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The Application of VR and AR in the Digital Preservation of Old City Cultural Elements

Naai-Jung Shih* and Hui-Xu Chen
National Taiwan University of Science and Technology, Taipei, Taiwan
shihnj@mail.ntust.edu.tw, ko83277@gmail.com

Abstract

Interactions between cultural heritage and pedagogy deserve investigation in an as-built environment under a macro- or micro-perspective of urban fabric. The goal of the research is to preserve old city cultural elements of Lukang. We present a VR and AR application for the digital preservation of old city cultural elements. In total, 68 3D photogrammetry models were created for VR and AR. We applied a smartphone-based platform for this novel application scenario. The interaction had been achieved between urban fabric, cultural heritage, and pedagogy. The illustration of the full-scale experience of the smartphone app was achieved for co-relating the dependence between urban fabric and cultural elements.
Keywords: VR, AR, photogrammetry, cultural heritage

1 Introduction

One of the typical efforts conducted for cultural sustainability is to preserve old city elements in a digital form for display, inspection, interaction, or measurement. The cultural entities need to be interacted with on Internet, so that a wider group of people can be involved to experience the craftsmanship or the knowledge under a realistic visualization.

Lukang, which is located in central Taiwan, is a town full of historical heritages. It is famous for exquisite buildings, old streets, and many artifacts. The unique architectural style and urban fabric have evolved from the earliest stages of its development (1683–1777), development peak (1784–1836), recession (1851–1888), degeneration (1895–1943), recovery (1945–1987), to current development phase (1988–now). It is located on the west coast of Taiwan and was formerly the second-largest harbor between the 17th and 19th century. Its competitive advantage disappeared after port silting and the rejection of railroad deployment [1][2]. The slowdown of local development and modernization eventually prevented the city's over-expansion and the potential deconstruction of historical heritages.

*Corresponding author

Heritages in Lukang are closely related to historical landscape, humanity, and building styles with the preservation well-conducted for a long time. The well-known old streets, where are full of relics, are part of the Heritage Preservation District mainly made of the Zhongshan Road, Zhongzheng Road, and peripheral districts. Based on former government promotion strategies, cultural industry has been evolved with unique characteristics and makes Lukang a famous tour site in central Taiwan. This site is full of characteristic foods, handcrafts, or religions. All the temples, shops, and food booths are connected to historical blocks in a unique circulation pattern. In order to document the famous old streets, we applied 3D photogrammetric modeling of the Zhongshan Road using an unmanned aerial vehicle (UAV) (Figure 1).

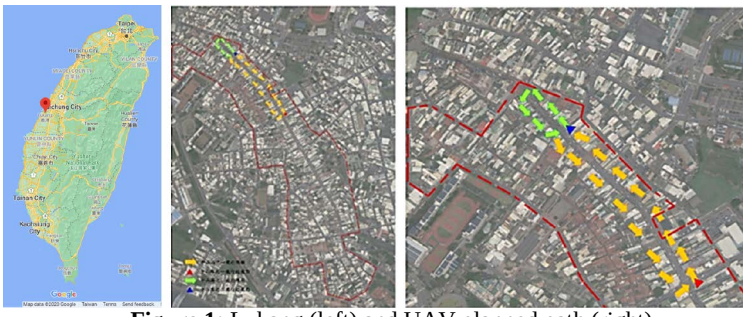

Figure 1: Lukang (left) and UAV planned path (right)

2 Research Purpose

This research aims to preserve old city cultural elements of Lukang. Interactions made to 3D data should be explored to a level that is feasible for pedagogy or tourism application. To achieve this, virtual reality (VR) and augmented reality (AR) apps should be applied to integrate with smartphone and a 3D photogrammetry model to facilitate the representation of urban fabric in a dependent and co-existing relationship with cultural elements. An old street in Lukang should be selected and modeled accordingly. Its local identity and the proof of historical development should be elucidated using an AR system for a characteristic tourism and pedagogical experience. Corresponding 3D contents should also be created and reviewed in different urban contexts.

3 Related Studies

Augmented reality (AR) has been widely applied to combine virtual information and to interact with a real environment in real-time [3][4][5][6]. AR applications have been succesfully implemented from education to medical practice [7][8][9]. Similarly, tourism can be experienced using technologies in virtual or augmented form [10]. VR and AR have been of interest to tourism researchers [11][12], in which tourists can be provided with detailed local information [13][14][15][16]. A user can explore reality and retrieve new information through interactive and highly dynamic experience with the assistance of mobile AR applications [17][18]. With a broader perspective of relics and associated landscapes, social awareness of culture can also be enhanced, and regional heritage can be protected [19].

AR is under different technology limits. For example, marker-based AR and markerless AR are two major AR types [20]. The former is often applied in tourism-related research. However, arranging and pasting markers on building surfaces usually causes difficulty and aesthetic concerns. In contrast, markerless AR is a more suitable approach for diversified scenes [21][22].

