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RESTORATION OF A STEMMED FRUIT BOWL USING 3D TECHNOLOGIES

Abstract: 3D digitization is not used only for documentation, researching and presenting of three-dimensional objects in virtual environment but, with help of a computer reconstruction and 3D printing, also for restoration of museum objects. In this paper a restoration of several damaged stemmed fruit bowl (two pieces with different damages) is described. The object is from the National Museum of Slovenia and its ceramics collection. The bowl is highly perforated throughout its surface; therefore making new fragments with conventional procedure would be a long standing and complicated restoration process. Consequently we try to improve already mentioned restoration process using 3D technologies. First, both pieces of the bowl were 3D digitized with a portable 3D scanner. On the basis of digitized data a 3D reconstruction of missing fragments was made. Afterwards the fragments were 3D printed in material similar to plaster, inserted directly into both pieces of fruit bowl and finally infiltrated during conservation-restoration process. A presented case shows that 3D technologies can improve standard conservation-restoration process and can make it faster, less complicated and more accurate. Process also gives a collateral product in a form of 3D digital model – of an original object and reconstructed one – that can be presented virtually.

Keywords: 3D digitization, 3D printing, computer reconstruction, restoration, museum object

1. Introduction

Today 3D technologies are more and more used for documentation, recording and presenting material heritage. Without them conservation-restoration work would be hard to become realized, and many projects in Slovenia [1] and abroad [2] proves this fact. With 3D digitization in a non-destructive way the shape and the texture of the heritage object is scanned. This assures a safe handling with the object. Digital data is usually used in virtual environment, but with 3D printing physical copy can be made. Copy helps researchers in their examinations or can be displayed as a tactile model at the museum exhibition.

In restoration 3D digitization is already widely known principle of data acquisition of objects. The data are usually used for accurate planning of preventive conservation and restoration of heritage objects. Data can also be used for making smaller or larger copies with a CNC machine in polyurethane foam, stone or wood. Since 3D printing is still relatively expensive, larger copies, made with this technology are rarely done. At the moment 3D printing is, because of its accuracy and fast building, more suitable for smaller (less than 1 m high) objects or for making scale models [3].

At the National Museum of Slovenia restorers at the Department of Conservation and Restoration are working also with ceramic and porcelain (porcelain is also a ceramic material) objects, beside other materials. These two materials are different by their characteristic – ceramic can be very porous and absorb liquid inside the body easily, where a porcelain is hard and non-porous. Therefore the conservation-restoration process must be selected carefully.

We examined usefulness of 3D technologies in conservation-restoration work with museum ceramic objects on two differently damaged pieces of the stemmed fruit bowl from the National Museum of Slovenia. The bowls are highly perforated; therefore making new missing parts would require longstanding and complicated restoration procedure. Our main aim was to improve restoration work with a help of 3D technology. On the basis of 3D digital data that we acquired, reconstructed missing fragments were 3D printed in a material similar to plaster. All of these fragments were then used directly in a restoration of both pieces of the bowl. In the first phase we supplemented just the larger missing fragments of the damaged bowls. Until now we haven't find any case that describes an insertion of 3D printed plaster like fragments into a porcelain museum object. We wish restorers with similar experiences contacted us.

2. A stemmed fruit bowl as a museum object

In the ceramics collection of the National Museum of Slovenia there is a table service made by the Royal Vienna Porcelain Manufactory (Wiener Porzellanmanufaktur) in the neo-classicist style of the early 19th century. In accordance with the trend, the service comprises a dinner set together with dessert, coffee and tea wares. The various vessels of the service are decorated by geometric sequence of perforations with gilded borders and at that time fashionable floral pattern [4, 5].

The set for dessert consists of several plates and bowls. The most significant among them are the three perforated stemmed bowls for fruits and sweets. Two stemmed bowls are severely damaged (Picture 1). One of the damaged bowls has only one half of its foot left, on the second bowl the whole foot is missing. The bowl without foot is also missing some areas of its body. Both bowls have also some other smaller damages.

Because of the museological doctrine that we want to present to museum visitors an adequate impression of the past, in our case the whole diversity of the tableware forms, we decided on complete reconstruction of the foot and body of both bowls.


Picture 1: Two damaged pieces of stemmed fruit bowl (National Museum of Slovenia).

