Development of Past General Townscape Simulation System Using Time Series Design and Ukiyo-e Style Rendering

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***Abstract*— Herein, we present a landscape simulation system that reproduces general town scenery from the past using a game engine to understand the historical culture of a given area. To reproduce a general townscape of the Edo era, we referred to historic documents and maps, and sought feedback from the local residents to develop the system. In addition, because we use a game engine, our proposed system that can change the time zone, season, and weather as specific expressions. Furthermore, we attempted Ukiyo-e style rendering. Some residents evaluated the system using head-mounted display. We found that the components modeled by the proposed system were accurate. The developed system will be opened to all local residents shortly**

Keywords- Landscape; Simulation; Ukiyo-e

I. INTRODUCTION

In recent years, the preservation of regional history and culture has become difficult due to urbanization, depopulation, declining birthrate, and aging. In Japan, measures are taken to conserve all types of cultural properties as per the cultural property protection law; however, the general historical culture of a local area that has prevailed over the long periods of time is not designated as cultural property. There is no attempt to conserve it, and without the determination of its value, it is bound to be lost with time. In 2007, the Agency for Cultural Affairs advocated the "Basic Concept of History and Culture," which established policies to inherit popular cultural assets in local communities and to utilize them comprehensively. To facilitate these goals, autonomous and continuous regional design that takes advantage of the unique characteristics of a given region is required. Furthermore, it is expected that this design will utilize cultural assets as a regional resource to strategically disseminate information about them.

Herein, we focus on the general historical and cultural landscape of a local area and develop a landscape simulation system to capture the historical culture of the region by visualizing it in a simplified manner.

Various attempts have been made to digitally reproduce historic and cultural landscapes. Sheng et al. reported the development of a photorealistic virtual reality (VR) reproduction of Reizei-ke, which consists of the Japanese court noble residence [1]. In addition, Fukuda et al. reproduced the old castle of Japan [2]. Ergun et al. reported the reconstruction of historical and complex architectures in the 3D digital format using various scanning techniques and computer graphics [3]. Although these approaches are modeled precisely for single buildings such as prominent temples, 3D modeling at the urban level requires an enormous amount of data. Some preliminary studies have been conducted for landscape simulations at the urban scale. Dylla et al. built a virtual city using procedural modeling techniques in the Roma Reborn Project [4]. Nakaya et al. developed a virtual model of Kyoto using geographical information systems and VR, and attempted to represent past and present urban landscapes [5]. These simulations reproduced past landscapes with interactive elements at the urban level; however, the cost of reproduction was high owing to the use of a dedicated system. In this study, using a game development environment, we develop a system that reproduces past urban landscapes without excessive cost. The system can also be used for areas that are not famous sightseeing locations.

A previous work reports a streetscape simulation system using real-time rendering [6]. In this work, we focused on large-scale updating of a system based on feedback from local

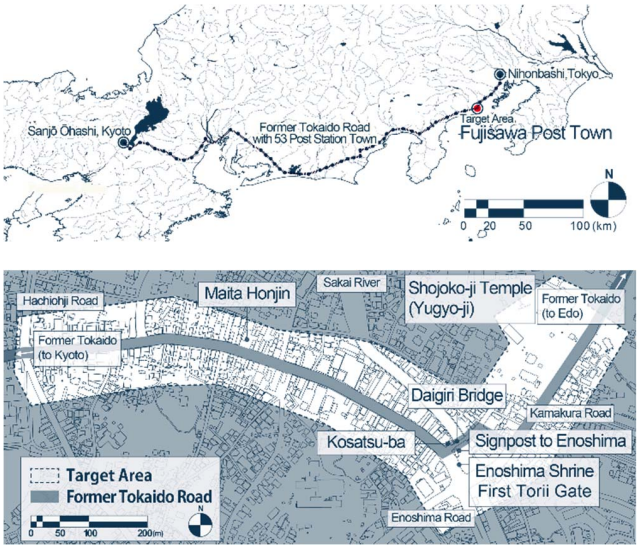

Figure 1. Target Area - Fujisawa Post Town on Former Tokaido Road in the Late Edo Period.

978-1-7281-2297-7/19/$31.00 ©2019 IEEE
DOI 10.1109/CW.2019.00068

citizens obtained after releasing the system to the public. The present work uses this feature and also refines the system by adding expressions used in game engines, thereby allowing it to change parameters of the landscape image, such as time, season, and weather. We also develop an Ukiyo-e like view simulation using edge detection of objects and shaders.

