



3D Scan-Based Cultural Study of Old Street Architectural Forms

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Abstract: This research aims to build a digital urban landscape based on as-built environmental information for cultural studies of old streets. Scans were made to the streets and facades in a famous sightseeing location, Yingge Old Street, in northern Taiwan. A 3D laser scanner was used to record buildings, plants, and open spaces in a static configuration starting from a bridge as the gateway to the city. The final urban information creates a precise description of objects with colors and textures feasible for internet browsing and infrastructure illustration and measurement. A study was made on the second contour and the micro expression of the old streets, which represents the cultural characteristics. A new design style as a new symbolic representation of the entrance to the old street was explored as a visual illustration that contrasts between modern design vocabulary and traditional old street components, or international style and traditional ceramic icons like a brick chimney and pot walls. This study considers the local cultural icon should comprise objects with 3D as-built configuration as the best representation approach. 3D scan has been proven to be one of the best approaches to achieve this goal.

Keywords: 3D scan, old street, architecture

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I. INTRODUCTION

The study was conducted to a sightseeing site in north Taiwan: the Yingge Old Street, in which the shops along main streets were scanned. The context of this research exists in the urban fabric under the scale of a city block like a part of the digital urban landscape, based on as-built environmental information for cultural studies of old streets. This is a preservation-oriented study that illustrates the urbanscape of an old city for its new appearance in the 21st century, with the scope defined by its historical forms and city characters. From the viewpoint of architectural data, recorded details should include street facade, open space, skywalk, and local culture icons.

The significance and potential outcomes of this study should focus on the discovery of a new local image from the entrance to the old street. As a kind of new symbolic representation, regional characteristics are very interesting from a planning scale to the size of a local shop, in

terms of pavement, landscape, lighting facility, street furniture, signage system, etc. For a better description, a field recording method should be provided and proofed as an appropriate approach to meet the goal of a thorough representation of urban fabric and the second contour, based on the unique as-built geometric configuration. The approach could also lead to the creation of most updated as-built representation of the old street as a convincing digital twin of reality.

From practice point of view, technology should serve a feasible and an effective field 3D data collection manner which is considered as an as-built or as-shown data collection approach. The recording process should be able to replicate the on-site reality in order to be shared, delivered, investigated, or promoted. In traditional 2D-oriented preservation method, historical annotations of cultural entity have been made through filming, photographing, map, measurements, or interview. The levels of

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reality may vary by contents or details in terms of texture, shape, or accuracy. In the findings of previous field studies of street-facing buildings, the as-built street scenes have been successfully presented with rich details on the facades. Although architectural drawings are used for decades as legal documents for spatial representation, the comprehension of drawings can also vary by persons or expertise. In other words, the perception of architectural details may be different if recorded street facade, open space, skywalk, and local culture icons are not well-presented. It's necessary to construct the digital twin of a site with the hierarchy of context presented in a comprehensive manner that is feasible for cultural studies of urban elements.

The outline and organization of this paper are structured as follows.

- Introduction
- Literature review
- Research purpose and methodology
- The construction of 3D street model
- The presentation of old street characters
- Discussion
- Scan system
- Conclusion

II. LITERATURE REVIEW

Cultural characteristics and tourism are closely related in Taiwan. Cultural relics are one of the most genuine ways to experience a culture and history [1]. A historic district with sustainable development must possess the positive characteristics of consciousness of local culture, cultural identity and collective memory, and significance [2]. A sustainable concept of city development can stimulate and attract new residents, tourists, and investors [3]. The constant development of a town's tourism industry enables it to create more tourist-specific routes [4].

