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Implementing the "ARC Model" in the U.K.
——Digitising Sword Ornaments at the British Museum

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1. Introduction

The British Museum holds a vast collection of sword ornaments from throughout Japanese history, including over 1,000 *tsuba* 鐔/鍔. These were handguards that sat between the handle and the blade of an *uchigatana* 打刀 or *tachi* 太刀, designed to prevent the wielder's hand from accidentally slipping.[1] They varied in thickness, size and material while also displaying advanced craftsmanship in the field of metalwork.[2] Yet over time they grew to be more decorative than practical, with samurai commissioning ever more elaborate and luxurious swords to display their status. This means that these items can be difficult to catalogue effectively in a text-based medium. There are the standard challenges of identifying production details and provenance but there is also the additional issue of accurately describing the objects. Many *tsuba* are intricate and ornate, they lack unified titles, and they are often one-of-a-kind. How do you represent items like these in any detail using words alone? Writing the descriptions falls to experts, and even with their careful examination, it is still challenging to fully express the true nature of a highly-decorated physical item with just text. Multiply this out for a whole collection and it can be difficult for a researcher of *tsuba* to even grasp what is available to see, never mind what is worth their time.

One solution to this problem is digital photography, using images as well as words. At the beginning of 2023, the British Museum had yet to digitise their *tsuba* collection. Therefore from 16–27 January, Matsuba Ryōko, Lecturer in Japanese Digital Arts and Humanities at the Sainsbury Institute for the Study of Japanese Arts and Cultures (SISJAC), ran a project with four research assistants to address this deficiency.[3] In this report we will summarise and discuss the results of the project, which we first presented as part of the 116th ARC International Seminar held on 26 April 2023. It will start with our methodological and philosophical groundwork, continue with the process and challenges of digitising in two and three dimensions, before concluding by reflecting on the importance of these initiatives in the digital age.

2. Audience, Realism, and the "ARC Model"

Any photography project has to answer two fundamental questions: Who is the audience of these photographs and therefore what should we focus on? In other words, what makes a good photograph? Before commencing digitisation, we needed to grapple with these questions to inform our methodology. We decided to aim towards researchers, as they are likely to be the most interested in the details of *tsuba* and their design. Therefore, our task became capturing the visual and technical features of *tsuba* at a quality high enough to enable analysis for research purposes. With that established we adopted a framework that would allow this to happen: the "ARC Model".

The "ARC Model" was developed by Professor Akama Ryō at the Art Research Center (ARC), Ritsumeikan University, to combine the roles of archivist and researcher when creating master data for image databases.[4] Dr Matsuba has implemented this in the U.K. since 2013, with the British Museum *tsuba* project being her sixth.[5] Those adopting the process are able to not just take photographs, but have the specialist knowledge required to identify and record all the important aspects of their subjects. It also provides a chance for young scholars to gain skills in digital humanities and research by handling historical objects themselves. Essentially, researchers create digital products for use by other researchers. Akama defines the "ARC Model" in a 2010 essay, and we focused on a number of specific points in our work.[6] Those were completeness, efficiency, high-quality, use of

specialist knowledge, collation on the job, and the relinquishment of copyright claims on the understanding that the digital products will be made public. Our schedule was therefore designed to incorporate the above. We spent the first two days testing light and camera settings and developing a methodology. Then we conducted a workshop with digitisation specialists and museum curators, who provided feedback and suggested improvements to help us better understand our methodology. This meant we could achieve a high quality of the product. As we went, we not only photographed each item but also collated and labelled the image files in accordance with the British Museum's accession numbers, creating the metadata in real time. Once we were done and the images had been processed, they could then be uploaded to the British Museum's public online catalogue.[7)]

This allowed us to photograph all 1,013 *tsuba* that were not on active display at a rate of approximately 200 *tsuba* a day, achieving our goals of completeness and efficiency.[8)] However, to achieve this efficiency we had to limit ourselves to top-down photographs of only the obverse and reverse of each item. Yet *tsuba* are highly decorated three-dimensional objects that benefit from being rotated and viewed from all angles. Our digitisation could not replicate that. This is where we had to be creative with our method. We decided to experiment with both 2D and 3D image capture, using each method's strengths to complement the other. 2D photography is fast at scale but has a limited perspective, while 3D models are more realistic and can be manipulated by users but are prohibitively slow to produce. So we settled on a system where we would digitise the top and bottom aspects of every *tsuba* in 2D while also creating fully-rotatable 3D models of the most ornate artefacts. This meant that we could simultaneously digitise every object in the collection in a small timeframe and properly represent those with more complex, wrap-around designs. It is through this multifarious approach and our use of the "ARC Model" that we hoped to create the highest quality database possible.

