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Paper:

Three-Dimensional Measurement for Revitalization of Intangible Cultural Properties After Disasters

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Various traditional festivals have taken place in most of the community in the coastal areas of the Tohoku region before the 2011 Great East Japan earthquake. Recent studies have revealed that reviving these festivals plays a crucial role for people to reconstruct a community life in the tsunami-affected area. Despite the importance of the intangible cultural properties, not only outfits used but also crafts to make those kits were swept away by the 2011 tsunami. Under this background, this research attempts to record the three-dimensional data of those materials used in festivals and folk performing arts. This project aims to construct the database of those props used for the intangible cultural properties and offer three-dimensional data to the disaster-affected area to rebuild their community life. Another goal of this explorative project is to create a methodology of three-dimensional measurement in the field of the disaster humanity science. By scanning cultural properties in disaster-prone areas not only in Japan but also in other countries, the project attempts to connect international networks to discuss the applicability of this method.

Keywords: disaster humanities, Core Research Cluster of Disaster Science, intangible cultural properties, SfM/MVS, 3D measurement

1. Introduction

The coastal area of Northeast Japan (Tohoku region) is known for a wide variety of folk performing arts. There are more than 1,400 unique intangible cultural properties, such as Kagura, Shishimai (the lion dance), and the Shishi-Odori (the deer dance). The earthquake and tsunami that struck the coastal area in 2011 swept away a great number of people and houses, as well as intangible cultural properties that were embedded in their daily lives.

The prompt reaction of researchers and devotees of the folk performing arts in the wake of the disaster was precise.[1] They collected and accumulated information to understand the situation and effects after the tsunami, making full use of various networks, the mediating relief supply, and the backup funds to restore goods used in folk performing arts [1–3]. Like other supporters and volunteers, researchers considered the reconstruction of the livelihood to be the top priority. Certain communities attempted to revive the folk performing arts and festivals within a few months after the tsunami, notwithstanding that they were in the midst of confusion. Surprised by the "unusual speed" [4] of the people to recover intangible cultural properties, researchers helped them to apply for grants and offered support to secure locations for practice, as well as for the storage of the surviving props. These actions enabled the restoration of certain intangible cultural properties in local communities within three years after the earthquake.

As of May, 2014, the Intangible Cultural Heritage Information Network website [5], created by The Tokyo National Research Institute for Cultural Properties, reported the condition of the folk performing arts and festivals in three prefectures (Iwate, Miyagi, and Fukushima) three years after the tsunami (**Table 1**). To date, the revival of folk performing arts and festivals has remained a common topic in the news coverage (**Fig. 1**), showing the importance of the intangible cultural properties to the tsunami-devastated communities after eight years already passed. Local residents frequently overlap the revival of the folk performing arts or local festivals with the revival of their communities.

Why did the local communities that suffered from the disaster organize folk performing arts and festivals in the midst of the disorder, although they did not know how their life would be after a year or several months? Cultural anthropologist Florence Lahournat described the imme-

1. It is worth noting the difference between the concepts of tangible and intangible cultural properties. On the one hand, the value of tangible cultural properties consists in maintain the original condition as long as possible. On the other hand, intangible cultural properties inherent the change whose state go with the context of the local community. The difference between the concepts of tangible and intangible cultural properties have impacts on the assessment of the "damage," the idea of the "preservation," and the content of the "support" after disasters. Therefore, although the rescue program for the tangible cultural properties seems faster than those for intangible cultural properties, one cannot simply compare the speed of the recovery. It is one of the backgrounds here to describe the work of researchers and devotees of the folk performing arts after the tsunami. The national or prefectural governments, which quickly developed the rescue program for tangible cultural heritages, later conducted research programs to investigate how the intangible cultural properties had been affected by the tsunami.

Table 1. Number of Intangible Cultural Properties in the tsunami-devastated area from the Report on Intangible Cultural Heritage Information Network website.