Cultural characteristics and tourism are created within the domain of urban fabric which evolves into specific local spatial patterns [5]. The fabric, which is mainly defined by building enclosures and open spaces, also contributes to the image created by local people and historical government policies, and further propagated by residents and tourists. Local fabric comprises of different representations, such as images, 3D models, maps, or architectural drawings. 2D drawings or 3D Digital Terrain Models (DTM) are usually used for the basic reference of spatial structures. GIS technology is used in the interpretation of urban fabric status [6]. For a more detailed description of as-built geometric information, Unmanned Aerial Vehicle (UAV) or aerial Light Detection and Rang-

ing (LIDAR) can add spatial data with different levels of accuracy [7]. The amount of data opens up opportunities in various fields of study [8], especially when showing the complexity of city objects and their interrelationships [9].

In architecture, 3D scan has been used toward more complicated building configuration [10, 11]. Scan application in architectural survey has been enlarged to urban scale and be integrated with computer vision, digital photogrammetry, and computer graphics [12, 13, 14, 15]. In Finat's study [16] of small towns and midsize urban spaces, the space information and the cases were categorized based on the characteristics, purposes, and contents of subject.

In order to comprehend urban culture, the connection between urban scale and street scale has to be established. The urban fabric, as a summation of urban artifact and cultural representation, usually features specific appearance and structure under a framework that interprets the interrelationship between building and street elements. The representation of urban fabric requires as-built data to verify the relationship between space and architectural form. Instead of list traditional 2D-oriented preservation method, a few technologies should be explored from the direct use of DTM and GIS information to 3D data retrieval using UAV, LIDAR, or photogrammetry. Previous researches have proofed the evolutionary data retrieval method of 3D scan is feasible and would lead to a more focused study with the details and forms of architecture in a well-defined manner.

III. METHOD AND MATERIALS

Most of the old streets in Taiwan are popular sightseeing places with rich historical characteristics. Related studies are mainly conducted with interviews or surveys with images taken for illustration purpose. Considering the cultural icon usually comprises objects with 3D configuration, study should be made to construct the interrelationship between culture-related subject and surrounding environment for a thorough representation of urban fabric. 3D scan seems to be one of best approaches to achieve this goal in recording as-built scene.

3D scan is a non-intrusion method which carries the nature of reverse engineering. The part of building, which is out of reach, can also be scanned from a distance [7, 8]. The range of a 3D scanner varies from less than 1 meter to more than 1000 meter, depending on which type of scanner is used. The surface of an object does not have to be contacted to be measured or modeled.

3D scan data can be collected and carefully integrated for the most effective illustration of local cultures. Expe-

riencing a route through the 3D data leads to the creation of a new urban fabric definition in terms of building enclosures and additive parts like signage or urban furniture. A new application paradigm of 3D scan data should be applied and used to proof the feasibility in illustrating urban icon which is close-related to the identity of Yingge Old Street (Fig 1), especially at the entrance.

The research objectives include:

- Modeling digital urban landscape, based on as-built environmental information for cultural studies of old streets.
- Recording urban fabric under the scale of a city

block. From the viewpoint of architectural details, recorded details should include street facade, open space, skywalk, and local culture icons.

- Historical space re-discovery and historical subject retrieval. The data of this study will lead to an as-built and as-shown approach of field 3D data collection method.

The cultural and urban fabric explorations include: (1) scan and illustration of old street fabrics (Fig 2); (2) scan street commercial activity and culture aspects; and (3) scan spaces and buildings around culture icons.



