An AI Classifier for Post-Disaster Aerial Imagery

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Outline

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Motivation

Civil Air Patrol (CAP) collects thousands of aerial images after disasters!

Source: http://units.flwg.us/FL249/airborne-photography.aspx

Images are used to assess damage to homes and infrastructure

But it can be hard to find the most useful ones.
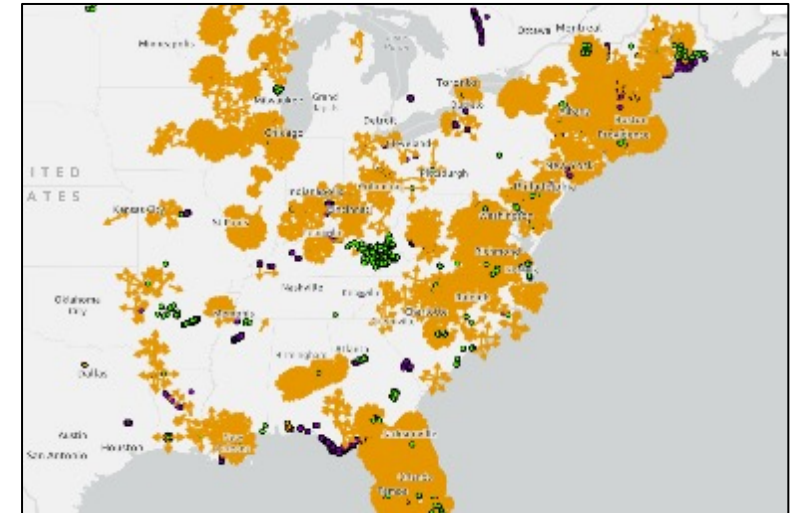
We need a way to filter the images to find the most useful ones

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MIT LL previously trained an artificial intelligence model to identify the contents of images

MIT LL developed a labeled CAP dataset, the Low Altitude Disaster Imagery (LADI) dataset, as part of a NIST-funded effort and released it open source in 2020.
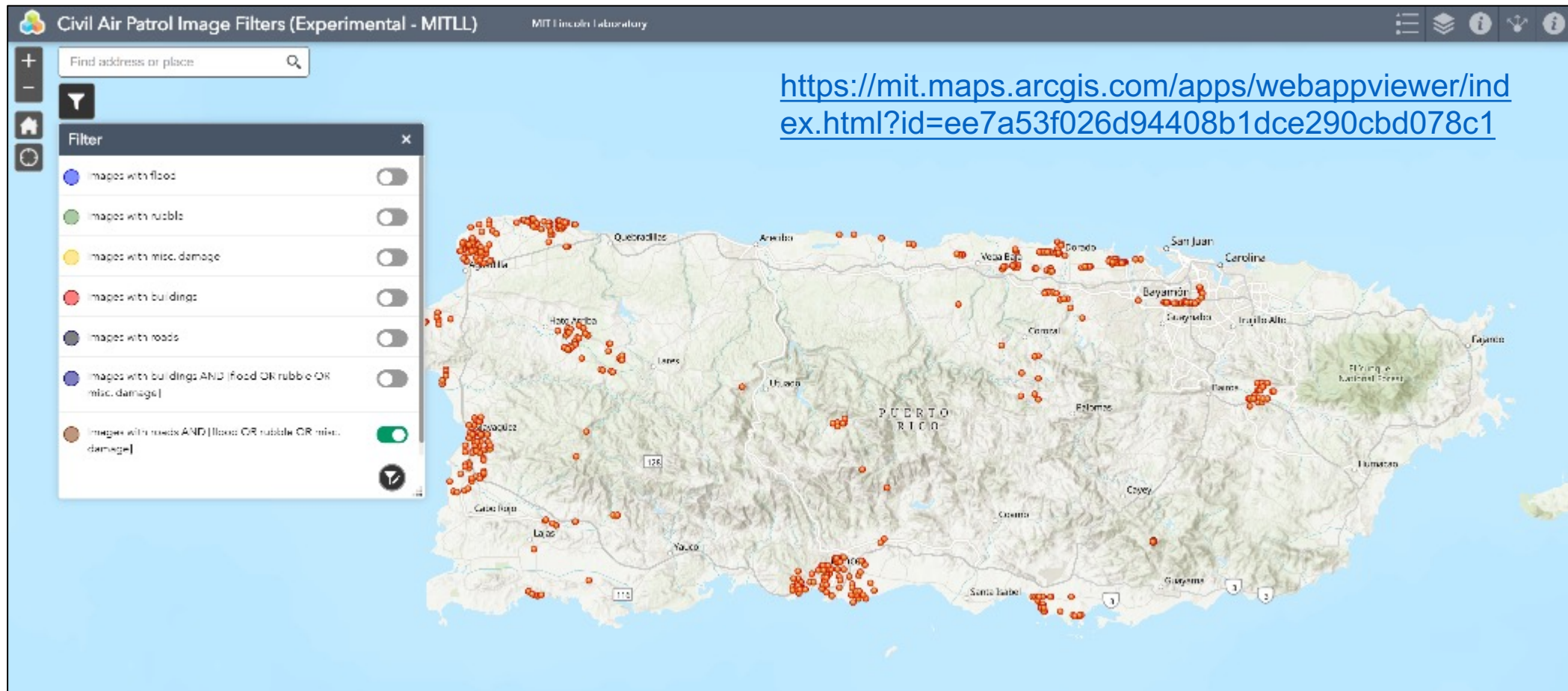
Demonstrations
- 2021: Hurricane Ida, Kentucky Tornadoes
- 2022: Hurricanes Fiona, Ian

