Empowering Disaster Response with Social Media and GeoAI: Opportunities and Challenges

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AutoCarto 2022@Redlands, CA

Session 9: Use and Misuse of Geographic Information in Social Media

CaGIS

GEAR Lab

Explore & Resolve

Increasingly Frequent Disasters

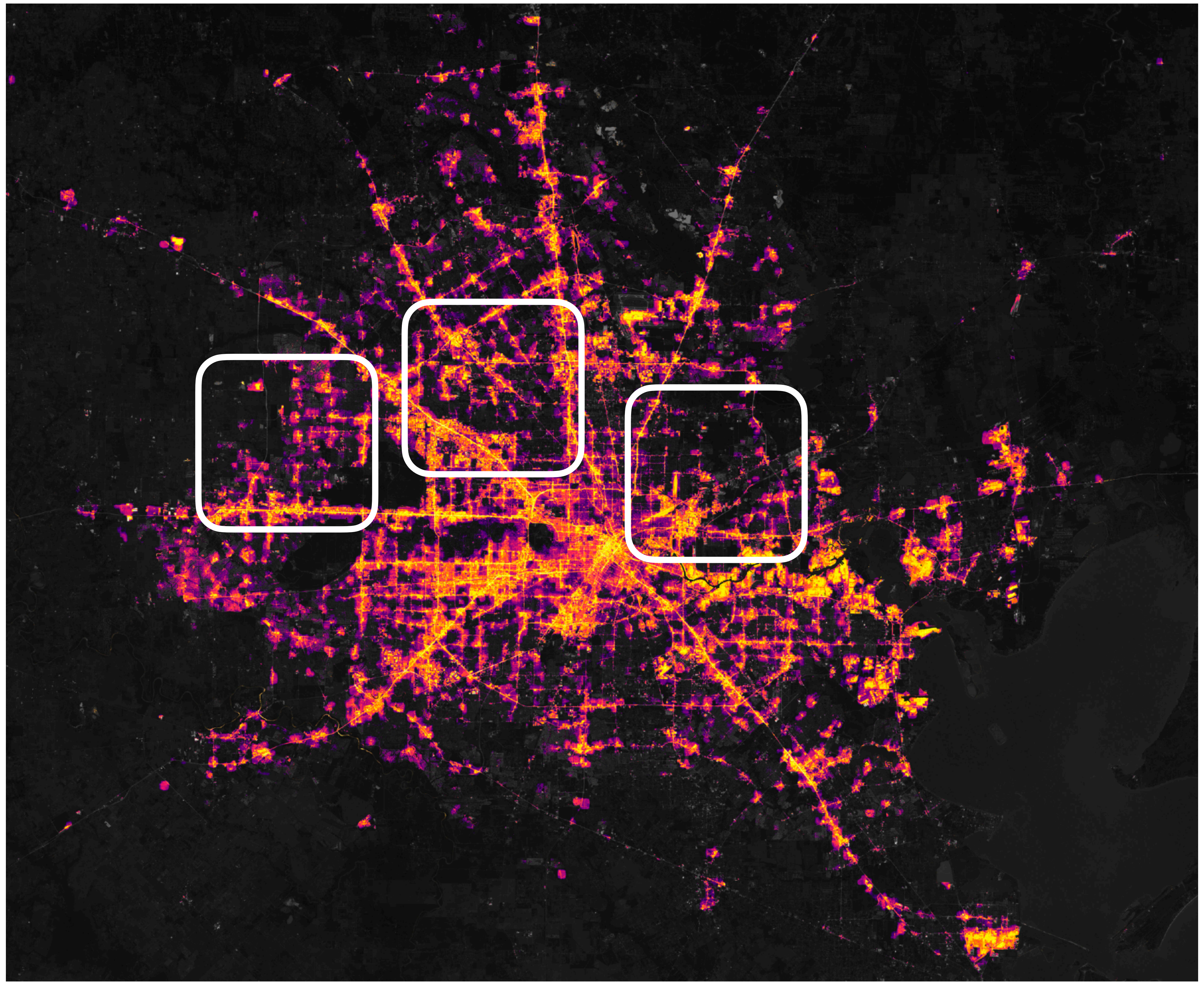
Wildfire, California 2020
(Source: New York Times)

