Disaster Scene Description and Indexing (DSDI)

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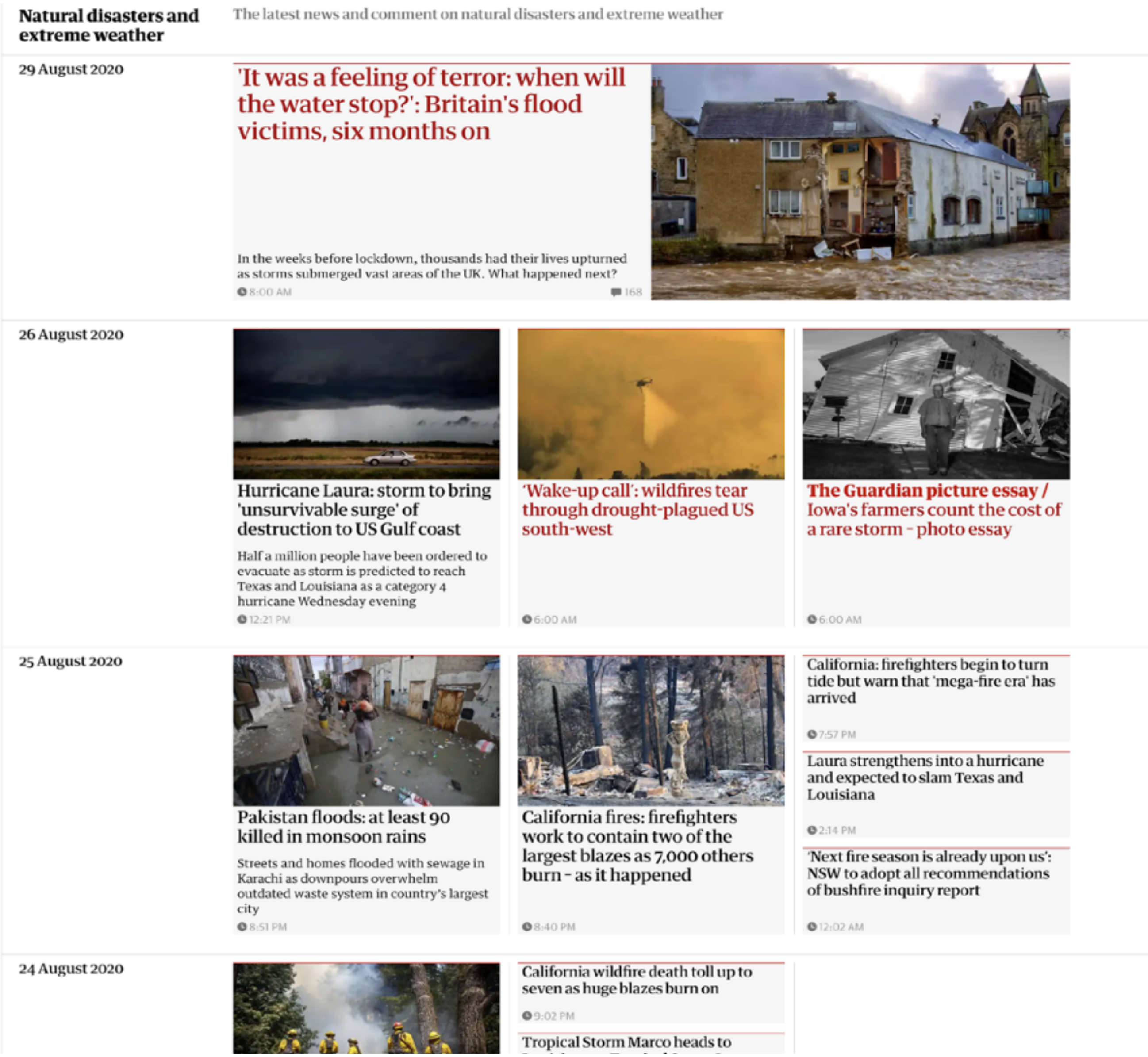
NIST Disclaimer

Introduction - DSDI

- Video and imagery data can be extremely helpful for public safety operations.
- Natural Disasters, e.g.,
  - Wildfire
  - Hurricanes
  - Earthquakes
  - Floods
- Man-made Disasters, e.g.,
  - Hazardous material spills
  - Mining accidents
  - Explosions

Some recent natural disasters.



Natural disasters and extreme weather

The latest news and comment on natural disasters and extreme weather

29 August 2020

'It was a feeling of terror: when will the water stop?': Britain's flood victims, six months on

In the weeks before lockdown, thousands had their lives upturned as storms submerged vast areas of the UK. What happened next?