	Iwate	Miyagi	Fukushima	Total
Folk performing arts	183	216	487	886
Festivals	136	124	279	539

本吉神楽面 再生の舞

石巻・釣石神社で7演目披露

27枚復元「復興の励み」

石巻市北上町の釣石神社で28日、東日本大震災の津波で流失し、8年ぶりに復元された神楽面による本吉法印神楽が奉納された。装束や舞台も新調され、地域住民は「復興の励みになる」と歓迎した。

春祭りの前日祭として執り行われ、神楽面全27枚の復活を本殿に報告後、神楽を奉納。「古事記」を題材にした「磐戸開」「魔王退治」など7演目が披露された。地元の女川法印神楽の神楽師11人が参加し、約4時間をかけて舞った。

同神社宮司で本吉法印神楽会会長の岸浪均さん(64)は「神楽面が戻ってきて感無量だ。衣装や道具も新しくなった。今後は後継者の育成に一層力を入れたい」と意欲を見せた。

神楽面は東北古典彫刻修復研究所（上山市）が制作した。奉納を見守った渡辺真吾副所長(43)は「ゼロからの作業で、神楽会とは10回ほど打ち合わせを重ねた。平成が終わるタイミングで完成させられて良かった」と話した。

地元のにっこり自治会の千葉宏一会長(72)は「震災後は借り物の道具だった。本物は違う。被災した地域にとって復興の励みになる」と喜んだ。

復元された面と新しい衣装で舞が披露された本吉法印神楽

Source: Kahoku Shinpou, April 29, 2019

Fig. 1. News coverage of Kagura in Ishinomaki, Miyagi, reporting the restoration of the masks eight years after the tsunami.

diate reaction of the people of Ogatsu, Ishinomaki, after the tsunami. They started to search for masks, costumes, flutes, and props in the debris a few days after the tsunami to restart the Kagura, a Shinto theatrical dance. According to Lahournat, their attitude can be understood as the "search for a new normal," which was previously associated with the life in Ogatsu as "something natural," like "the air" [6]. Sociologist Kyoko Ueda, who has been carrying out fieldwork in disaster-affected areas, conducted research on two festivals that have been officially designated as intangible cultural properties by the Japanese Government: the Soma Nomaoi (horse-race festival) in Fukushima after the Great East Japan earthquake (2011) and the Tsuno-tsuki (bullfighting festival) in the Niigata prefecture after the 2004 earthquake. She reported that the communities in both Fukushima and Niigata sought to resume the festivals immediately after the disasters occurred, often prioritizing them over the need to address the uncertainties and hardships in practical and vital aspects of their lives. This revealed the crucial role of intangible cultural properties as inextricable elements of community life, as well as their importance in the efforts of the communities to restore order [7]. Moreover, folklorist Shuichi Kawashima suggested that folk performing arts and festivals create the sense of returning to the familiar daily life [8].[2] Thus, preserving intangible cultural properties can be perceived as one of the vital aspects of community life after disasters have occurred [11].

2. Problem: Necessity of a Database for the Recovery of Intangible Cultural Properties

The recovery of community life after disasters is important; however, reviving intangible cultural properties is not an easy task. Difficulties include the shortage of young generations to be passed down traditional knowledge and the loss of costumes and props that are essential in festival performances. Given that intangible cultural properties play a significant part in the revitalization of community life,[3] the delay in resuming daily life becomes a hurdle for the recovery of local communities.

In the context of community recovery after disasters, how can disaster humanities contribute to solving this problem? This research attempts to supplement the previous approach of supporting the recovery of intangible cultural properties by applying digital technology. One of the research projects employing digital technology in the field of intangible cultural properties is led by the specialist of education. Shinichi Watabe employed motion capture to record the three-dimensional data of the body movements of the performers [13], which helped to pass on knowledge of dancing to younger generations. Research projects in which the technology of three-dimensional measurements has been employed have contributed remarkably in various research fields concerning disasters [14]. Based on the approaches that were followed in the aforementioned projects, this research attempts to use three-dimensional measurements to help post-disaster recovery within the field of disaster humanities.

As previously stated, one of the critical obstacles for

2. An illustration of them is the Shishi-Odori (the deer dance), observable in the Sanriku coastline in Miyagi and Iwate. One of the main occasions in which the deer dance is performed is the *hakaodori*, namely, the grave dance. It is the dance often performed during the *bon* season to appease the spirit of family members who passed away. What is interesting about the deer dance after 2011 is that they repeatedly played within the event to commemorate the victims of the Great East Japan earthquake [9]. Appropriating the familiar practices (Shishi-Odori was strongly connected with the context of daily lives) for the unusual occasions can be interpreted as one of a way to cope with disaster, making the catastrophic event into "more familiar 'unusual event,' and what we might even say was 'usual'" [10]. In addition to the communal aspect of the intangible cultural properties, this feature to confront the crisis and reconstruct the context of daily life should not be underrated.
3. Kawazoe et al. pointed out that even festivals that are not traditional help to build networks among the community and contribute to disaster prevention [12].

the recovery of intangible cultural properties is the loss of costumes, props, and other instruments, such as the lion head used in the lion dance. Notwithstanding the change in generations and the gradual transformation of the performance, props for intangible cultural properties can serve as a reference point that can guarantee the continuity within local communities and preservation of their identities.

