Virtual Kyoto Project: Digital Diorama of the Past, Present, and Future of the Historical City of Kyoto

Tomoki Nakaya[1], Keiji Yano[1], Yuzuru Isoda[2], Tatsunori Kawasumi[1], Yutaka Takase[3], Takashi Kirimura[3], Akihiro Tsukamoto[3], Ayako Matsumoto[3], Toshikazu Seto[4], and Takafusa Iizuka[4]

[1] College of Letters, Ritsumeikan University,
56-1 Tojiin-kita-machi, Kita-ku, Kyoto, Japan
{nakaya,yano,kawasumi}@lt.ritsumei.ac.jp
[2] College of Asia Pacific Studies, Ritsumeikan Asia Pacific University,
Beppu City, Oita, Japan
yuzuruisoda@gmail.com
[3] Kinugasa Research Organisation, Ritsumeikan University,
56-1 Tojiin-kita-machi, Kita-ku, Kyoto, Japan
takaseyutaka@yahoo.co.jp, {tkiri,atv28073}@fc.ritsumei.ac.jp,
ayakom@fj9.so-net.ne.jp
[4] Graduate School of Letters, Ritsumeikan University,
56-1 Tojiin-kita-machi, Kita-ku, Kyoto, Japan
{gr0008sf,gr0051xe}@ed.ritsumei.ac.jp

Abstract. Using the recently developed 3D GIS (Geographic Information System) and related visualisation technologies, we have created a digital diorama of an entire historical city, which can be used to virtually travel through different realistic landscapes at different times in the history. The digital diorama called Virtual Kyoto is the virtual geographic environment of the past, present, and future of the historical urban spaces in Kyoto City by constructing geotemporal-referenced 3D models of cityscape elements at different eras. In order to promote digital humanities studies on the arts and culture of traditional Kyoto, Virtual Kyoto is used as a digital platform for constructing a web-based digital museum interface with geographic data-linkages to numerous historical and cultural digital contents. We also explore the possibility of using Virtual Kyoto as an information environment to discuss the future of the historical city of Kyoto with the effects of city planning activities such as landscape policies or the possible damage due to disasters on historical landscapes.

Keywords: 3D GIS, virtual reality, digital humanities, landscape planning, 3D urban model.

1 Introduction

The original diorama, invented by Louis Daguerre in 1822, exhibited large landscape paintings inside a theatre-sized facility for experiencing virtual trips to various

T. Ishida (Ed.): Culture and Computing, LNCS 6259, pp. 173–187, 2010.

monumental landscapes [1]. By controlling light effects and turning physical stage sets, the device gave striking panoramas that swiftly switched between day and night and between different time periods. Its smaller variant has been widely adopted as a museum displaying tool for collected objects in an artificial scene. The recently developed 3D GIS and virtual reality methods provide an opportunity to create a digital variant of the diorama to contextualize spatial objects in a virtual geographic environment (VGE) with flexible controls to alter the viewer's position and the contents of the environment [2].

Digital diorama has several advantages over the original diorama: (1) a large physical space to store the contents is unnecessary, even for modelling a large geographic environment; (2) the contents can be easily edited or replaced for various purposes; (3) the system is open to other databases so that any set of digital contents can be linked to geographic positions; and (4) the virtual environment can be shared through networks, particularly the Internet.

In this study, we aim to explore the possibility of using a set of digital dioramas of the Japanese historical city Kyoto, called Virtual Kyoto [3], as a digital platform to enhance information sharing of the arts and culture of Kyoto as well as encouraging the discussion on the future of this historical city and its rich cultural heritage. Virtual Kyoto was created as a GIS-based VGE of the past and present historical urban spaces in the city by constructing a large amount of geotemporal-referenced 3D models of cityscape elements from different ages. So far, our published studies [4-6] have mainly focused on the restoration and modelling of historical landscapes using various modern and historical sources of geographic information. Such efforts of restoring the past can be regarded as a virtual journey through memories of this great historical city. We here take up the ideas and methods of the digital diorama Virtual Kyoto, to retrieve and assemble information on the arts and culture of Kyoto and apply it to planning considerations of the city's future landscape.

This Virtual Kyoto project has been a part of the 'Kyoto Art Entertainment Innovation Research (2002-2006)' undertaken at Ritsumeikan University under the auspices of the 21st Century Center of Excellence (COE) program funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The program is now managed by the Digital Humanities Center for Japanese Cultures and Arts under the Global COE program (2007–2011). In accordance with the recent trend to use new-generation digital recording techniques for chronicling cultural heritages [7], a large amount of digitally archived materials from the arts and culture sector have been accumulated through these programs, including collections of digitalized fine arts, scanned old maps, laser-scanned floats, CAD models of existing historical buildings, and motion captured traditional artistic performance, e.g. 'Noh' and 'Kabuki'. Virtual Kyoto was originally intended to be a platform for integrating such various digitalised contents for contextualizing them in geographic locations (Fig. 1).

