Title:
A Section-based Illustration of Old Street Fabric and 2nd Contour Using 3D Scan Data

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Introduction:
Taiwan sightseeing sites are famous with distinguished culture characteristics made by architectures and activity. Culture is the foundation for the sustainable development of a society [7]. The combination of activity and cultural relics are one of the most authentic ways to experience a culture and its history [1]. Tourist experience will directly influence a town's administrative strategy for related development. A sustainable development of the heritage must include the positive characteristics of consciousness of local culture and cultural identity [9]. After the local government settled in Taiwan 1949, the shutdown of original ceramics supply and the increasing demands of local market has created a great opportunity to expand Yingge business scale as a ceramic town to a significant level. The business was expanded overseas with exported bath or sanitary accessories in 1962. The success did not last long. Local ceramic industry transformed into new business model under the crisis of raised labor wage and offshore business migration in 1980s. Since 1990, a new tourism and leisure model was developed and an image of ceramic town was created upon the design of a new museum and a series of old street renovations. Considering the impact to the economy, Yingge has been fortunate in overcoming the ceramic depression by industry transformation. Now the city, which is marketing its old history with related scenes, has dedicated almost the entire area for tourism.

Research Purpose and Methodology:
The purpose of this study is to explore the cultural and urban fabric of Yingge Old Street. In order to collect and present the most updated configuration, as-built scenes were scanned on ground level to simulate the visual experience of pedestrians. The data illustrate street commercial activities, booths, and culture aspects that are enclosed by open spaces or buildings around culture icons. The illustration needs to be made based on as-built scenes to prevent measurement error and distortion in reality, in the meantime levels of abstraction can be performed with manipulated format and perceivable fabric configuration. As a decomposition of explanatory pedestrian roaming experience, one of the major types of illustrations is the section-based illustration for old street fabric and 2nd contour. The 3D point cloud model, from which the sections are originated, is presented with an auxiliary inspection aid of smartphone AR.

The Construction of 3D Street Model:
A tour represents a space-traversal exploration to experience an unfamiliar urban fabric, in the meantime constructing a perception framework of the space for the individuals. The exploration of space comprises environment and occupants. The local environment and cultural heritage need to be evaluated or planned from the perspective of tourists in order to meet demands [3]. To preserve city landscapes and historical heritage, the experience of local residents and tourists also need to be fully

studied [2]. A 3D model is very useful to create a digital twin of urban fabric for the exemplification of spatial structure of tourists and local residents. The current urban simulation technology is evolving, in which the 3D point cloud model can be used to display geometries and to create a combinative representation with other model formats in great details [8]. Digital simulations of streets can make it easier to elucidate complicated situations and fulfil the demand for data communication [5].

The whole project aims at the historical space re-discovery and subject retrieval. The purpose of this study leads to an as-built and as-shown approach of field 3D data collection (Fig. 1, left). The hierarchy of 3D street details covers from a skyline to a shop. The scan path is purposely planned to connect local old streets and the skywalk from the entrance to the city. The model is considered as a database feasible to maintain the consistency among derived drawings. While the original old street data were usually too fragmentary, the as-built model presents an integrated source of information in a higher hierarchy to be referred by individual scene.

Fig. 1: 3D street scans and street 2nd contour defined by different elements.

Urban Fabric

The purpose of 3D street reconstruction is to create a reference between an as-built 3D environment model and local cultural elements to support the study of urban fabric, by fulfilling the representation needs from the geographic configuration of Yingge and the perception of tourist and local residents. Towns with a historical emphasis usually feature various kinds of space combinations. The complicated geographical environment of Yingge has created a rich facade hierarchy and an attractive street pattern.

Urban elements, which make a significant contribution in delivering historical imagery, can easily define a domain-specific fabric. Nevertheless, these fabric definitions are not included in cadastral or geographic data. The referred relationship between the elements and urban fabric can only be created by 3D scans in a digital representation of the as-built scenes during cultural festivals, weekends, or national holidays. A point cloud model, which integrates recent urban renovation plans and elements, is created and still can be referred by a cadastral or geographic map. For example, a series of historical satellite images has been retrieved around old streets and shown the changes of urban fabrics 39 years ago. As-built data has created a connection or reference between all the experiences, expectations, and cultural characteristics. By providing the as-built spatial framework, a tourist's spatial structure can be presented by the 3D model.

Street Second Contour:

Building enclosures are determined by the first and the second contour, in which different visual patterns may apply. Original building exterior elements are contributed by the earlier design as the first contour. Then, the second contour appears when the facade was remodeled to meet living or business needs after years or a series of modifications. Many Asian countries and regions have street façade dominated by the second contour [4]. In contrast, European streets are mainly presented by the first contour. The second contour is made of new constructions or temporary installations added to the walls or spaces closely adjacent to the street-facing facade. Due to the tourist consumption demand, local residences have been transformed from living to commercial use. Ground floors are renovated into souvenir shops with newly installed advertising boards, lighting fixtures, canopies, display windows, or stands protruding from the walls (Fig. 1, right). These installations, which define the configuration of the second contour, have replaced the original old street contour in Yingge.

