACM.

Kimerling, A. J., A. R. Buckley, P. C. Muehrcke, and J. E. Muehrcke. *Map Use: Reading, Analysis, Interpretation, Seventh Edition.* Redlands: ESRI Press Academic, 2011.

MacEachren, A. M. H*ow Maps Work. Representation, Visualization, and Design.* New York, London: Guilford Press, 1995.

MacEachren, A. M., M. Wachowicz, D. Haug, R. Edsall, R. and Masters, R. "Constructing Knowledge from Multivariate Spatiotemporal Data: Integrating Geographic Visualization with Knowledge Discovery in Database Methods". *International Journal of Geographic Information Science*, 13 (1999): 311-334.

Martínez, Roger Louis. "From Sword to Seal: The Ascent of the Carvajal family in Spain: 1391–1516." Ph.D. dissertation, University of Texas at Austin, 2008.

Martínez-Dávila, Roger Louis. "Jews, Catholics, and Converts: Reassessing the Resilience of Convivencia in Fifteenth Century Plasencia, Spain." *Journal of Spanish Portuguese and Italian Crypto Jews 1* (Spring 2009): 95–119.

Martínez, Roger Louis, Victor R. Schinazi, Katja Wolff, Paddington Hodza, Skye Swoboda-Colberg, Mubbasir Kapadia, Yuka Ichimura, and Ece G. Turnator. "'La Mota': A Christian Assumes Ownership over Jewish Homes, circa 1416." Filmed August 3, 2015. YouTube video, 12:52. Posted August 3, 2015. https://youtu.be/H5MwORpIb7U.

Martínez-Dávila, Roger Louis, Victor R. Schinazi, Katja Wolff, Paddington Hodza, Skye Swoboda-Colberg, Mubbasir Kapadia, Yuka Ichimura, Ece G. Turnator, Sean T. Perrone, Francisco Garcia Serrano Nebras, and David Alonso Garcia. "The Revealing Cooperation and Conflict Project." Accessed on June 1, 2016. http://revealingcooperationandconflict.org.

Olea, Ricardo A. and George Christakos. "Duration of Urban Mortality for the Fourteenth-Century Black Death Epidemic." *Human Biology* 77, no. 3 (June 2005): 291–303.

Poulakos, S., M. Kapadia, A. Schüpfer, F. Zünd, R. W. Sumner, and M. Gross. "Towards an Accessible Interface for StoryWorld Building." In *AIIDE 2015 Workshop on Intelligent Narrative Technologies* (Santa Cruz, USA, November 14-15, 2015), no page.

Rhind, D. W. "Why GIS?" In *ARC News* 11, 3 (Summer 1989): 9-28.

Rosell, Cayetano. *Cronicas de los reyes de Castilla desde Don Alfonso el Sabio hasta los Catolicos Don Fernando y Doña Isabel. Tomo primero.* Madrid: Biblioteca de Autores Españolas, 1953.

Seed, Patricia. *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640.* Cambridge: Cambridge University Press, 1995.

Sánchez Loro, Domingo. *Historias Placentinas Ineditas: Primera parte catalogus episcoporum ecclesiae Placentinae. Vol. B.* Cáceres: Institución Cultural "El Brocense" Diputacion Provincial de Cáceres, 1983.

Shoulson, Alexander, Nathan Marshak, Mubbasir Kapadia, Norman I. Badler, "ADAPT: The Agent Development and Prototyping Testbed." In *ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*, March 22-24, 2013. Dublin: ACM.

Shoulson, Alexander, Max Gilbert, Mubbasir Kapadia, Norman I. Badler, "An Event-Centric Planning Approach for Dynamic Real-Time Narrative." In *ACM SIGGRAPH Motion in Games*, November 6-8, 2013. Dublin: ACM.

Shoulson, Alexander, Nathan Marshak, Mubbasir Kapadia, Norman I. Badler, "ADAPT: The Agent Development and Prototyping Testbed." *IEEE Transactions on Visualization and Computer Graphics* 20, 7 (2014): 1035-1047.

Spielvogel, Christian and Laura Ginsberg Spielvogel. “Speaking the Language of Digital Natives: Role-Playing Simulations in the Communication Classroom.” *Electronic Journal of Communication. 20: 1&2 (2010).* http://www.cios.org/EJCPUBLIC/020/1/020123.html Accessed June 1, 2016.