In addition to be considered as a tool, the function of AR or virtual reality (VR) has great potential to facilitate the comprehension and to improve the engagement of a scene upon the interaction with 3D entities. Tourism experience contributes to the logic and language of tourism information systems [23] built by multimedia contents or personal stories. To promote a similar content afterward, a representation of past virtual environment can enrich the structure of an information system for a vivid tourism experience.

4 Photogrammetry, VR, and AR

This project had created more than 68 3D models in different sizes and categories. Most of the models were generated by photogrammetry modeling application Photoscan® and Autodesk Recap® using a series of images, taken by digital camera or UAV (Figure 2). The size of physical model varied from an entire street to a house number plate. For example, a religion parade was filmed by a UAV for about 5 minutes. One of every 10 frames was retrieved using Free Video to JPG Converter®. In total, 1228 images were retrieved and created a 3D model after 12 hours and 24 minutes. The UAV system, a DJI-Mavic Air®, was connected and controlled through a Samsung Galaxy Note 8® smartphone.

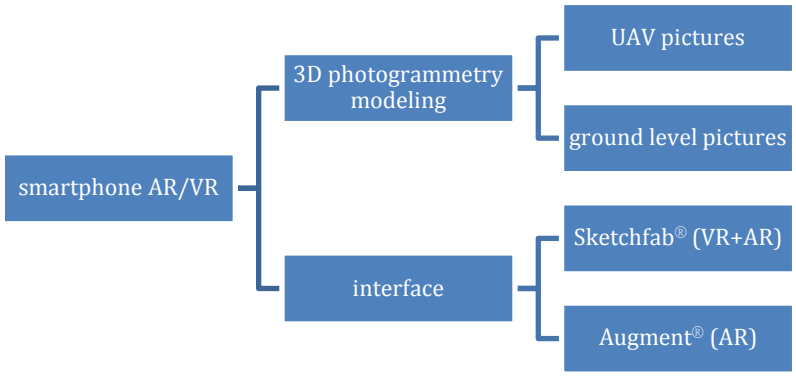

Figure 2: Smartphone platform of AR and VR using photogrammetry modeling and application interfaces

The 3D models constructed for Lukang can be promoted in terms of VR or AR platform to fulfill the preservation and pedagogy needs of cultural heritage.

- VR: VR was made by the application of a smartphone-based app Sketchfab® (Figure 3). The 3D models in OBJ format were uploaded to Sketchfab® through Internet interface. Either a user can browse a 3D model using a VR goggle (Figure 4), or through a general 3D device, such as a smartphone, a notebook, or desktop to interact with on the screen.

- AR: AR was made by the application of a smartphone-based app Augment® (Figure 5). All 3D models were uploaded to Augment® cloud database and assigned with a QR code. A user can either scan the QR code or just tab the surface detected by the smartphone to bring up the 3D model to the scene. Augment® can be operated in a markerless mode.

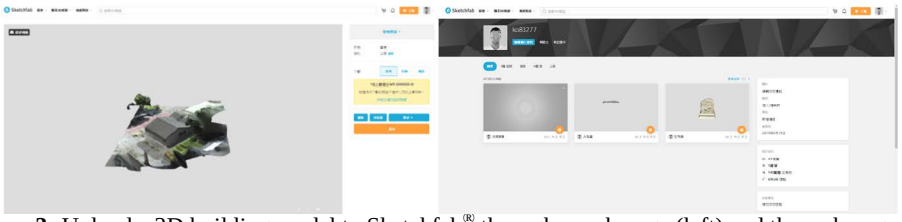

Figure 3: Upload a 3D building model to Sketchfab® through a web page (left) and the web page of a list of uploaded models (right)

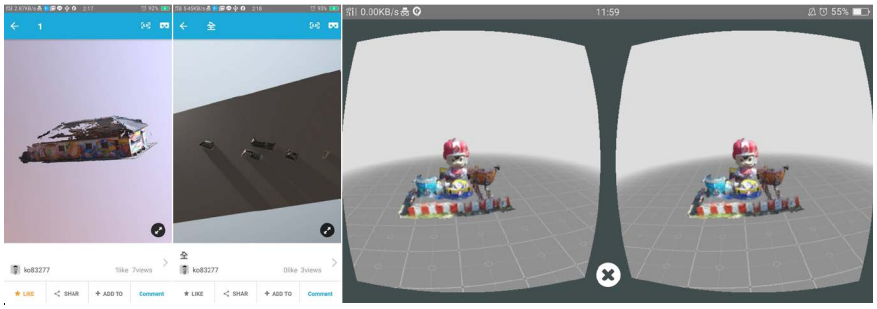

Figure 4: A Sketchfab® model was browsed using a smartphone (left) or using a VR goggle (right)

