GIS-BASED MONITORING SYSTEMS FOR KYO-MACHIYA IN KYOTO CITY

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ABSTRACT:

This paper discusses construction of GIS-based monitoring system for Kyo-machiya or traditional wooden townhouse in Kyoto. The system is based on "Kyo-machiya Community-building Survey," for which the Kyoto City Government, Ritsumeikan University, architects and volunteer citizens have been working together since October 2008. In this field survey, we use ArcPad, a mobile GIS, in PDA to get exact geo-spatial information of houses and buildings with their photos. Kyo-machiya's survey entries include types, conditions, some design elements of the façade, if it is vacant or not and so on. The monitoring system is under construction with the aid of ArcGIS and Photofield; the latter is free spatial photo album software, created by Dr. Hideyuki Fujita, the University of Tokyo (http://www.s-it.org/photofield/). This GIS-based monitoring system can certainly assist landscape analysis and city planning for historical landscape preservation. Moreover, it is convertible to monitor other types of architecture including cultural heritages.

1. INTRODUCTION

In Kyoto, an old capital of Japan founded in 794 A.D., there remain a large number of historical buildings such as temples, shrines, Kyo-machiya or traditional wooden townhouses, and western-style buildings of the pre-war period. This is because Kyoto was exempted from war damage, unlike other cities in Japan. These architectural pieces contribute to Kyoto's historical landscape. However, these Kyo-machiya and modern western-style buildings have been facing a crisis as their number is decreasing rapidly due to renovation. In order to preserve such important architecture, the Kyoto City Government has implemented several measures such as the 2007 Kyoto Landscape Policy. At the same time, the City Government has started to figure out the overall situation of these houses and buildings.

For this aim, the Kyoto City Government, universities in Kyoto, architects and volunteer citizens have been conducting Kyo-machiya Community-building Survey since the late 1990s. Currently, the third stage of the Survey is underway. The past two surveys conducted in 1995-1998 and 2003-2004 did not cover the entire Kyoto City but focused on the central part of the city. These surveys made it possible to identify about 28,000 Kyo-machiya within the city center. Moreover, the research team of Ritsumeikan University created GIS database of Kyo-machiya, which can be used to monitor their architectural changes effectively.

A large amount of geo-spatial information and a great number of photos of Kyo-machiya and western-style buildings have already been collected through the previous two surveys. Based on their results, a monitoring system is under construction with the aid of ArcGIS and Photofield; the latter is free spatial photo album software.

The purpose of this paper is to give an overview of this GIS-based monitoring system for Kyo-machiya and to show some results of the third survey starting from October 2008.

2. KYO-MACHIYA COMMUNITY-BUILDING SURVEYS

So far, conducted were two large-scale surveys of Kyo-machiya in 1995-1998 and 2003-2004. In addition to that, the first modern architecture survey was led by the Kyoto City Government, NPOs and universities in Kyoto in the early 2000s. In the first and second machiya surveys, only the paper sheets were used to record data, which required a fair amount of time to put them into GIS database. Established in 2004 for the first time, the database clearly shows Kyo-machiya's changes occurred between the first and second surveys.