The rest of this paper is organized as follows. We provide a brief explanation of the construction of Virtual Kyoto in section 2. Then, section 3, we describe a method to use Virtual Kyoto for constructing a new online digital museum interface with geographic data-linkages to the numerous historical and cultural digital contents including information on culturally valued landscapes. Then, we explore possibilities of using landscape simulations and GIS-data overlays to discuss the future of the historical city of Kyoto and the effect of city planning activities such as landscape policies (section 4) or the possible damage due to disasters on the historical landscapes (section 5).

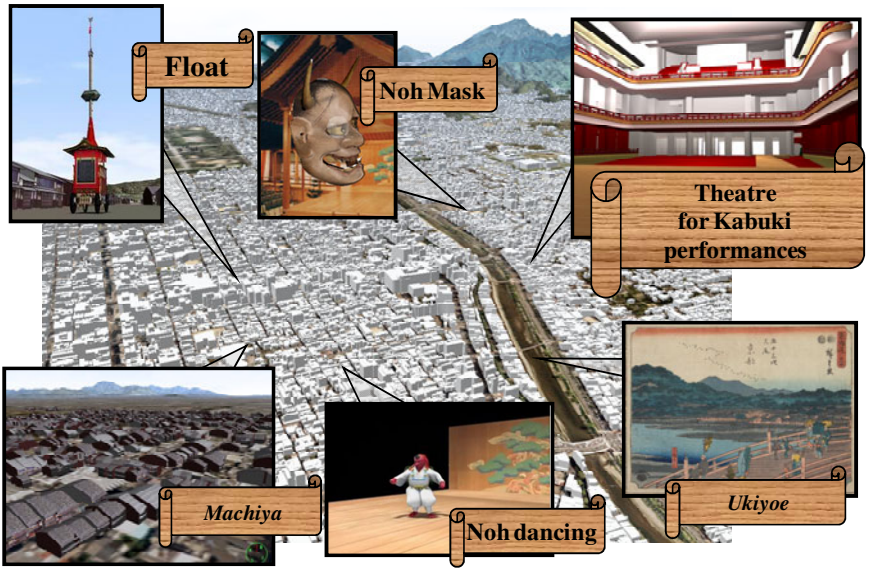

Fig. 1. Concept of Virtual Kyoto integrating digitally archived contents of Kyoto arts and culture

2 Virtual Kyoto

VGEs have emerged along with the rapid development of geotechnologies to enhance 'realism' of geographic representation [2]. A popular application of VGE is the so-called 'virtual city' that is a digital representation of the geographical and geometrical reality of a city. One of the most advanced virtual cities is being created in the Virtual London project by CASA (Centre for Advanced Spatial Analysis), University College London. Virtual London is a large scale 3D GIS with CAD models of Greater London using state of the art computer technology. It is designed for professional use by architects and planners but is also targeted at the wider public through various processes of public participation across the web [8,9].

By highlighting the city's function as an area for collective interactions of various people, the concept of the digital city was also coined by researchers in informatics. In Kyoto, the project of 'Digital City Kyoto' ran from 1999 to 2001 supporting and facilitating social interactions for urban everyday life by developing a web-based social infrastructure. Although the digital city does not necessary entail a VGE of a city, Digital City Kyoto included an interface layer of VGE for the main street, Shijo Street, and a world heritage site, Nijo Castle, in which users can virtually walk through the environments [10,11].

Our Virtual Kyoto is similar and deeply related to conventional virtual city projects such as Virtual London, and digital city projects with VGE interface such as Digital City Kyoto. However, Virtual Kyoto has a unique feature that distinguishes it from its counterparts. In particular, it is a 4D GIS of almost the entire city including a time dimension added to the conventional three dimensional GIS/CAD models. It can store

various geographical information from different historical eras. This unique feature has been crucial from the outset as the goals of the Virtual Kyoto project were focused on depicting the history of the city, as well as reconstructing the city's past urban landscape. Compared to Digital City Kyoto, Virtual Kyoto does not currently provide a general social interaction platform but it is expected to facilitate public-participation for collecting and sharing the information on arts and culture of Kyoto, and eventually to contribute to create an environment for better everyday living in Kyoto.

In Virtual Kyoto we have adopted MAPCUBE® data from CAD Center, Increment P and Pasco, Ltd., for creating the present landscape modelling. The data consists of prismatic 3D building block models based on the building footprint and height for the whole city of Kyoto (Fig. 1). The 3D models are created by extruding the building footprint to the height obtained by an air-borne laser-profiler which recorded height values at an interval of 2.5 m with an error within 15 cm (http://www.mapcube.jp/en/product.html). We replaced the simple extruded building model, 'white model', with detailed CAD models with photo realistic texture images for buildings regarded as landmarks in the historical Kyoto landscape, such as world heritage temples and shrines.

