Footprint in the Sand: Crowd-sourcing Soil Mechanics & Applications in Erosion Measurement

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INTRODUCTION: We have all experienced walking on a sandy shoreline, leaving somehow romantic footstep in the sand, but what are its impacts on the environment, and can these footprint be used as a proxy of anthropogenic impacts?

In the present project, the authors have been examining the use of SfM-MVS (Structure-from-Motion) applied to micro-geomorphology / micro-topography in a volcanic sand deposit at Unzen Volcano (South Japan), in order to correlate footsteps 3D data with the biometric data of the individual who left the footprint.

HYPOTHESIS & OBJECTIVES: Starting from the hypothesis that SfM-MVS can be used to accurately measure displacement in sandy deposit, the present research aims to test the feasibility and validity of the proposed method.

METHODOLOGY: One of the three researcher was invited to walk on the sandy deposit at Unzen Volcano. His walk was recorded in a video with a ruler in the background (see A in the figure). Afterwards, 150 photographs of the "walked-surface" were taken with a Sony (RX100 III mounted with a Zeiss lense <800 $US) hand-camera, to which the - now traditional - SfM-MVS photogrammetric method was applied. The scale of the model was generated using a ground-scale that served as Cartesian reference frame, and from which the RMSE and MAE error were calculated. The calibration of the scale was done using 12 tie-points with known X,Y,Z. The pointcloud was then exported as a .ply file into CloudCompare to calculate the displaced volumes of sand.

RESULTS: The model covered 1.5 m length x 0.5 m, from which two full footprints were identified (figure B and C). The generated point-cloud comprised 2.16 million points, while the densified pointcloud comprised 55 million points. Results from one single footstep have shown that 140 cubic millimeter of sand were moved, either outward from the footstep or compressed underneath the footstep. Multiplied by the size of a single stride, it is then possible to estimate volumes of sand moved on average for a given type of material and a given slope.

CONCLUSION: It is expected that future research will see the multiplication of such dataset, which, in turn, will help building estimates of walking track erosion, notably based on biometric characteristics of the track-users, as well as the footwear, linking to questions for the outdoor industry such as what is an environment-friendly shoe-sole.

Keywords: SfM-MVS, sand compaction, soil geomechanic, footprint analysis and erosion