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3D Digitalization of selected specimens of the Anthropology and Ethnology Museum of Florence with Artec Spider

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ABSTRACT

Tridimensional imaging methodologies are becoming more widely used in museums and cultural heritage studies. They are often used in association with graphic counterparts such as virtual or augmented reality and 3D prints. 3D data obtained with these techniques are acquiring increasing utility in various museums, from conservation to public dissemination. Here we test the efficiency of 3D scanning using Artec Spider on various types of museum specimens in. Here we report the results of exploratory tests of 3D scanning on different artifacts belonging to the collection of the Anthropology and Ethnology Museum of Florence using Artec Spider devices. The specimens differed not only for their provenance and culture of origin, but more importantly, for the materials they are made of. Results are in general more than satisfactory, with both geometry and texture acquired correctly and with great visual impact. Some materials (e.g., thin, or made of tiny separated components were somewhat problematic. Nevertheless, Artec Spider appears to be better than many other 3D scanners (e.g., Next Engine) in terms of time and quality of the acquisitions. Further tests on other materials, or with other scanning techniques, would add to current knowledge on the increasingly important application of digitals tools and methodologies in museum settings.

Key words:
museology, conservation, dissemination, digital methodology, 3D surface scans.

RIASSUNTO

Digitalizzazione di alcuni reperti del Museo di Antropologia e Etnografia di Firenze con scanner 3D Artec Spider

Le metodologie di 3D imaging sono diventate sempre più di uso comune in contesti museali e dei beni culturali, spesso in associazione con altre tecnologie (quali stampa 3D, esperienze di realtà virtuale o aumentata). Oggetti digitali e tridimensionali ottenuti dall'applicazione di queste tecniche stanno diventando sempre più utili nel rispondere alle esigenze proprie dei musei (dalla conservazione, alla divulgazione, alla educazione museale). A questo scopo, risulta importante testare l'efficacia di diversi strumenti digitali su campioni museali diversi. In questo lavoro riportiamo i risultati dei primi test di scansione 3D su vari artefatti appartenenti alle collezioni del Museo di Antropologia e Etnologia di Firenze usando lo scanner Artec Spider. I campioni selezionati differiscono non solo per la provenienza e la cultura di origine, ma anche per il tipo di materiale che li compone, un fattore importante nella nostra ricerca. I risultati sono eccellenti, poiché si è raggiunta la corretta acquisizione sia delle geometrie che della texture, con in aggiunta un ottimo e accattivate effetto visivo dell'oggetto 3D creato, in gran parte degli artefatti. Alcuni materiali (come ad esempio quelli molto sottili, oppure costituiti dall'assemblaggio di parti molto piccole separate tra loro), tuttavia, si sono rivelati problematici. Ciononostante, Artec Spider offre ottime prestazioni, anche quando confrontato con altri strumenti (Next Engine), in quanto a tempi di acquisizione e qualità delle immagini acquisite, elaborazione e rendering. Ulteriori test su altri materiali, anche sperimentando nuove modalità di scansione, potranno aiutare a raffinare la nostra comprensione dei campi di applicazioni di queste tecniche digitali.

Parole chiave:
museologia, conservazione, divulgazione, metodologie digitali, scansioni 3D di superficie.

INTRODUCTION

Over the last twenty years the application of digital techniques and methodologies in museums and cultural research institutions has become increasing productive. Digital techniques offer numerous advantages (Cunningham et al., 2014) from the purely scientific objectives to providing more engaging educational experiences and expanding classical museum exhibitions, via e.g., virtual reality or other edutainment applications (inter alios Pavlidis et al., 2007; Wachowiak & Karas, 2009; Kęsik et al., 2017; Pollalis et al., 2018; Bastir et al., 2019; Bartolini Lucenti et al., 2020). Digitalization of museum collections also helps promote the best practices of open science and exchange in a range of different contexts including repatriation (inter alios Bigoni et al., 2012; Hollinger et al., 2013).