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New capability to filter points to find ones that show damage or other features of interest

The classifier had not been validated and had middling performance on new data.

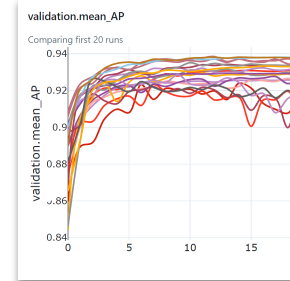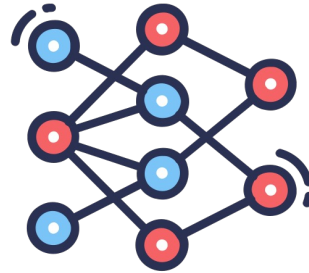LINCOLN LABORATORY
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Project overview

Goal: All new CAP images will receive labels when they are uploaded through the FEMA CAP image uploader, so that we can filter the images when doing damage assessments.

1. Create new training data
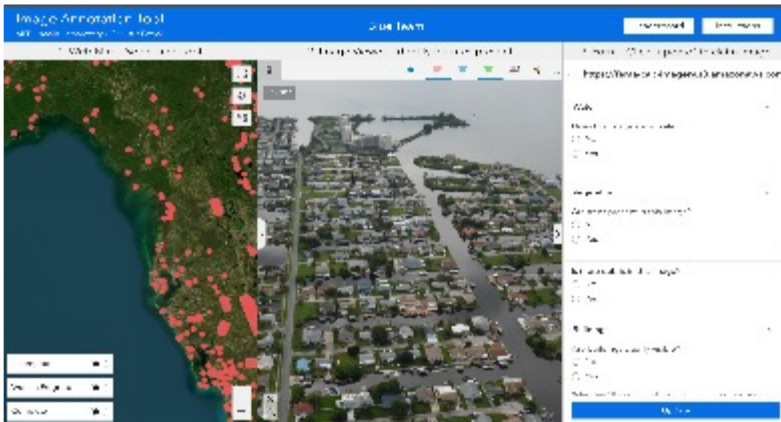
2. Retrain the AI model

3. Release LADI v2 dataset and model open source

Crowdsourcing campaign overview

- **Photos from all federal disasters in 2023 and numerous historic incidents**
  - **10,086 images in two rounds (4035, 6051)**
  - **Hurricanes, floods, tornadoes, earthquakes, fires**
  - **Contiguous US, Alaska, Hawaii, and some territories**

- **Triplicate reviews**
  - **46 volunteers from CAP FEMA damage assessment team participated**
  - **Three teams: Yellow, Green, Blue**
  - **Over 250 estimated man-hours**

- **16 questions per image**
  - **Water, trees, debris, buildings, roads, bridges**
  - **Presence of features and damage to features**
  - **Open text field**

