Accurate volumetric measurement of tsunami boulders using 3D point clouds

*Yuichi S. Hayakawa[1], Hisashi Aoki[2], Koudai Kishino[2], Akira Maekado[3]

1. Center for Spatial Information Science, The University of Tokyo, 2. Tokyo Gakugei University, 3. University of The Ryukyus

Volumetric measurements of large tsunami boulders have been a challenging issue. Although manual measurements have often been carried out to estimate the size of boulders, the volume may not be directly measured in such a manner because of their complex shape and vegetation covers. Alternatively, three axes (long, medium and short) are often used as representative size parameter of a boulder. However, the accurate measure of the volume is necessary for quantitative assessments of the transport processes of tsunami boulders. Here we perform field measurements of three-dimensional morphology of tsunami boulders in the southern Ryukyu Islands using 3D technologies including terrestrial laser scanning (TLS) and structure-from-motion multi-view stereo (SfM-MVS) photogrammetry either by an unmanned aerial system (UAS) or ground-based camera. The 3D point cloud data obtained by TLS and UAS-SfM are registered and georeferenced, manually filtered to remove vegetation, and converted to 3D mesh data by calculating normal and reconstructing 3D surfaces. The TLS-derived data is used as the reference, while UAS-derived data is utilized for the measurements of widely-distributed tsunami boulders. Although detailed topographic features such as the surface roughness are much better represented in the TLS-derived data, the resultant mesh volumes are nearly the same for both data with <1% difference. The TLS- and UAS-derived volume data are compared with those by manual measurements, showing a good linear correlation. The accurate measure of the volume of tsunami boulders is used for the reconstruction of the potential kinematic energy of tsunami waves, suggesting the presence of higher tsunamis in the southwestern side of the Ryukyu Islands.

Keywords: terrestrial laser scanning (TLS), SfM-MVS photogrammetry, unmanned aerial system (UAS), point cloud, 3D mesh