Based on these data, we are conducting the third survey, whose scope is broadened out in such a way as to add the south part of Kyoto, Fushimi area, and other areas along some old, major roads in Kyoto City to the central part covered in the past surveys (Figure 1). To predict locations of unknown Kyo-machiya outside of the city center, we rely on the Kyoto City's land use survey which could tell us when wooden houses were constructed. As a result, about 50,000 Kyo-machiya are estimated to exist in the entire city.
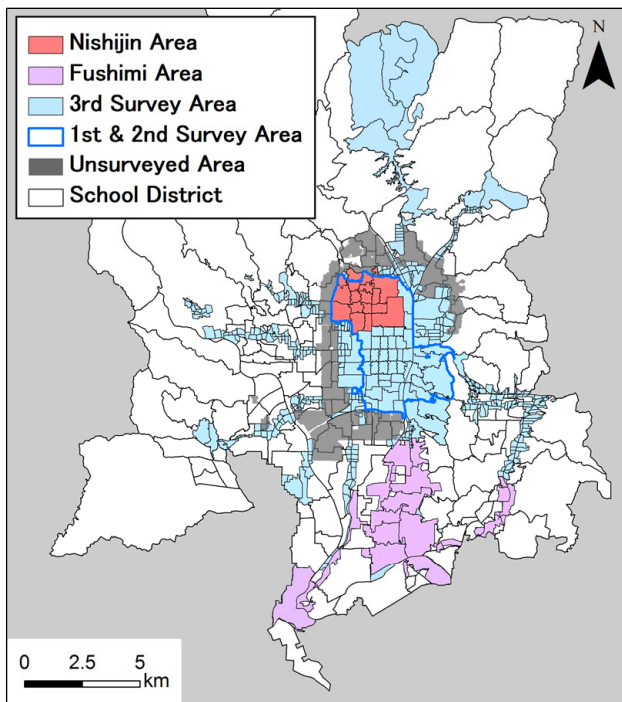

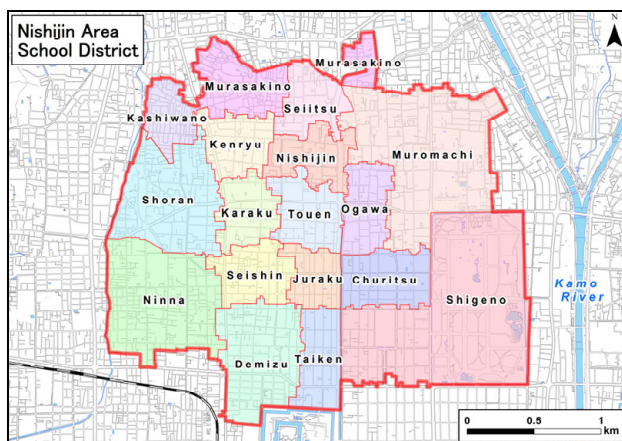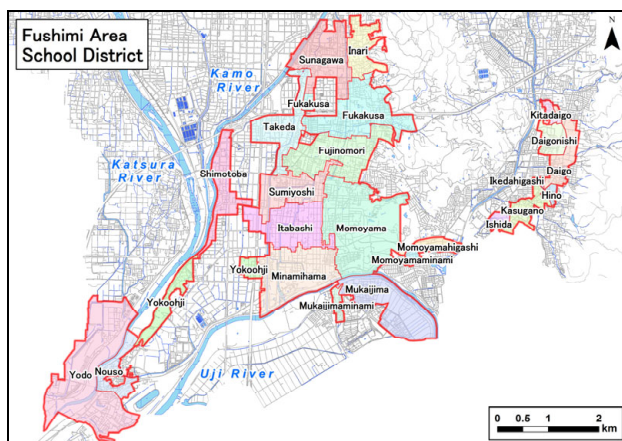* Corresponding author.
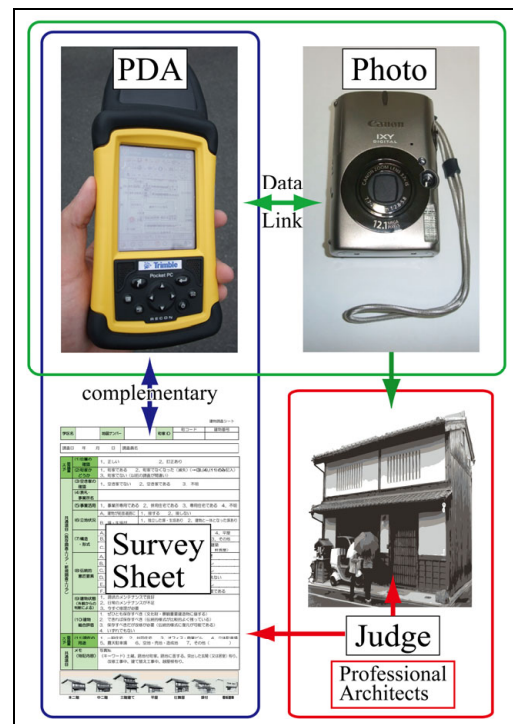
Figure 1. Study area

