Batak Toba Cultural Heritage and Close-range Photogrammetry

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Abstract

This paper discusses the use of close-range photogrammetry techniques for documenting a traditional Batak Toba house in Samosir Island, North Sumatra. The discussion is to bring awareness of its possible uses for preserving traditional houses and promoting them as cultural heritage. The most significant role of the method in cultural heritage is its future for 3D visualization for the public engagement in cultural heritage conservation programs. Close-range photogrammetry techniques produce a photorealistic 3D model of the house that helps people understand the sophisticated and complex house form more easily. They have provided flexibility in data acquisition as the non-metric camera is affordable and operable by anyone. Compared to other 3D modeling techniques, the close-range photogrammetry delivers a variety of data, from 2D images of photographs, dense point clouds, geometry of the object, and solid 3D model.

1. Introduction

Research on the documentation of traditional forms of houses in Indonesia up to now is mostly undertaken for anthropological interest in material culture. Research with the aim of reconstructing building types for its symbolic meaning and customs relating to the habitation is rarely organized. Concern about the sustainability of vernacular architecture and a growing interest in cultural heritage has led to an ever greater appreciation of traditional houses, with its organic integration of buildings into their natural surroundings. This concern manifests in various attempts to describe particular building traditions and to study them in their natural and social contexts.

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In most regions of Indonesia, traditional patterns of social living are eroding and giving way to new personal initiatives. Adaptations of traditional house forms for everyday life are self-evident. The process resulted in building a new construction that its appearance is still being associated with a traditional form, yet it meets individual aspirations and pride in local ethnic identity. At the same time, national tendencies towards cultural differences are being countered by accentuation of local ethnic culture. This phenomenon contributes to the attempt to a better understanding of what are the most important parts in an architectural creation.

New house forms are not constructed in an open ground. They reinterpret architectural heritage whose origins are shared by the community. Knowledge of architectural heritage, for this reason, is indispensable for understanding a particular local development in formal manifestations and symbolic meanings. How architectural structures express ideas about relationships within the social and cosmic universe has been researched elaborately worldwide. The Encyclopedia of Vernacular Architecture of the World (1997) by Paul Oliver is one of the most significant results.

A traditional house has an important position as it stands for the concept of a unifying principle (Levi-Strauss in Schefold, 2003, p.4). The rich decorations and complicated building construction underline the importance of a house as a unifying principle. House forms are often related to status differences and emphasized as an effort to achieve a higher social status. This condition implies that modification of buildings is related to the effort of endorsing personal ambitions (Schefold, 2003, p.7). Most of the houses certainly have a prime practical function as they are shelters and storage rooms. Nevertheless, architectural features appear under the influence of different owners. Structural solutions of a raised floor for tropical soils and dangerous animals indicate logical reason. However, respectively, the house form is conceived as an image of the under-middle-upper world of the cosmos. The formal features of houses are influenced or determined by symbolic meaning, and local manifestation of each feature may be expressed technically in quite different ways.

Vernacular architecture is abundant throughout regions in Indonesia and variation in form and use of dwellings and traditional houses are numerous. Indonesian vernacular architecture represents the cultural heritage of maritime regions, and a great diversity of local forms is being generated. Traditional houses as representative of Indonesian vernacular architecture reflect fundamental meanings of a house in its technical construction as well as in its symbolic richness. They are carrier of the collective memory of the community. Increasing the understanding of past and modern developments in vernacular architecture of Indonesia becomes central to gain new insight into architectural creation and dwelling traditions.

Recently, increasing attention has been given to the uses of modern technology for the documentation of cultural heritage. Digital information technology has begun to transform the process of understanding the past. Computerized methods of documentation have grown more and more important for opening up potential in addressing new challenges and concerns of cultural heritage. The objective of this paper is to demonstrate the use of digital technologies for documentation of cultural heritage and the profound impact on the ways cultural heritage is protected and promoted. The paper presents the potential of 3D digital documentation on traditional houses and the use of close-range photogrammetry for documenting a Batak Toba traditional house as a case study.