Fig. 1. Street scenes in Yingge

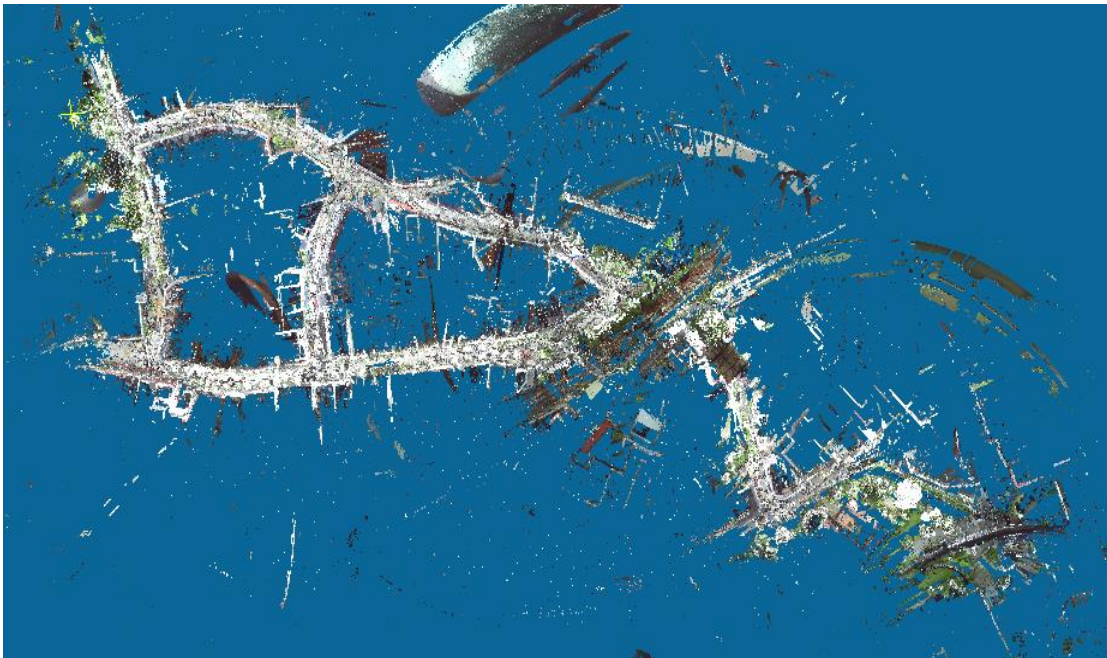


Fig. 2. The scope of Yingge 3D point cloud model

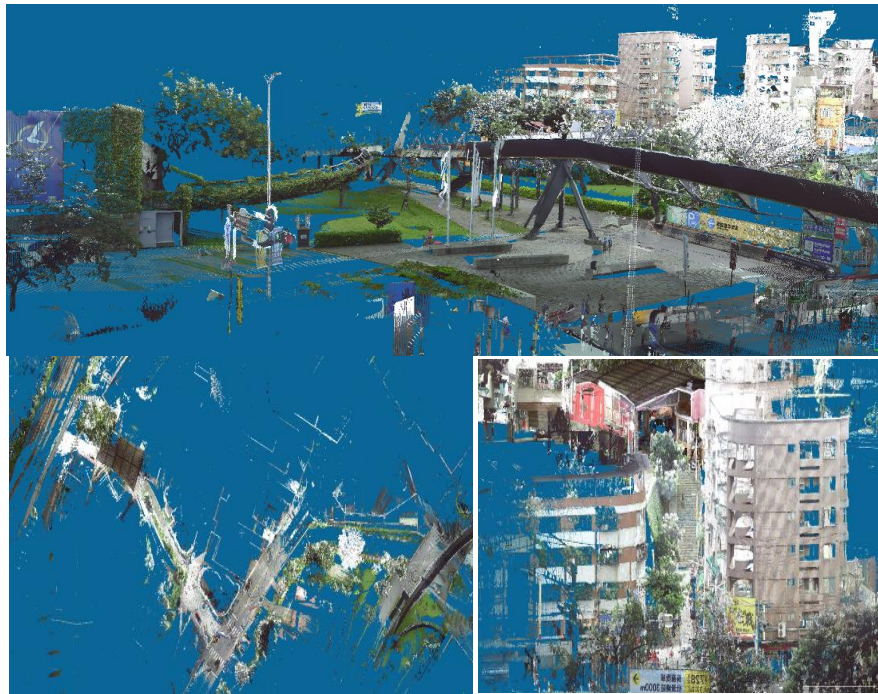


Fig. 3. 3D point cloud of the skywalk and the view made from it to the old street

