Rapid Building Detection in Population-Dense Regions with Overfitted Machine Learning Models

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Abstract : The quality and quantity of global satellite data have been increasing exponentially in recent years as spaceborne systems become more affordable and the sensors themselves become more sophisticated. This is a valuable resource for many applications, including disaster management and relief. However, while more information can be valuable, the volume of data available is impossible to manually examine. Therefore, the question becomes how to extract as much information as possible from the data with limited manpower. Buildings are a key feature of interest in satellite imagery with applications including telecommunications, population models, and disaster relief. Machine learning tools are fast becoming one of the key resources to solve this problem, and models have been developed to detect buildings in optical satellite imagery. However, by and large, most models focus on affluent regions where buildings are generally larger and constructed further apart. This work is focused on the more difficult problem of detection in populated regions. The primary challenge with detecting small buildings in densely populated regions is both the spatial and spectral resolution of the optical sensor. Densely packed buildings with similar construction materials will be difficult to separate due to a similarity in color and because the physical separation between structures is either non-existent or smaller than the spatial resolution. This study finds that training models until they are overfitting the input sample can perform better in these areas than a more robust, generalized model. An overfitted model takes less time to fine-tune from a generalized pre-trained model and requires fewer input data. The model developed for this study has also been fine-tuned using existing, open-source, building vector datasets. This is particularly valuable in the context of disaster relief, where information is required in a very short time span. Leveraging existing datasets means that little to no manpower or time is required to collect data in the region of interest. The training period itself is also shorter for smaller datasets. Requiring less data means that only a few quality areas are necessary, and so any weaknesses or underpopulated regions in the data can be skipped over in favor of areas with higher quality vectors. In this study, a landcover classification model was developed in conjunction with the building detection tool to provide a secondary source to quality check the detected buildings. This has greatly reduced the false positive rate. The proposed methodologies have been implemented and integrated into a configurable production environment and have been employed for a number of large-scale commercial projects, including continent-wide DEM production, where the extracted building footprints are being used to enhance digital elevation models. Overfitted machine learning models are often considered too specific to have any predictive capacity. However, this study demonstrates that, in cases where input data is scarce, overfitted models can be judiciously applied to solve time-sensitive problems.

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