An important aspect of Kyoto rises from the fact that the city, founded in 794 AD, was the historical capital of Japan and still retains a large number of historical architecture such as temples, shrines, machiya, and modern western-style buildings of the pre-war period. This is a rare case in Japan; the city managed to escape damages during World War II. Our strategy in restoring historical Kyoto involves the modelling of present day Kyoto as a virtual city, then replacing the newer buildings with traditional buildings as we go back in time. For this purpose, various sources of past landscapes including aerial photos or old maps, landscape drawings and paintings were collected and georeferenced in a GIS environment. For restoring the early landscape of ancient Kyoto called Heian-kyo (ca. 8^{th}–12^{th} centuries), landscape modelling was independently conducted by following blue-prints of physical miniatures of the Heian-kyo diorama that were made to mark the 1200^{th} anniversary of the founding of the city in 1994. Fig. 2 demonstrates 3D sceneries portraying many geographical objects at three different eras in Virtual Kyoto (see [3,4,5,6] for details on the modelling procedure of these geographic environments). For the landscape visualisation, we employed UrbanViewer™ (CAD Center, Ltd.), a virtual reality desktop application for real-time viewing of detailed urban scenes using a 3D urban model of MAPCUBE®.

We have thus created the digital diorama of Kyoto as a 4D GIS environment (3D space plus time dimension) of Kyoto landscape elements. This supports a number of new areas of geographic inquiry, especially with its ability to represent the implications of historical changes in landscape on the city's current and future policies.

Virtual Kyoto comprises the following four functions: (a) archiving georeferenced materials such as current digital maps, old topographic maps, cadastral maps, aerial photos, picture maps, street photos, landscape paintings, archaeological sites data, and historical documents; (b) creating a database of all existing buildings including machiya, early modern buildings, and shrines and temples including those of historical and cultural significance; (c) creating 3D models of the buildings mentioned above; and (d) estimating and simulating land use and landscape changes over the study periods using the aforementioned materials.

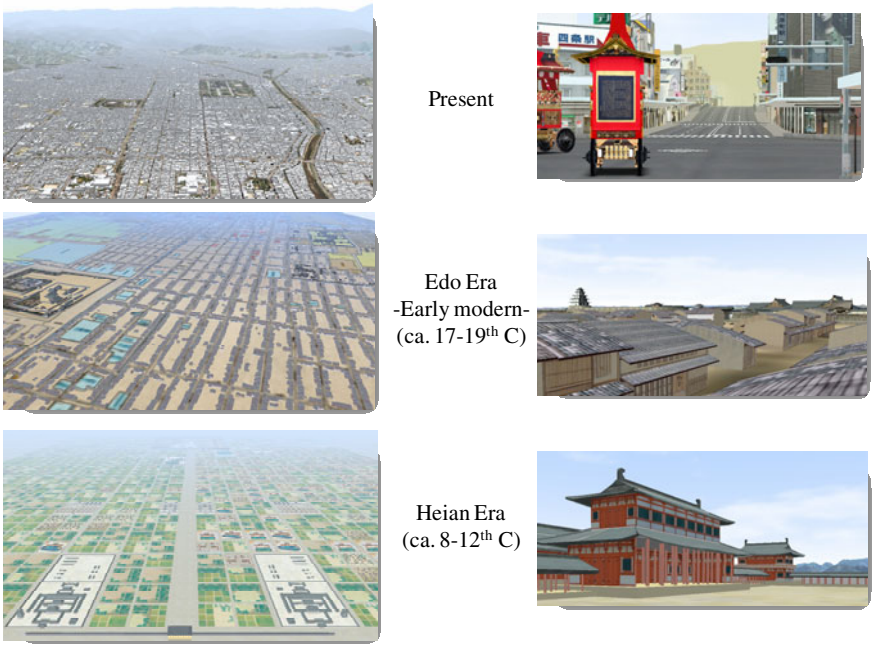

Fig. 2. Digital dioramas of Virtual Kyoto at present and in two historical eras

3 Digital Museum of Kyoto Arts and Culture on Web-Based Digital Diorama

Following the original intention of the Virtual Kyoto project, we currently maintain a web-site using the 3D web-GIS engine, UrbanViewer™ for Web (CAD Center, Ltd.), to disseminate the digital diorama contents of Kyoto with links to other digital archives of Kyoto arts and culture. The URL of the site is as follows:

http://www.geo.lt.ritsumei.ac.jp/uv4w/frame_e.jsp

Like GoogleEarth (Google Inc.) and Virtual Earth (Microsoft Inc.), the engine enables us to transmit and receive a great amount of 3D landscape information including buildings, landforms and textured images with interactive manipulation of view settings on ordinary DSL-level-speed internet infrastructure by LOD (level of detail), data compression and streaming techniques of smoothed images. LOD is a technique that is widely used for virtual reality to control in real time the quality of 3D models' display. It automatically changes the display/non-display of 3D objects and also displays the object's geometry and texture images with the appropriate data amount and resolution according to the distance between the client and the viewed objects and the client's viewing angles.