Figure 4. Sharing of roles in the survey

The current survey starting from October 2008 aims at collecting valuable information on approximately fifty thousand Kyo-machiya and about two thousands examples of western-style architecture, including their accurate locations and attributions, as far as they can be assessed from the outside.

Usually, maximum 15 survey teams spend a day to finish conducting field survey of one school district. Kyoto has about 200 school districts that correspond to neighbourhood communities. Since the survey should be approved by residents beforehand, we ask representatives of school districts for their cooperation.

In this field survey, we use ArcPad, a Mobile GIS, in PDA to get exact geo-spatial information of houses and buildings with their photos. Kyo-machiya's survey entries include: its type, its condition, some design elements of the façade, and if it is vacant or not. Introduction of PDA can help us save time for data entering and decrease input errors. As a result, we can easily update the existing GIS database of Kyo-machiya with highly accurate data.

Figure 2. School districts in Nishijin area

Survey teams consist of members from the Kyoto City Government and Ritsumeikan University, as well as professional architects and volunteer citizens. Around 3,000 persons joined the surveys between mid-October 2008 and March 2009. This paper mainly discusses the areas of Nishijin (Figure 2) and Fushimi (Figure 3) where we have finished the survey recently.

Each survey team consists of three to four members with each playing different roles of: using architectural expertise; entering data in PDA; writing down survey sheets; and taking photos. This formation makes it possible to get highly accurate data efficiently (Figure 4). Each team normally covers 50 to 80 Kyo-machiya on average for five hours of the survey.

Figure 3. School districts in Fushimi area

3. MONITORING SYSTEMS FOR KYO-MACHIYA

3.1 Kyo-machiya GIS-database

Kyo-machiya GIS-database is based on the three Kyo-machiya Community-building Surveys as mentioned above. This GIS-database consists of maps and attributes on ESRI ArcGIS and MS Excel. We manage Kyo-machiya's locations by presenting them as points on the maps. Based on the three surveys for the city center, therefore, produced are three sets of GIS data with points. Each point has its unique ID number, through which we can link its attribute data of one time slice to that of the other time slices. By doing so, we can investigate how Kyo-machiya's spatial distribution changed during the time period of the three surveys. As available are large-scale residential maps, i.e. Zenrin Town Map II (1:2,500) and Kyoto City Urban Planning Map (1:2,500), which specify shapes of buildings and parcel lots, if we need, we can transform point-GIS data to Polygon GIS data in order to measure specific Kyo-machiya's dimensions such as its frontage, depth, and area, by using ArcGIS (Isoda et al., 2005).

Table 1 shows attribute data, compiled from the field surveys. These attribute data are based on judgements from the outside by professional architects. The data entry items include survey members' subjective assessments of architectural conditions such as "Good, Moderate, or Need to repair." When considerable differences are found in their judgements, we can revise them using frontal photos provided by Photofield which we will explain in the following section. These attribute data can help us assess Kyo-machiya's conditions easily from various viewpoints.