Winter storm Uri, Texas 2021
(Source: Wikipedia)

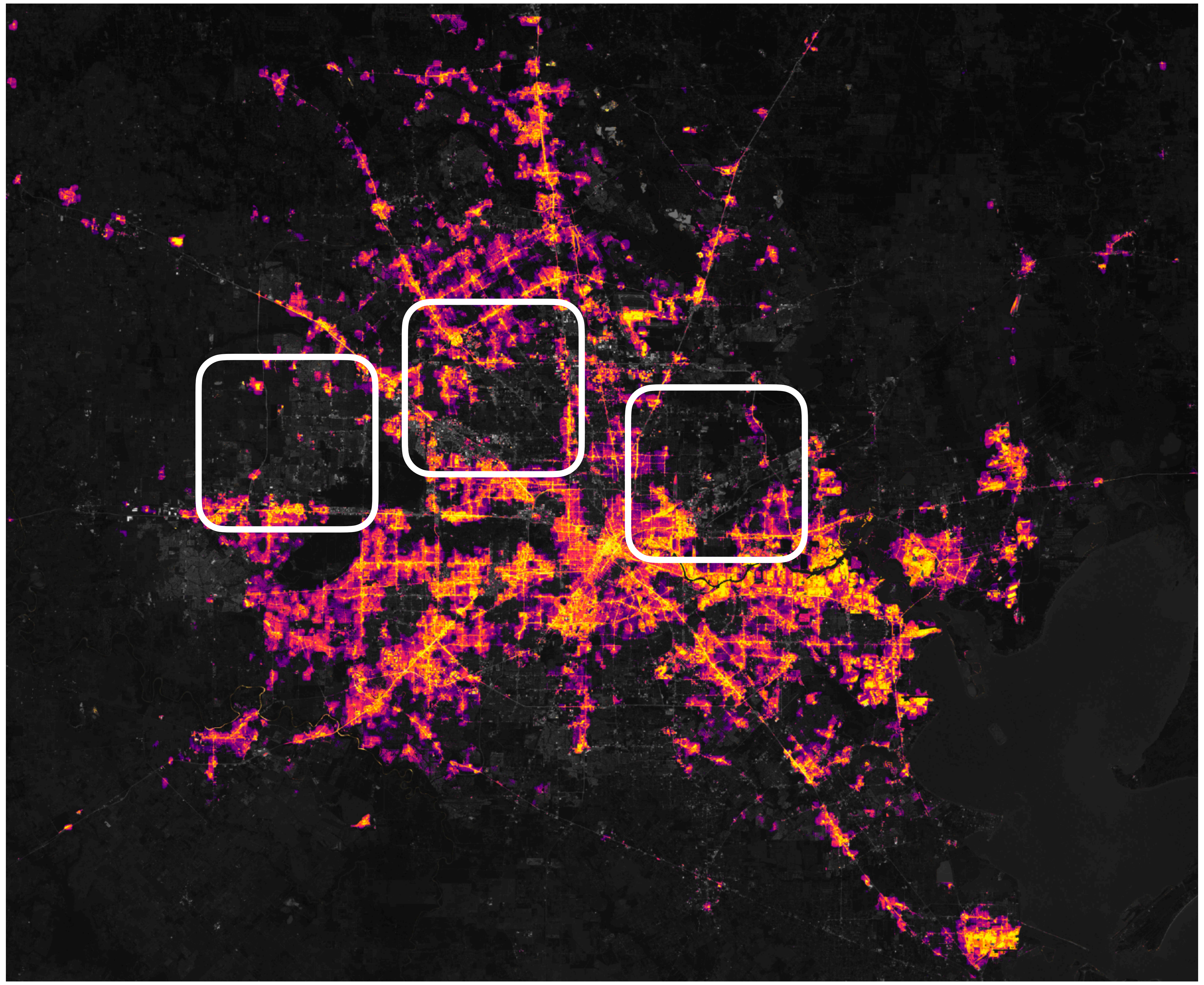
Beichuan Flash Flood, Sichuan 2022
(Source: NetEase)