Cultural properties, such as the lion head used in the lion dance or the masks for Kagura, are of great importance. However, after the tsunami, their reconstruction presented certain difficulties. According to Tatsuya Okamoto, an artisan who worked in Miyamoto Unosuke Shouten – a renowned workshop that restored a great number of lion heads used in the lion dance in the coastal areas of the Tohoku region – reported that the reconstruction of cultural properties required a considerable amount of time and effort. Some of the local communities have limited records of cultural properties, such as photos or documents. Okamoto travelled numerous times between Tokyo and Tohoku to confirm the details that were required to create a trial product [15]. To reconstruct the lion head, Okamoto collected basic data, such as the size, shape, materials, weight, and colors of the original one. Certain communities owned photographs of the original lion head. However, in most cases, it was difficult for him to recreate important elements, including the size, thickness, and internal dimensions of the original. *Agosun*, the measurement of the jaw, was the most basic element for the restoration of the lion head. Nevertheless, it is rarely recorded because typically, photographers capture the face and not the lower portion of the lion head, which can only be seen from the backside. In certain cases, he relied entirely on the memory of the people to restore the lion head because there were either no records or the records had all been lost [16]. Based on the prototype of the lion head, he had to adjust the size, colors, etc., repeatedly for several months. The more time it takes for the reconstruction, the later the community is recovered.

3. Aim of the Study: Three-Dimensional Measurements for Intangible Cultural Properties

To solve the problem, this project aims for the three-dimensional measurement of the props such as masks and lion's head used for the post-disaster recovery of intangible cultural properties. The database for storing three-dimensional records, particularly key data, such as the size, thickness, and internal dimensions,[4] of those props and releasing it as a digital archive can help people to perform festivals and folk performing arts and contribute to the protection of intangible cultural properties and immediate recovery from the disaster.

In certain cultural-properties studies, the technology of three-dimensional measurements has been applied in the field of architecture and archeology with the purpose of preserving valuable structures and cultural properties, such as shrines and statues. Recently, curators have been utilizing this technology to record three-dimensional data of images of Buddha for the creation of replicas [17]. Storing three-dimensional data is very important in reducing the risks that arise from disasters, theft, and destruction. Meanwhile, it also brings opportunities for new experiences in the museum in that visitors can touch and feel the exhibits. Although such research works have been rarely focused on the recovery of community life after disasters, they demonstrate the applicability of this technology in the field of intangible cultural properties. Moreover, the cost of introducing three-dimensional measurements in this research field continuously decreases. Therefore, this is an excellent opportunity to assess how effective this technology is for our study. In the following sections, the possibilities and the limits of this new technique in the field of disaster humanities will be examined.

4. Methods and the Object of the Study

Several methods exist for the three-dimensional measurement of objects. In this project, a non-contact method has been employed; the principles of this method were explored in the early 1990s and have been widely applied to various fields. Moreover, we will employ both a passive and an active method for the acquisition of three-dimensional data [18].

In the former method, the principle of triangulation is used to calculate the distance between the viewpoints and the object. The Metashape software can estimate the point of the cameras that capture images of the same object from different angles (this system is referred to as structure from motion (SfM)) and can build a dense cloud of the object with colors from a relatively sparse point cloud (this system is referred to as multi-view stereo (MVS)).

In the latter method, the structured light is projected on the surface of the object. The shape of the object is calculated by capturing the distorted patterns of light. To create the three-dimensional object, we used Artec Eva, a handheld three-dimensional scanner, and the Artec Studio software to create the three-dimensional model.

In both methods, a great number of digital images are required to create a three-dimensional model, and the object can be measured quickly, compared with the use of laser scanners. Moreover, the instruments used for three-dimensional scanning are portable and are battery-powered, which satisfies the aim of our study. The objects that are studied in this project are mainly the masks and the lion heads, which are the props used in folk performing arts, such as the Kagura or the Shishimai. Considering the approximate length of the object (from 30 cm to 80 cm) and the various photography or scanning conditions, we implemented the aforementioned methods in our study.