Tobler, W. R. “On the First Law of Geography: A reply.” *Annals of the Association of American Geographers*, 94 (2004): 304-310.

Van Driel, J. N. “Three dimensional display of geologic data.” In *Digital Geologic and Geographic Information Systems*, edited by J. N. Van Driel and J. C. Davis. (Washington, DC: American Geophysical Union, 1989): 57-62.

Wall, John N. “Virtual Paul’s Cross Project: A Digital Re-Creation of John Donne’s Gunpowder Day Sermon.” Accessed July 3, 2016. https://vpcp.chass.ncsu.edu.

Worboys, Michael F. and Matt Duckham. *GIS: A Computing Perspective*, Second Edition. Boca Raton: CRC Press, 2004.

Figure 1: GIS Map of Late 14th-Early 15th Century Plasencia (Spain)

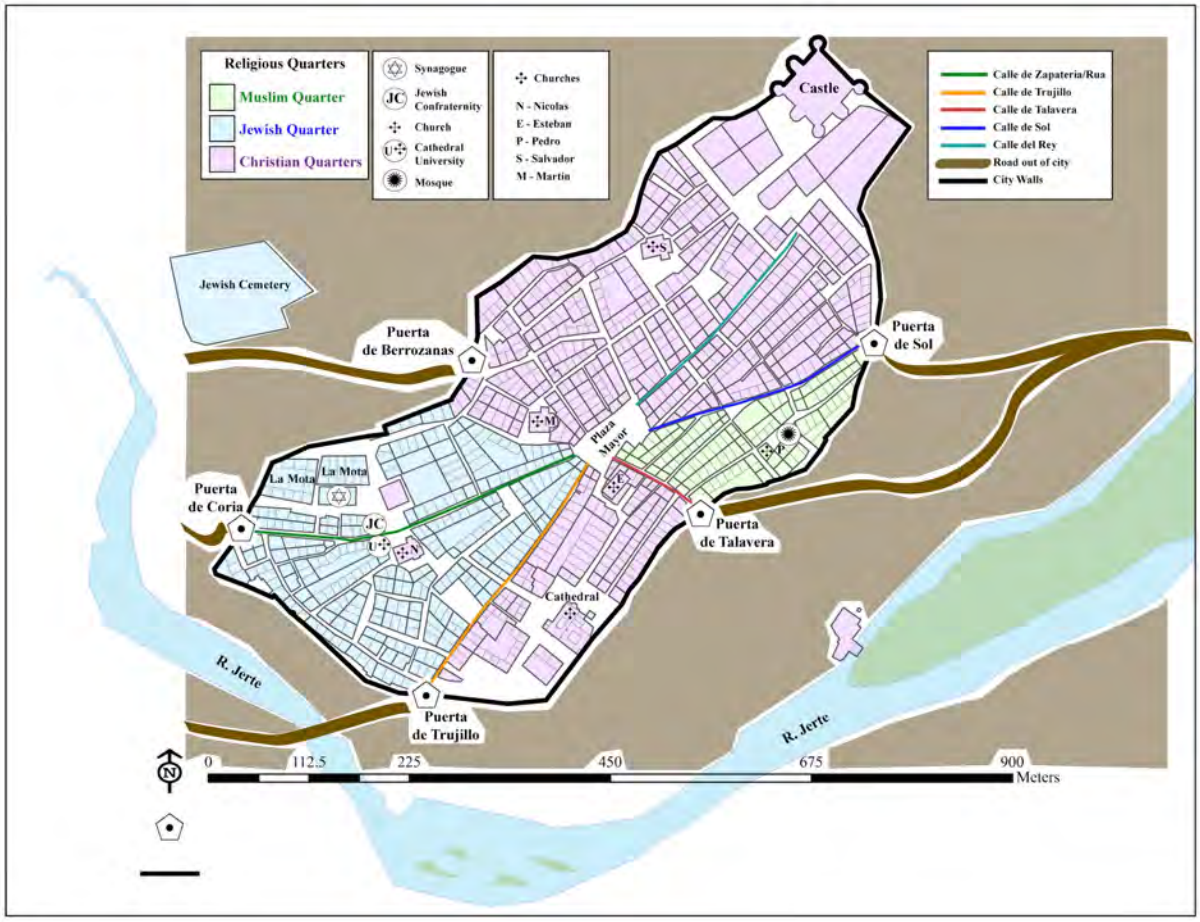

Table 1: Data Layers for 2D map of Plasencia

Layer Name	Example of Features	Feature Geometry	Attributes	Data Source(s)
Streets	-	Line	Name, Length	T1, T2, T3, T4
Footpaths	-	Line	Length	T5
Buildings (footprints)	-	Polygon	Area, Owner1, Owner2, OwnerN [1], Year	T5, T6
City boundary	-	Polygon	Name	T1, T2, T3
Jurisdictions	Ecclesiastical, Political, Religious Group	Polygon	Name	T7
Landuse/ landcover	Streams, Marketplaces, etc	Point [2], Line, Polygon	Length, Area	T5
City gates	-	Point	Name	T1, T2, T3
Parcels	-		Area, Owner1 [1], Owner2, OwnerN, Year	T1, T2 ,T3, T7
Elevation	DEM	Grid	Height	T8

Sources: T1 (Callejero de Plasencia, c. 2013, Ex. Ayuntamiento de Plasencia); T2 (*Plano de poblacion Plasencia, Caceres*, c. 1900-1910); T3 (*Plano de Plasencia, MSS. 2650*, c. 1590); T4 (*Plasencia: Heraldica, Historica y Monumental.* Plasencia, 1997); T5 (OpenStreetMap); T6 (ArcGISOnline web mapping services); T7 (*Actas Capitulares, Libro 1, 1390-1455*); and T8 (http://www.intermap.com/).

Notes: [1] Future iterations of Virtual Plasencia will document temporal changes in building ownership; [2] Future iterations of Virtual Plasencia will require multiple layers of features

