3D shape analysis for high performance grout

Schladitz, Katja and Godehardt, Michael
Fraunhofer-Institut für Techno- und Wirtschaftsmathematik, Image Processing Department, Kaiserslautern, Germany
katja.schladitz@itwm.fraunhofer.de

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Introduction

Aggregates of grains like sand, grit, and gravel are important ingredients of building materials like asphalt, concrete, or grout. The grain mixture highly determines the rheological and mechanical properties of the final material. State of the art is to control the size distribution by sieving using normed sieves. The grains shapes are obviously not captured that way. However, packing densities and along with them the resulting mechanical properties of the mixtures do depend on the joint size and shape distribution. Here, we therefore examine various shape characteristics based on 3D image data of grit beds.

Materials and Methods

Samples of sand and grit from different deposits and from sieve grades 0.25-0.5mm up to 5-8mm were imaged by computed tomography. Segmentation of individual grains in the resulting gray value images is a prerequisite of a detailed shape analysis. Binarization into grain system (foreground) and air (background) is easily achieved after correction of global gray value fluctuations. Touching particles can in principle be separated using the usual morphological procedure applying the watershed transform on the inverted Euclidean distance image. However, the irregular shapes and even more seriously porous grains complicate the separation considerably. A strategy for detecting and correcting over-segmentations is outlined.

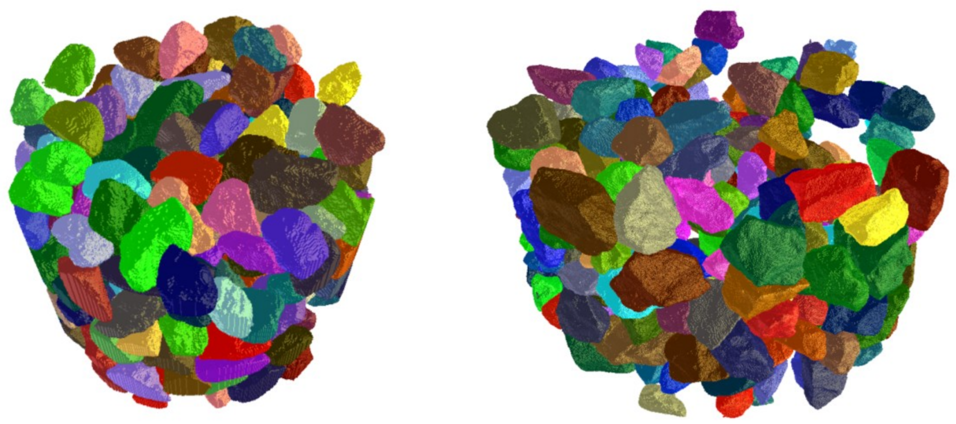

Figure 1. Quartz from the Lower Rhine region. sieve grade 2-4mm , and Jura pearls. Volume rendering of the 384 and 608 separated grit grains. Colors just illustrate the grains labels. CT imaging ProCon X-Ray, pixel sizes 17.1µm and 8.6µm.

After the segmentation, a wide variety of particle characteristics is computed in order to find those correlating the strongest with experimental results in a second step. We investigate the intrinsic volumes, isoperimetric shape factors, shape characteristics derived from the minimal volume bounding box, and elongation and elongation index. The elongation L is the longest geodesic distance of two points within the particle and the elongation index is the proportion of L and volume V, normalized such that a ball attains value 1: $\pi L^3/6V$.

Results and Discussion

In particular the elongation index is by definition well suited to distinguish between sharp, pointed and more round grain shapes. The Jura pearls turn out to be considerably more elongated although they are much finer (mean diameters of equal volume balls 1.3mm for the Jura pearls and 3.3mm for the Lower Rhine grit), see the histogram in Figure 2.

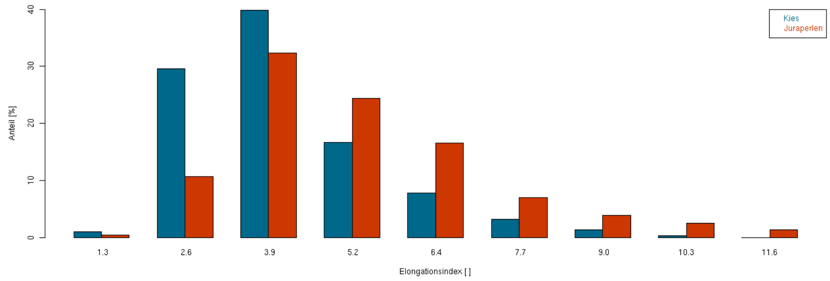

Figure 2. Elongation index for the two samples shown in Figure 1.

Conclusion

The complex shape of sand and grit grains can be characterized based on 3D image data. Differentiation of different types and different sieve grades is possible.

Acknowledgments

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