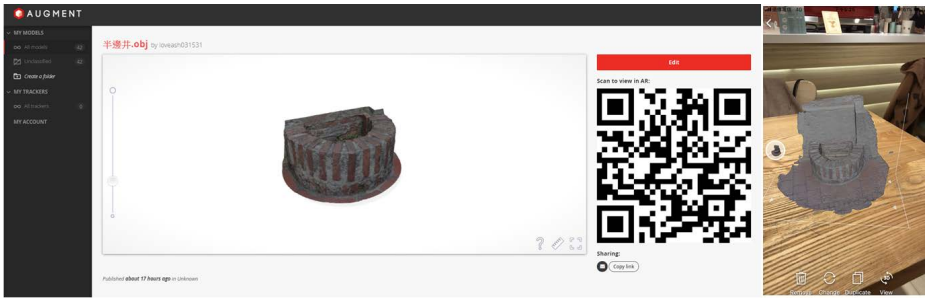

Figure 5: Assign a model on web version using QR Code (left) and browse on a smartphone (right)

5 Exemplifications

Many old street elements in Lukang were modeled in as-built 3D form. In order to promote their importance in historical development and the combinative nature of local characteristics, a markerless AR system should be used for tourism or pedagogical experience by correlating 3D contents in different urban contexts as well. A series of exemplifications was made to historical buildings in

Ximending, Taipei. The Red House is one of the important sites of local cultural and creative industry. Similarly, the building façade on Zhongshan road was also renovated during the period of Japanese Colonial Rule. The simple composition of geometries presented a concise and plain style with decorations for owner's social and wealth standing. In contrast, the Red House is a brick building of two-stories high. Its parapet was decorated with a gable on each side. By relocating a Lukang façade next to it, a comparison was made to the style and the composition of opening, details, molding, or material (Figure 6). Since a model was scaled, rotated, and relocated as wanted, an object's volume and orientation was adjusted purposely for a relatively correct proportion to each other for paired match. A minor adjustment was also made to align molding or brick layout to find out the potential displacement or deviation in pattern.

A comparison, which is made in a real environment with selected movement to orient oneself, helps positioning a user under the inspection mode similar to how the original craftsperson conducted building examinations a long time ago. The relative scale between the real building and the crowd is very helpful in estimating dimensions during daytime and in the evening. Interestingly, the weather and luminous condition of the site where a comparison was made becomes part of the reality. The diversity of the possible appearances of the studied subject now is of concern, since the façade can be different in a sunny or a raining day. A series of AR versions was created associated with matching scenarios. The openness of a complete AR app actually enriched the definition of reality.

Figure 6: The original historical building (left) and a newly overlaid building façade for comparison

6 Discussions

The application of Sketchfab® and Augment® in VR and AR has encountered problem in presenting correct color attribute. The situation mainly occurred when the normal of 3D faces was not properly corrected. For example, in the browsing test for 3D models of an art village, the original model setting was made of the combination of buildings and the ground with projected map. Unfortunately, the map did not appear properly. The color attribute remained when the object was browsed from the host webpage on desktop computer. Nevertheless, the texture disappeared when it was browsed from a smartphone.

This study subjected to certain levels of constraints in the application of hardware and software.

- The UAV was a perfect system to take aerial images quickly in a large area. However, the flight plan suffered sudden wind and the blockage of advertisement panels above street in low altitude. The system was operated by one person. The 15 minutes battery life also limited the filming range and time.
- The large number of images required intensive computation of CPU and graphic accelerator. The number varied from 10 to above 1000. Although certain application supports cloud-based computing, the host-based application took 15 minutes to a few days to compute a scene. The size of 3D model was huge.
- Photogrammetry applications came with different levels of efficiency in uploading, detailing, and smoothness in operation procedures.
  - Stability may prevent uploading large number of images continuously. Additional management has to be planned to partition site in a smaller modeling block under a controllable size and followed by the registration of all segments.
  - Different application may result in different levels of details, even the same set of image were applied. For example, 3DF Zephyr® and Altizure® usually created models preferable than the others did in the tests.
  - The automatic execution of command scripts did facilitate the creation of models without keeping watching the computation process and waiting for consequent command inputs.
  - The selection of higher quality level of point cloud was compromised due to almost endless computing time. A lower level of details was applied instead with decimation.

7 Conclusion

This study converted physical artifacts to digital format for the documentation of cultural entities and street blocks. In total, 68 3D photogrammetry models were created for the old city cultural elements. The artifacts were applied in a VR or AR environment for pedagogical purpose. The 3D platform and cloud database enabled an Internet-based presentation. The interaction platform of VR and AR can be used to facilitate the preservation of Lukang history even after the existing setting is demolished in the future.

The VR or AR application was used as a sustainable assistance in cultural preservation. The temporary installation deployed during annual festival was displayed again at the same location. The 3D documentation can be used to recovery original configuration upon the damages caused by natural disasters. This study did not purposely program VR- or AR-related apps. Instead, open resources of app were applied for a low learning curve and a higher accessibility on a smartphone platform. This attempt was proofed to be feasible in the preservation of cultural entities with more interactions to draw people's attention as a pedagogical approach for students or visitors. The interaction had been achieved between urban fabric, cultural heritage, and pedagogy. The illustration of the full-scale experience of the smartphone app was achieved for co-relating the dependence between urban fabric and cultural elements.

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