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Use of 3D photogrammetry for measurement of river bed porosity

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Porosity is one of the key characteristics of the sediments on a river bed. It defines the suitability of a river as spawning place for salmonids, the amount of oil that is contained in geological river deposits and the life-time of hydropower reservoirs. Nevertheless, little is known about natural variations in porosity, partly due to a lack of proper measuring equipment.

The recommended technique for porosity measurements in field conditions is the water replacement method, in which a sediment sample is taken and the amount of water needed to fill the pores of the sample is measured. Division of pore volume by total volume of the sample then returns the porosity. The weakness of this technique is the determination of the in-situ sample volume. Normally, this is done by positioning a plastic ring on top of the sediments prior to sampling and placing a plastic liner is into it. After shaping the liner to conform to the irregular soil surface, the ring is filled with water. After removing the water and liner, a sediment sample is taken, and the pit is covered with the liner and filled with water again. The difference in water volume before and after excavation of the pit represents the sample volume. Because it is very difficult to fill the pit two times to exactly the same level with water, the uncertainties in sample volume can be large. Moreover there is a risk of holes in the liner, and the technique becomes very time-consuming if large samples are needed (for instance in case of heterogeneous coarse sediments).

The objective of this study was to determine if the accuracy of porosity measurements can be improved by using 3D photogrammetry to determine the in-situ sample volume. We performed two series of each about 50 porosity measurements in the Rhine River: the first series with the traditional method to measure sample volumes and the second series with a structured-light 3D scanner (Z-Snapper, Vialux) to measure sample volumes. The scanner was placed about 170 centimeters above the sample pit and scanned an area of about 90 x 70 cm with a cell size of 0.3 x 0.3 cm and a vertical resolution of about 0.01 cm.

The use of 3D photogrammetry strongly sped up porosity measurements, but contrary to the expectation, the measurement accuracy did not increase significantly, partly because the 3D scanner had troubles scanning a heterogeneous surface of wet, shiny, differently colored grains and partly because it appeared difficult to georeference the scans because the sharp-edged reference points that we installed were hardly recognized by the scanner.

It is expected that these problems can be solved in near future, and from then on 3D photogrammetry will be a good alternative to the traditional method of porosity measurements. This hopefully leads to a boost of porosity measurements. The results will not flow directly into morphological river models, but will help to understand the physical state of the river bed, which will help to improve morphological computer models indirectly.