Title of your report

So2Sat - 10^{16} Bytes from Social Media to Earth Observation Satellites

Research institution

[1]Remote Sensing Technology Institute, German Aerospace Center

[2]Data Science in Earth Observation, Technical University of Munich

Principal Investigator

Xiaoxiang Zhu[1,2]

Researchers

Yuanyuan Wang[1,2], Yilei Shi[3], Vytautas Jancauskas[1], Marie Lachaise[1]

Project partners

[3]Chair of Remote Sensing Technology, Technical University of Munich

SuperMUC-NG project ID(s) of the projects you report in this article

pr53ya, pr45ne

Introduction

The rapid urbanization poses fundamental challenges to our societies across the globe. New phenomena of urbanization, such as megaregions and informal settlements, have raced too far ahead of our current understanding of urbanization, which is mostly based on the United Nation's population figure. Therefore, the scientific question of the project *4D City* (pr45ne) and *So2Sat* (pr53ya) [1] is: how does the global urban geographic figures, including geometry, thematic, population density, evolve over time, and in what detail can we observe and measure them?

Our scientific objectives is for the first time systematically fuse the remote sensing data and the massive data available from GIS and social media to map 3D urban infrastructures and their evolution over time, i.e. 4D, in high resolution and on a global scale.

The outcome will create a first and unique global and consistent **3D/4D spatial data set** on the urban morphology of **settlements**, and a multidisciplinary application derivate assessing **population density**. This is seen as a giant leap for urban geography research as well as for formation of opinions for stakeholders based on resilient data.

Results and Methods

We use a combination of traditional signal processing methods, and deep learning to reconstruction our 3D/4D city models. Previously, we have developed the world's first algorithm to reconstruct urban 3D models from a very small TanDEM-X radar image stack. This is a task usually requires at least 20 images. We employed modern signal processing techniques, including non-local means filtering, as well as compressive sensing (CS), to accomplish this challenging task by using just 5 TanDEM-X interferograms. This algorithm provides the height estimate of buildings in large scale, which has been demonstrated in the last report.

To get the height of individual buildings, previously we have studied the utilization of the building footprint freely available in OpenStreetMap (OSM). However, we found that the OSM footprint is not globally available. In fact, it is estimated that only 10% of the buildings in the world are covered by OSM. Therefore, we started a few years ago developing a new algorithm to automatic extract building footprint from optical imagery [2]. In the last year, we have successfully achieved this goal, and produced the world's first global building footprint map from Planet imagery. Figure 1 demonstrates a small crop of our global building

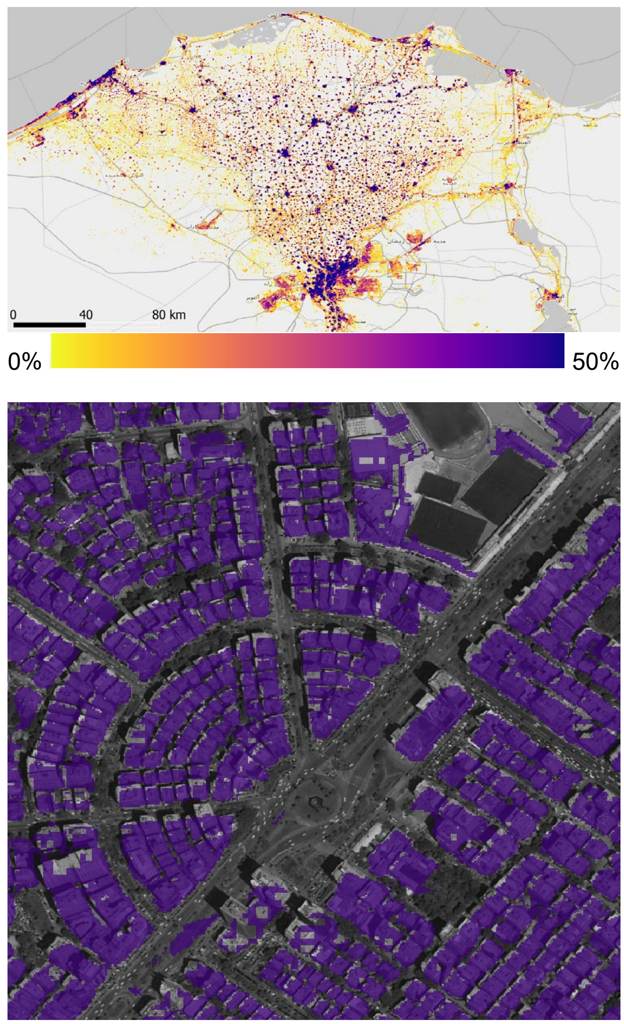

Figure 1. Upper: buildup density around Cairo, Egypt, and lower: individual building footprint in the center of Cairo.