To reduce the amount of data to be transmitted, a simple way of data reduction is used on extruded building models that often occupy a large space in a view. This

reduction method stores the geometry data as the polygon of its base shape and height instead of the polygons of all the surfaces. In order to achieve smooth real-time display of the texture images, different resolutions of the images as well as digital terrain models are stored in the database server. According to the distances between the viewing positions and viewed objects, and the client's viewing angles, the web server orders the database server to extract the image data with the most appropriate resolution for the client's view and the extracted image data are sent to the client's PC. For browsing through a website constructed by the engine, a client is required to use Microsoft Internet Explorer with the UrbanViewer^{TM} for Web plug-in installed.

In the web-based digital diorama of Virtual Kyoto, users can freely fly over or walk through landscapes of Kyoto at different times (present, early 20th century, and 12th century). Fig. 3 shows an example of such an instant virtual time-travel as viewed on the web. A pair of views using the same viewing position and angle but showing scenes at different time periods vividly demonstrate how one could feel the sense of the ancient landscape around Heian-kyu, the rectangular ancient imperial palace that was built at the beginning of Heian-kyo in late 8th century, and which was largely transformed into the current built-up areas with irregular skylines of buildings. We

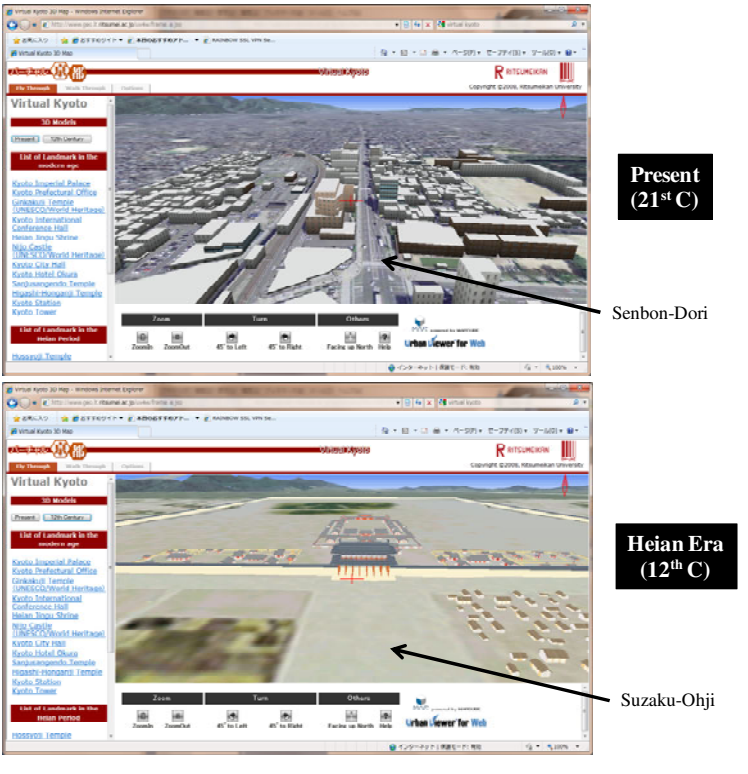

Fig. 3. Virtual time-travel of Kyoto landscape on web

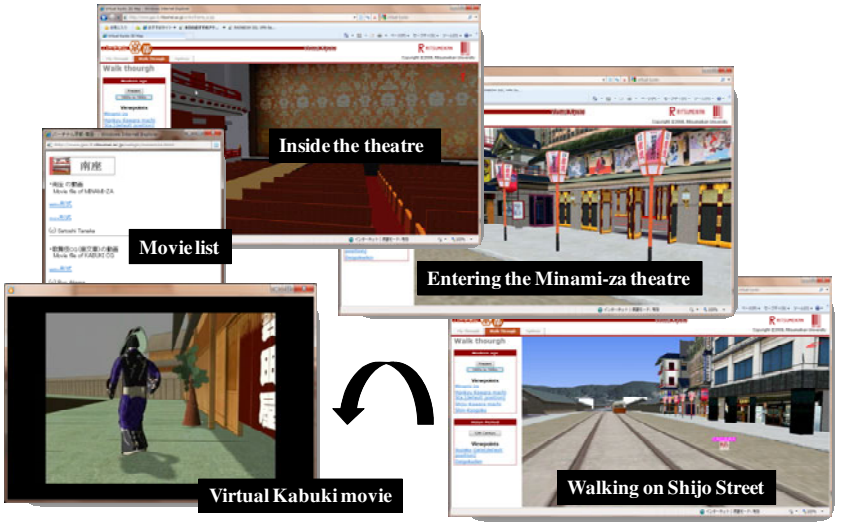

Fig. 4. Virtual tour of virtual Kabuki performance in Virtual Kyoto

see that a current major street, Senbon-Dori still runs along the ancient route of the main Heian street, Suzaku-Ohji, connected to the former palace main gate, but that the width of the current street is much narrower compared to that of the ancient one.