8:00 AM 168

26 August 2020

Hurricane Laura: storm to bring 'unsurvivable surge' of destruction to US Gulf coast

Half a million people have been ordered to evacuate as storm is predicted to reach Texas and Louisiana as a category 4 hurricane Wednesday evening

12:21 PM

'Wake-up call': wildfires tear through drought-plagued US south-west

6:00 AM

The Guardian picture essay / Iowa's farmers count the cost of a rare storm - photo essay

6:00 AM

25 August 2020

Pakistan floods: at least 90 killed in monsoon rains

Streets and homes flooded with sewage in Karachi as downpours overwhelm outdated waste system in country's largest city

8:51 PM

California fires: firefighters work to contain two of the largest blazes as 7,000 others burn – as it happened

8:40 PM

California: firefighters begin to turn tide but warn that 'mega-fire era' has arrived

7:57 PM

Laura strengthens into a hurricane and expected to slam Texas and Louisiana

2:14 PM

'Next fire season is already upon us': NSW to adopt all recommendations of bushfire inquiry report

12:02 AM

24 August 2020

California wildfire death toll up to seven as huge blazes burn on

9:02 PM

Tropical Storm Marco heads to

Source: The Guardian Newspaper

Introduction - DSDI

- Situational awareness in disaster-affected areas is crucial for the safety and effectiveness of first responders.
- Oftentimes, the communication systems go down in major disasters, which makes it very difficult to get any information regarding the damage from affected populations.
- Aerial imagery can quickly provide awareness across wide stretches of affected regions.
- Current analysis of aerial imagery is largely manual - automated methods could significantly improve response time and effectiveness.

Introduction - DSDI

- Computer vision capabilities have rapidly advanced recently with the popularity of deep learning.
  - Research groups have access to large image and video datasets for various tasks.
- However, the capabilities do not meet public safety needs.
  - Lack of relevant training data for public safety applications.
- Most current image and video datasets have no public safety hazard labels.
  - State-of-the-art systems trained on such datasets fail to provide helpful labels.

Training Dataset

- In response, the New Jersey Office of Homeland Security and MIT Lincoln Laboratory developed a dataset of images collected by the Civil Air Patrol of various natural disasters.
- The Low Altitude Disaster Imagery (LADI) dataset was developed as part of a larger NIST Public Safety Innovator Accelerator Program (PSIAP) grant.
- Two key properties of the dataset are:
  - Low altitude and oblique perspective
  - Disaster-related labels and imagery

Training Dataset

- The training dataset is based on the LADI dataset hosted as part of the AWS Public Dataset program.
- It consists of 20,000+ annotated images.
- The images are from the Atlantic hurricane season.
- Lower altitude criteria distinguishes the LADI dataset from satellite datasets to support development of computer vision capabilities with small drones operating at low altitudes.
- A minimum image size of 4MB was selected to maximize the efficiency of the crowd source workers; lower resolution images are harder to annotate.

Testing Dataset

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- A pilot testing dataset of about 5 hours of video was distributed for this task. The dataset included videos from USGS Nepal earthquake response.
- The testing dataset was segmented into small video clips (shots) of a maximum of 20 sec.
- The videos were from earthquake, hurricane, and flood affected areas.
- Total number of shots: 1825.

<u>Shot Statistics</u>
Min: 2 sec
Max: 20 sec
Median: 16 sec

Testing Data: Example Videos

Testing Dataset - Categories

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- Hierarchical labeling scheme: 5 coarse categories, each with 4-9 more specific annotations.

Damage	Environment	Infrastructure	Vehicles	Water
Misc. Damage	Dirt	Bridge	Aircraft	Flooding
Flooding/Water Damage	Grass	Building	Boat	Lake/Pond
Landslide	Lava	Dam/Levee	Car	Ocean
Road Washout	Rocks	Pipes	Truck	Puddle
Rubble/Debris	Sand	Utility Or Power Lines/Electric Towers		River/Stream
Smoke/Fire	Shrubs	Railway		
	Snow/Ice	Wireless/Radio Communication Towers		
	Trees	Water Tower		
		Road		

Annotation

- We used full time annotators instead of crowdsourcing.
- For each category, a practice page was created.
- This page included multiple examples for each label.
- The annotators were also given 2 videos as a test to mark the labels visible in them.
- This allowed the annotators to become familiarized with the task and labels before starting a category.