Here, the studied object that will be presented is the

4. For key features, such as weight and colors, we need to employ measuring instruments other than three-dimensional scanners. Conducting interviews is also necessary for the identification of the material quality.

prototype of Shishigashira (lion head), which was used during the restoration process of the lion head after the 2011 tsunami. Miyamoto Unosuke Shouten, the aforementioned workshop specialized in traditional craftwork, restored 50 lion heads using this type of prototype. One of the prototypes is now stored at the Tohoku History Museum. Tohoku University made an agreement with the Tohoku History Museum for joint research on this project, which allowed the development of a three-dimensional model of this object as a feasibility study. By comparing the processes and the results of the methods for obtaining three-dimensional measurements, in this study, we will attempt to improve the methodology and identify the possibilities and the limits of our project.

5. Three-Dimensional Measurement of the Lion Head

In this section, we will describe the process of obtaining three-dimensional measurements for each method.

5.1. Metashape with a Digital Camera

The process of the three-dimensional measurement using the SfM/MVS technique through Metashape is as follows. The following instruments were used.

- Digital camera and lens: DC-GF9 and LUMIX G VARIO 12–32 mm (Panasonic), respectively.
- Software: Metashape Professional for Windows 64-bit 1.5.2 (Agisoft)

The photography session took place in the Tohoku History Museum. First, we printed the markers from Metashape and attached them to the box on which the lion head was placed (**Fig. 2**). The box functioned as a ground control point (GCP). The digital camera was fixed to the tripod during the photography session. The lion head was placed on a turntable with the GCP. Three different positions of the lion head were captured (normal, reverse, and reverse with its mouth opened). Approximately 90 min were required to capture 356 images. The F-number was fixed on 9, and the shutter speed was set to "Auto."

The images were processes with Metashape as follows. We first converted the RAW files to TIFF files, and we imported them to Metashape. We divided the photos into three groups (referred to as "chunks" in Metashape) according to the three different positions of the lion head, and we separately processed them as follows. After the process of Align Photos, Build Dense Cloud, and Build Mesh, we removed any unwanted noise and background. Then, we aligned and merged three chunks into one and repeated the same procedure (Align Photo, Build Dense Cloud, and Build Mesh) for the merged chunk. The workflow parameter was set to the highest precision, except for the final process of the Build Dense Cloud command. **Fig. 3** illustrates the results of the three-dimensional measurement.

Fig. 2. Capturing images for Metashape processing using a tripod, a digital camera, and an iPad.

Fig. 3. Three-dimensional model of the lion head using Metashape.

5.2. Artec Studio with Artec Eva

The process of three-dimensional modeling using the Artec Scanner (**Fig. 4**) and the corresponding software was as follows.

- Scanner: Artec Eva (Artec)
- Software: Artec Studio 12, version 12.1.1.12 (Artec)

We scanned the object in the same photography studio in the museum; however, in this case, without the use of GCPs, a tripod, or a setpaper. We switched off certain fluorescent lights in the studio, which was eventually proven to minimize scanning errors. As in the case of Metashape, we scanned the object in all three different positions. Less than 1 h was required to capture 12 cuts of scans (3 for the entire image of the object, 3 for the upper jaw, 3 for the lower jaw, 2 for the ears that are separable from the main body, and 1 for the entire image, when the object was up-

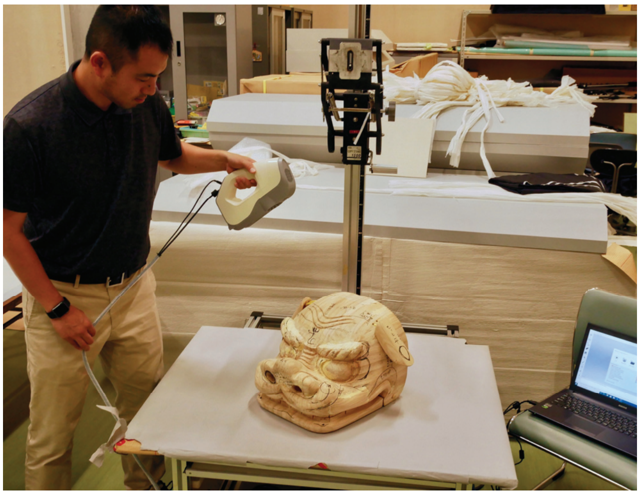

Fig. 4. Scanning a mask with Artec Eva.