Glancing across the digital diorama, we can browse existing historical arts and cultural materials by clicking geolocated markers with labels of the digital contents. We herein make use of the digital diorama as a gallery or museum platform of digitised fine art objects related to specific locations in Kyoto.

Fig. 4 demonstrate how the system enables a virtual tour that includes experiencing a virtual Kabuki performance, created by the technology of motion capture of Kabuki actors, at the historical theatre, Minami-za, on Shijo Street. The tour begins with a walk down the street that may represent the early Showa era (ca. 1920–1930) then a change in the skyline of buildings and vistas of the mountains conveys the feeling of the rapid urban development after World-War II. We can seamlessly walk into the theatre from the road to see a virtual Kabuki performance; the inside of the theatre is also modelled and incorporated the online virtual environment. By clicking the link marker in the theatre, a popup window showing the list of streaming movies appears. Although there are currently only two movies of digitised performances in our system, in the future it would be possible to experience a series of virtual experimental performances. In earlier townscape settings, we hope to present a variety of older style performances in old theatre stages by combining motion-captured movements with old costumes reflecting those in historical records.

As for historical landscapes, it is difficult to evaluate how physical landscapes are culturally assessed and valued. A clue may be obtained from popular landscape paintings that are often read by architects or geographers for debating humanistic values of historical landscapes [12]. The web-based Virtual Kyoto has a set of links to

Fig. 5. Browsing Ukiyoe landscapes in Virtual Kyoto

digitalized art contents, scanned images of traditional Japanese Ukiyoe woodblock prints (Fig. 5). The sets of Ukiyoe landscapes that date back to the Edo Era (ca. 17th–19th centuries) provides a way to see lost landscapes. The views from the Ukiyoe paintings are geolocated in the diorama and are also linked to the Ukiyoe Database System maintained by the Ritsumeikan Art Research Center, which provides detailed information of each items and enable a search for other Ukiyoe contents by using keywords such as theme, painter and year.

As seen in Fig. 5, we often find mountains in the background of Ukiyoe prints, contrasting with the subject of the urban scene. Since many of the well-known places in Kyoto are situated near mountains, the main theme of the Ukiyoe stands out when it is set against those backgrounds which are used as a 'borrowing landscape' – a concept of traditional landscape design applied in many Japanese gardens. It exemplifies that the vistas on surrounding mountains from specific viewing points in the city have been appreciated as landscapes with the cultural values of Kyoto.

4 Landscape Simulator Using Editable Diorama of Kyoto

As seen in the previous section, historical Kyoto vistas of mountains often have a cultural meaning. We are particularly conscious of this when bonfires are lit to send off the dead during the All Souls (Obon) festival on August 16th, which marks the peak of Kyoto's hot late summer. Publicized to tourists under the name of 'Daimonji Gozan Okuribi', (the Five Mountain Great Character Sending Off of the Dead), a bonfire formed as a great character is lit for each of the five mountains at night. This broadly popular annual event was well established in the Muromachi (ca. 14th–16th centuries) and Edo (ca. 17th–19th centuries) eras.

