Title:
3D Scans for Weather-damaged Sculptures

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Introduction:
The creation and maintenance of different kinds of authenticity is explored for the preservation of weather-damaged sculptures. This is a one-year cultural heritage preservation project led by Juming Museum, to scan stone and copper sculptures by the famous Taiwanese sculptor, Ju Ming. Two approaches were applied to the sculptures. They were based on the use of suitable scanners for the different materials, sizes and conditions, as a way to extend previous studies and facilitate future research. The scanned 3D data led to the identification, inspection, quantification, and comparison of deteriorated and damaged parts. By combining existing procedures and minimizing the learning experience for museum researchers, this project not only prepares geometries of different resolutions to make the transfer of the model's data proceed smoothly, but also recommends the virtual tools and setting for research-related work.

Main Idea:
Heritage preservation is a project which integrates planning, design, and resources [3]; it involves many roles, from data acquisition to web page creation [3]. As all maintenance efforts need to be planned ahead, information should be in the simplest possible digital format to minimize the need for specific, or possibly obsolete, software [3]. The public needs access to cultural heritage subjects over the web with real time interactions [4]. The results must also be presentable for large audiences and pedagogical purposes in the virtual world [1,2,5]. This project was conducted outdoors, where daylight variations were a great concern, as opposed to those scanned in a lab with controlled lighting in the virtual world.
Ju Ming (Fig. 1) was born in 1938, and is one of the foremost artists in contemporary Taiwan. He was trained in traditional crafts, and is regarded as a symbolic figure in the Taiwanese Nativist Movement of the 1970's. The Juming Museum has conducted a series of studies regarding environmental effects and sculptures' physical reactions to weather. The museum is located in the northern shore of Taiwan on a windward hillside that directly comes in contact with northeastern monsoons. The climate is not only humid and wet, but the region is also exposed to high levels of pollutants carried over by these monsoons. Also, the sulfuric gases emitted by Datun Mountain (active volcano) react with moisture and atmospheric substances to produce sulfites and sulfuric acid, all of which lead to the acidic erosion of outdoor sculptures.
This is a one-year scan project (2011.4 – 2012.5). The involved target sculptures are divided into two themes according to grouping, materials, locations, and the period when the work was created:

- Taichi Square: a total of 8 sculptures were scanned. The "Taichi Series" emphasizes the subject's body and movement. The original molds of these cast copper alloy sculptures are made of Styrofoam which is carved and chopped with electric saw to create the abstract form and rough

texture. A long-range 3D scanner, a Leica HSD 3000 (300 meters with 90% reflectivity) was used to retrieve geometric data (Figs. 1, middle).

Fig. 1: The artist Ju Ming, a sculpture, the control over the resolutions of the model, 3D scanned data with image mapping and in full geometry resolution shown in high density mesh (over 7,000,000 polygons), and 3D-printed using a RP machine

- Stone Conservation Lab: Complex details on the stone body and surface are presented. The entire collection consists of 30 works ranging from 50 to 200 cm in height. The largest piece is a sculpture cluster of 27 close-set units. Deterioration was rapid and visible. A short range Artec HM-T hand-held 3D scanner (30-120 cm) was used for the geometric and photo-realistic color texture retrieval (Figs. 1, right).

Scaled-down Geometry for Preservation Requirements and Presentation
The original scan results are archived. Nevertheless, file size increases with the object dimensions and scanning resolutions enlarged. The dimensional changes are greater with the copper sculptures, by up to about 20 meter, compared to the stone sculpture's range of 50-200 cm. At first, the original mesh was decimated with the size or resolution of mapping images at the same time, then the images were reduced separated. For geometries (polygons), both the curvature priority and the polygon count were employed. Although the former can maintain more details, the small number of polygon count usually eliminates most of the details.

Interaction in Virtual World and Physical World
For promotional and inspection purposes, the web pages and RP models are used as "interfaces" for the virtual 3D model. The original 3D models that are used to be retrieved only by researchers are now accessible to the public. A user can use the two data types as an index to pinpoint, reference, and communicate a specific region of interest. The webpages are linked to the museum's existing website. The two sections of the webpage are designed with similar requirements and purpose, and are viewed using similar elements. The pages were built with Tourweaver® customized interfaces.

Scan Verification of Weathering Deterioration
Comparisons were made between changes that occurred within this one-year period; to achieve this, the model's chronological records were aligned to mark specific changes in terms of location and boundaries. The matching and comparison of the changed landscape with the main part of the sculpture showed a 1/4 of a specific sculpture buried under newly renovated grounds. Cracks caused by rock stress are also shown. Cases of weathering include Nos. 3, 6, 7, 11 and 13 (head divestiture), 15 (partially buried), 17 and 18 of the individual stone sculptures, and 3, 4, 23, 25 and 27 of the sculpture cluster.

Conclusions:
By applying two different scan approaches to the two types of sculptures, multiple levels of reality were explored in terms of material, size, complexity, and weather conditions. This project stands out from other local digital preservation cases, where data were the display-oriented turnkey result, with the extended scope of planning, applications, and promotional interfaces. In addition to integrating preservation plans, designing, and resource management, this project has solved problems caused by extensive variations in scale and mutual obstructions. The sculptures' different appearances are also explored to facilitate inspections in both the virtual and physical settings. With regard to concerns

about the adaptability and convenience of the new working environment, simple tools with extended functionalities were applied to a feasible example of the researchers' cultural heritage preservation work.

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References:
[1] Allen, P.K.; Stamos, I.; Troccoli, A.; Smith, B.; Leordeanu, M.; Hsu, Y.C.: 3D Modeling of Historic Sites Using Range and Image Data, Proceedings of the 2003 IEEE International Conference on Robotics &Automation, Taipei, Taiwan, 1, 2003, 145-150.
[2] Haval N.: 3-Dimensional Documentation of Complex Heritage Structures, IEEE MultiMedia, 7(2), 2000, 52-56. http://dx.doi.org/10.1109/93.848429
[3] Hedstrom, M.: Digital Preservation: A Time Bomb for Digital Libraries, Computers and the Humanities, 31, 1998, 189–202. http://dx.doi.org/10.1023/A:1000676723815
[4] Manferdini, A.M.; Remondino, F.: A Review of Reality-Based 3D Model Generation, Segmentation and Web-Based Visualization Methods, International Journal of Heritage in the Digital Era, 1(1), 2012, 103-123. http://dx.doi.org/10.1260/2047-4970.1.1.103
[5] Trapp, M.; Semmo, A.; Pokorski, R.; Herrmann, C. D.; Dollner, J.; Eichhorn, M.; Heinzelmann, M.: Colonia 3D Communication of Virtual 3D Reconstructions in Public Spaces, International Journal of Heritage in the Digital Era, 1(1), 2012, 45-74. http://dx.doi.org/10.1260/2047-4970.1.1.45