Satellite Imagery and Deep Learning for Earthquake Rapid Response: Compiling a Training Dataset for Building Collapse Detection Framework

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Abstract

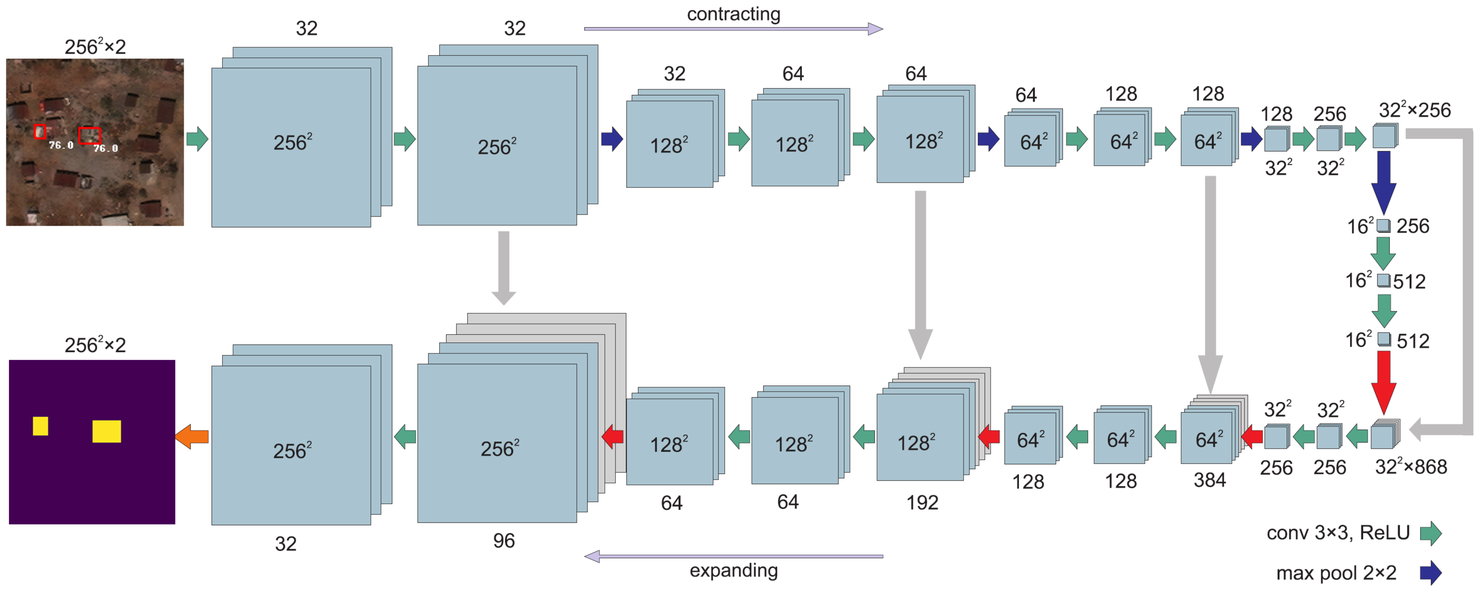
Rapid detection and classification of building damage after earthquakes is crucial for loss estimation, rapid response, and research. Collapsed buildings are usually among the places in which highest number of human casualties are reported after an earthquake event is recorded. Remotely sensed data such as very high resolution satellite imagery can be used immediately after an event to detect collapsed building. We are proposing to use Machine Learning algorithms to build a framework that can automatically detect collapsed building. For this purpose, there is a need to build an appropriate dataset for training and testing the algorithm. Recently, Department of Defense (DOD) released the xView dataset (Lam et al, 2018) for this purpose; however, many instances in the dataset are not suitable as they do not mimic an earthquake-induced collapsed pattern. We can use freely available satellite images after recent earthquake events to improve the xView dataset.

