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xBD: A Dataset for Assessing Building Damage from Satellite Imagery

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DEFENSE INNOVATION UNIT

Logistics, resource planning, and damage estimation are difficult tasks after a natural disaster, and putting first responders into post-disaster situations is dangerous and costly. Using passive methods, such as analysis on satellite imagery, to perform damage assessment saves manpower, lowers risk, and expedites an otherwise dangerous process.

Building Annotations	700,000
Countries Represented	15
Area	5,000 km2
Disaster Types Represented	Dam collapse, earthquake/tsunami, flood, landslide, volcanic eruption, wildfire, wind
Environmental Factors Represented	Fire, water, smoke, lava, wind

xBD: the largest building damage assessment dataset to date.

This work presents a preliminary report on xBD, a new large-scale dataset for advancing change detection and building damage assessment for humanitarian assistance and disaster recovery research. xBD provides pre- and post-event multi-band satellite imagery from a variety of disaster events with building polygons, classification labels for damage types, ordinal labels of damage level, and corresponding satellite metadata.

More details at https://xview2.org

"xBD: A Dataset for Assessing Building Damage from Satellite Imagery" (paper presented at CVPR 2019)
https://arxiv.org/pdf/1911.09296.pdf

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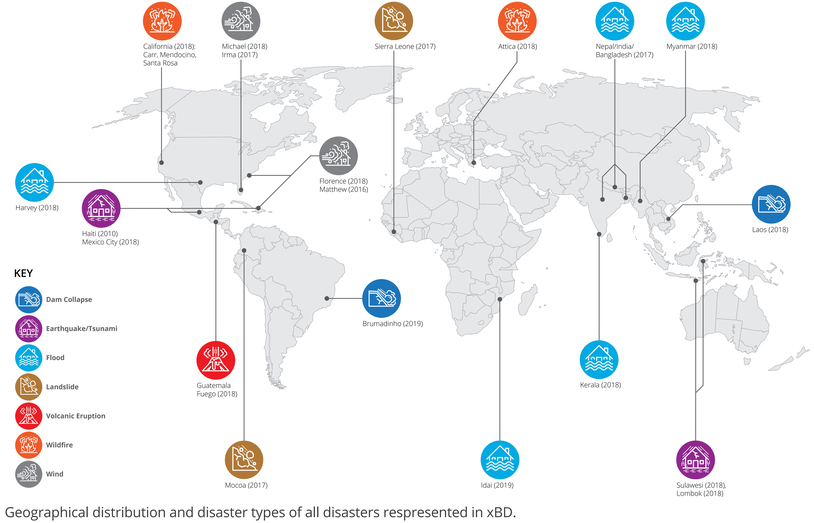
Disaster Level	Structure Description
0 (No Damage)	Undisturbed. No sign of water, structural or shingle damage, or burn marks.
1 (Minor Damage)	Building partially burnt, water surrounding structure, volcanic flow nearby, roof elements missing, or visible cracks.
2 (Major Damage)	Partial wall or roof collapse, encroaching volcanic flow, or surrounded by water/mud.
3 (Destroyed)	Scorched, completely collapsed, partially/completely covered with water/mud, or otherwise no longer present.

The Joint Damage Scale, a common framework for classifying damage.

We also present the Joint Damage Scale, a first attempt to create a unified assessment scale for building damage in satellite imagery across multiple disaster types, structure categories, and geographical location.

The Joint Damage Scale is based mainly on HAZUS, FEMA's Damage Assessment Operations Manual, the Kelman scale, and the EMS-98. Literature from the GIS community and expert insights from the California and Indiana Air National Guards and the US Air Force, help ground the scale in operational relevance.



Geographical distribution and disaster types of all disasters respresented in xBD.

Examples of wind damage. None, minor, and major (left to right).

Examples of fire damage. None and destroyed (left to right).

Examples of flooding damage. None to destroyed (left to right).

The xView 2.0 Challenge

Potential use cases for xBD include the following:

xBD provides

- building polygons
- ordinal regression labels for building damage
- multi-class labels for environmental factors that caused the damage.

Given training data of pre- and post-event imagery pairs, the challenge is to create models and methods that can extract building polygons and assess the building damage level of polygons on an ordinal scale. Furthermore, the models and methods must assign an additional multi-class label to each polygon that indicates which natural force caused the damage to the building.

Data Set Splits

Split	Images	Polygons
Train	18,336	632,228
Test	1,866	109,724
Holdout	1,866	108,784

Baseline Model

Our baseline model for the xView 2.0 challenge consisted of two parts. First, a localization model based on SpaceNet (https://spacenetchallenge.github.io/) is used to segment buildings from background, which achieved an Intersection of Union (IoU) of 0.97 and 0.66 respectively. The second model assigns a ordinal damage scale label to each segmented building that contains a pretrained 50 layer residual network backbone combined with a smaller convolutional network trained for this task.

Baseline Model Damage Classification Performance

Damage Type	F1 Score	Precision	Recall
No Damage	0.6631	0.8770	0.5330
Minor Damage	0.1435	0.1971	0.1128
Major Damage	0.0094	0.7259	0.0047
Destroyed	0.4657	0.5050	0.4321

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