2. Traditional Batak Toba House as a cultural heritage

A traditional Batak Toba house is a rectangular building on stilts, which can be accessed by wooden steps from the ground. Typical of a Batak Toba house is the steeply rising roof with eaves. The huge roof is in the shape of a saddleback with sharply projecting gables. The space under the roof is closed off with triangular gables and the space under the roof is not divided up into separate rooms. The sides and rear of the house have only a small window. The façade of the house is covered with carved motifs, which are painted in three natural colors: white, red and black. The front wall and the gable of the house are decorated with extensive figural and ornamental decoration.

Several families used to live in the house, and the substructure of the house is used for livestock. Batak Toba houses rarely exist in isolation as they make up a group of buildings as part of a small village. Each village usually consists of no more than ten houses built close together in the immediate vicinity of agriculture land.

A traditional Batak Toba house represents cosmological ideas of their inhabitants. The space for animals in the substructure symbolizes the underworld. The living area that is raised on stilts is the people’s place that represents the middle world. The high roof that corresponds to the place of gods represents the upper world. The creation of the house is the work of the people and the users, without the help of a trained professional. It is mostly built up by
individuals, who build as they do because the knowledge has been informally passed on from generation to generation. Usually, the community enforces unwritten rules in that house forms vary little over time.

Traditional houses play a vital role in the collective memory of Batak Toba people as they reveal events, societal issues and progress of the lives of people. Nevertheless, every year some of these houses disappear due to the lack of concern and technical knowledge. Aligned to Pierre Nora’s observation on collective memory (Crysler, C. Greig, Cairns, Stephen, Heynen, Hilde, 2012, p. 299), place of memory is needed to preserve cultural heritage from its destruction. Physical space is the place at which memory becomes visible as a collective identity (Crysler, C. Greig, Cairns, Stephen, Heynen, Hilde, 2012, p. 300). French sociologist Maurice Halbwachs argues that memory is not intrinsic or given, but rather produced in shared social space of everyday life. For Halbwachs, memory is socially grounded and collective: a matter of how minds work together in society and how their operations are structured by social arrangements. (Halbwachs in Crysler, C. Greig, Cairns, Stephen, Heynen. Hilde, 2012, p. 299).

Recent research on the role of built environments argues that a memory is attached to the artifact through shared processes of signification rather than discovered and released by skillful analyst (Crysler, C. Greig, Cairns, Stephen, Heynen, Hilde, 2012, p. 300). For this reason, traditional buildings should be understood as a medium of social change rather than formal categories because the social processes shape them. The knowledge of a lifestyle, social relations, building techniques, meaning of social life of the past generations can be acquired from traditional houses. Building traditions and the architecture of traditional houses have provided Batak Toba people with a sense of identity and meaningful collective memory. To be kept alive, this collective memory must be continuously recreated and transmitted from one generation to another. The documentation of these traditional houses, in these circumstances, deals with methods and conditions of collective memory that are important because they raise awareness about cultural heritage. Making the cultural heritage accessible to the public will apparently encourage creativity and self-respect in Batak Toba communities and individuals. From now on, documentation can also provide a basis for formulating strategic plans to improve their living conditions. New tools of digital technologies have tremendous potential for addressing new challenges and concerns of the existence of traditional houses.

3. The close-range photogrammetry for documentation of buildings

Traditional survey and conventional architectural representation are typically 2D visualizations of an object that consists of plans, sections, profiles and rectified images. To understand the object comprehensively, one has to extract 2D information and to build a 3D geometry simulation in their mind. The process is not a simple and immediate operation, and often can only be done by experts and professionals. In the past, architects built physical models to represent the design three-dimensionally.

Capturing and modeling of a real building is very challenging, and up to the present there have been a number of 3D presentation techniques in use. Current 3D architectural visualization models have been mainly focused on graphical and visual representations with limited support for semantic and inter-disciplinary analysis. A more sophisticated 3D model beyond visualization is immensely required to response multifunctional and multi-representational operation purposes.