Figure 2: Medieval Plasencia Data Layers Overlaid Over Contemporary OSM Map

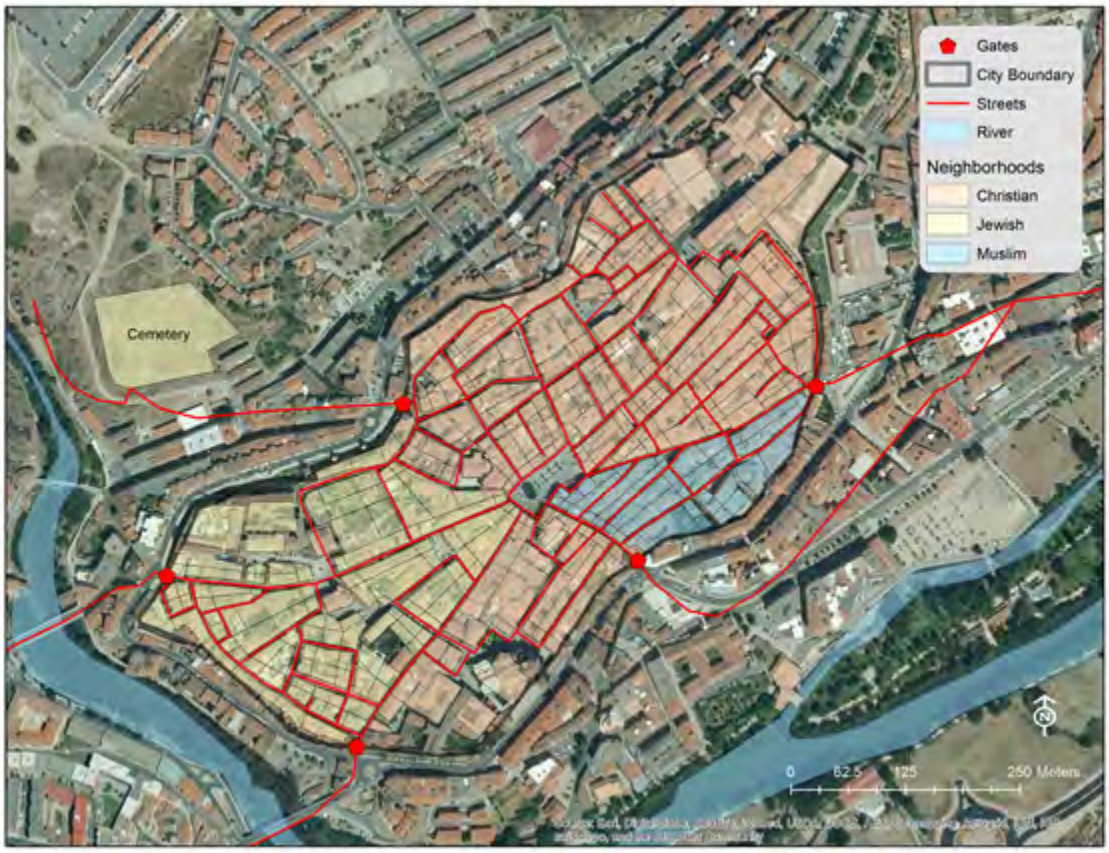

Figure 3: Plaza de St. Nicolas with Church of St. Nicolas (left), Synagogue (center), and Palacio de los Marqueses de Mirabel (right)