Apart from these clear benefits the increased use of digital methods is also due, to the technical advances (e.g., Morena et al., 2019; Kogan et al., 2020), and to the reduced cost of digital data capture instruments. A recent report by ICOM (2020) showed that the global pandemic has led many museums to increase their use of digital methods. However, museums have chosen after the lockdown to make their collection available online (18%) or to organize digital exhibition (16%), By comparison, there was a 47.5% increase in social media activity (ICOM, 2020). The use of 3D technologies in anthropological and ethnological context is restricted to a few international institutions (Trinchão Andrade et al., 2012; Hollinger et al., 2013; Enkhbat, 2015; Schmidt, 2016; Raimundo et al., 2018; Bartolini Lucenti et al., 2021). Similarly, the number of Italian museums of natural history that are using digital technologies as part of their exhibitions is limited, perhaps due to an underestimation of the potentiality and benefits such methods. As a step to benefit from the use of digital methods in museum we tested for the first time Artec Spider on artifacts kept in the collections of the Museum of Anthropology and Ethnology of the University of Florence. We attempted to evaluate the efficiency, accuracy and resolution of the scanner acquiring specimens of different materials including wood, metal, mother-of-pearl, and feathers.

MATERIALS & METHODS

Scanning methodologies – Artec Spider is a high-resolution blue light technology 3D scanner. It belongs to the Earth Science Department of the University of Florence under the responsibility of one of the authors of this contribution (L.R.). This hand-held scanner is compact, well adapted, for in situ scans. Its small size provides it with a reduced field-of-view between a maximum of FOV = 18.0 x 14.0 cm and a minimum of 9.0 x 7.0 cm. Its maximum resolution is 0.1 mm and its accuracy is around 0.05 mm, making it is well-suited for small objects. The speed of capture is 8.0 fps at maximum (Artec Group, 2020). We followed the scanning protocol for the high-resolution 3D scanner Artec Spider as previously described (Bartolini Lucenti et al., 2021). Raw data were acquired with multiple passes of the scanner on the selected specimen; these data were then elaborated with the dedicated software Artec Studio 15 Professional which enabled the data to be cleaned, aligned and refined. The software allows to create the 3D mesh of the specimens, apply the color texture and finalize the file.

Specimens selected for the study – Table 1 resumes the principal information on the eleven specimens considered for this study. The relevant discriminator factor that guided the selection of the objects was the variety

N. cat.	Type of specimen	Macroarea	Locality	Culture	Material	Result
UNIFIE 3939	Whistling vase	South America	Perù	Chimu	terracotta	✓
UNIFIE 4053	Cuchimilcos	South America	Perù	Chancay	terracotta	✓
UNIFIE 7026	Cuchimilcos	South America	Perù	Chancay	terracotta	✓
UNIFIE 9827	Necklace	Indonesia	Engano	Engano	mother-of-pearl, glass	!
UNIFIE 9828	Necklace	Indonesia	Engano	Engano	mother-of-pearl, glass	!
UNIFIE 10766	Idol	Indonesia	Sumatra	Batak	steatite	✓
UNIFIE 10767	Idol	Indonesia	Sumatra	Batak	metal	✓
UNIFIE 32028	Iku-bashui	Japan	Hokkaido	Ainu	wood	✓
UNIFIE 32049	Iku-bashui	Japan	Hokkaido	Ainu	wood	✓
UNIFIE 33854-8	Earring	South America	Amazzonia	Yanomami	wood, feathers	✗
UNIFIE 33854-26	Earring	South America	Amazzonia	Yanomami	wood, feathers	✗

Tab. 1. Resuming table of the selected specimens of the Museum of Anthropology and Ethnology of the University of Florence considered for this study. Note the different material of which these artifacts are made of. Last column accounts for the results of the 3D scans. Symbols: "✓" represents successful reconstructions; "✗" stands for unsuccessful scans (see discussion for details); lastly, "!" reports those case in which we were able to obtain good 3D reconstruction for some part of the specimens but not for the whole specimen (see discussion for details).

of materials they are composed of, including polished artifacts, with low reflectivity, or made from terracotta, wood, metal, feathers, or mother-of-pearls. The artifacts come from various regions and times across the world and belong to different cultures. Specimens are ranging from Engano culture and of Batak people of Sumatra (both from the Elio Modigliani's Indonesian collection) (Bigoni et al., 2019), to objects from the Ainu culture of Hokkaido (Fosco Maraini's collection) (Bigoni & Roselli, 2020). Also, ceramics from Precolumbian times (Dionisio & Bigoni, 2017; Dionisio et al., 2017) and recent ornaments of Yanomami of Amazonia were included (Saffirio and Damioli collection). Among all these artifacts, a few were already previously studied and scanned using the laser scanner Next Engine, i.e., UNIFIE 10767 (Bigoni et al., 2019).