Annotation

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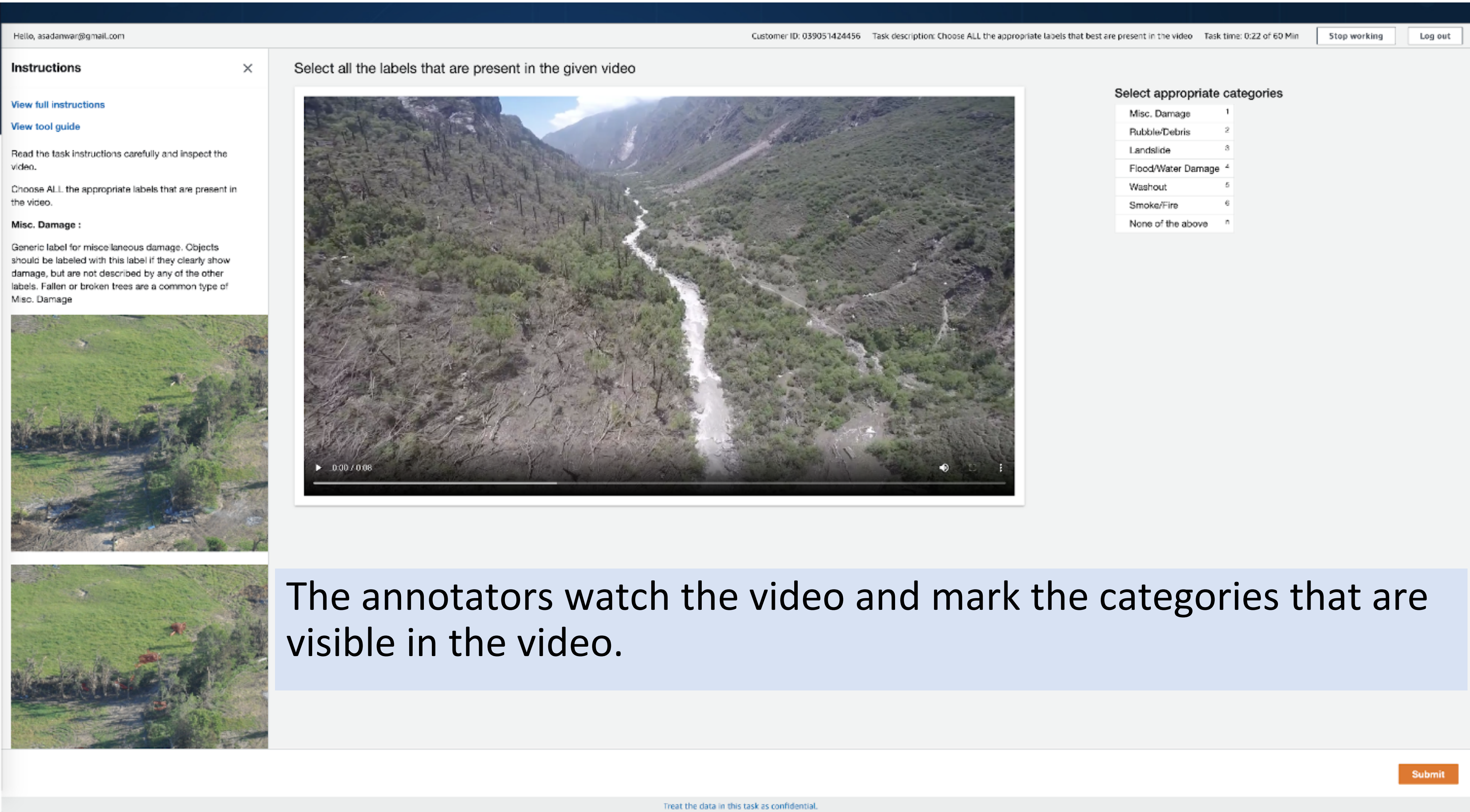
- We had 2 full time annotators to annotate the testing dataset.
- We used the Amazon Augmented AI (Amazon A2I) tool.
- The annotators worked independently on each category.
- For each coarse category, they marked all the specific labels that were present in the video.
- To create the final ground truth, for each shot, the union of labels were used.



The annotators watch the video and mark the categories that are visible in the video.

DSDI Task

- Systems are required to return a ranked list of up to 1000 shots for each of the 32 features.
- Each submitted run specified its training type:
  - LADI-based (L): The run only used the supplied LADI dataset for development of its system.
  - Non-LADI (N): The run did not use the LADI dataset, but only trained using other dataset(s).
  - LADI + Others (O): The run used the LADI dataset in addition to any other dataset(s) for training purposes.