Figure 4: 3D Model of the Church of St. Nicolas

Figure 5: 3D Model of the Synagogue

Figure 6: 3D Model of the Palacio de los Marqueses de Mirabel

Figure 7: Final Placement of 3D Models in Virtual Plasencia

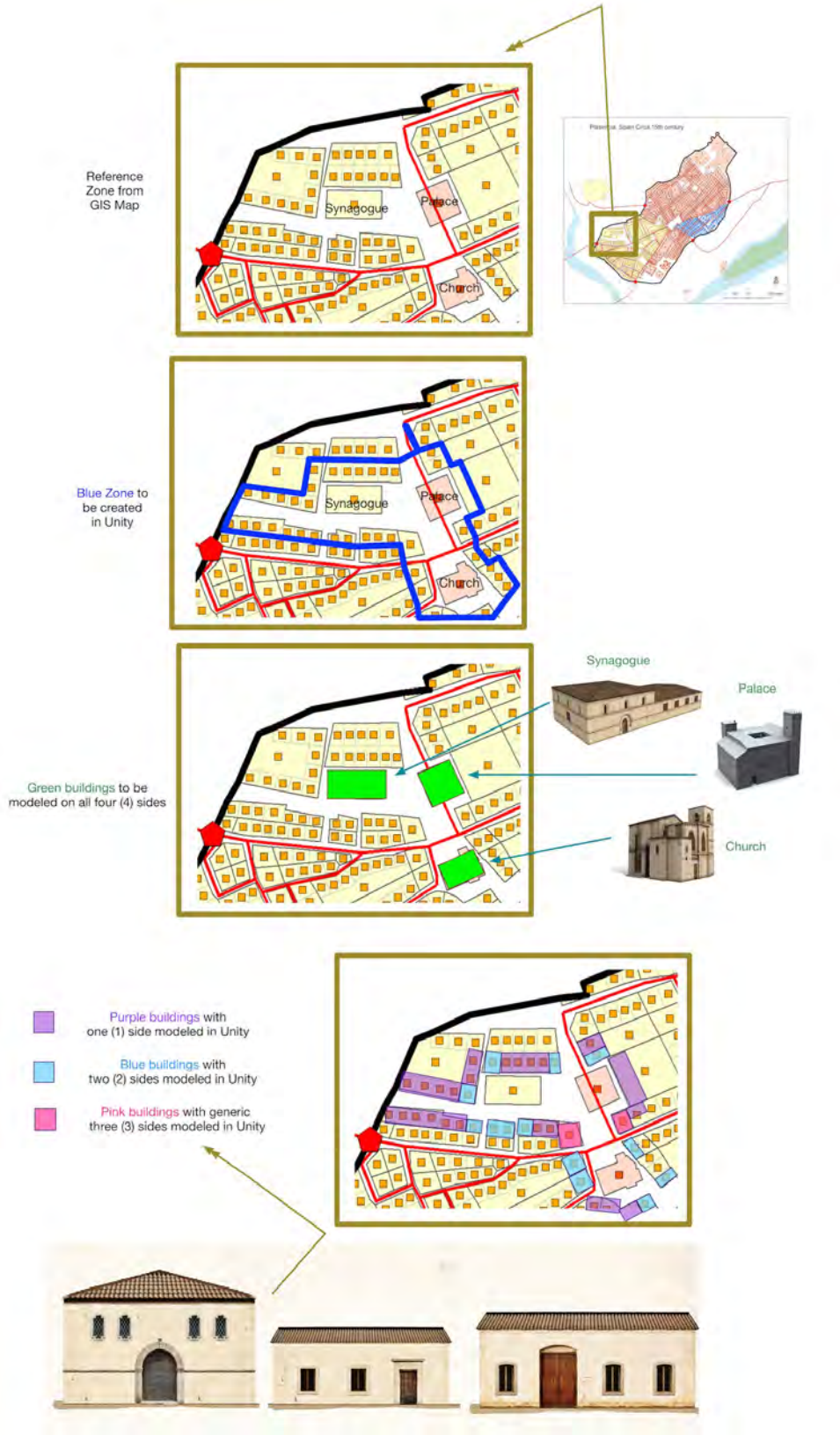