Uneven Disaster Impacts

VIIRS Nighttime Light Image in Houston, United States



Feb 7, 2021 (Pre-Storm)



Feb 16, 2021 (Post-Storm)

Image Source: NASA

Social Media Data

Social media users in US
2008: 24%
2021: 82%

Accessible via any online devices at any place

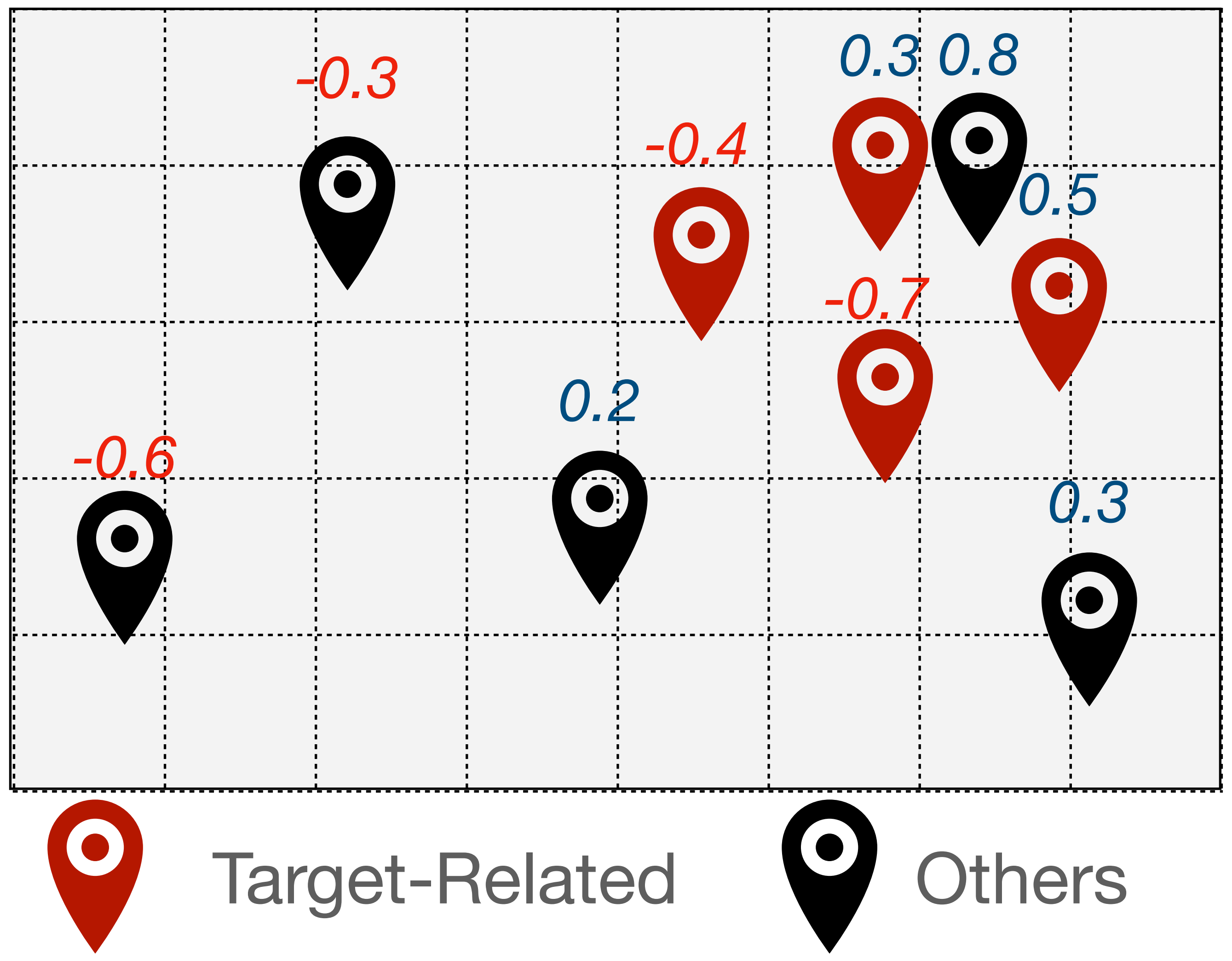
Twitter: 500 million/day
Facebook: 1 billion/day
Instagram: 40 million/day

Geographic information:
Geo-tags, coordinates, addresses, etc.