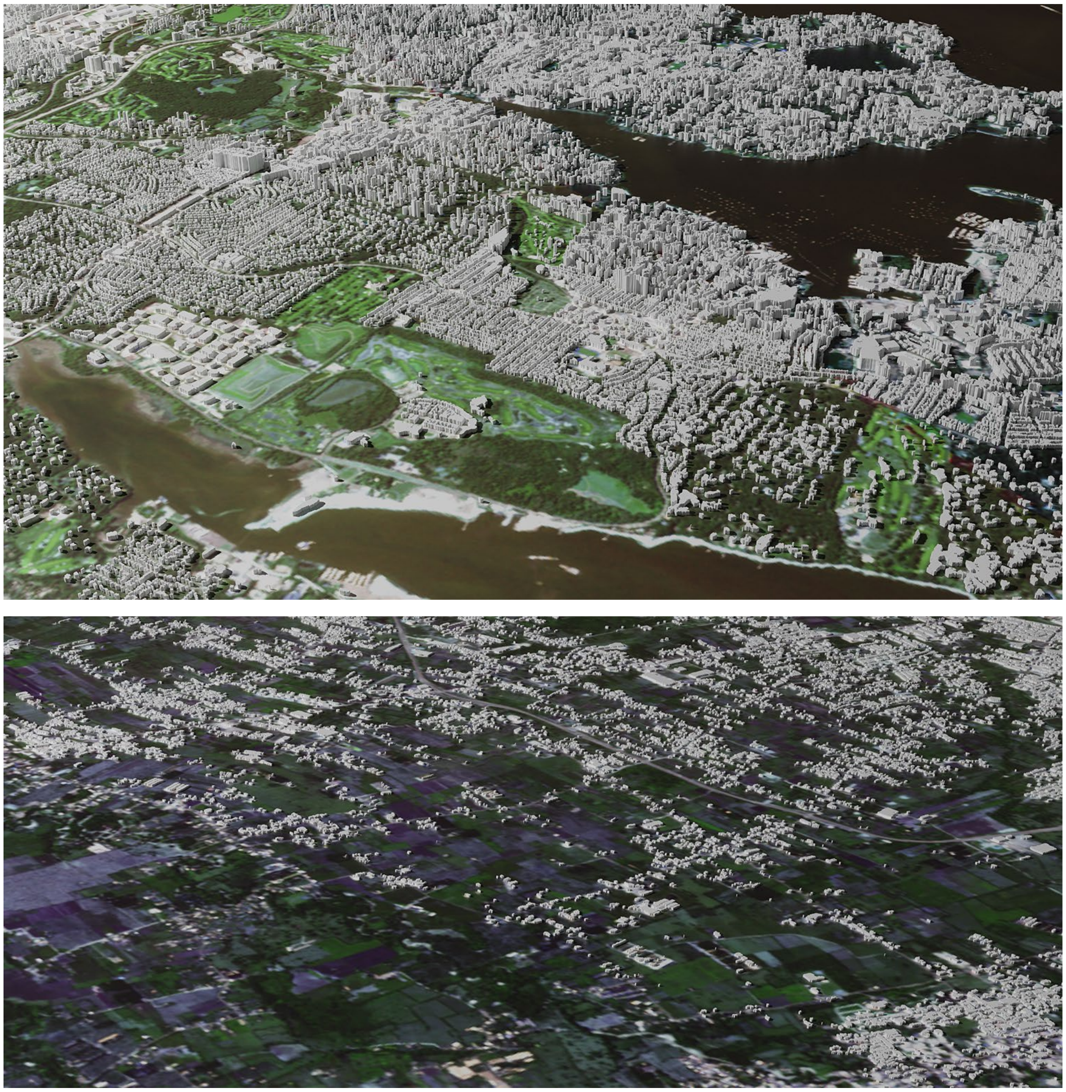

Figure 2. The LoD1 building model of New York and Santiago de Chile calculated and rendered on SuperMUC-NG.

footprint. The upper figure shows the density of the build-up area around Cairo, Egypt. The lower figure shows the individual building footprint in the center of Cairo.

Combining the height estimation and building footprint, we are able to create the so-called Level of Detail 1 (LoD-1) building model in a large scale. Figure 2 shows the LoD1 model of Dar es Salaam, created and rendered using our algorithm on SuperMUC-NG. We have created such 3D model for over a thousand cities whose population is larger than 300,000 according to the United Nation's population figure in 2014. Those LoD-1 urban models in a global scale are a great leap from the state of the art.

Ongoing Research / Outlook

Currently, we are improving and finalizing the global 3D model reconstruction. After finishing mapping the largest cities, we intend to apply this algorithm to everywhere we are able to detect a human settlement. This will create a full global coverage of the 3D building model. In addition, we have finished the mapping of local climate zones of 1692 largest cities in the world [3]. In the future, we aim at a global local climate zones classification.

SuperMUC-NG is vital for the success of our projects, because the sheer data volume and the processing hour required by our projects can only be accommodated in SuperMUC-NG. Our projects currently takes more than 1 petabytes of storage in SuperMUC-NG, to which we are grateful. This biggest challenge in our project is also its big data nature.

References and Links

[1] "www.so2sat.eu." www.so2sat.eu (accessed Jan. 14, 2022).

[2] Q. Li, L. Mou, Y. Hua, Y. Shi, and X. X. Zhu, "Building Footprint Generation Through Convolutional Neural Networks With Attraction Field Representation," *IEEE Trans. Geosci. Remote Sens.*, vol. 60, pp. 1–17, 2022, doi: 10.1109/TGRS.2021.3109844.

[3] X. X. Zhu *et al.*, "The urban morphology on our planet – Global perspectives from space," *Remote Sens. Environ.*, vol. 269, p. 112794, Feb. 2022, doi: 10.1016/j.rse.2021.112794.

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