II. SYSTEM DEVELOPMENT

A. Modeling of Spatial Elements

We select Fujisawa Post Town and Enoshima (Kanagawa Prefecture, Japan) in the Edo era as the target areas (Fig. 1). At the time of interest, the post town contained many inns for tourists. During 1843, according to historic documents, the population of Fujisawa Post Town was approximately 4000 and it contained approximately 900 houses [7]. These documents also mention information regarding the building fronts and the number of rooms they contained, as well as the names of the inns and shops. Based on this information, 3D building models were imported into Blender using details created by 3ds Max (Autodesk, Inc.). The relevant material and other settings were selected, and then arranged in part units in the game engine. We used UNITY (Unity Technologies) as the game engine in this development environment.

The landscape evaluations carried out in previous studies clarified that dynamic elements such as people and vehicles are spatial components are likely to garner more attention than static elements such as buildings [8]. We thus created human models considering the behavior exhibited by the residents and visitors in the town at the time. The human models, which included loop animations that repeat defined actions, were automatically generated within the set range, and moved toward a specified destination. The human models were created by Lightwave, imported into Blender, and set up for animation. The models were then imported into the game engine, and the animations were controlled using a script. The animations of the human models were verified, and movements of persons wearing Japanese clothes of the style prevalent at the time were created. Elements attached to the humans, such as umbrellas, baskets, and lanterns, were also modeled. Our human models carried a lantern at night and opened an umbrella if it was snowing or raining (Fig. 2).

Figure 2. A Human Model Carrying a Lantern at Night (a) and the Model Holding an Umbrella in Rainy Weather (b).

B. Changes to Landscape Over Time

The landscape image can be changed depending on the time, season, and weather, even in a town composed of the same elements. In this system, various elements over time can be freely changed by the user, and the mode in which these environments can automatically change was also developed.

The change in time was represented by the position of the sunlight source. The position of Fujisawa Post Town was set at the latitude of 35°20' and the longitude of 139°30', and the position of the light source was determined. To express the season, the light source was set by matching the position of the sun with the data of the month and day. As a result, the

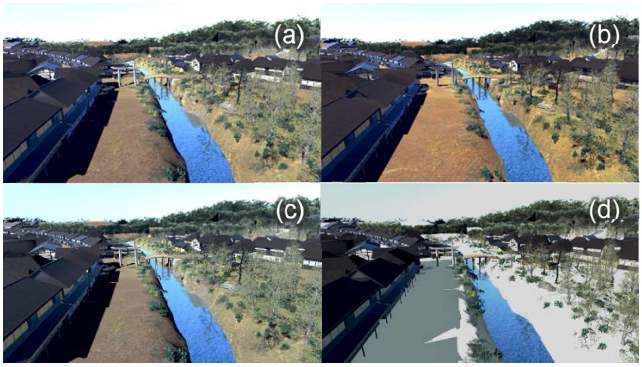

Figure 3. Seasonal Expression: a) Vernal Equinox; b) Summer Solstice; c) Autumn Equinox; d) Winter Solstice (Time: 10:00 h, Year: 1862).

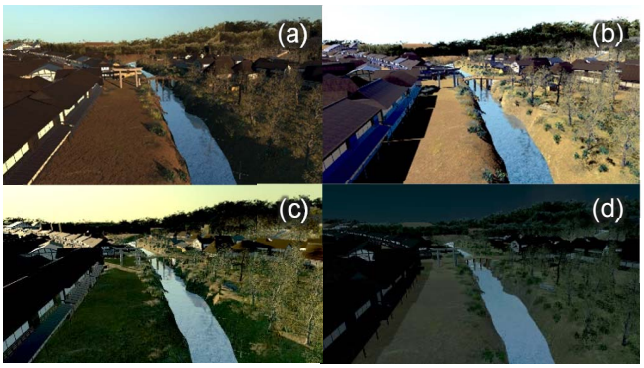

Figure 4. Time Expression: a) 06:00 h; b) 12:00 h; c) 18:00 h; d) 00:00 h (August 23, 1862).

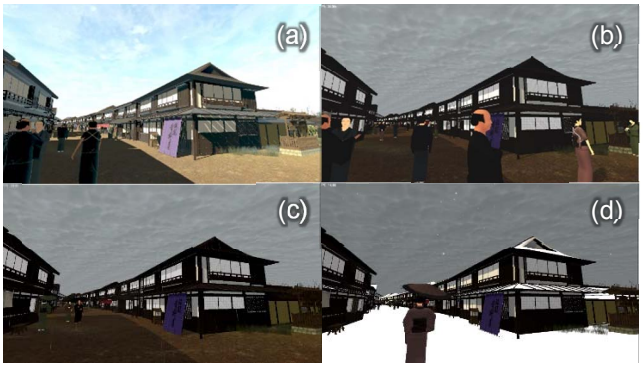

Figure 5. Weather Expression: a) Fine Weather; b) Cloudy Weather; c) Rainy Weather; d) Snowy Weather (January 20, 1862).

position of the sun differed depending on the month and day; different impressions could be obtained notwithstanding the fact that the time zone remained unchanged. In addition, the nighttime landscape was synchronized with the data of the month and day, because the brightness at nighttime differs greatly between the new moon and the full moon (Figs. 3 and 4).