Real-time streaming data

Connections between human and events

Social Media Data - Challenges



Noises

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Biases

Research Questions

- ❖ How can we extract disaster information from noisy social media?
- ❖ Can social media data be used to improve disaster response?
- ❖ How can we remove the bias in social media data?

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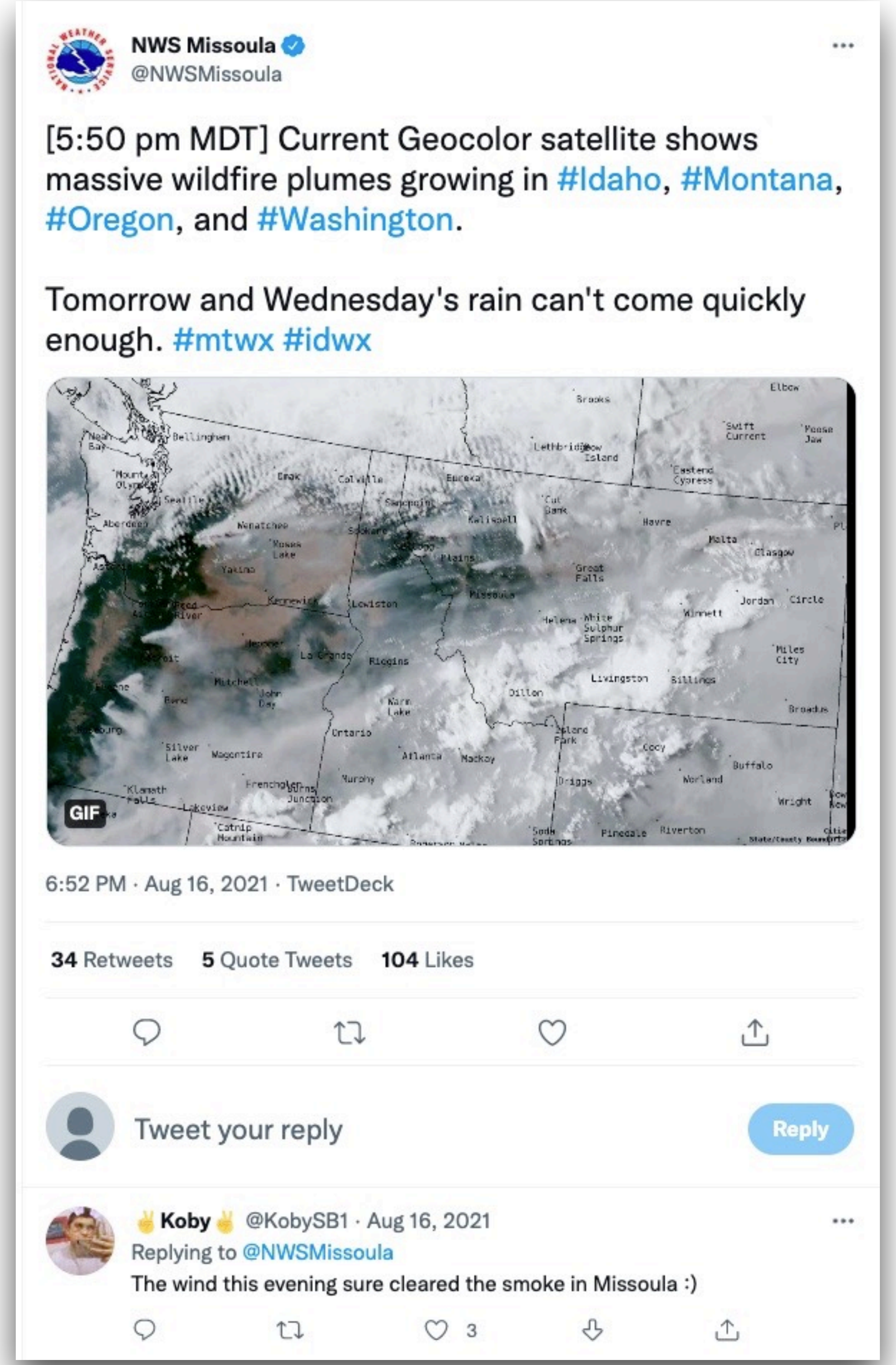
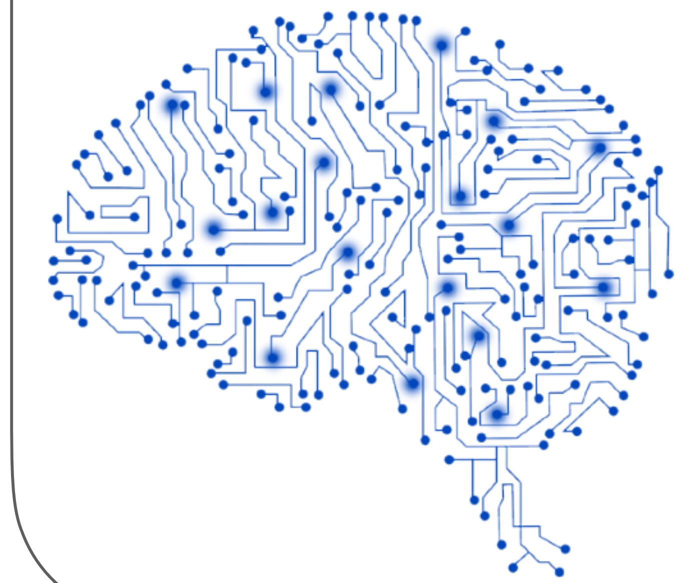
Disaster Information on Social Media