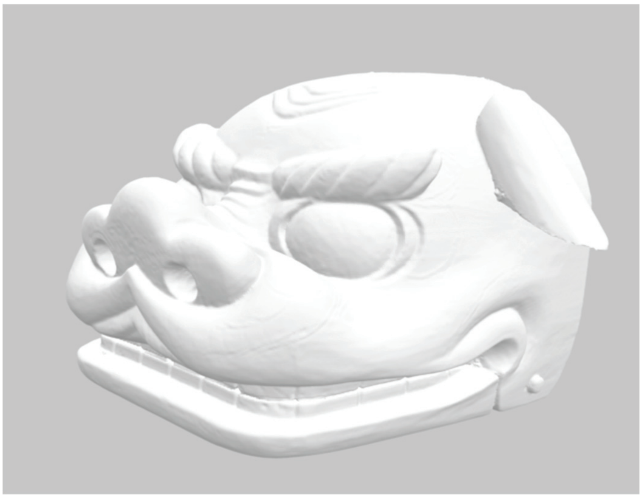

Fig. 5. Three-dimensional model of the lion head using Artec Studio.

side down). After the scanning using Eva, we copied the scanned file and shared it with a collaborating researcher. Next, the same data were processed with Artec Studio independently; each research party used its own PCs.

The image processing with Artec Studio was as follows. We first removed frames that contained errors from each of the scanned data, as well as unwanted noise and elements from the scans. Then, we aligned the selected scans (4 scans), and proceeded to the global registration to simultaneously optimize the frame position among the scans. After removing the outlier, a three-dimensional textured model was created (fast fusion) (**Fig. 5**). Approximately 2 h were required to complete the process with Artec Studio.

We used the same Windows PC (Core i7, RAM 32.0 GB) both for Metashape and Artec Studio. The PC used by the collaborating researcher for the Artec Studio processing had almost the same specifications.

6. Results: The Characteristics of the Methods

Three findings were identified from the results of the three-dimensional measurement of the lion head.

First, the results obtained from the aforementioned methods had very small difference. Some differences in details may be identified if the models or the dense cloud would be compared using certain software, e.g., the Cloud Compare software. In certain other research fields, such as archeology, these details are important because marks or traces of curving indicate how objects were manufactured thousands of years ago. However, we aimed to obtain relatively rough design data for the restoration; therefore, there was no significant distinction between the models.

At present, it is too early to conclude this topic because it was our first attempt to construct a three-dimensional model using each method. However, if we cannot identify significant differences between the two methods after becoming proficient in three-dimensional measurement, we could focus on differences in terms of other elements. In terms of the price to purchase, the SfM/MVS method using Metashape has an advantage. The educational license of the standard edition of Metashape cost only $59; moreover, a full-specked single-lens reflex digital camera is not required. However, in terms of the processing time, the Artec Studio is incomparably fast in creating three-dimensional models, even though one acquires proficiency in Metashape. It should be noted that the higher the price of the PC is, particularly the price of the GPU, which accelerates the speed of three-dimensional imaging, the faster the processing will be.

Second, the level of proficiency or experience might cause differences in the results of the three-dimensional measurement. In the process of three-dimensional modeling with Artec Studio, two researchers used the same scanned data in different PCs using the same software; however, the results varied significantly. **Fig. 6** presents the three-dimensional model created by a collaborating researcher using smooth fusion. When compared with **Fig. 5**, more coarseness appears to be present. **Fig. 7** is the surface–distance map created with Artec Studio; it shows the distances between the surfaces of models. The green area, which covers most of the surface in the map, indicates the area that the surfaces of the two models coincide. The red color corresponds to a positive distance between the model surfaces (+1.00 mm), and the blue indicates a negative distance (−1.00 mm). The root mean square of the distance between the models was 0.779629, which reveals the coarseness in the model created by the collaborating researcher. The red areas, cracks between teeth or hollows under the nose of the lion head, should have been dented. However, these dents were not present in the three-dimensional model processed by the collaborating researcher. This result implies that not only the recording with the scanner but also conducting the three-dimensional measurement process using the PC and software can be considered expert skills or "crafts."