Submissions

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1. **Number of Teams**

   9

2. **Number of Submissions**

   30

3. **LADI-Based Training**

   21

4. **LADI + Others**

   9

Evaluation Metrics

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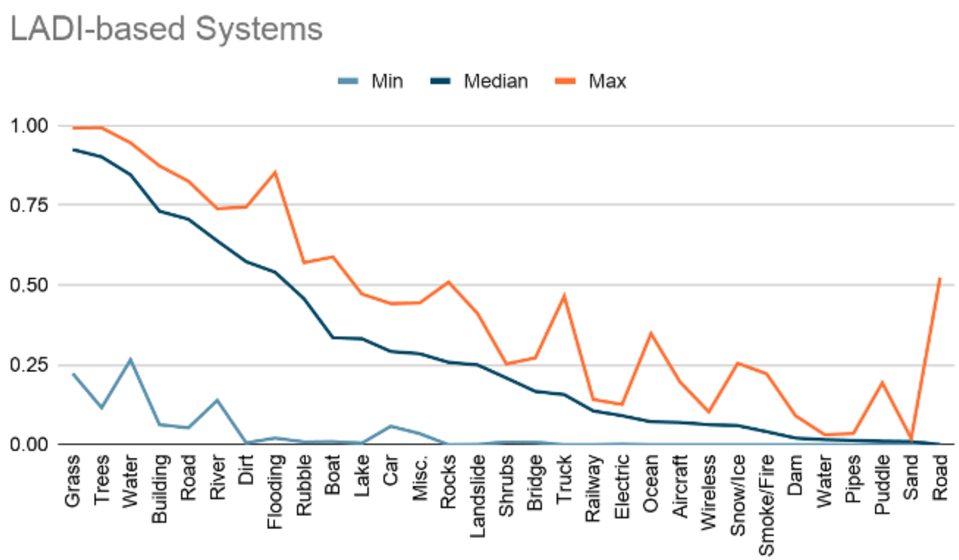
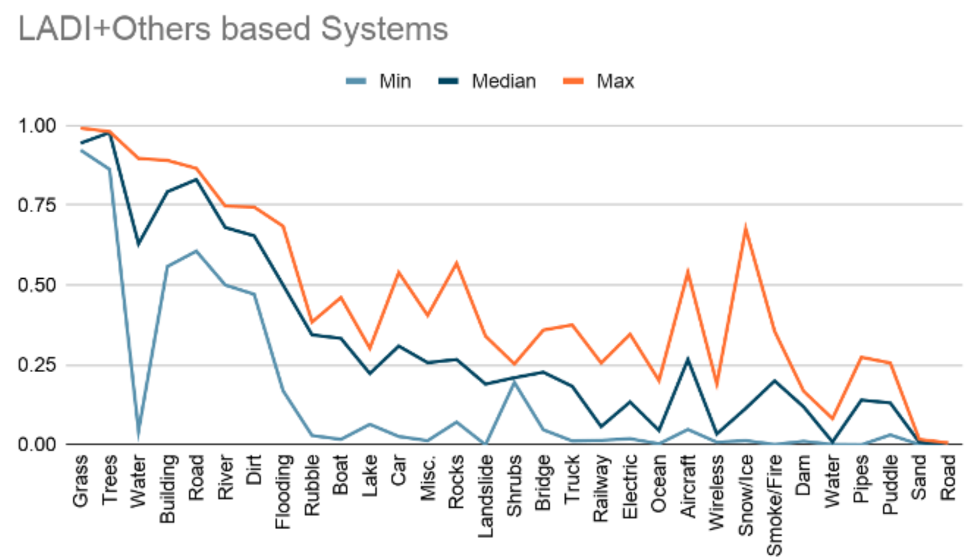
- The following evaluation metrics were used to compare the submissions:

Metric	Description
Speed	Clock time per inference (reported by participants).
Mean Average Precision (MAP)	Average precision is calculated for each feature, and the mean average precision reported for a submission.
Recall	True positive, true negative, false positive, and false negative rates.