- **Campaign dates: December 19-30, 2023**

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Questions

- **Does this image show water?**
  - **Is there clear evidence of flooding (any water that is not normally there?)**
    - **Is there clear evidence of flooding around structures?**
- **Are trees present in this image?**
  - **Are any trees damaged? (uprooted, downed, flooded, burned)**
- **Is there debris in this image?**
- **Are buildings clearly visible?**
  - **Does this image clearly show any affected buildings?**
  - **Does this image clearly show any buildings with minor damage?**
  - **Does this image clearly show any buildings with major damage?**
  - **Does this image clearly show any destroyed buildings? (wind, fire)**
- **Are roads clearly visible?**
  - **Does this image clearly show damaged roads? (flood, pavement damage/washout, debris)**
- **Are bridges clearly visible?**
  - **Does this image clearly show damaged bridges? (flood, pavement damage/washout, debris)**
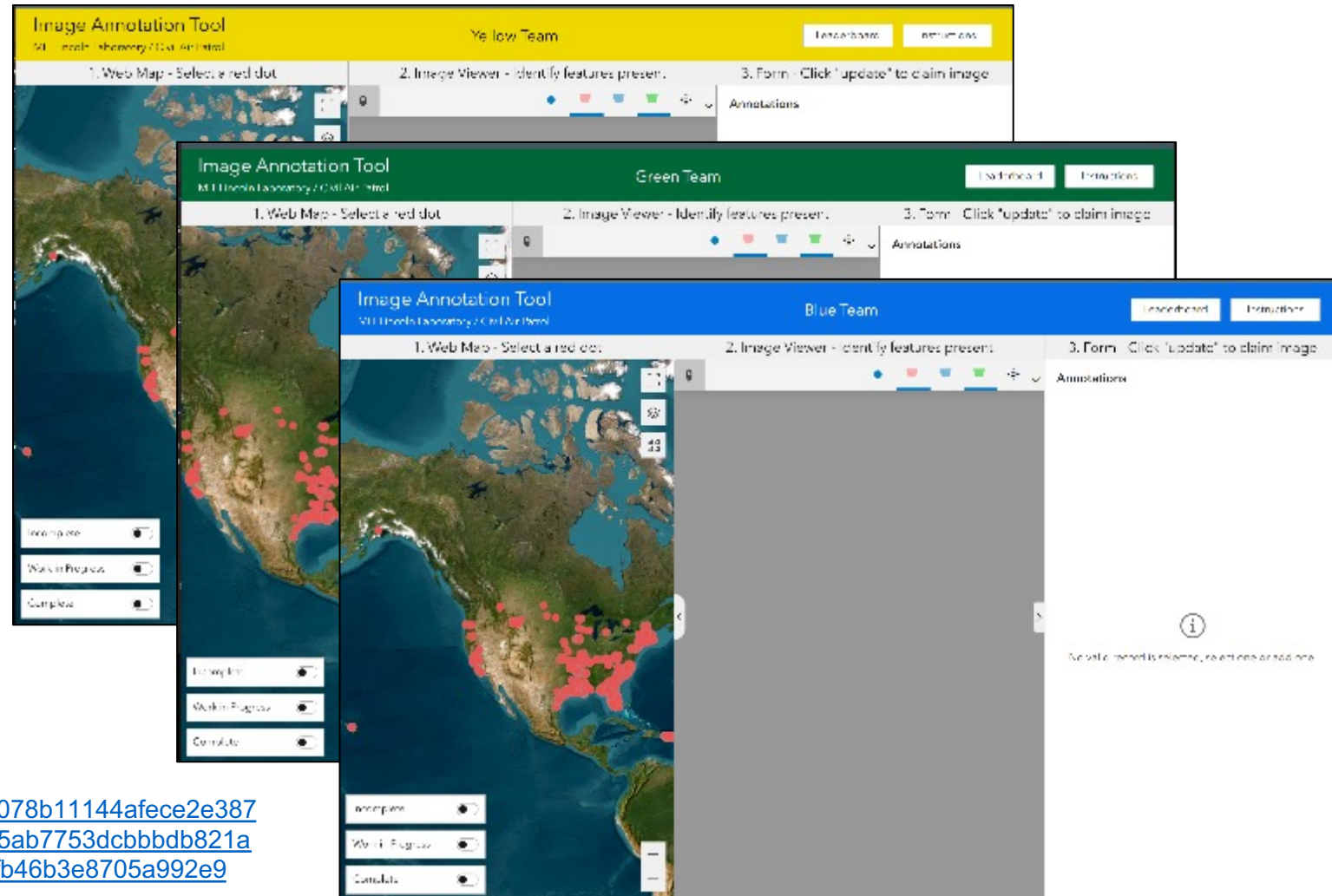- **Please describe any other useful information this image provides.**