Figure 8: Virtual Plasencia's Informational and Navigational Tools

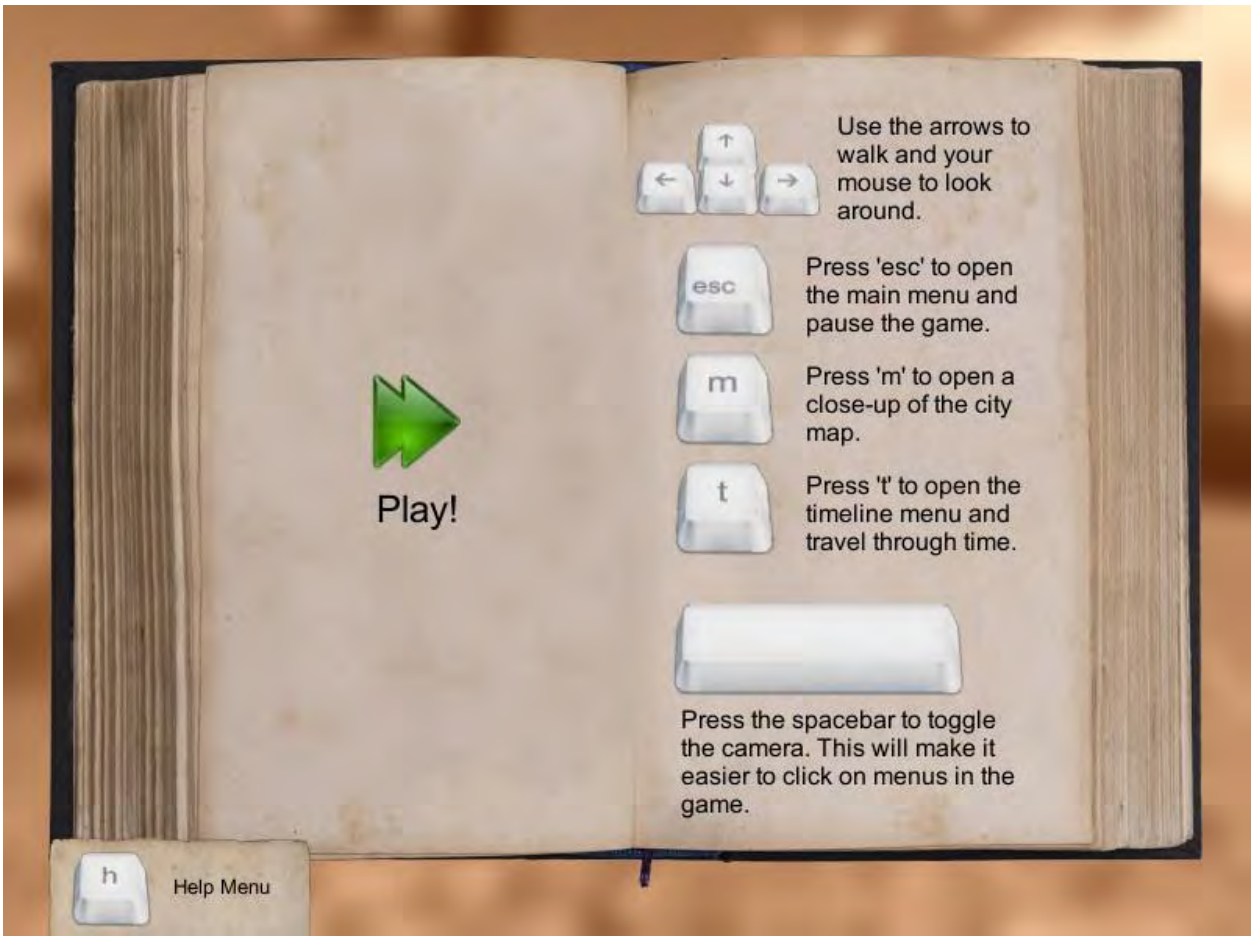

Figure 9: Virtual Plasencia's Time Travel Menu

Figure 10: Jewish Communal Gathering

Source: https://youtu.be/H5MwORpIb7U?t=182