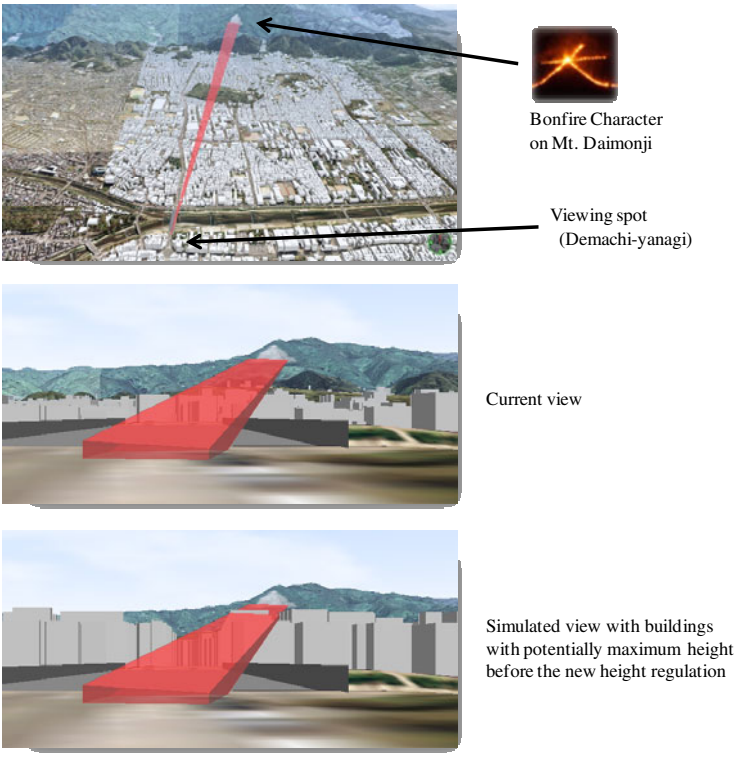

Fig. 6. Evaluating potential risk of obstructed view from possible development

Demachi-yanagi, the meeting point of the Kamo and Takano rivers, is a popular viewing spot to see the first bonfire lit on the hillside of Mt. Daimonji (Nyoigatake). Virtual Kyoto was applied to evaluate the potential risk of obstructing this view due to possible future development of buildings with the maximum height allowed under the previous building and development regulations. In Fig. 6, a red half-transparent board represents the vista line from the viewing spot to the fire bed of the bonfire character.

While no building height currently exceeds the line, the clear view could potentially be obstructed by future development and buildings that comply with the building height restrictions (see the bottom image in Fig. 6). To avoid such potential destruction of historical views in Kyoto, the Kyoto City Government initiated a new landscape policy in 2007 (the Kyoto City Landscape Policy)[13], to protect the beautiful historical urban landscape of the city. The policy puts direct control on the appearance and height of buildings from four aspects: height restriction in the city centre; conservation of scenic views and 'borrowed landscapes' from certain viewing spots; design restrictions on buildings; and regulation against the display of outdoor advertisements. Following this new scheme, 38 magnificent vistaed views and 'borrowed landscapes' were designated as heritage views to be conserved and new height regulations based on altitude were introduced, with the help of landscape simulations, so as not to hamper those significant vista.

Current street view

Simulated street view without exterior signs and electric poles

Web-GIS interface for simulating the street view with radio buttons to display or hide exterior elements

Fig. 7. Simulating street view on Shinmachi Street

The changes in building exteriors, the impact of removal of business signs and billboards, burying electrical cables, and other related changes from proposed regulations can be also envisioned with landscape simulations in Virtual Kyoto. We developed a simulator of detailed landscape elements on Shinmachi Street in the central district of Kyoto (Fig. 7). The local town along the street is one of historical community called 'Hoko-machi', where a large float called 'Yamahoko (or Yamaboko)' that parades in the Gion Festival is maintained.

Walking through such a simulated streetscape, users including local residents and local governmental officers can get a feeling for the possible results of new street exterior regulations or voluntary actions to improve streetscapes. Considering the fact that some landscape modification such as removing electric poles are quite costly, and more importantly that the new regulations are quite controversial among different stakeholder groups such as developers, local residents and newcomers living in high-rise apartment houses, it is vital to publicly share the possible results associated with the landscape regulations for meaningful debate on the future of the city. As part of web-based Virtual Kyoto, we also developed web-based simulators with buttons to display or hide each landscape elements in Shinmachi Street. As an environment of PPGIS (public participating GIS) [14], the web-based system is expected to encourage public participation in discussions on landscape policy and promote involvement and commitment from a wide range of public sectors.

5 3D Hazard Map of Kyoto Using Digital Diorama

As an extension of the previous landscape simulation, we can also see the impact of disasters like floods or earthquakes by overlaying thematic layers of hazard risks over the digital diorama of the city. We have created and distributed another version of the web-based digital diorama of Virtual Kyoto, 'the Safety and Security 3D Map of the Historical City Kyoto' combined with the hazard map and crime statistics of the city. This can be found at http://www3.rits-coe.jp/ritsumei_kyoto/.

Hazard maps are maps that show information regarding evacuation facilities/spaces and the degrees of hazard risks, to help prepare for future disasters. The Kyoto Fire Department created an award-wining hazard map (a city-wide map was prepared in 2004; maps of each ward were published in booklet form in 2005) showing disaster-related facilities such as hospitals, and various hazard risks from landslides, floods and earthquakes. It combines a voluminous amount of geographical data in a GIS. We use this information for our 3D hazard map system.

As in the case of the previously shown web-based Virtual Kyoto, the 3D map is an interactive map displaying realistic landscapes in which we may freely fly through the virtual scenery. Most hazard maps have two-dimensional views of broad areas but a 3D map permits movement within the map, allows exploration of the distribution of various risks at different scales and angles so that a user can explore and understand the hazard risks related to their own spheres of activity. Using the relational database engine with spatial index, the system has a function to search locations of facilities such as police stations, hospitals, and evacuation shelters with their attributes (such as capacity of shelters) as well as cultural heritages and national treasure architectures around the current view point.

Kyoto hosts a large number of historical buildings such as temples, shrines, machiya (traditional wooden townhouses), and western-style buildings of the pre-war period. Particularly, a great number of world heritage and national treasure architectures are accumulated in Kyoto. These architectural heritages significantly contribute to Kyoto's historical urban landscape. It is estimated that if a serious disaster hit Kyoto, a large number of heritage sites would be lost and their restoration would be extremely expensive. Thus, establishing a policy to mitigate possible damages of historical sites by future disasters is important to sustain the historical landscapes in Kyoto [15,16].