3. The preparing and making of the reconstructed missing fragments

3.1 The 3D digitization. The reconstruction started with a 3D digitization. During the 3D digitization the condition and the damaged parts of the bowls were precisely documented.

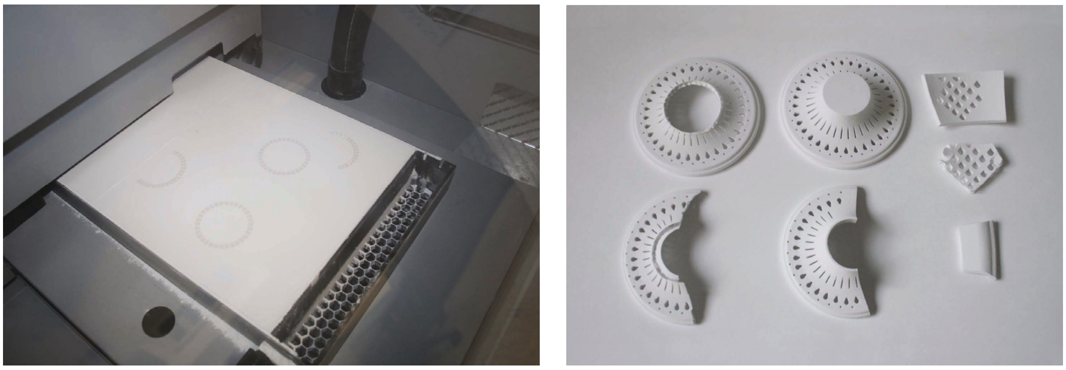
The shape of the objects was scanned with a handheld 3D laser scanner ZScanner 700 CX (Z Corporation), which uses a red light for scanning. The object that we are 3D digitizing must stand on a black plate with a reflective dots. Those dots stand for easier positioning of the 3D scanner in space. The other possibilities: We can cover the object with dots or with a net which those dots are on. The 3D scanner calculates the time that the laser ray travels to the object and back on to the sensor. During digitization capturing of the object's surface (or/and texture) can be seen on the screen. This means that the point cloud is joining into polygons in real time. Therefore we can watch building of the digitized surface of the object [6]. The 3D scanograms were later edited (noise was removed and the surface of the object was closed) in Geomagic Studio 12.

3.2 The 3D computer reconstruction. On the basis of the gathered data, about the original shape and holes (i.e. sections of missing fragments), the 3D computer reconstruction of the larger missing fragments was made (Picture 2). Several computer 3D models (fragments) of missing areas were reconstructed: a foot, a half of a foot, a part of a body and a part of an orifice. All fragments, except a part of an orifice (straight conclusion) were made in two varieties: one was made to match the shape of the missing fragments (1) and one was made larger of the missing fragments with straight conclusions (2). The first variety (1) was used for restoration, because they were easier to work with. 3D computer reconstruction was made with NURBS modeler Rhinoceros 4.0, and partly with software for scan editing Geomagic Studio 12.

Picture 2: Computer reconstructions (blue) of two feet together with 3D scanograms (grey) (IB-PROCADD).

3.3 The 3D printing of the fragments for replacing the missing areas. Virtual reconstruction was transformed into a physical form with 3D printing. It is important, that every model is watertight, so that the 3D printer perceives it as a solid model. With other words: a 3D model's surface can't contain holes and other anomalies. The 3D printer transforms data of a 3D model into 2D pictures of each layer of the model. Building of a physical model with a 3D printer runs with exchanging of a process of adding a thin layer of resin on a thin layer of powder, similar to plaster. During the whole time of the 3D printing process we see just one layer (thickness: 0.089 mm) of the part, because all lower layers are hidden in powder. The process is continued until the whole part by its height is built. When the part is built, unglued powder can be removed with a vacuum cleaner. Small final parts of the powder can be removed by blowing. Unglued powder can be recycled and used at the next 3D printing.

Parts, taken directly from a 3D printer are still fragile; therefore they need to be impregnated with epoxy or other resins. In our case, the fragments were impregnated after reshaping process (during restoration), because it was important that the 3D printed parts were soft for handling. All the parts were 3D printed at once (build volume: 203 x 254 x 203 mm) with a ZPrinter 450 (Z Corporation) (Picture 3) [7]. The reconstructed copies of the missing parts were included into the process of object completion [8].