3. 2D Photography and Specialist Digitisation

So how did this play out in the 2D space? As noted above, the British Museum had not methodically digitised its *tsuba* collection. The reference database was available to view online but few items had photographs.[9)] Our project aimed to fill this gap. The only efficient way to do this in two working weeks was to use basic 2D photography, which our team had experience with. Nevertheless, this was a new challenge for us and the Japan section at the British Museum. Unlike books or paintings or scrolls, *tsuba* are inherently three-dimensional and present a variety of hurdles that need to be overcome. This required that we perform rigorous testing and create a new methodology for digitising the objects, an inherent part of the "ARC Model".

Attaining high quality was the most important factor for our work, to which our main hurdle was finding appropriate lighting. We started by positioning the artefacts in a reflective box with LED light bars to provide even exposure, but this is where the nature of *tsuba* first became an issue. They are metallic and shiny, heavily textured, often inscribed with signatures, and contain multiple holes. This meant that direct, even light was ineffective. Direct light flattened their texture, made the inscriptions difficult to read, and sometimes resulted in reflective glare. Meanwhile, the holes cast internal shadows onto the paper, lowering the visual quality of the photographs. Our solution to this was three-fold. First, we placed the *tsuba* onto a lightbox that shone up from underneath and eliminated most of the internal shadows. Second, we adopted continuous raking, angling the light bars diagonally to boost the 3D texture of the designs. Third, we adjusted the shutter speed to 1/8s and the aperture to f/14. We carefully monitored our camera settings to attain the best results: we reduced the aperture to its smallest possible size, accelerated the shutter speed, and fine-tuned the settings to emphasise the patterns on the *tsuba*. This approach resulted in digital images like those seen in Fig. 1, which effectively depict the colour, depth, and intricacy of the *tsuba*.[10)] However, one problem remained – the inscriptions continued to be difficult to decipher. The only way we could rectify this was to use flash such as in Fig. 2. Unfortunately, this ruined the colour contrast of the image, so we decided to capture both normal and flash photographs of each object. This took extra time but was to the collection's benefit as it allows the user to choose which type of photograph they would prefer to consult depending on their interest. In fact, it sometimes even made the inscriptions easier to read than if one were viewing them in real life.

Fig. 1. Shōjō Tenmin 猩々天民 [unnamed *tsuba*]. Obverse, 1952,0211.17.
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Fig. 2. Shōjō Tenmin 猩々天民 [unnamed *tsuba*]. Obverse with flash, 1952,0211.17.
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Yet this was not the only issue. *Tsuba* provide another unexpected challenge in terms of their orientation. We had to capture the designs on both sides of each object, but this meant that for file storage and cataloguing purposes, we had to identify the top side (obverse) and the bottom side (reverse) of each *tsuba*. The "ARC Model" accounts for this through its focus on specialist knowledge in digitisation, so this should have been a simple case of following precedent.[11] As shown in Fig. 3 the central blade hole (*nakago hitsu* 茎櫃) should point upwards, and for the obverse, the crescent-moon-shaped knife hole (*kozuka hitsu* 小柄櫃) should be to the left and the cloud-shaped sword-needle hole (*kōgai hitsu* 笄櫃) should be to the right.[12] This worked for the majority of *tsuba* but there were exceptions. There were examples where both sides were identical, examples where both holes were crescent-moon shaped, and examples where there were no holes at all. So, what were we to do when faced with something like Fig. 4? Consequently, our primary objective was to define a set of shared standards within our team to enhance our comprehension of the task at hand.

Fig. 3. [unnamed *tsuba*]. Obverse with annotations by the authors, OA+.3331.
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Fig. 4. [unnamed *tsuba*]. Obverse, 1981,0128.16.
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The 2D photographing process was therefore defined by the tenets of the "ARC Model". By taking both normal and flash photographs of each object and following their orientation standards as closely as practicable, we attempted to create as representative a digital reproduction as we could using our specialist knowledge. This gives the catalogue's users as much information as possible with minimal interference from us. There are doubtless limitations to this process; a flat representation of a textured object will always be inferior to seeing it in real life. But there is no more efficient way to digitise these items en masse.

