As part of the “Smart Replica” theme initiated by Maaike Roozenburg, we made a proof of concept in the minor on Advanced Prototyping at the Faculty of Industrial Design, Delft University of Technology. The top figure presents an impression of the final result: an exact replica in porcelain of an 18th century sugar cup + lid, the decorations function as markers for a handheld AR overlay. On the cup, the augmentation is a 3D animation floating on top of the physical object, while the physical lid is covered exactly with a virtual golden decoration that matches the original lid.

Most of the technologies that we used require only a basic skill level with some experience in 3D modeling (CAD or visualization). A close account of this developmental process can be found on the weblog http://porcelain2011.weblog.tudelft.nl. Below, the most essential steps are discussed.

**3D scanning**
The original Loosdrecht’s porcelain objects are part of the collection of museum Boijmans Van Beuningen. They measure approximately 8 cm and due to their fragility non-contact scanning had to be selected. A medical Computer Tomography scanner was employed, in which a radiation source and the detectors rotate around the sample and measure the attenuation of the x-rays of the sample from different angles. In the slice the pixel resolution is approximately 0.2 mm, yielding a result which is still sufficient to inspect object thickness and geometry. Furthermore, the scans gave a surprising effect: the gold decorations (“goudluster”) caused distortions in the scanned geometry.

**3D Reconstruction**
A substantial part of the reverse engineering is the digital reconstruction of the scanned point clouds into a valid, 3D CAD model that is printable. In this case, much effort was spent to convert the collection of jpeg pictures of 2D slices into a valid 3D mesh. However, this was not possible given the time constraints and we ended up extracting a vertical section view to generate a working revolves in Rhinoceros - a regular type of CAD package.

In the cup, an AR tag was embossed, to be used as an optical marker. A 3D print was made with a polyjet technique in maximum resolution (an Objet Eden, accuracy 16 micron).

**Manufacturing and decoration**
Based on the 3D prints, molds were made in plaster to pour the porcelain clay into. After drying the mass, the molds were carefully removed, baked and painted, after which a final transparent glaze was applied.

**Augmentation**
For mobile AR, we chose Junaio - a straightforward smartphone application that offers location-based augmentation as well as image recognition. The so-called GLUE functionality allowed us to overlay 3D models and animations on top of predetermined images (pattern) with a web-based interface to adapt the scale, rotation, and position of the objects. For modeling we used 3D Studio Max, which could export in the proprietary .md2 format with a special plugin. The augmentation of the lid was a gold version of the same object, which was simply a modified version of the same reconstructed 3D file of the lid. The cup was extended with an animation of several portraits that seemed to float in the air.

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Replicated cup and lid in porcelain, augmented by animated 3D graphics on a smartphone.

Original Loosdrecht sugar cup and resulting mesh model after the CT scan.