Towards High-Resolution Global Urban 3D Model from TanDEM-X Data

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The significance of a global digital elevation model (DEM) with a resolution of 1 m level would be equivalent to that of the Human Genome Project, because it would transform the monitoring, modeling and the prediction of natural disasters, climate change and Earth surfaces processes in general [1]. For example, global annual losses due to flooding are predicted to reach US$1 trillion by 2050 [1]. Errors in current DEMs can lead to errors in the prediction of hydrological runoff volume by several percent [2]. Such prediction error will cause inevitable loss of finance and life. This is particularly true for urban research, as more than half of the global population lives in urban area [3], yet a DEM that is accurate and large enough to support the research of the rapid urban development is nonexistence. The available DEMs either lack in coverage, such as LiDAR DEM, or lack in accuracy, such as the TanDEM-X DEM.

The vision of this paper is to reconstruct a highly accurate global 3D urban model from TanDEM-X data. The current TanDEM-X global DEM has a high quality (12 m posting, absolute height accuracy 10 m, relative height accuracy 4 m) close to the HRTI-3 standard. However, when it comes to urban mapping, layover effects caused by the side-looking nature of the radar satellites handicap the use of TanDEM-X data for a precise 3D reconstruction in urban areas. Although, the state-of-the-art SAR tomographic (TomoSAR) inversion [4] allows an accurate height estimation up to 1 m from tens of (typically 20-100) images, most part of the world is only covered by three to five TanDEM-X images. To go beyond this limit, this paper proposes a novel framework of TomoSAR using a minimum number of acquisitions to obtain rapid and accurate height estimation, which is essential to our vision of global high-resolution 3D urban modelling.

[1] G.J.-P. Schumann, P.D. Bates, J.C. Neal, K.M. Andreadis, “Technology: fight floods on a global scale,” Nature, 507 (2014), p. 169.
[2] T. Kenward, D. P. Lettenmaier, E. F. Wood and E. Fielding, “Effects of Digital Elevation Model Accuracy on Hydrologic Predictions,” Remote Sensing of Environment, vol. 74, no. 3, pp. 432-444, 2000.
[3] United Nations, “World Urbanization Prospects: The 2014 Revision,” Department of Economic and Social Affairs, Population Division, United Nations, New York, 2014.
[4] X. X. Zhu and R. Bamler, “Tomographic SAR inversion by L1 norm regularization – The compressive sensing approach,” IEEE Trans. Geosci. Remote Sens., vol. 48, no. 10, pp. 3839-3846, Oct. 2010.