Table1. Attribute data of Kyo-machiya

Items		Categories		
(1) Position		1. Correct	2. Incorrect	3. New
(2) Is this a Kyo-machiya?		1. Yes	2. No (demolished)	3. Mistake
(3) Empty house		1. No	2. Yes	3. Unclear
(4) Doorplate		(name)		
(5) Usage		1. Office	2. Multipurpose house	
		3. Dwelling house	4. Unclear	
(6) Type	(A) Structure	1. Two-story house	2. One-and-half story house	
		3. Three-story house	4. One-story house	
	(B) Roof	1. Gable	2. Gambrel	3. Others
	(C) Options	1. All of house with renovated façade		
		2. A part of house with renovated façade		
		3. Row house		
		4. Houses with a fence		
		5. Roji (smallest units of alleys) lane houses		
		6. N/A		
(7) façade	(A) Type of wall	1. Stud wall	2. Half-timber	
	(B) Entrance door	1. Yes	2. No	
	(C) two-story with traditional window	1. Yes	2. No	
	(D) Mud or plaster walls	1. Visible	2. Non-visible	
	(E) Fitting of one-story	1. Lattice door	2. Window back with lattice door	3. N/A
(8) Condition		1. Good	2. Moderate	3. Need to repair
(9) Special affairs		1. Value of cultural property		
		2. Need of improvement structures		
		3. Goodness of streetscape		
		4. Kyo-Machiya with roji		
		5. Shimotaya ("closed shop" town houses not used as business)		
		6. Heavy degradation		
(10) Present urban landuse		1. Low-rise residential housing		
		2. Store		
		3. Apartments		
		4. Office/Commercial building		
		5. Covered parking lots		
		6. Open parking lots		
		7. Open spaces		
		8. Others		

3.2 Results from Nishijin and Fushimi areas

As a result of the third survey, we could know there exist 10,540 Kyo-machiya in Nishijin area (Figure 5), and 5,815 in Fushimi area (Figure 6). The result also demonstrates distribution of Kyo-machiya. Nishijin is located north of the city center, and we already have data accumulated from the previous surveys of the area. Figure 5 shows Kyo-machiya

uniformly spread around the area, except for some large open spaces that indicate the Imperial Palace and other large constructions. Compared to that, Figure 6 reveals Fushimi area with Kyo-machiya's concentration in relatively small, old built-up areas and along old major roads that have existed since before World War II. Since this is the first survey for the area, we cannot investigate changes of Kyo-machiya.
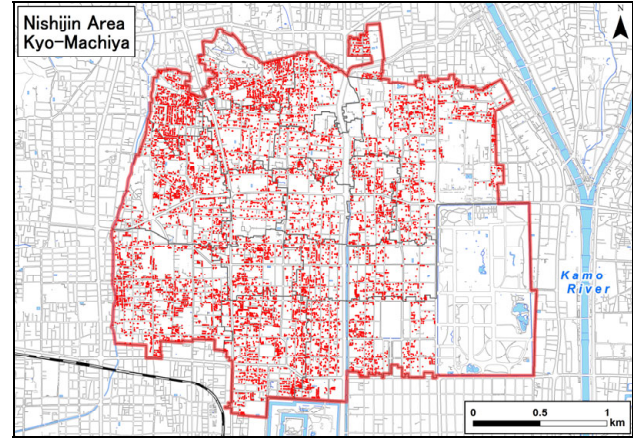

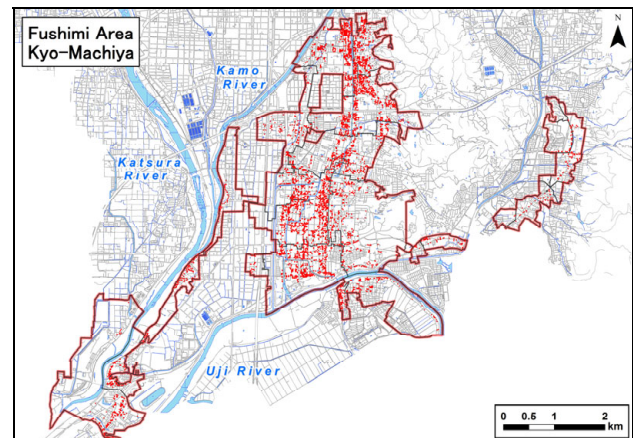Figure 5. Distribution of Kyo-machiya in Nishijin area

Figure 6. Distribution of Kyo-machiya in Fushimi area

Comparison between the second and the third survey results of Nishijin reveals the fact that 923 (9.4%) Kyo-machiya were demolished, as shown by Kernel density estimation in Figure 7. Moreover, the current database tells us that, after the demolition, the Kyo-machiya were replaced by: new low-rise residential housing (55.9%); open parking lots (13.8%); open spaces (10.8%); and apartments (10.4%).

