Estimating Vessel Properties from 3D Scans for Comparison, Categorization and Archiving

In the field of archeology measurements with regards to vessels are still research desiderata. In particular, the cups, jars and mixing bowls which were used during an antique banquet are still a black box. It is important to verify whether there were universal measurement units for a filling volume for each type. For this purpose, different vessel properties for comparison and categorization need to be acquired. Typical properties include the dimensions, filling volume and cross sections of these vessels. The manual process of obtaining this data is labor intense, restricted to non-destructive techniques and depends on the specific form of each individual vessel. In general, calculating the filling volume cannot be done using liquids as they may damage the object. Therefore, approximate solutions with granulated material are often used instead. Visualizing cross sections and contours involve at least some artistic freedom as they are based on photographs and a limited number of measurements of the object. The object’s form, e.g. thin, elongated openings also restricts the locations of where the measurement may take place.

Nowadays, the possibility to create 3D scans with e.g. laser or computed tomography allow precise measurements of the scanned objects. In our current research project, we will initially focus on about 470 laser scanned antique ceramic vessels. The goal is to create a comprehensive online database with either estimated or known properties which can then be used to compare vessels and categorize them. Known properties are the weight and the complete scan of the outer surface. Partly known or unknown properties to be estimated are the material’s geometric density, the vessel’s interior geometry and its filling volume. Since surface scanners measure only visible parts of an object, its inner surface is typically unknown. The resulting database will enable us to distinguish vessels with special emphasis on their filling volumes.

Our contribution is twofold, automatically generating 2D visualizations of vessels and an approach for geometry reconstruction for volumetric computations.

In order to compare archeological vessels, the need for visualizing a vessel’s cross sections and profile is often desirable. Cross sections are 2D cuts through the object exposing important features like handles, openings and the wall thickness at specific locations. Cross sections are closely correlated to an object’s symmetry properties. For perfect rotationally symmetrical objects a cross section plane is placed in such a way that it splits the object in two equally mirrored parts. Typical real-life objects do not expose a perfect symmetry, but especially with pottery like cans, vases or jars there exists an approximate reflective symmetry. This symmetry is often found near the object’s center, splitting the object in two approximately mirrored parts. We apply existing techniques for determining rotational and reflective symmetry properties and automatically decide on the best suitable cross section planes.

As for the second part, we currently develop a new algorithmic technique to reconstruct the missing interior geometry of a vessel using the known scanned parts, the weight and a material density estimation. The result is a plausible manifold geometry which can be further used to calculate the vessel’s filling volume. The algorithm involves displacing the outer known surface by an initial estimate of the wall’s thickness and merging the displacement with the partly known scanned inner surface. The resulting object’s volume can then be calculated and is compared to the expected object’s volume. The expected volume depends on the known weight and on a given estimate for the material density. The difference between expected volume and calculated volume is then used to
refine the initial guess for the wall’s thickness. In an iterative fashion using a binary search we arrive at a final geometry within the bounds of a defined error metric.

In the future it is planned to include international partners and subsequently merge their 3D data with our online database. The collective information will help to understand regional characteristics of vessels possibly with pinpointing to the originating workshops the vessels were produced in.