4. Adventures in the Third Dimension

But what happens when efficiency and scale are not necessarily the desired outputs? *Tsuba* are three-dimensional objects; their patterns often wrap around the edges or show one consistent design flowing from obverse to reverse. Therefore, this project also experimented with 3D modelling. This technology allows the user to view a *tsuba* from all angles, which offers a more realistic representation. While the British Museum has rarely implemented 3D models in their digital space, the nature of *tsuba* provided fantastic grounds to expand upon the work that has already been done.[13)]

Our main tool was the Artec 3D Space Spider industrial scanner, a lightweight hand-held device that boasts an impressive ability to capture colour, texture, and geometry.[14)] It is simple and intuitive; you only have to point it at a rotating item and it captures the item from every angle. Although designed for product engineers it has had some use on the 3D modelling platform Sketchfab, with limited examples of *tsuba* in particular.[15)] Nevertheless it provides some major advantages over traditional photography. For example, there was no need to adjust individual settings such as aperture or shutter speed as the scanner does it automatically. We also had far fewer environmental factors to consider. The machine provides its own lighting with each scan frame so the space overall does not need to be carefully controlled. This makes it easier to transport and set up the equipment. In this project we could work in a compact area without significant preparation, using handcrafted bases to support the *tsuba* as we scanned them. There was no requirement to regulate orientation or zoom, and the process allowed us to achieve models such as Figs. 5 and 6. These were extremely well-captured, showing ridges, engravings, uneven surfaces, damage, and weathering. The models also display a wide array of colours, with even the accession numbers clearly visible. The performance of the scanner was clear, both simpler to set up than 2D photography and giving outputs more faithful to the realities of the *tsuba* themselves.

Fig. 5. [unnamed *tsuba*]. Obverse, 3D model, TS.72.
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Fig. 6. [unnamed *tsuba*]. Reverse, 3D model, TS.72.
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So why did we not just model every *tsuba* in 3D? The main issue revolved around speed. Each *tsuba* took a minimum of 30–40 minutes to digitise, which is not scalable for over 1,000 items. At that rate, the full collection would take a minimum of 500 hours (approximately 12 weeks) to process. Additionally, the reflectivity of the *tsuba* themselves once again posed a challenge. The Artec Scanner produces a real-time preview of one's model so one can understand how much of the item has been captured and what has been missed. Yet for many of the *tsuba* models the reflectivity of the metal caused spiky anomalies to appear and obscure the scan. Our inability to utilise real-time construction meant we were slowed down as we had to rely solely on our technique to ensure we captured all of the object. Another unexpected issue appeared when we were forming the 3D models. For unclear reasons the texturing of the *tsuba* often merged into the base, leaving white shadows on the scans. This problem was fixable using other software but stalled us further and meant we could only move forward thanks to Artec's advice.[16)] These issues come together to mean that while 3D modelling was effective, it could not be applied to every *tsuba* in the collection. We could only select approximately 50 items with the most complex designs for this side of the project, and for the foreseeable future, this is unlikely to change.

This programme was also an opportunity to test how 3D scanning fits within the "ARC Model", and indeed there were some elements that applied well to 3D digitisation. When using the Artec scanner it is up to the user's discretion to judge the readiness of the model. This means that the expertise of the researcher is vital in understanding what a high-quality product is. Furthermore, 3D modelling creates much more realistic representations of the items, allowing the user to overcome the barriers of fixed-perspective photography.[17)] Accession numbers can also still be linked to each artefact, although the software outputs a folder containing various

files rather than one file. With more files to handle, there could be renaming errors but this problem can be circumvented if one names the files as one scans.[18] 3D scanning as a concept, however, does run into issues considering the preference for completeness in the "ARC Model". In an ideal world every *tsuba* would be digitised in this way, and while with practice the speed of capture can be increased it is still not efficient or scalable at present. Therefore, if we were only using Artec's scanner then we would have to sacrifice the completeness of the whole collection in return for more realistic captures. Even so our experiments with 3D modelling were largely successful, and it will be up to the individual institution to decide whether they prioritise the efficiency of 2D or the realism of 3D capture.

5. Conclusion

During the COVID-19 pandemic, the temporary suspension of access to museums led to an increase in the use of online platforms, encouraging these institutions to make digitised records public and accelerate the digitisation of their artefacts. But this is not an isolated occurrence. In the past, museums aimed to preserve artefacts physically and pass them on to future generations. However, in the information age, they are widening their scope to include the digital reproduction of objects and are getting better at presenting these materials to the public. Museums are actively using evolving technology to foster an understanding of cultural heritage through research, collection, preservation, interpretation, and display. As such, digitisation is an important step within this process.[19]

This is not to say that direct interaction with research objects is no longer crucial. We cannot create a perfect reconstruction of a real item in a digital space no matter how hard we try. Even so, producing and distributing high-quality photos offers several advantages. They allow researchers to see intricate details that are difficult to observe with the naked eye; they eliminate spatial and temporal limitations; and they prevent information from being centralised in one place. But most importantly, these images make surrogate viewings possible. Museums have vast collections with only a fraction ever exhibited at one time due to space constraints or the fragility of the items themselves. Digitisation is a key part of overcoming this hurdle. By enabling remote access to objects, we can increase accessibility, avoid exposing them to the dangers of human contact, and additionally reduce the carbon footprint generated by physical visits to holding institutions. This will ultimately empower new and diverse international perspectives, and will only ever improve the quality of studies.