Figure 7 demonstrates which part of Nishijin has suffered from demolition most severely. One of the factors affecting the destruction appears to be if existent Kyo-machiya is vacant or not. Most of vacant ones would be rented. With declining birth rate and a growing proportion of elderly people, many Kyo-machiya households are facing an acute shortage of successors.
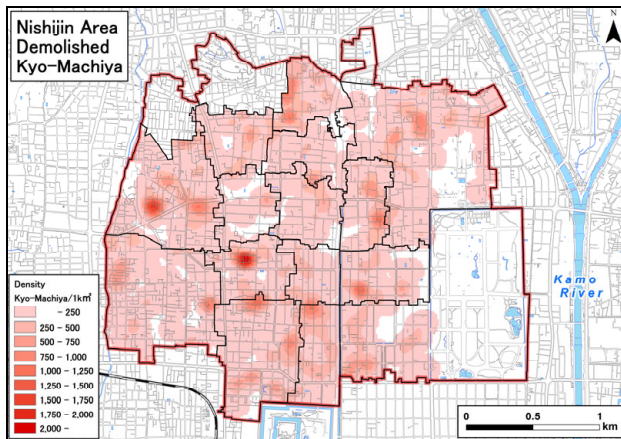
Figure 7. Density of demolished Kyo-machiya in Nishijin area

Figure 8 shows density of the vacant Kyo-machiya in Nishijin area. Many vacant ones can be found located along lanes called *rōji* (Figure 9), which is less than 4 meters wide. Unable to provide favorable residential conditions, these *rōji* areas would invite further their demolition, as well.

In order to conserve Kyo-machiya, it is important to monitor not only their conditions but also residential conditions of the areas through constant updating of the GIS database,

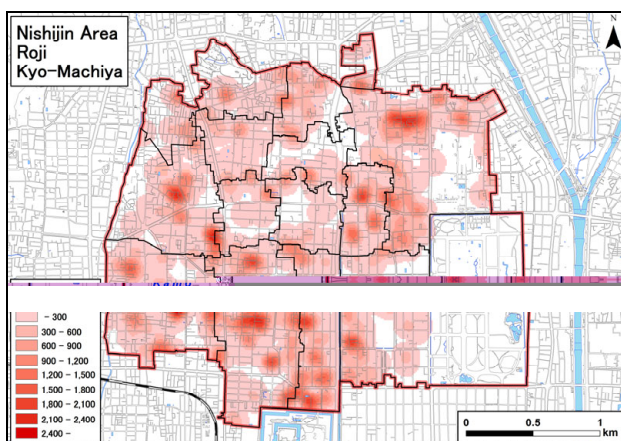Figure 8. Density of vacant Kyo-machiya in Nishijin area

Figure 9. Density Kyo-machiya facing Rōji in Nishijin area

3.3 Photofield

Introduced to the third survey are photo shooting of every Kyo-machiya as well as PDA. Visual materials have a great advantage in quantity of information when conserving Kyo-machiya, designating cultural heritages and important cityscape buildings and strategizing urban planning.

A monitoring system for Kyo-machiya is under construction with the aids of ArcGIS and Photofield. Photofield is free spatial photo album software, created by Dr. Hideyuki Fujita, the University of Tokyo (http://www.s-it.org/photofield/). Figures 10 and 11 show two examples of Photofield images .