Crowdsourcing app architecture
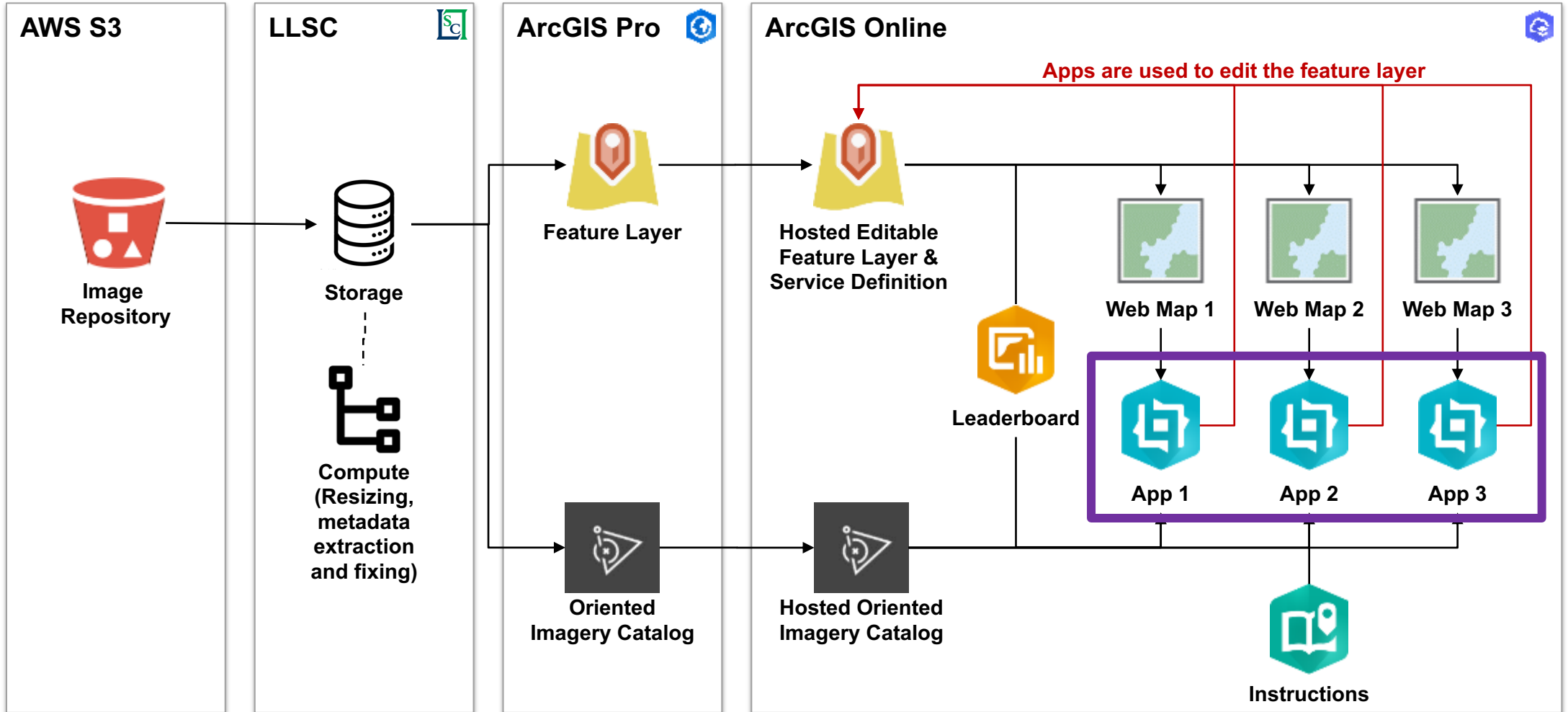
Three apps, one for each team

- **The apps are the same except for the color-coded header.**

- **Access controlled through ArcGIS Online in collaboration with FEMA.**

Yellow: https://experience.arcgis.com/experience/3f627ea99ab44078b11144afece2e387
Green: https://experience.arcgis.com/experience/f1575e74fcd5425ab7753dcbbbdb821a
Blue: https://experience.arcgis.com/experience/12fa91ed79234f0fb46b3e8705a992e9

