Deep Ensemble Learning for Rapid Large-Scale Post-Earthquake Damage Assessment

Application to 2023 Turkiye Earthquakes Satellite Images

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NHERI Natural Hazards Engineering Research Infrastructure
2024 NHERI Computational Symposium
February 1-2
Los Angeles, California

Enriching satellite imagery with **damage proxy maps** and **pixel-based deep ensemble learning** improves the **generalizability** of rapid damage assessment models across **different urban textures.**

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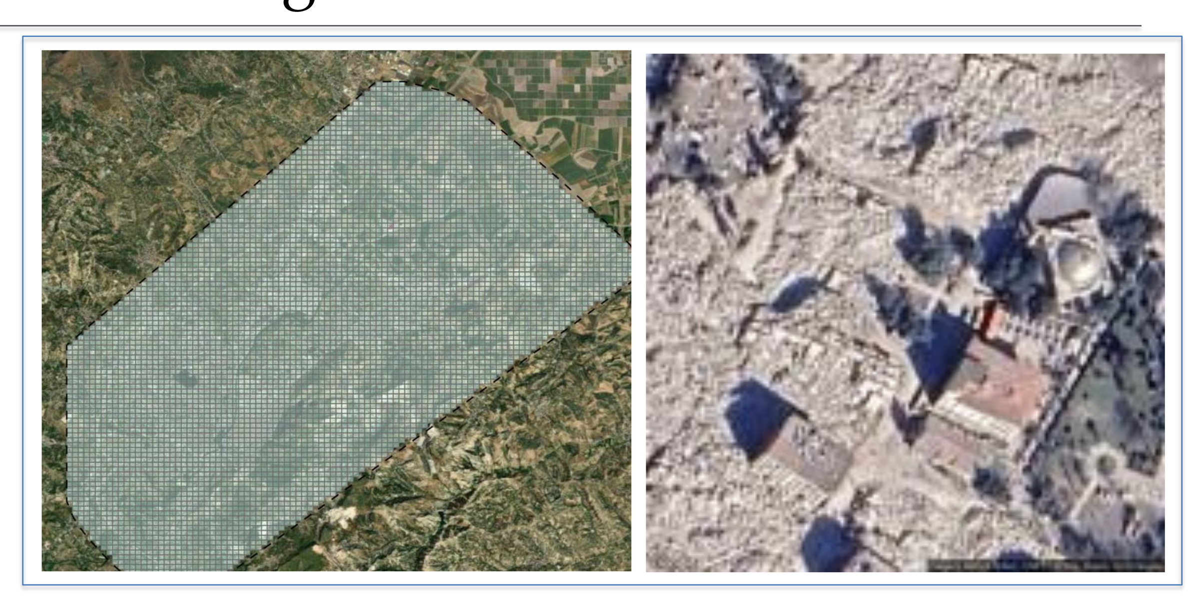
Introduction

- Generalizing parametric models to unseen data has always been a challenge.
- Generalizability in rapid post-event damage assessment is a crucial capability due to the diverse manifestations of damage across urban textures.
- 2023 Turkey earthquakes and the subsequent comprehensive on-site damage surveys offered a unique chance to develop and examine the generalizability of deep-learning-based rapid post-event damage assessment tools.

Case study: 2023 Turkiye earthquake

- Antakya (train), and Gaziantep and Maras cities (test) were chosen.
- Regions were broken down into 150-by-150-meter blocks.
- Pre- and post-event images were taken from Bing[1] and Google Maps[2]
- All image blocks of Antakya were labeled by our team into two groups: partially or fully collapsed (D) buildings, and buildings of damages other than collapse (P).



Antakya city region, divided to blocks (left), a sample block post-event satellite image (right).

Methods

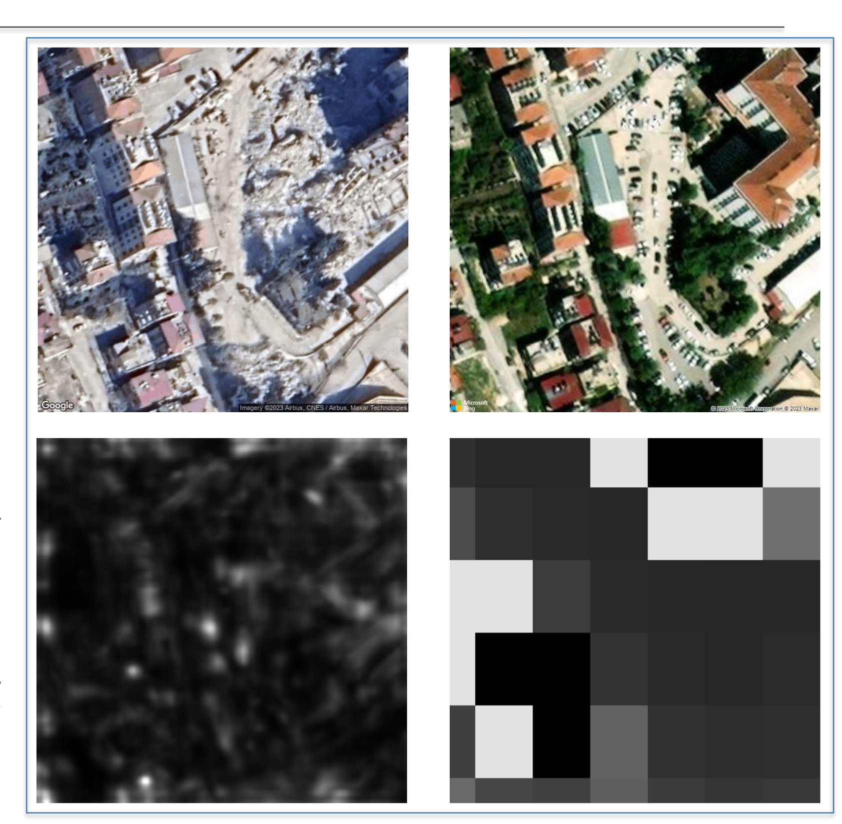
Visual strategy: Appending damage proxy maps (channels) to RGB satellite images.