The Photofield display consists of four parts: a map, a list of photos, a list of attribute data, and selected photos. Red points on the map indicate spatial distribution of Kyo-machiya. The map has basic view functions of pan and zoom controls. As for the background map, we can use geo-referenced image maps such as large-scale residential maps and old topographic maps. The background of Figure 10 is Zenrin's large-scale residential map and that of Figure 11 is an old large-scale urban planning map produced in 1953. The latter map suggests the built-up area at that time. In terms of its operations, we can convert ArcGIS shapefiles to XML files in Photofield by using ArcScript that we developed.

The Photofield display has many functions and features. When the user selects a Kyo-machiya by clicking it, for example, its photo comes up on the top right of the display. Then, you can zoom in and out this photo in order to check its conditions. Also available are its attributes which show up under the photo. Moreover, when the user selects some picture from the list of photos at the bottom of the display, a point of the selected Kyo-machiya gets highlighted on the map. He can also select Kyo-machiya based on attribute data. That is, if he selects some category, e.g. "Good condition," points of applicable Kyo-machiya get highlighted on the map, and their photos appear at the bottom (Figure 11).

Showing the map, images, and attribute data all together in one display, therefore, Photofield is extremely useful to get a quick overview of survey results and check entry errors.
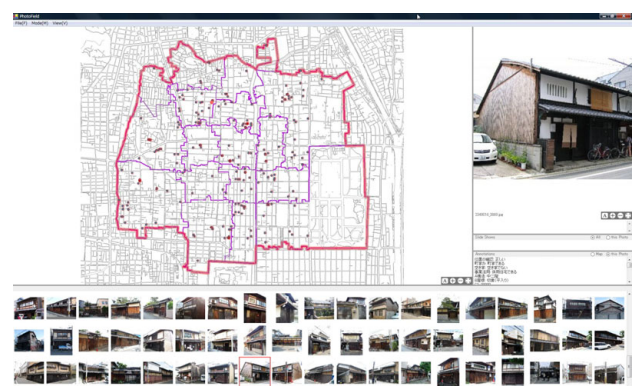

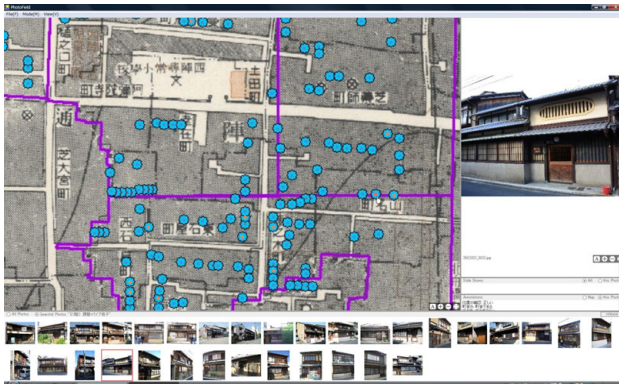Figure 10. Photofield image in Nishijin area

Figure 11. Kyo-machiya with "good condition" in Photofield

4. CONCLUSIONS

By the end of March 2010, we will finish the third Kyo-machiya Community-building Survey completely. After that, the GIS-based monitoring system will be completed, which contains GIS data of Kyo-machiya for the city center at three different time slices: the late 1990s, the middle 2000s, and the late 2000s. We are also planning to develop the same system for the entire city of Kyoto with a high degree of usability. In short, the GIS-based monitoring system makes it possible the following:

1)   To trace transitions of Kyo-machiya's spatial distribution by comparing multiple surveys;
2)   To identify scenic landscapes and Kyo-machiya-concentrated areas; and
3)   To monitor changes of Kyo-machiya easily.

With these clear advantages, this system can certainly assist landscape analysis and city planning for historical landscape preservation in future. Moreover, it is convertible to monitor other types of architecture, including cultural heritages.

ACKNOWLEDGEMENTS

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