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Leaderboard

Usernames redacted for privacy

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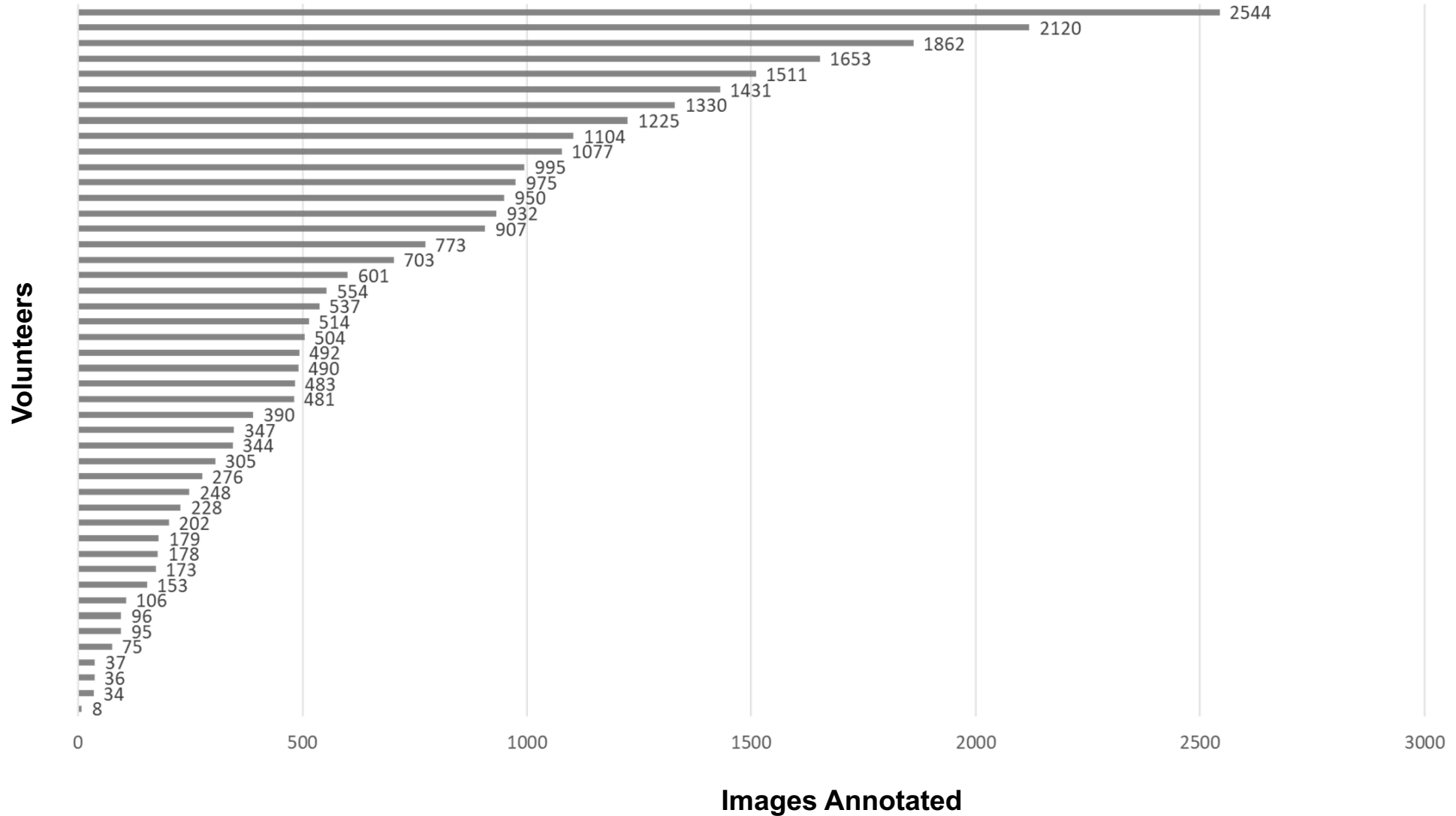
Results

Training approach

Data Preparation

- **Majority vote for annotation**
- **Image Augmentations**
  - Resize, Crop, Color Jitter, Normalize
- **Train/Validation/Test splits**
  - Train: 8k (2015-2022)
  - Validation: 1k (2015-2022)
  - Test: 1k (2023)

Training

- **Evaluate various open-source architectures/base models**
- **Select top 5 base models, run hyperparameter tuning**
  - Learning rate
  - Optimizer algorithm
- **Select top candidates**
  - Considering performance, model size

AI base models evaluated

- **Sourced 25 pre-trained image classification models from 🤗 Hugging Face repositories**

- **Fine-tuned on crowdsourced data using the MIT LL TX-Green super computer**

- **Selected top-5 candidates using mean Average Precision metric on Validation set**

- **Selected two final candidates based on different architectures**
  - LADI-v2-classifier-small (based on google/bit-50)
  - LADI-v2-classifier-large (based on microsoft/swinv2-large-patch4-window12to16-192to256-22kto1k-ft)

- **Will train final versions with validation and test set included for deployment**