Picture 3: 3D printed fragments (IB-PROCADD).

4. Restoration of a stemmed fruit bowl

4.1 The condition of the bowls before restoration. The fruit bowls had different damages and were masterly restorated in the past. Old glue had become brittle during the years and the bowls started to collapse. The fruit bowls had missing areas; some of the missing areas were replaced with plaster. For the bowl with missing foot a copy of the foot was made with solid wood and painted to match the object. Because of the weak glue, the edges of an added plaster parts were damaged. Also the stem was little taller than it should have been. Therefore we decided not to glue back these parts.

4.2 The completion of the bowls with the 3D printed fragments. As mentioned before, we had two different 3D printed fragments available. We used those which were as similar as possible to the shape of the missing areas, because they needed very little work to be adapted to the original object. The material for the 3D printing is very similar to plaster: fragile, but more elastic, therefore fragments needed to be impregnated after the adaptation. Experiments indicated that epoxy resin Araldite 2020, which is usually used for restoration of glass and porcelain objects, was also suitable for impregnated 3D printed fragments. The fragments and the object were glued together with the same epoxy resin Junctures were finished with the same mixture of epoxy resin and the powder (ZP 150) which was primarily used for 3D printing. Because surface of the 3D printed parts was a little bit too rough, and dissimilar from original surface of porcelain bowl, we tried to find the way to smooth it. Smoothing with emery paper was too rough; therefore we tested if coating parts with more layers of epoxy resin would smooth the surface. We also wanted to reach the appearance of porcelain. Therefore we had to colour the used epoxy to match the colour of the object. Then the surface was still a little bit rough and became non-absorptive. It also didn't have the same gloss as the objects surface, but the surface of the part was more than suitable for coating it from epoxy resin that had pigments mixed in, because the epoxy did stay on the surface. When epoxy had hardened, coating with uncoloured epoxy resin the whole part was still needed. That's how we reached the appearance of a glaze. Last layer of coating should be added when the resin, added before, has started to set (Picture 4).

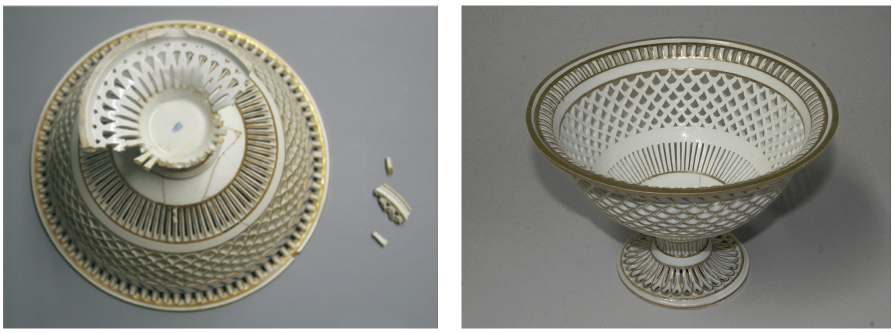
The process is ideal for replacing complex and large missing parts in ceramic objects. The only deficiency is in replacing thin translucent porcelain parts of objects, because 3D printed parts are not translucent. This problem can be solved by testing different additive manufacturing technology or by making a silicone mould and mould from transparent foil from the 3D printed parts [9, 10]. Missing fragments can then be cast from pure and proper coloured Araldit 2020 [11].

Picture 4: Supplementation of the bowl (less damaged) with 3D printed fragments (National Museum of Slovenia).

5. Conclusions and further work

The presented case shows that 3D technologies are opening new possibilities for making reconstructions and replacing missing areas in objects in several restoration fields. At the same time the mentioned technologies facilitate and simplify the work. They also make the standard conservation-restoration process faster, less complicated and more accurate. The process also gives a collateral product in a form of 3D digital model – of an original object and reconstructed one – that can be presented virtually.

In the first phase of reconstruction we decided to focus only on lager missing parts of the bowls. The reason was a lack of experiences with including 3D printed parts into porcelain objects. Till now we have restored only less damaged bowl (Picture 4 and 5). More damaged piece is still in the process of restoration. Eventually we are planning to reconstruct and include also smaller parts to the other bowl.



Picture 5: Damaged and restored bowl (National Museum of Slovenia).

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