Figure 11: A Simple Conversation Between Two Actors

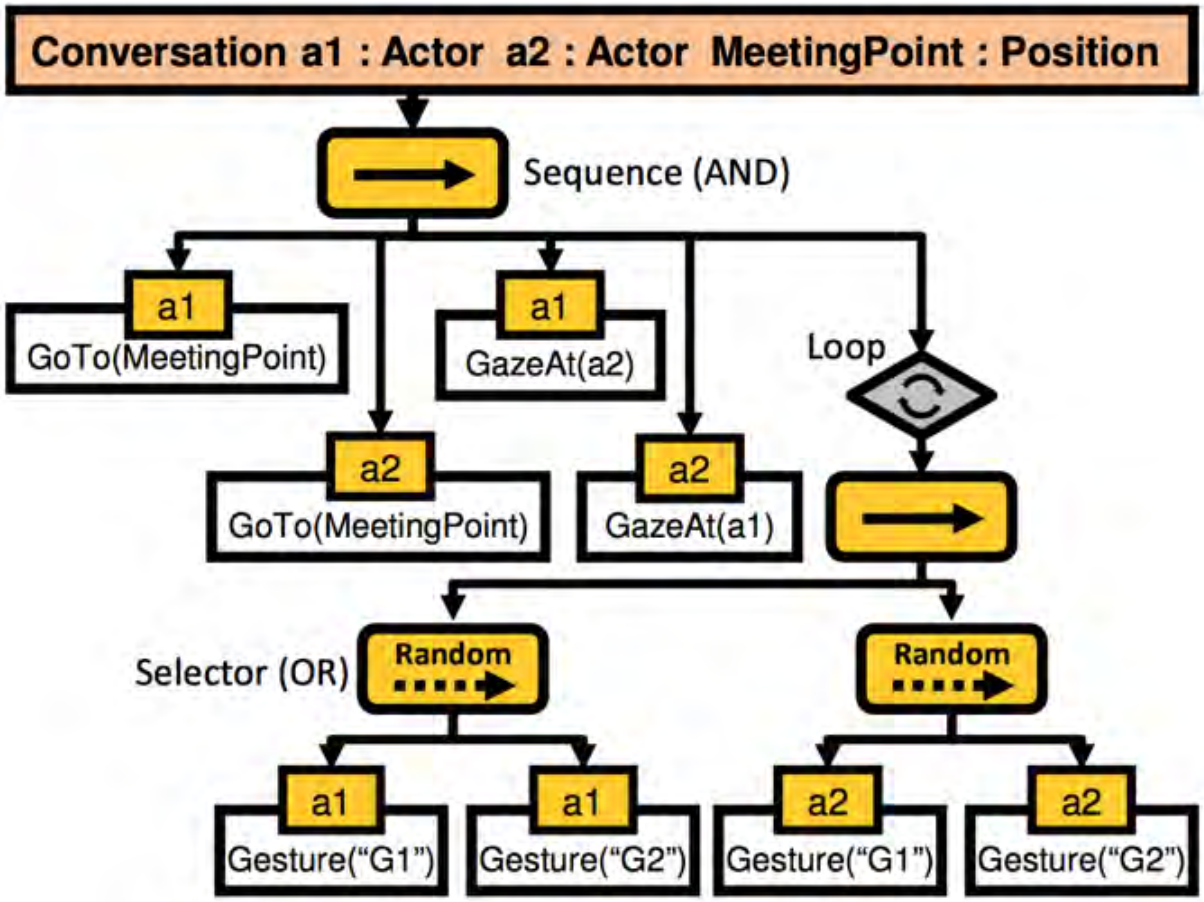

Figure 12: Fernando de la Mota and Yucef Castaño Greeting Event

Source: https://youtu.be/H5MwORpIb7U?t=278

Figure 13: A Simply Story Arc in our GUI