- apple/mobilevitv2-1.0-imagenet1k-256
- facebook/convnextv2-huge-22k-384
- facebook/convnextv2-large-22k-224
- facebook/deit-base-distilled-patch16-224
- facebook/deit-base-patch16-224
- google/bit-50
- google/efficientnet-b0
- google/efficientnet-b7
- google/mobilenet_v1_1.0_224
- google/mobilenet_v2_1.0_224
- google/vit-base-patch16-224-in21k
- google/vit-base-patch32-224-in21k
- google/vit-base-patch32-384
- google/vit-huge-patch14-224-in21k
- google/vit-large-patch16-224-in21k
- google/vit-large-patch16-384
- microsoft/beit-base-patch16-224-pt22k
- microsoft/focalnet-base
- microsoft/resnet-152
- microsoft/resnet-50
- microsoft/swin-large-patch4-window7-224-in22k
- microsoft/swin-tiny-patch4-window7-224
- microsoft/swinv2-large-patch4-window12-192-22k
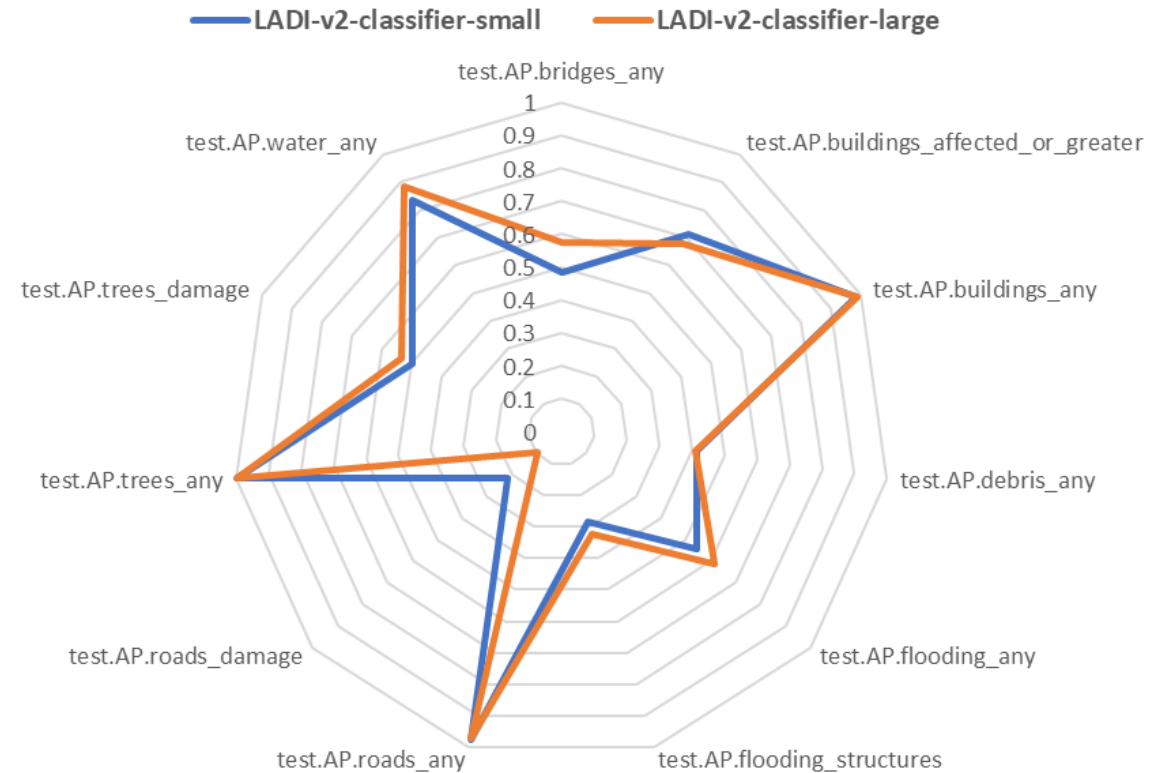- **microsoft/swinv2-large-patch4-window12to16-192to256-22kto1k-ft**