Motivation

- The abundance of readily available (free and commercial) satellite imagery

Collapsed buildings after 2017 Iran earthquake in Sarpol-e-zahab. Images from Planet Lab and Google

Collapsed buildings after 2017 Pueblo earthquake in Mexico City. Images from Digital Globe

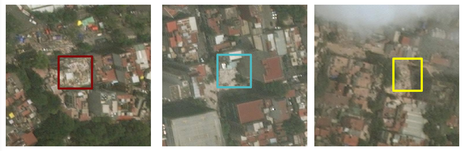


Architecture of the U-net deep convolutional networks. The 2D input image size here is 256 x 256 pixels. The input image is from xView dataset with 2 red-labeled instances of "demolished building". The output of the network, in this case, is a binary mask locating where the collapsed buildings are. The network architecture has been modified after Ronneberger et al. (2015).

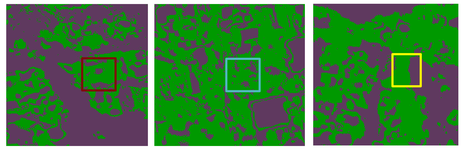
Maximum Likelihood

- Pixel-wise classification on the satellite imagery made available by Digital Globe in near real time after the 2017 Pueblo earthquake in Mexico City
- Variation in spectral information of collapsed buildings are high
- User accuracy is low; the classified image is noisy
- Need to improve results by using deep convolutional networks

Input mask

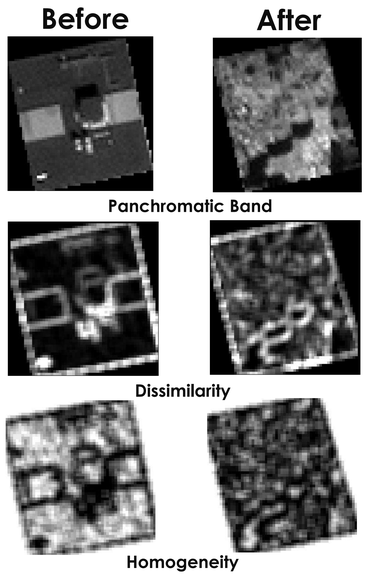


Model Prediction



Collapsed Building

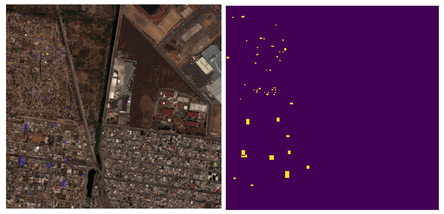
- The texture of the roof will change after collapse



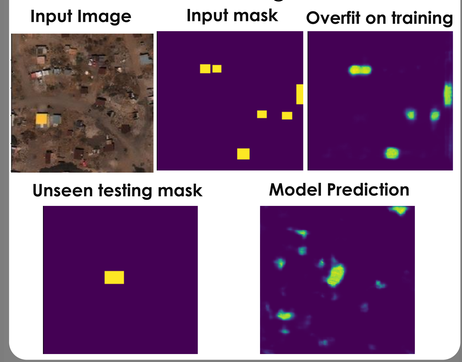
- Could use building footprint of pre- and post event imagery to improve the Maximum Likelihood results

Deep Learning

- Build binary mask out of labels

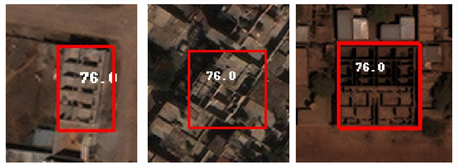


- Break down the image and labels into smaller pieces and fit the model on training data and test it on unseen images



xView Dataset

- The most important incentive of this project
- provided very recently by Defense Innovation Unit Experimental (DIUx) and National Geospatial –Intelligence Agency (NGA)
- from Digital Globe and taken by WorldView-3 satellite with 30 cm pan-sharpened RGB resolution
- more than a thousand instances of "demolished building" across the world



Reference

- Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." *International Conference on Medical image computing and computer-assisted intervention*, pp. 234-241. Springer, Cham (2015).
- Lam, Darius, Richard Kuzma, Kevin McGee, Samuel Dooley, Michael Laielli, Matthew Klaric, Yaroslav Bulatov, and Brendan McCord. "xView: Objects in Context in Overhead Imagery." *arXiv preprint arXiv:1802.07856* (2018).