Currently our system includes only cultural heritages and national treasure architectures but in the future it would include other types of historical buildings, such as machiya. Machiya in Kyoto is specifically called *kyo-machiya* for its distinctive character and there remain about 48,000 kyo-machiya in various conditions across the historical parts of the city. We have constructed a GIS-based monitoring system for kyo-machiya with the aim of supporting the government's step towards preserving this traditional architectural style [17,18]. The system is based on the 'Kyo-machiya Community-building Survey', on which the Kyoto City, Ritsumeikan University, volunteer architects and citizens have been working together since October 2008. In this field survey, we have used the Mobile GIS (ArcPad) in PDA to extract the exact geospatial information on houses and buildings in addition to their photographs. The

A bird's eye view on flooding risk along Kamo river

View of building collapse risks caused by a possible earthquake (Hanaore fault) around Higashi-Honganji temple

Fig. 8. 3D hazard map generated using Virtual Kyoto

information is maintained by ArcGIS and PhotoField [19], a photo-album application with geographic information (Fig. 9). The machiya survey entries include: its type, its condition, design elements of the façade, and whether or not it is vacant. Such information of overall machiya condition with accurate geographical coordinates may be useful for assessing hazard risks of neighbourhoods filled with machiya (e.g. for fire propagation or road blocking) as well as for realising fragmented historical cityscapes at a risk of being lost by a possible disaster.

Combining such field survey results of historical buildings with the 3D hazard map using Virtual Kyoto would efficiently empower policy makers as well as local residents to consider the necessity of formal and informal rescue organizations to protect or prepare endangered cultural landscapes for future disasters.

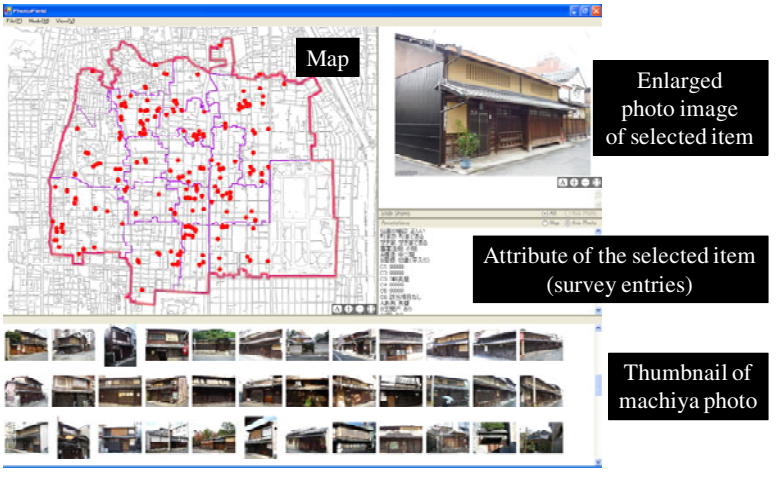

Fig. 9. Sample screenshot of kyo-machiya GIS database using PhotoField: geographic locations, attributes, and photographs of well-preserved kyo-machiya identified by field survey in northern central part of downtown area of Kyoto

6 Concluding Remarks

Since the passing of laws regulating the preservation of old Kyoto in 1966, the city has introduced many development restrictions and ordinances to preserve its historic character. The largest number of streetscapes and buildings that need to be preserved as cultural assets in Japan exist in Kyoto. Post-war Japan has seen rapid economic growth, and Kyoto's streets have already undergone extremely fast changes and innumerable historical monuments and places have been destroyed by the impact of development. The remaining heritage sites and landscapes are still endangered by future developments and disasters.

In this paper, we have described how to apply the digital diorama, Virtual Kyoto, to share valuable information regarding the historical city, from historical vistas shown in arts to simulated sceneries with possible future scenarios. In particular, by using the web-based diorama to distribute 3D panoramic scenes to clients, it will be possible for many people to use the perspectives to learn from and appreciate the city's historical environment combined with arts and cultural contents of Kyoto. In the process, the city's historical memory will become the common domain of many people and a base for discussing the future of the historical city. Digital humanities [20], a newly emerging field for studying humanities using digital information, may encourage debates on city culture between humanity and policy-planning researchers by sharing digital information in a shared information environment like the digital diorama.

One challenge is to extend the use of the digital diorama, Virtual Kyoto, and enrich it through possible public input involving a wider range of people for collective thinking of the past, present, and future of the historical city, Kyoto. Further research is needed to evaluate how the nature of digital diorama that enables shared realistic viewing experience of landscapes might change public involvement in of archiving historical materials and decision making in city planning.