RESULTS & DISCUSSIONS

As can be seen in tab. 1, Artec Spider, without significant problems, was scanned and rendered the digital reconstruction of almost all of the specimens. There were only a few cases in which the scan was not satisfactory. Major issues arose from the scans of specimens made of feathers, i.e., UNIFIE 33854-3 and 33854-26. These two Yanomami earrings (Bigoni & Saffirio, 2014) have a wooden stylus to which feathery portions sprouts (as in UNIFIE 33854-3) or are attached to (as in UNIFI 33854-26). Figure 1 shows the process and results of the scans of one these specimens, UNIFIE 33854-3. In this case problems in the acquisition arose directly in the first steps of the digitalization (Fig. 1 a, b). The raw aligned scans display missing portions (black portion in fig. 1 a, b), where the scanner and the software were not able to capture data, in spite of the number of passes or orientation of the specimen. It should be noted that such missing information is not in undercut or shaded areas, but specifically close to margin of the feather. As expected, this lack of information affected the 3D mesh (Fig. 1 c-f). All the feathers in the mesh show jagged margins where the 3D object remain open and in the ventral side several aberrant shapes (lumpy, rounded artificial mesh) are prominent. Nevertheless, despite these evident problems, fig. 1 also show that central portion of the mesh have high-resolution details both in the mesh-only visualization and in the textured-mesh such as the bulging rachis and the barbs object (Fig. 1 c-f). This result implies that the problem scanning this type of specimens lies in the structure itself of the object, i.e., the gossamer nature of the margin of feathers. Data acquisition proceeded as expected in the portion in which more surface of the object is available. Another instance in which results are less than optimal is that of the necklace with the mother-of-pearls pendant (beautifully decorated, from Engano culture of the Modigliani's Collection, UNIFIE-9827 and 9828) (Fig. 2). Here, the most significant portion of the specimen, the engravings on the internal surface as well

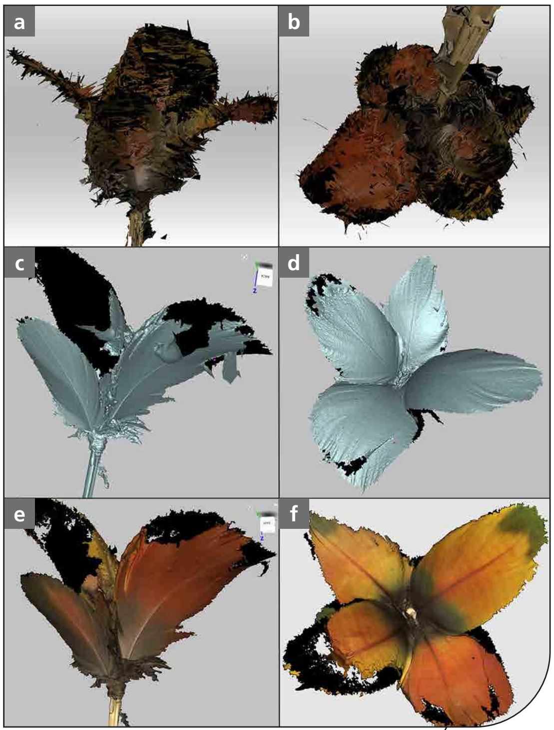

Fig. 1. Results of the scans with Artec Spider and rendering 3D with Artec Studio 15 Professional of the Yanomami earring, UNIFIE 33854-3. **a,b)** Raw data acquired by Artec Spider as shown in the native software Artec Studio 15 Professional resulting from four different passes. Note the black portions, representing the missing data, i.e., portion where the scan was not able to acquire data. **c,d)** 3D mesh of the earring UNIFIE 33854-3 showing undesired or problematic portion, especially the margin of the feathers, where the software was not able to build a closed and complete mesh. **e,f)** The same mesh with texture applied on it.

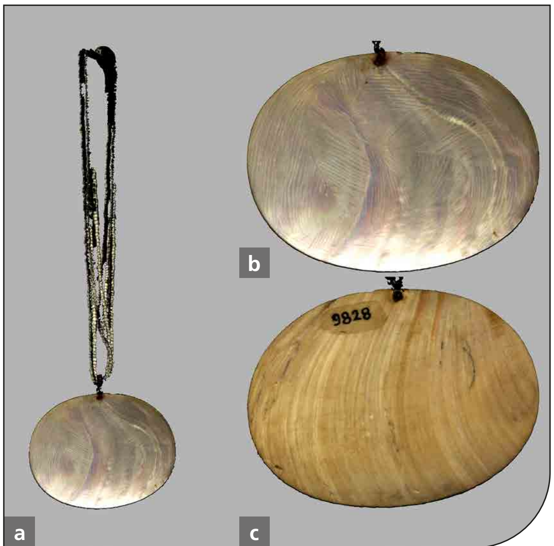

Fig. 2. Tridimensional object of UNIFIE-9828, necklace with mother-of-pearls pendant from Engano (see tab. 1). **a)** Specimen in anterior view. **b,c)** Closeup views of the pendant showing detailed features perfectly render in the digital specimen, both its anterior (b) and its posterior side (c).