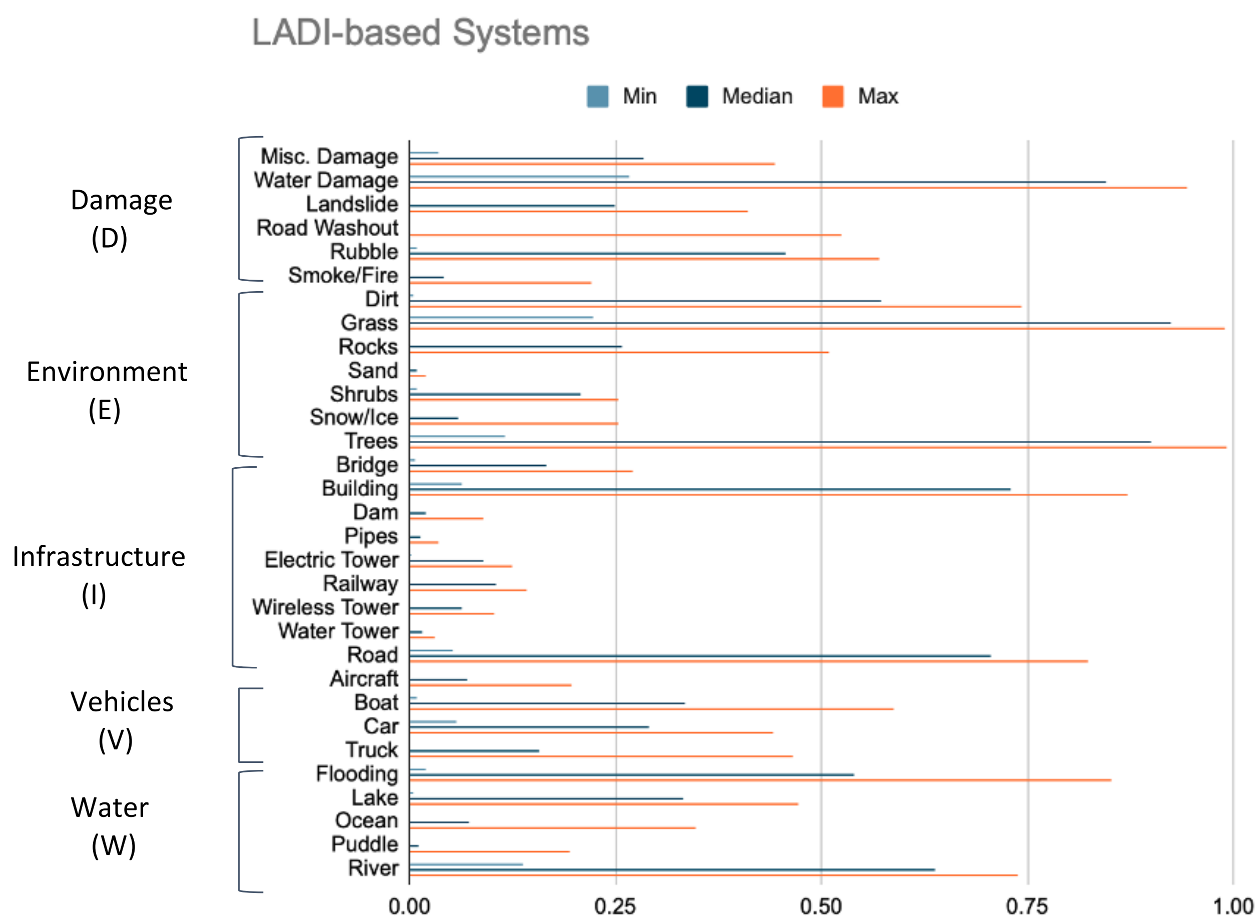
Results by Features



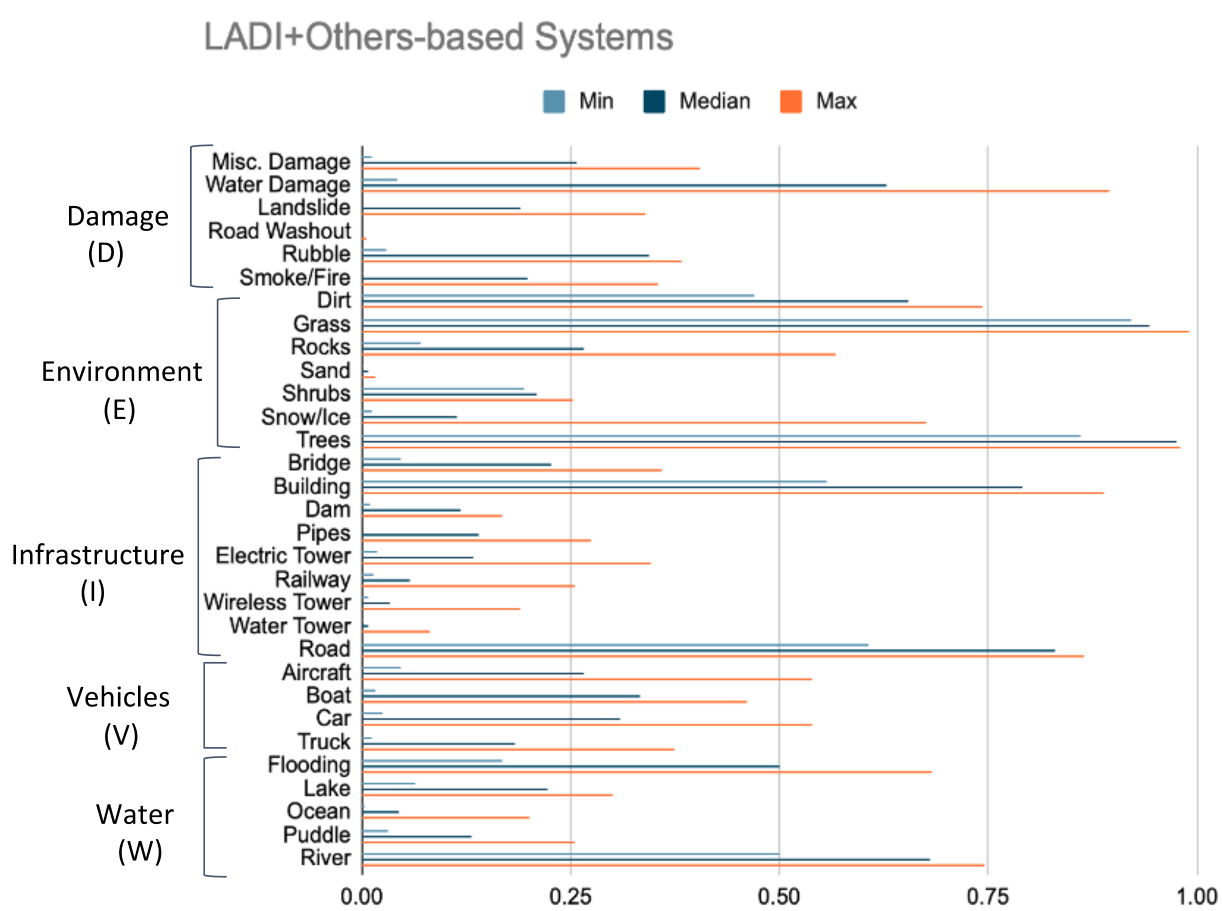


- Average precision values for each feature categorized by training type.
- 21 LADI-based runs ; 9 LADI+Others-based runs