Acknowledgments. This research project was financially supported by the Global COE Program (Digital Humanities Center for Japanese Cultures and Arts), Academic Frontier Project (Disaster Mitigation of Urban Cultural Heritage), and MEXT KAKENHI (Grant-in-Aid for Scientific Research (B) 21320161). We would like to thank our collaborators at Ritsumeikan University for permitting us to use the digital archives of arts and cultures of Kyoto: Prof. R. Akama (Virtual Kabuki in Fig. 4) , Prof. K. Hachimura (motion captured Noh dancing in Fig. 1), Prof. H. Tanaka (3D model of Noh mask in Fig. 1), and Prof. S. Tanaka (CAD model of Minamiza theatre in Figs. 1 and 4). We obtained the images of Ukiyoe shown in Figs. 1 and 5 from the Ukiyoe Database System maintained by the Ritsumeikan Art Research Center.

References

1. Gernsheim, H., Gernsheim, A., Daguerre, L.J.M.: The History of the Diorama and the Daguerreotype. Dover Publications, New York (1968)
2. Lin, H., Batty, M.: Virtual Geographic Environments. Science Press, Beijing (2009)
3. Yano, K., Nakaya, T., Isoda, Y. (eds.): Virtual Kyoto, Nakanishiya, Kyoto (2007)
4. Yano, K., Isoda, Y., Nakaya, T., Kawasumi, T., Matsuoka, K., Takase, Y., Kawahara, D., Kawahara, N., Inoue, M., Tsukamoto, A., Kirimura, T.: Creating virtual time-space of Kyoto. E-journal GEO 1(0), 12–21 (2006)
5. Yano, K., Nakaya, T., Isoda, Y., Takase, Y., Kawasumi, T., Matsuoka, K., Seto, T., Kawahara, D., Tsukamoto, A., Inoue, M., Kirimura, T.: Virtual Kyoto: 4D-GIS comprising spatial and temporal dimensions. Journal of Geography (Chigaku Zasshi) 117(2), 464–478 (2008)
6. Isoda, Y., Tsukamoto, A., Kosaka, Y., Okumura, T., Sawai, M., Yano, K., Nakata, S., Tanaka, S.: Reconstruction of Kyoto of the Edo era based on arts and historical documents: 3D urban model based on Historical GIS data. International Journal for Humanities and Arts Computing 3(1-2), 21–38 (2009)
7. Baltsavias, E., Gruen, A., Gool, L.V., Pateraki, M.: Recording, Modeling and Visualization of Cultural Heritage. Taylor & Francis, London (2006)
8. Hudson-Smith, A., Evans, S., Batty, M.: Building the Virtual City: Public Participation through e-Democracy. Knowledge, Technology & Policy 18(1), 62–85 (2005)
9. Hudson-Smith, A., Milton, R., Dearden, J., Batty, M.: Virtual Cities: Digital Mirrors into a Recursive World. In: CASA Working Paper 125 (2007)
10. Ishida, T.: Digital City Kyoto. Communications of the ACM 45(7), 76–81 (2002)
11. Ishida, T.: Activities and Technologies in Digital City Kyoto. In: van den Besselaar, P., Koizumi, S. (eds.) Digital Cities 2003. LNCS, vol. 3081, pp. 166–187. Springer, Heidelberg (2005)
12. Higuchi, T.: The Visual and Spatial Structure of Landscapes. MIT Press, Cambridge (1988)
13. Kyoto City: Kyoto City Landscape Policy: Forming Timeless and Radiant Kyoto Landscapes (September 2007), http://www.city.kyoto.lg.jp/tokei/cmsfiles/contents/0000062/62129/HP-English.pdf
14. Ramasubramanian, L.: Geographic Information Science and Public Participation. Springer, Heidelberg (2010)

15. Muranaka, A., Nakaya, T.: Economic valuation of the historic landscape restoration from disasters: a case study using the CVM in Kyoto, Japan. Rekisitosi-bosai-ronbunsyu (Papers on Disaster Mitigation of Historical Cities) 3, 245–252 (2009)
16. Muranaka, A., Nakaya, T.: Investigation into the Willingness-to-Pay for the historic landscape restoration from disasters by structural equation modeling. Papers on Environmental Information Science 22, 73–78 (2008)
17. Seto, T., Matsumoto, A., Iizuka, T., Yano, K.: Public Participation GIS of Historical Landscape: A Case Study of Kyot-Machiya Community-building Survey in Kyoto City. In: Proceedings in the 22nd CIPA Symposium, p. 5 (2009)
18. Iizuka, T., Matsumoto, A., Seto, T., Yano, K.: GIS-based Monitoring Systems for Kyo-Machiya in Kyoto City. In: Proceedings in the 22nd CIPA Symposium, p. 5 (2009)
19. PhotoField – Spatial Photo Album, http://www.s-it.org/photofield/
20. Schreibman, S., Siemens, R., Unsworth, J. (eds.): A Companion to Digital Humanities. Blackwell, Oxford (2004)