The Decomposition of Axial Street Geometry:

One of the main purposes of creating 3D scam model is to illustrate the complexity of urban fabric and the 2nd contour. Although 3D model can be studied for a better perception of the city in a macro view, sections can provide an orthogonally scaled measurement in a simplified form. In order to show visitor's tour down the street in different visual arrangements, this study applies Cloudcompare® to define the axis and the length of intervals between two sections perpendicular to the street axis, for sequential and compressed images of the street. Depending on the bay width of shop or pedestrian walking speed, the interval is changeable. Since most of the streets are not straight, the sections are either aligned to the axis or projected in the same orientation to match the viewpoint of visitors. Fig. 2 shows a series sections marked in red were made to the street at 1.5-meter thickness in 4 meter interval. This set of sections contributes an entrance image in which tourists approach the old street through a skywalk above a railroad. With the alignment made to axis of railroad or street, a different pattern is shown with either a clearer definition of boundary or a blurred buffer of space containing a collection of 2nd contour elements.

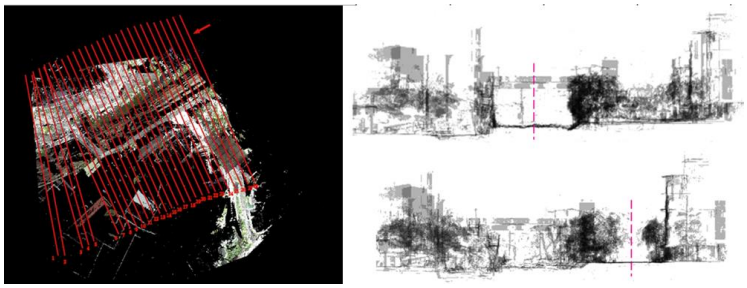

Fig. 2: Layer of street sections and overlaid image aligned to separated axis.

Fig. 3: The variation of skyline and street open space from near to distant.

The vertical street axial-perpendicular sections can be either presented individually or by sets. The entire building front can be divided into three parts: the ground level, the body, and the skyline. Created intervals are used to show the diverse interpretations of scene.

- Visual and physical emphasis of boundaries:
  - Scene in near, middle, or distant regions;
  - Projected skyline and real physical boundary in open space: The images vary as the skyline can be perceived from a distance as a projection, or the combination of solid building enclosure and the soft tree crowns in front (Fig. 3).

- Elevation-based configuration:
  - 2nd façade;
  - Business activity at ground level and above.
- Sequential reference of pedestrian scale and activity by sections.

The skyline has to be created manually because it is a collective image projected from a distance. Different types of outlines reveal a complicated nature of urban fabric in a vertical manner and in different combinations of artifacts. The retrieval of the original point clouds was scanned and registered automatically through a series of scans. In contrast, part of the filtering process has to be made manually. The skylines were drawn as a study process that connects traditional vector drawings that can hardly be made from the most updated urban as-built physical scenes. The process is closely related to the approaching images perceived by tourists with projections filtered from far end to near side, while traveling down the old street or approaching the entrance.

Augmented Reality:

The section-based illustration of old street fabric and 2nd contour, which actually comes from as-built 3D scans, should be displayed as needed to provide an inspection from other orientations for study purpose. One of the major Augmented Reality (AR) characteristics is to combine real and virtual objects in a real environment. A facade about 10 meters long was selected and converted into polygons in Geomagic Studio®. The original point clouds were converted from points, polygons, decimated polygons, OBJ format, FBX format, to AR files in several stages. The larger model was divided into 5 equal parts with about 500000 polygons each, in about 20% of original polygon numbers in total. The file size of all 5 parts was reduced from 312 MB in OBJ format to 125 MB in FBX format, a 40% of original size. FBX files were converted to AR app in 170.7 MB prior to being loaded into smartphone. The displayed AR object is one of the five parts. It is made of 235,754 polygons (Fig. 4) with 10.7 MB in FBX format that was converted from 28.3 MB OBJ files with 1.65 MB JPEG file. The OBJ geometries were originally 3D scanned, meshed, and segmented into about 3 million polygons, which were decimated into three levels of size in 495.7, 70.3, or 10.7 MB of FBX file. Increasing polygon number causes screen display delay with flickers. An iPhone 8 XS Max®, which is equipped with A12 CPU with 4 GB RAM and 64 GB internal storage, was used.

Fig. 4: The screen shots and two viewing angles of AR object on iPhone.

Scan System:

A 3D scanner, Faro Focus 3D® laser scanner, was used to capture as-built environment data that associate with local culture entities. The advantage of this approach is to create 3D model capable of identifying a space or a location at the first sight, with data precise enough for measurements in 1:1 scale. With a middle scan range of 80-120m, streets of about 1400 meter long were retrieved in 67 scans. Other than the scanner's host platform, the data were exported to Meshlab®, CloudCompare®, and Geomagic Studio® in different resolutions for measurement and visualization purpose.

Conclusion:

The loss of a town's vitality, uniqueness, and humanity can be prevented with continuous attention and improvement [6]. 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 formation of the old street has been rediscovered. Its entrance illustrates a visual language contrasting between modern design vocabulary and traditional old street components. The application of 3D scan data was extended to AR on a smartphone, in which point clouds were wrapped into polygons. Although huge polygon numbers slowed down frame rate for a smooth display, the level of details and reality did illustrate a promising future for mediated manipulation of data.

Future studies would investigate the connection between different urban development stages in order to verify the possible evolving evidence 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 by versions as an indication of boundary or geographic distribution of interests.

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