Third, the data size produced by the two methods dif-

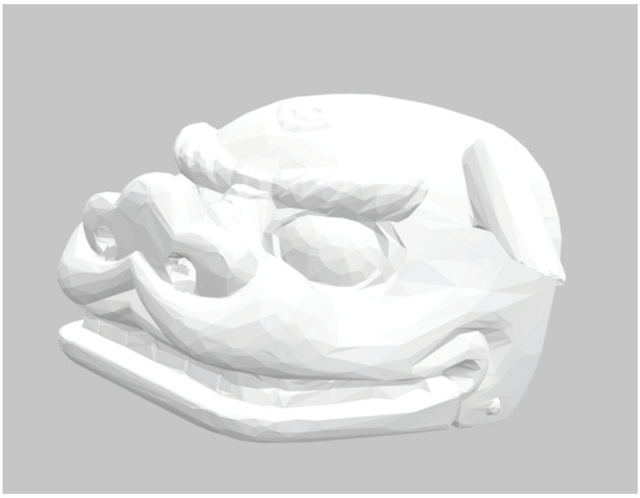

Fig. 6. Three-dimensional model of lion's head with Artec Studio processed by a joint researcher.

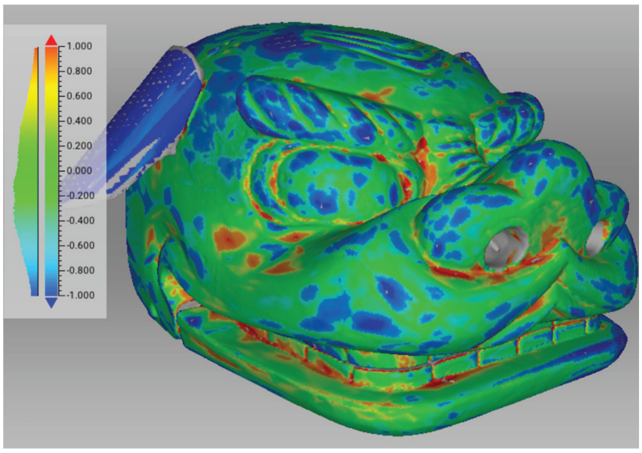

Fig. 7. The surface–distance map made by Artec Studio which shows the deviation of the forms of the models.

fered. The size of the Metashape file and that of the corresponding files, including original photograph, occasionally exceeded 10.0 GB. In contrast, the file size of the scanned file of Artec Studio was approximately 5.0 GB. As is known, the total data size can affect the hardware performance.

7. Prospects for Further Research

We have identified several characteristics of the three-dimensional measurement technique by examining and comparing two methods. Although certain findings were not novel to the experts, it should be considered that knowledge on three-dimensional scanning of props concerning intangible cultural properties are limited at present. Therefore, it is important to describe the trials and errors of our experiments.

Several remarks can be made regarding the future prospects of this study.

First, one of the reasons why the lion head was selected as a research object was the possibility of conducting comparative studies within local communities in Japan, as well as internationally in the future. The lion dance is one of the intangible cultural properties observable in other disaster-prone Asian countries, such as Taiwan and Indonesia. By recording three-dimensional data and comparing the sentiments that people foster toward festivals can create opportunities for comparative cultural studies on intangible cultural properties.

The second point refers to the remaking of the props. When cultural property is lost or severely damaged by a disaster, its restoration or repair is based on the existing records, such as photos or documents, if any exist. However, the color information provided in these records conversely obscures evenness, and causes optical illusions to misrepresent the real shape of the lost properties. Considering this, three-dimensional data provides the record of the pure form of the lost properties and enables a near-identical reconstruction. Therefore, the project could benefit from drawing knowledge from other research fields, such as archeology, museology, and conservation science, which are more advanced in this subject.

Finally, existing research works on digital archives from other fields, such as informatics and archive studies, should be considered in the project for constructing a three-dimensional database. Overlapping three-dimensional data of the lion head can provide insights on diachronic change or form differences between two objects that can aid comparative studies as well. By including knowledge from the aforementioned research fields to the project, methodological and theoretical innovations could be derived in the field of disaster humanities.

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Selected Publications:
• Y. Fukuda and S. P. Boret, "Theodicy of Tsunami: A Study of Commemoration in Aceh, Indonesia," N. C.-K. Lin (Ed.), "Religio-cultural Pluralism in Southeast Asia: Inter-communion, Localization, Syncretisation and Conflict," pp. 227-242, Center for Multi-Cultural Studies, National Cheng Kung University, 2019.
• "Transition of Rituals in the Nagasaki City Atomic Bomb Memorial Ceremony," Int. J. of Japanese Sociology, Vol.24, Issue 1, pp. 78-91, 2015.

Academic Societies & Scientific Organizations:
• Japan Sociological Society (JSS)
• International Sociological Association (ISA)
• International Society for the Sociology of Religion (ISSR)