IV. THE CONSTRUCTION OF 3D STREET MODEL

The whole project aims at the historical space re-discovery and historical subject retrieval. The purpose of this study leads to an as-built and as-shown approach of field 3D data collection method. The scan path (Fig 2) is purposely planned to connect local old streets and the skywalk at the entrance to the city (Fig 3). Fig 2 shows the major street scene in which scans were made on ground levels and covered street facades on both sides. Final cloud model was registered using reference points inside overlapped areas of adjacent scans. The data then can be manipulated as required, for example, to measure street width, to slice 3D point cloud sections, or to outline skyline by projecting street façade orthogonally. Both individual scans and the final model are 3D files can be exported to different CAD or VR platforms through appropriate 3D formats. 3D point cloud and new building model can be combined for more realistic design evaluation.

The model is considered as a central database to control the consistency among drawings derived from it. As the original old street data were too fragmental to have a whole perspective, the as-built model presents a reliable source of information which is placed at a higher hierarchy for the reference made by individual building, during the period when scans were made.

The hierarchy of 3D street details covers from a skyline to a street-side shop. The model features higher

efficiency of 3D manipulation in zooming or panning. A variety of elements can be seen in following categories.

- Entrance: The entrance to the old street was explored in terms of a specific visual experience that contrasts between modern design vocabulary and traditional old street components (Fig 3).
- Shop and signage: 3D cloud model illustrates shop front and related advertisement panels in details (Fig 4). The signage is clearly presented with contents in terms of food picture, price, promotion, or shop name in 1:1 scale.
- Contrasting skyline: Skyline represents a typical urban identity which includes tall buildings with huge mass and small shops decorated by sophisticated facade signage system. The contrast shows the vocabularies of repetitive pattern of tall buildings and the faded building volume covered by customer-made artifacts like advertisement panels or roof additions. Pedestrian's viewpoint used to be limited at ground level and restricted by landscape or buildings. In order to generate a front parallel projection view of street facade or section, skyline can be created in different vertical orientations by rotating the cloud model or boxing specific region for best display. The skyline in contrasting configuration indicates the co-existence of new and old urban renewal stages (Fig 5), not just in a larger urban scale, but also in a micro viewpoint of street development.

- Street elements: Street elements comprises signage (Fig 6), landscape, pavement, furniture, etc. in different scales and relative settings along walk-

ing axis. Some elements, which contribute to the configuration of urban fabric, are deployed permanently or temporarily.



Fig. 4. The second contour and micro expression on street facade



Fig. 5. Street section view



Fig. 6. Street elements in a photo (left) and in a point cloud (right)

V. THE PRESENTATION OF OLD STREET CHARACTERS

Many Taiwan sightseeing sites are famous with distinguished culture characteristics made by architectural style and tourism activity. The former represents buildings and related installations, and the latter involves interaction made between local residents and tourists. One of the most influential elements of style is called second contour, which is indicated by the new constructions or tem-

porary installations added to the enclosure of a building. In many Asian countries and regions, the visual pattern of a street facade is dominated by the second contour [17]. The second contour and the micro expression contribute many culture-inspired object designs like signage and shop front installations along the old street (Fig 4 & Fig 7). Walking environment in a commercial area, which is contour-related, is very important for pedestrians, as the related issues include basic functions, maintenance quality, visual aesthetics, number of activities, etc.



Fig. 7. The old street facade with different characteristics

In Yingge, street space is related to the connection of activities and the scale of open space. Specific local street scene has been created by ceramic products, the sense of enclosure, and the shops. The linear space of traversal used to be created without clearly defined boundary. Now the street characters should be preserved and re-vitalized as historical assets. Since the globalization of urban environment has been eliminating local identity gradually in these days, the artifacts and activity should be precisely recorded by a 3D scanner, so future study can be conducted correctly.