as the features of the outer surface of the shell of the shell were correctly rendered in the 3D object, (Fig. 2 a-c). However, the tiny vitreous beads that compose the necklace or those that hold the pendant presented particular challenges. Again, similar to the case of feathers, the critical features do not lie in the material itself. These beads are solid and with perfect reflectivity to be captured during the scans. The problem is the difficulty in obtaining a perfectly identical position of the beads from one pass to the next, they move or are displaced from their original position when specimens are flipped upside-down for the scan. These movements cannot be avoided even changing the setup of the digitalization (e.g., scanning of the specimen hanging from a tripod) as the mesh showed in fig. 2 was obtained with such precautions in mind. Nevertheless, unlike the case of the Yanomami feathery earrings, the most informative part on the light of ethnography is the pendant. In this part the scan results were excellent, and allowed an assessment of the engravings, better to those made from 2D photographs.

Excellent acquisition and digitalization results were obtained from all specimens: from the terracotta as that of the whistling vase (with a smooth surface) or of the cuchimilcos (rough), to wood (of the polished surface) or metal and steatite, resulted suitable for the scan (Tab. 1). One of the scanned specimens, UNIFIE-10767, an idol representing a deity of Batak from Indonesia, was scanned few years ago using a different digital tool (Bigoni et al., 2019). In that occasion the specimen UNIFIE-10767 was scanned using the laser scanner Next Engine with good results. In our new attempt, the scanner Artec Spider had the advantage to be more rapid and more accurate, both in the acquisition of geometries and texture of the specimen (which are simultaneous in Artec Spider). This result is evident from the direct comparison of the two objects obtained in the different scans (Fig. 3). The comparison between the two meshes shows that the mesh obtained from the scan with Next Engine has considerably less resolution compared to the one obtained with Artec Spider (Fig. 3 a, b). The surface of UNIFIE-10767 scanned with NextEngine is smooth and almost none of the details of the idol (the arms, the mouth, etc.) are visible (as noted by Bigoni et al., 2019). On the contrary, the surface of UNIFIE-10767 scanned with Artec Spider shows a great deal of details, comparable to those visible on the specimen at hand. As the image captured by Next Engine was not satisfactory, Bigoni and coauthors (2019) decided to apply the texture rendering using photogrammetric procedures. This improved the quality of the final 3D object. The digital specimen resulting from Artec Spider has similar valuable results on the texture mapping and rendering of the tridimensional object compared to photogrammetric application of the color, only with considerably less time.

Fig. 3. Comparison of the two 3D objects resulting from the scans of the specimen UNIFIE-10767. On the left side of each picture, 3D mesh obtained with the laser scanner Next Engine and on the right that acquired with Artec Spider. The objects are here reported as geometry-only (a, b) and in textured-mesh in anterior (**a**), posterior (**b**), left lateral (**c**) and lateroposterior (**d**) views, to better compare the results of the different scans.

CONCLUSIONS

The first explorative application of the high-resolution 3D scanner Artec Spider on specimens of the Museum of Anthropology and Ethnology of the University of Florence made of different materials has yielded valuable results. In general, solid materials do not pose problems for the digital rendering (Tab. 1). The only limitations evidenced by our results, probably concerning software limitations, are those regarding the thin objects or those composed of numerous, small, and independent parts. In these cases, the rendering was not completely satisfactory. For instance, feathers cannot be scanned at present with Artec Spider. Nevertheless, in most of the artifacts, the quality of color textures, general geometries, and tridimensional resolution of the 3D objects, were very high, and superior in comparison to other digital tools used in previous scans (Bigoni et al., 2019). The time necessary to complete the process of scanning, mesh reconstruction and texture mapping with Artec Spider and the dedicated software Artec Studio 15 Professional was relatively rapid. More importantly the quality and accuracy of the results are considerably higher. The use of such valuable methodologies is incredibly valuable in museum management, conservation and outreach, and will continue to increase their impact more and more in the near future.

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