Results by Categories

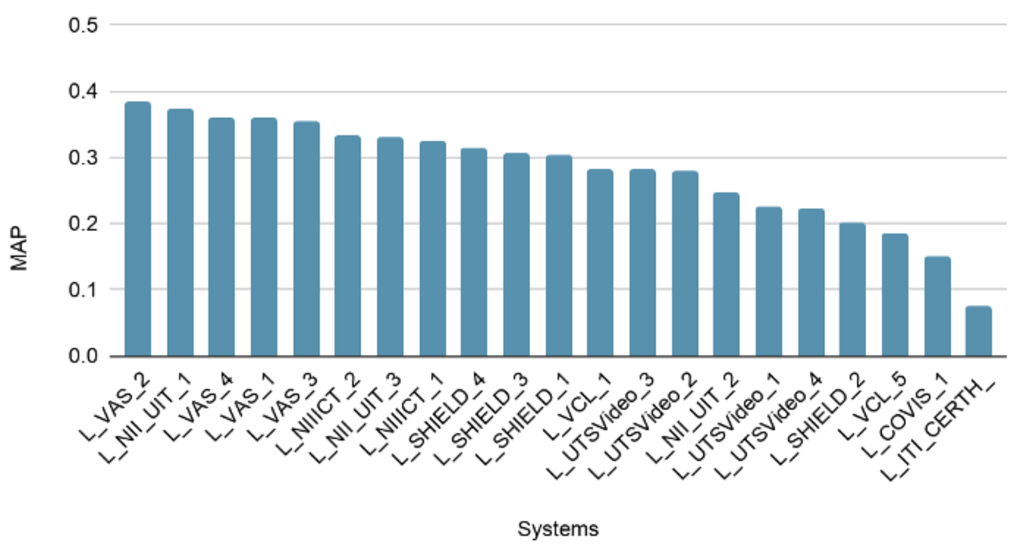


Results by Categories

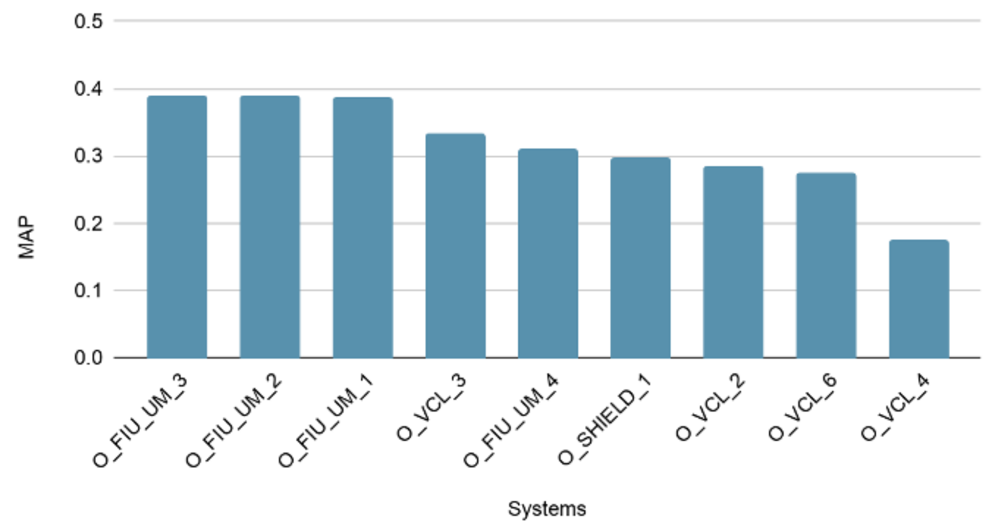


Results by Teams

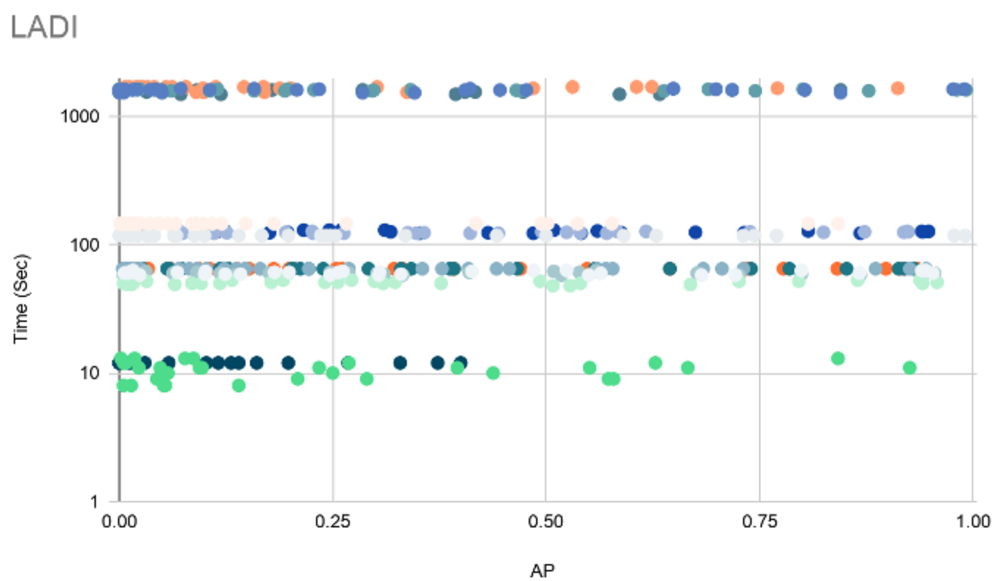
LADI-based Systems

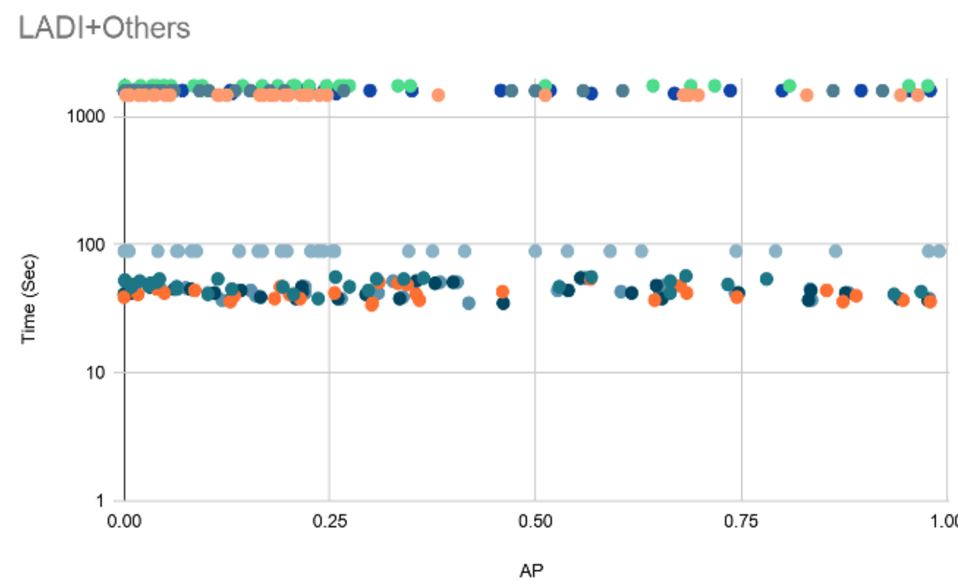


LADI+Others-based Systems



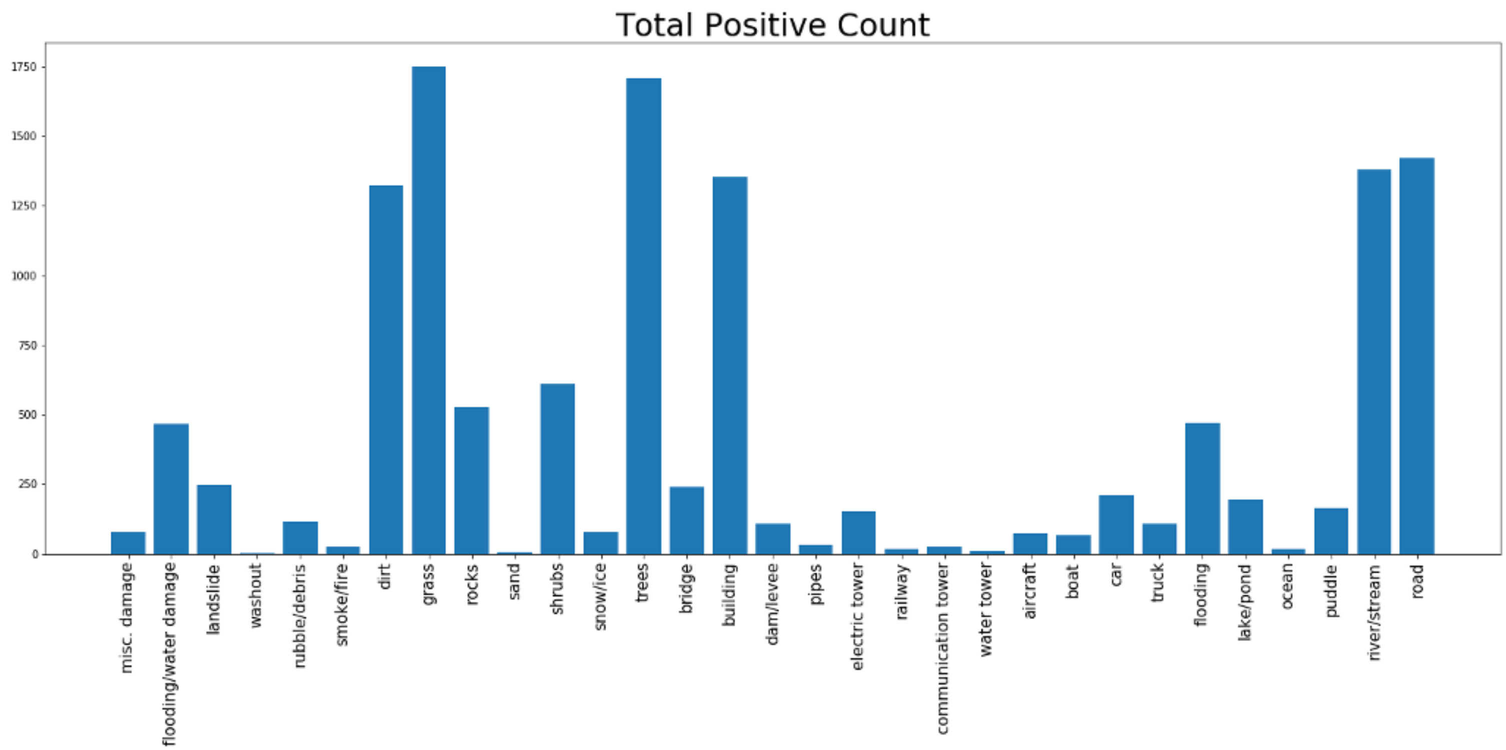
Efficiency





Each color represents a team’s AP scores.

Total Positives for Features



- Graph shows number of shots containing each feature.
- Some features (e.g. grass, trees, buildings, roads, etc.) occur much more frequently than others.

F-Measure

F-Score
0.0
0.2
0.4
0.6