Best candidate performance

Average precision (AP) of LADI-v2-classifiers (small, large) on validation and test sets. Higher is better.
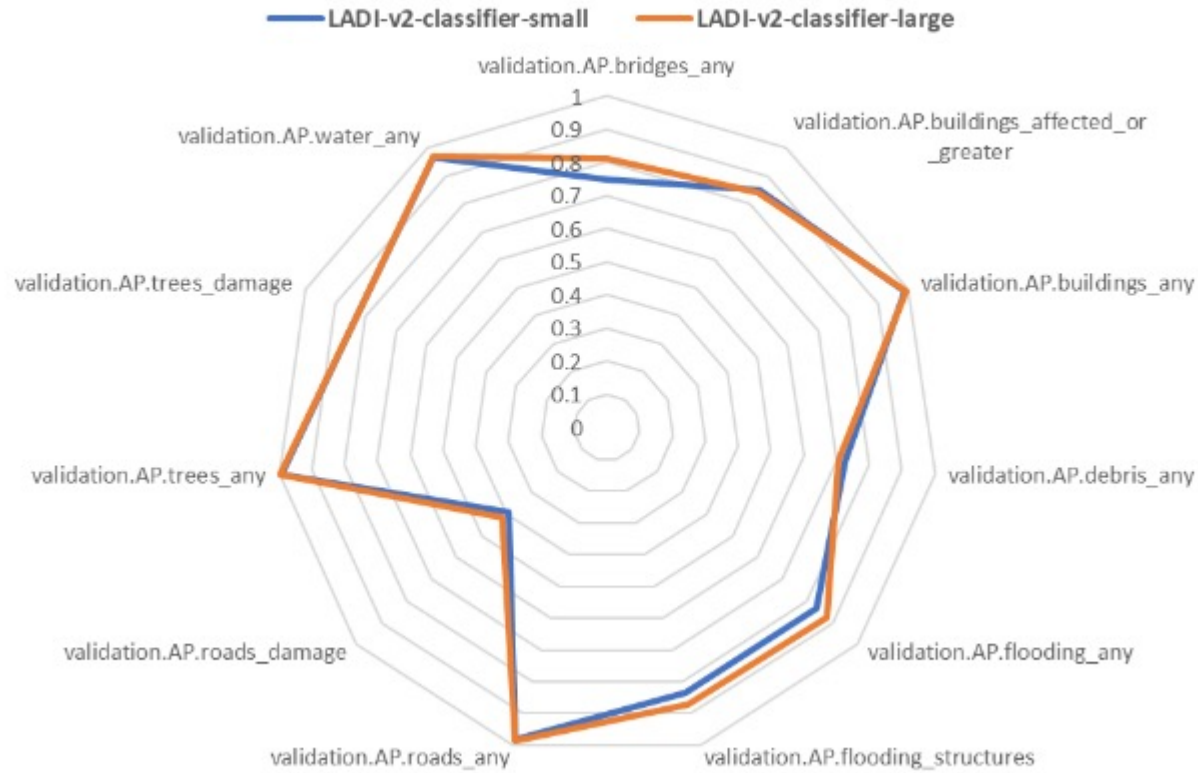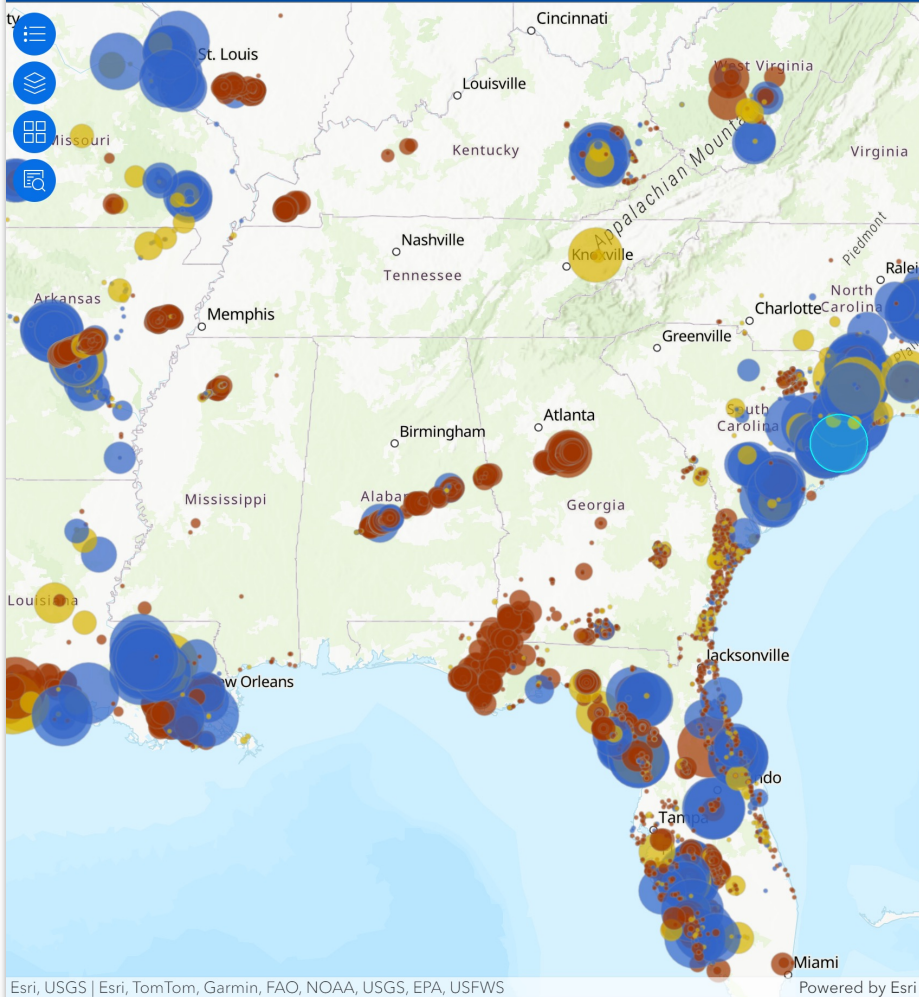

Performance degradation observed in out-of-sample prediction (2023 test set vs. 2015-2022 validation set), especially in damage-related categories. Performance of presence of water, trees, roads, and buildings is robust.