We view our project as a contribution to this ongoing and vital trend. Our output may have been to digitise the British Museum's *tsuba* collection, but the overarching philosophical goal was to increase access for researchers and promote Japanese cultural heritage to the public. Overall, by implementing and expanding upon the tenets of the "ARC Model" and branching out into the world of 3D modelling, our project made use of traditional and cutting-edge technology to capture the museum's collection in as complete and objective manner as we could. There are limitations to both of the digitisation methods that we employed. However, we believe that together they can complement and cover for each other's weaknesses. We hope that the methodology and research process laid out in this report will inform other studies on digitising three-dimensional artefacts, be they of *tsuba* or further afield in ceramics, weaponry or armour. Digitisation gives new life to objects and infinite possibilities to scholars and museums. Through the digitisation of *tsuba*, cultural treasures buried on the shelves of the British Museum are now ready to be revealed and shine.

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[Notes]

1) There are countless books on Japanese swordcraft; for a concise introduction in English see Harris [2004], pp. 8-39; for Japanese see 内藤 [2018].
2) *Tsuba* were made from gold, copper, iron, or *shibuichi* 四分一, a copper alloy. See 加島ほか [2003] for an in-depth overview of *tsuba* in general.
3) These were Joseph Bills (Keio University), Liam Head (UEA), Bori Ko (SOAS), and Yuhan Ji (SISJAC).

4) 赤間 [2010], p. 11; Akama [2010], p. 163.
5) The full list was presented as part of the 116th ARC International Seminar, "Implementing the ARC Model in the UK – Digitising Sword Ornaments at the British Museum." https://www.youtube.com/watch?v=PXEyI76bK90 (48:23, accessed 21 May 2023).
6) 赤間 [2010], pp. 11-16; Akama [2010], pp. 163-169.
7) At time of writing the British Museum allows users to license their images for commercial use or shares them under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) license for non-commercial uses.
8) We were unable to photograph any items that were on active display as this would have required removing them from the public gallery, but those items were already separately digitised by the British Museum.
9) As of 20 June 2023, of the over 1,000 *tsuba* in the collection only about 150 were digitised by our count.
10) These figures have been cropped for better comparison but the full images also include a colour chart to the left.
11) This precedent can be seen in catalogues such as 根津美術館学芸部 [2017]; 東京国立博物館 [1997]; and 岩切ほか [2022].
12) 中村 [1963], p. 8; 土子 [2022], p. 66. This orientation is based on how the *uchigatana* blade was held facing upwards. This means that technically *tsuba* from *tachi* blades, which were held facing downwards, should be photographed with the *nakago hitsu* facing down. However, it was often unclear which *tsuba* came from which type of blade so we photographed them all facing upwards.
13) The British Museum has uploaded some 3D models of various historic figures on their SketchFab page: https://sketchfab.com/britishmuseum.
14) This equipment was graciously supplied by the Digital Humanities department at the University of East Anglia. See https://www.artec3d.com/portable-3d-scanners/artec-spider for further details.
15) The Bowdoin College Museum of Art has a small number of *tsuba* scanned using the Artec 3D Space Spider scanner: https://sketchfab.com/3d-models/sword-guard-tsuba-birds-with-waves-a95a6c87a3db493fb2b6b0a076c0cfd2
16) Artec suggest that this issue can be resolved post-scanning by accessing the texture atlas, a flat version of the item's texture that has not yet been wrapped around the 3D mesh. From here one can erase the unwanted texture, although this requires time and familiarity with image editing and we were unable to test it during the project.
17) 赤間 [2010], p. 14; Akama [2010], p. 166.
18) 赤間 [2010], p. 15; Akama [2010], p. 167.
19) The relationship between using data for preservation, archiving, and curation is discussed further with the example of the National Museum of Korea in Kim, Boram and Lee, Jongwook 김보람, 이종욱 [2022], p. 124.

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