0.8
Features
misc. damage
flooding/water damage
landslide
washout
rubble/debris
smoke/fire
dirt
grass
rocks
sand
shrubs
snow/ice
trees
bridge
building
dam/levee
pipes
electric tower
railway
communication tower
water tower
aircraft
boat
car
truck
flooding
lake/pond
ocean
puddle
river/stream
road
L_VCL_5
L_ITI_CERTH_1
L_VAS_1
O_VCL_2
L_UTSVideo_2
L_UTSVideo_3
O_VCL_3
O_VCL_4
L_UTSVideo_4
O_FIU_UM_1
L_NIIICT_2
L_NII_UIT_1
L_SHIELD_1
L_VCL_1
L_COVIS_1
L_VAS_2
L_VAS_4
L_VAS_3
L_UTSVideo_1
O_VCL_6
O_SHIELD_1
L_SHIELD_4
L_SHIELD_3
L_NIIICT_1
O_FIU_UM_2
L_NII_UIT_3
L_SHIELD_2
L_NII_UIT_2
O_FIU_UM_3
O_FIU_UM_4

Conclusion and Future Work

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- Successful pilot. Shows need for datasets and benchmarks in public safety domain.
- Challenges include:
  - Small dataset and limited resources for annotation.
  - Training and testing dataset should be from the same distribution. Hard to do with different nature of calamities.
- Teams performed reasonably well on labels that were well represented in the dataset.
- We plan to continue with the task for 2021 with similar amount of videos as testing data.

Thank you!

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