The lack of graphical representation, textual archives, and heavily eroded traditional houses make preservation of traditional houses and development of house forms difficult. Documentation that reflects the characteristics of traditional houses and their surroundings is critically important for the reconstruction, building refurbishment and preservation of Batak Toba cultural heritage. In this situation, 3D digital modeling provides a robust methodology for capturing, analyzing and researching the evolution of traditional houses from different locations spread over time, geography and culture.

Digital technologies in documentation have developed enormously and changed the methods of building’s documentation from 2D to 3D (Geymen, 2009, Yastikli, 2007, Yilmaz, 2007). The use of 3D digital modeling by means of photogrammetry has increased because of its efficiency in regard to time, cost, accuracy and usefulness (Remondino, 2011, Remondino, 2010, Fassi, 2011). The importance of present day use of close-range photogrammetry in the acquisition of data for historical buildings is expanding.

The potential of 3D digital modeling is not only for its efficiency and accuracy of documentation, but it also encourages the requirements for public participation and engagement. Digital technology as the collection and
processing of data will promote innovative applications for community and individual involvement in heritage. Data collected by photogrammetry processes allows animated views of houses and their environments, which enable the sharing of stories, memories and traditions by local communities. The models display distinct building heritage by which invite local communities to create narratives of its traditions (Tait, 2013, Tait, 2014). Many people may then be involved in heritage management as active participants rather than as passive audience of heritage experiences.

Digital 3D visualization models may facilitate communication, interpretation and safeguarding of traditional buildings and places that acquire public heritage significance. The cultural heritage from now on might be interpreted collaboratively between inhabitants, professionals, associated communities and other stakeholders. 3D digital modeling may also provide context and tools for new approaches to cultural heritage management. The concern for digital modeling is not merely for recording, data processing, and visualization, but also helping to shape the meaning and direction of the heritage management.

4. The documentation of traditional Batak Toba House

The research undertaken is to apply close-range photogrammetric techniques for documenting a traditional house at Huta Siallagan in Samosir Island, North Sumatra. The documentation process combines digital photography with computing capabilities to capture highly accurate 3D data of the house. The main objective of the research is to construct 3D digital images of a traditional house by using close-range photogrammetry techniques. The research involves several steps: a) capturing the image of the house, b) processing the acquired image, and c) producing a 3D digital model.

Digital close-range photogrammetry captures images with a camera at close range and its basic model are central perspective projection. The image of the house is captured by non-metric cameras: Nikon D5000 for terrestrial photography and Canon Powershot S100 for aerial photography. The process begins with the camera calibration that includes camera focal length and lens radial distortion parameter. These parameters are needed in defining the 3D collinearity equation. The Photogrammetry techniques, in fact, rely on photographs and mathematical equations.

The 3D measuring uses photographs from at least two different locations. A “lines of sight” is developed from each camera to specific points on the façade of the house. Subsequently, points are mathematically intersected to produce the 3D coordinates of the point of interest. The next step is to fix common point on objects of photograph by image matching algorithm. The coordinate of fixed points will then be computed with 3D collinearity equation.

![Fig.1](image)

In obtaining a dense point cloud, points are spread on the façade of the house where edges and variation of coordinates are there. The point cloud is the sum of measurements made from a series of overlapping photographs taken from a variety of viewpoints. Stereo pair matching undertakes the dense point cloud generation. The software uses similarity of the images to determine corresponding points on both photographs and to determine the coordinates. In obtaining a complete 3D model, the process is repeated as many pairs needed.

Because of the complexity of house form and the density of buildings in its surrounding, it is very difficult to obtain the best geometrical system for photographs position and orientation. For this reason, both methods of terrestrial and aerial are necessary so that geometrical system will be appropriate for the computation and modeling...
process. In this documentation process, the object has been photographed convergently where the house was put as the central object.

![The camera position for overlapping terrestrial and aerial photographs. Source: Suwardhi, 2013.](image)

Image matching becomes the critical step to automatic data surveying and recognition. Image matching is required for surface generation and tie and control point measurement in the orientation and triangulation process. In this case, feature-based matching is extracting the basic image features of the house, such as patches, corners, junctions and edges. The following process is to determine coordinates of reference points by mathematical equation. At the same time, the process defines the position and orientation of taken photographs.