To express the weather, we considered four patterns: sunny, cloudy, rainy, and snowy. To depict rain and snow, we used an effect wherein particles appear to fall from the sky. For snowfall, shaders were used to depict the illusion of snow on surfaces such as buildings and roads (Fig. 5).

C. *Ukiyo-e Style Rendering*

Ukiyo-e is a unique style of painting created in the Edo era. It is characterized by multicolored woodblock prints. It was a genre painting depicting daily life at that time, and its subjects ranged from *bijinga* (a type of Ukiyo-e portraying beautiful women) to *yakusha-e* (prints of Kabuki actors), *shibai-e* (pictures of plays), *meisho-e* (landscapes), and so on. Along with a realistic rendering, we prepared an Ukiyo-e style rendering to view the chosen locations in this system using its unique style. We selected the style of *Utagawa Hiroshige* for the Ukiyo-e paintings as the basis of the rendering in this work. *Utagawa Hiroshige* is an Ukiyo-e artist who gained fame as a landscape painter. The "Tokaido fifty-three" are his representative works. His style features impressive landscape paintings in blue with blurring using multiple color boards (Fig. 6).

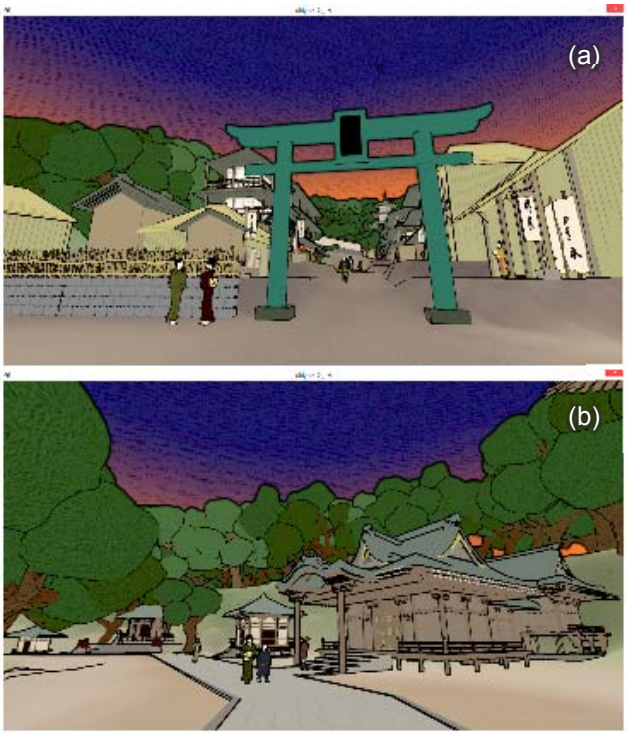

Figure 6. Ukiyo-e Style Rendering: Bronze Torii at the Entrance of Enoshima Shrine (a) and He-tsu-miya Shirine, One of Enoshima Shrine (b).

Edge detection was used as the method of Ukiyo-e style rendering to highlight the borders of the objects. The numerical value was set using the mode filter, and the values of depth sensitivity, normal sensitivity, and sampling distance were adjusted. We also added a Japanese paper texture layer over the materials of the spatial objects. We prepared an image rendered with several values and decided the value that most closely resembled Ukiyo-e through subject experiments. Some subjects complained of VR sickness when viewing the Ukiyo-e style of rendering reproduced with head-mounted display. This can be attributed to the fact that Ukiyo-e is a 2D print and that the rendering in the 3D space caused loss of cue information for depth. Thus, there appears to be room for improvement with regard to resolution and frame rate of the system. In addition, although this system employs free viewpoint movement, the VR sickness it causes in some subjects can be reduced or avoided by adopting a teleport system from one location to another.

III. CONCLUSION

To capture and convey information about the historical culture of two general local areas, we developed a historic landscape simulation system using a game engine. We examined the model shapes of the spatial components in order to reproduce them more accurately. In particular, expressions of time (day and night), seasons (spring, summer, autumn, and winter), and weather (sunny, cloudy, rainy, and snowy) were reproduced using the game engine. In addition, Ukiyo-e style rendering by object edge detection was implemented.

The developed system was tested by local residents at public facilities. A large-scale system update was possible, enabling implementation of the feedback received from the users at these exhibits.

In the future, we plan to extend the system according to the environment of the exhibition by adding features such as explanations of various old urban elements and comparison with the current landscape. Furthermore, we will generalize this system by developing a library of building units and urban facilities, and construct a platform for historical and cultural landscape simulation systems that can be used in various other local areas.

ACKNOWLEDGMENT

This work was supported by JSPS KAKENHI Grant Numbers JP19K12665.

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