VI. DISCUSSION

A tour magazine acts like a search index. Although images are usually provided with annotations to enhance the understanding of a place, the experience can be quite different from being there. Experiencing a space from a tourist's perspective is similar and yet different from what the true reality is. In addition, tourists may not have full opportunity to traverse the entire introduced routes to experience all sightseeing highlights in a limited period of time. While tourist usually try to go through what a magazine reports, an alternative is to provide a virtual environment that help people familiar with a place from a distance.

In this study, the 3D point cloud model provides a very detailed representation of real world. In comparing between the findings with previous studies, the answer is positive because the as-built street scenes have been successfully presented with rich details on the facades of street-facing buildings. From previous literatures point of view, technology is really a feasible and an effective manner as an as-built and as-shown approach of field 3D data collection method. The model in great details not only can be applied in virtual world for interactive inspection, but also can be retrieved for architectural practice use.

The scan data create a fabric definition in terms of following items:

- Building enclosures: The configuration of the original shape and remodeled parts were captured as in a most updated configuration.
- Drawings: The artifact or remodeled parts, which

have been created by modifying original design, can be documented for 2D drawings like plans, elevations, or sections.

- Skyline: A skyline is redefined including constructions added to roof level.
- Building envelope-related artifacts: The second contour now includes advertisement panels in different shapes and contents purposely added to building facades.

VII. SCAN SYSTEM

A 3D scanner, Faro Focus 3D[®] laser scanner, was used to capture as-built environment data that associate with local culture. The advantage of this approach is to create 3D model capable of identifying a space or a location at the first sight, with data also precise enough for measurements in full scale. With a middle scan range of 80-120 meter, a street about 1400 meter long was retrieved in a set of cloud models made by 67 scans. Other than by the scanner's host platform, the data were exported to Meshlab[®], CloudCompare[®], and Geomagic Studio[®] in different resolutions for measurement and visualization purpose.

Virtual data are usually applied to illustrate subject which is closely related to how people is usually perceived. A point cloud represents a collection of geometric data, which belongs to an object's surface and therefore can be used to show the appearance of the object. In the database, point clouds are represented in terms of x-, y-, and z-coordinates and attributes, such as red, blue, green color at different levels. 3D scan is considered as a non-intrusive technology. Therefore, areas blocked by other objects can only be scanned from other orientations.

VIII. CONCLUSION AND RECOMMENDATIONS

The digital urban landscape of Yingge Old Street was scanned and created based on as-built environmental layout. Old street-related studies are usually conducted with interviews or surveys with images taken for illustration purpose. This study considers the local cultural icon should comprise objects with 3D as-built configuration

as a best representation approach. The interrelationship between culture-related subject and surrounding environment is thus constructed for a thorough representation of urban fabric and the second contour. 3D scan has proofed to be one of best approaches to achieve this goal.

The study reveals that regional characteristics of the Old Street are very interesting from a planning scale to the size of a local shop, in terms of pavement, landscape, lighting facility, street furniture, signage system, etc. Although the result features the city with certain level of similarity with other sightseeing locations in Taiwan, a new design style as a new symbolic representation of the entrance to the old street has been discovered. The entrance illustrates a visual language contrasting between modern design vocabulary and traditional old street components, or between international style and traditional ceramic icons like brick chimney and pot walls.

The loss of a town's vitality, uniqueness, and humanity can be prevented through continuous attention and improvement [18]. Scan data, in terms of point clouds, were retrieved to represent the unique as-built geometric configuration. The digital models, which were used as the references for chronological comparisons, can discover configuration changes or show construction stages. This is very important recording process for a district with historical meaning. The scans should be conducted more frequently for future planning reference.

Future studies would include the investigation of the connection between different urban development stages in order to verify the possible evolving pattern of urban fabric. Government policies also need to be examined for the exemplification of culture-related instances. Historical satellite images should also be compared chronologically by years or versions as an indication of boundary movement and geographic distribution for local cultural studies.

Declaration of Conflicting Interests

No conflicts of interest are present in this study.

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