![Manual digitization for defining coordinates of points. Source: Nurhasanah, 2014.](image)

After the position and orientation of photographs are computed, screen digitization on photographs is undertaken to precede the reconstruction process of 3D modeling. The digitization process differentiated component of the house based on basic geometrical forms, such as lines, surfaces, planes and cylinders. This process of object’s segmentation is done manually in order to meet the required grouping of architectural expression. The photogrammetric software extracts 3D geometrical data and reconstitutes a 3D model from 2D images.

The 3D model of the house is created from the surface and texture information taken from photographs. For the purpose of visualization, texture information from photographs is transformed into the surfaces of 3D object. Based on the character of its architecture, the house is differentiated into three major building’s component: the substructure, the façade, and the roof. Each component is further divided so that more specified features of the house may be expressed. The roof is distinguished as the roof cover and the gable. The façade of the house is differentiated as ornamented and plain surfaces. The substructure is divided into vertical and horizontal structural elements.
Meaningful entities are generated from the house so as clearly to distinguish the building components and the architectural expression. A photorealistic 3D model of the house is created by adjoining surfaces and transforming photo textures to the surfaces. Through texture or specified surface, the architectural detail of the house can be exposed and well-articulated.

Fig. 4. Segmentation of the object. Source: Nurhasanah, 2014.

Fig. 5. (a) Gable component; (b) Roof cover. Source: Nurhasanah, 2014.

Fig. 6. (a) Substructure vertical elements; (b) Substructure horizontal elements. Source: Nurhasanah, 2014.
The most meaningful result of the documentation process is the visualization and representation of the unique forms of a Batak Toba house. The obtained 3D solid and textured images help people to understand the sophisticated and complex house form more easily. Two-dimensional drawings may be inadequate to understand the building, but visual presentations that are created by digital close-range photogrammetry make the architecture of the house more explanatory. The digital 3D model of the house makes easier for anyone to understand the complex spatial structure, even though, the house itself is not physically accessible. Close-range photogrammetry has enabled the exhibition of an architectural design to become more efficient and economical.

This research has been a great support for the preservation and promotion of Batak Toba house as a cultural heritage. One of the most important advantages of using digital close-range photogrammetry is in that measuring of high building despite its inaccessible environment becomes achievable. Correct documentation is necessary not only for the future but also for the contemporary usage and evaluation of traditional building’s performance. Regarding the documentation processes, the collected data from the measurements can also be used for other purposes in the future, can be shared with other users, and are easy to store on computers.
5. Conclusion

Digital technologies nowadays play a significant role in the documentation of cultural heritage. Digital technologies become the foundation and motivation for the long-term development of cultural conservation program. Its immediate and foremost contribution is the systematic method of documentation for the benefit of heritage protection endeavors. After that, a new approach to traditional houses documentation in practical application must be established to support and guide the advancement of cultural heritage conservation programs. An application for environmental controls and day-to-day maintenance needs to be exercised so as to provide safer and more stable environments for cultural heritage.

The increasing interest in cultural heritage protection requires improvement of traditional methods in the documentation and wider participation of more academic disciplines. Comprehensive research programs must be developed to break down barriers between disciplines so as to establish an open and coordinative mechanism for long-range development. Strategic arrangements should be made in cultural heritage conservation in which present concerns and future perspectives are taken into account. In transmitting the cultural heritage to the next generations, the preparation of measured drawing, reconstruction model, and the accuracy of documentation are considerably important.

Close-range photogrammetry techniques have enabled people to record the overall building that is not reachable by traditional methods of documentation. They provide flexibility in data acquisition as the non-metric camera can be operated by almost anyone and more affordable. Compared to other 3D modeling techniques, close-range photogrammetry delivers a variety of data, from 2D images of photographs, dense point clouds, geometry of the object and solid 3D model.

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