Machine Learning strategies:

- Two deep CNN- and ViT-based segmentation models were devised.
- A total of 6 segmentation models with different channel augmentation were obtained.
- A pixel-wise deep ensemble learning was carried out.

Damage detection:

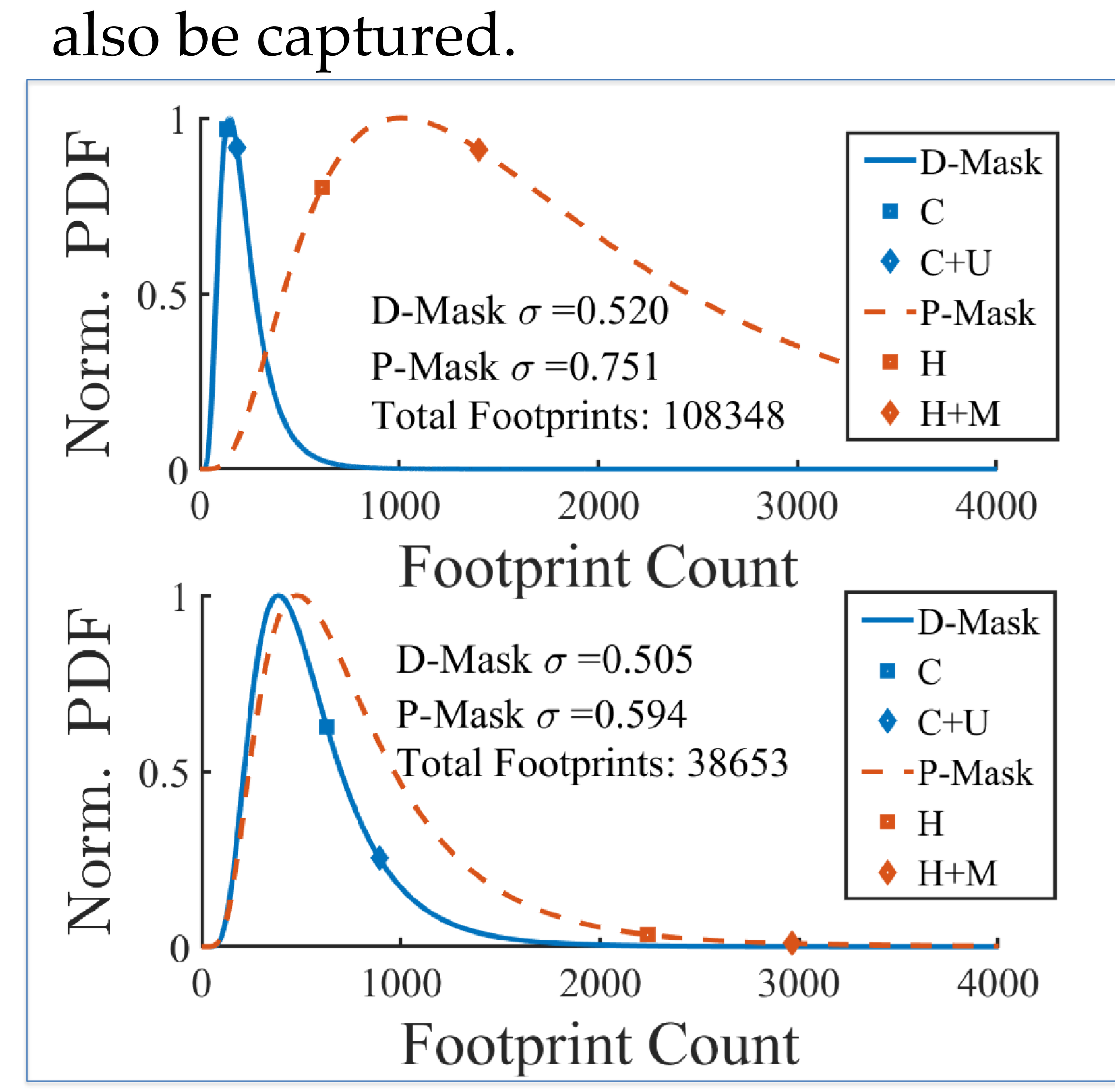
- Building footprint boundaries were taken from Microsoft[5]
- If damage segmentations overlapped a building's footprint over a threshold, then that building was labeled as damaged.



A block's (Top left to right): Pre- and Post-event satellite images for a block, (Bottom left to right): general-purpose CD model[3] and NASA ARIA[4] maps for that block.

Results

- Government damage survey classes were: Collapsed (C), Urgent Demolition (U), Heavily (H), and Moderately Damaged.
- We compared C and U with the segmentation label D, and H and M with the segmentation label P.
- Model uncertainty is captured by fitting a log-normal distribution to the damage detection results with different thresholds.
- This way, less severe damages could also be captured.



Gaziantep damage assessment (top), Maras damage assessment (bottom).

Conclusions

- Incorporating damage-proxy map channels and pixel-wise deep ensemble learning into satellite images boosts the generalizability into unseen urban textures.
- Treating less severe damages as more uncertain allows for effective estimation of damage severities.

References

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