Demo

https://experience.arcgis.com/experience/136c316e81db4a0e9af924c7d20ec8cb

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Proposed AWS implementation architecture

Build

Huggingface

LADI-v2-classifier-small
LADI-v2-classifier-large

Models hosted on hf

GitHub

LADI-classifier
inference demo
script repository

Tutorial for using model

LADI-classifier docker
repository

*Build docker
image for EC2
deployment*

Deploy

AWS Cloud

Amazon S3

fema-cap-imagery bucket

new images added to queue

Amazon SQS

new-images-queue

Queue triggers batch job

AWS Batch

Batch Job

g4dn.xlarge EC2
instance

ArcGIS Online

Label feature service

*inference script writes
output to AGOL feature
service via API calls*

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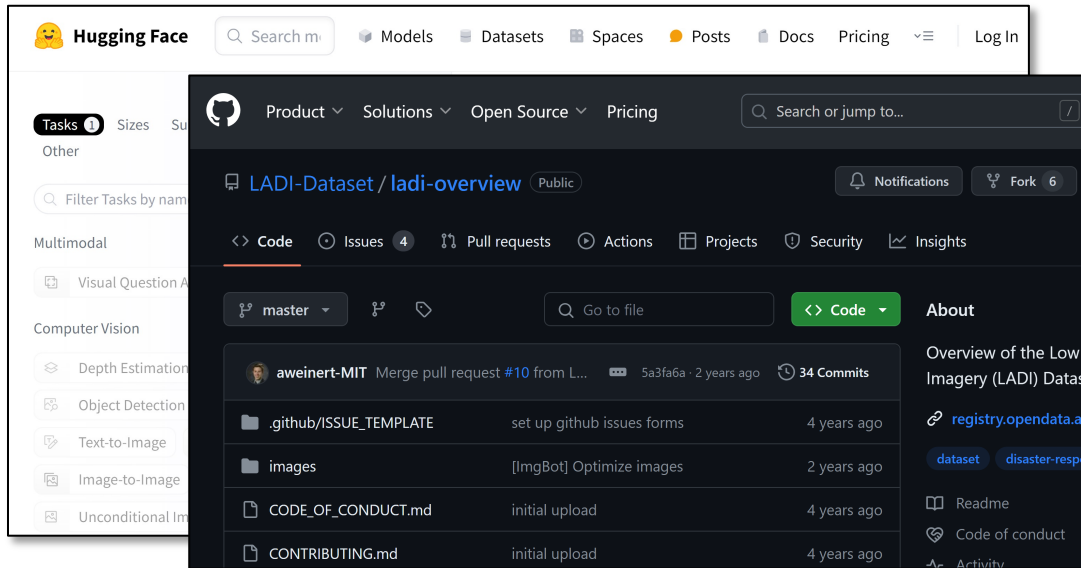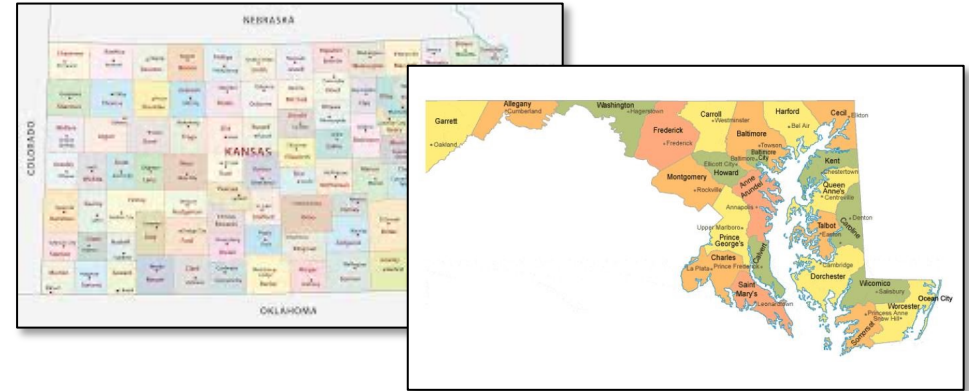MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Next steps

Project Completion

1. **Publish LADI v2 data and model open source on HuggingFace and GitHub by end of April, 2024**

2. **Support partners to deploy on AWS**

Future Development

1. **Fine tune and deploy for state partners**

2. **Implementations with Vision-Language Models**

Examples of "notes" input by volunteers
Agricultural rows
railroad bridges, tree debris against bridge pilon.
Power line/power station infrastructure; area around this infrastructure is flooded.
The house without roof shingles in the upper right corner has a dumpster present - possibly regular work or remondel. Not clear enough to declare it major damage.
A couple foundations with debris and a bulldozer on site. Other imagery layers show empty clean lots. Not obvious that this is a storm-related destroyed building.

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For updates on the LADI v2 dataset and models, follow us on GitHub:
https://github.com/ladi-dataset

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