Mining Location-Based Disaster Information from Social Media

Classifier



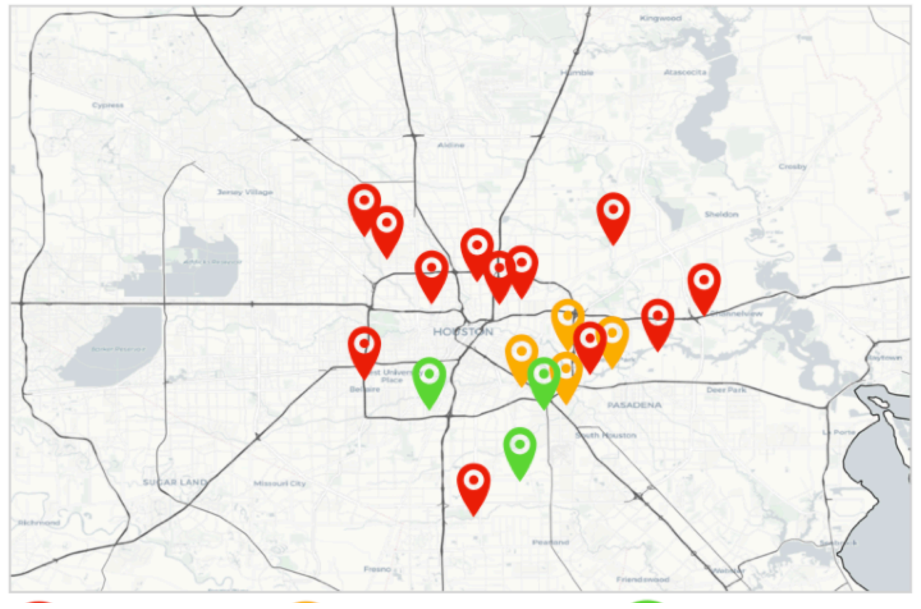
Toponym Recognition

"@houstonpolice My friends grandma is stuck in her attic 5742 Braeswood Blvd77096 Please try and help her"

"PLEASE PLEASE IN NEED OF RESCUE BEEN STRANDED FOR HOURS 6010 KASHMERE APT HOU TX 77026 @abc13houston @Fox26Houston @HoustonTX"

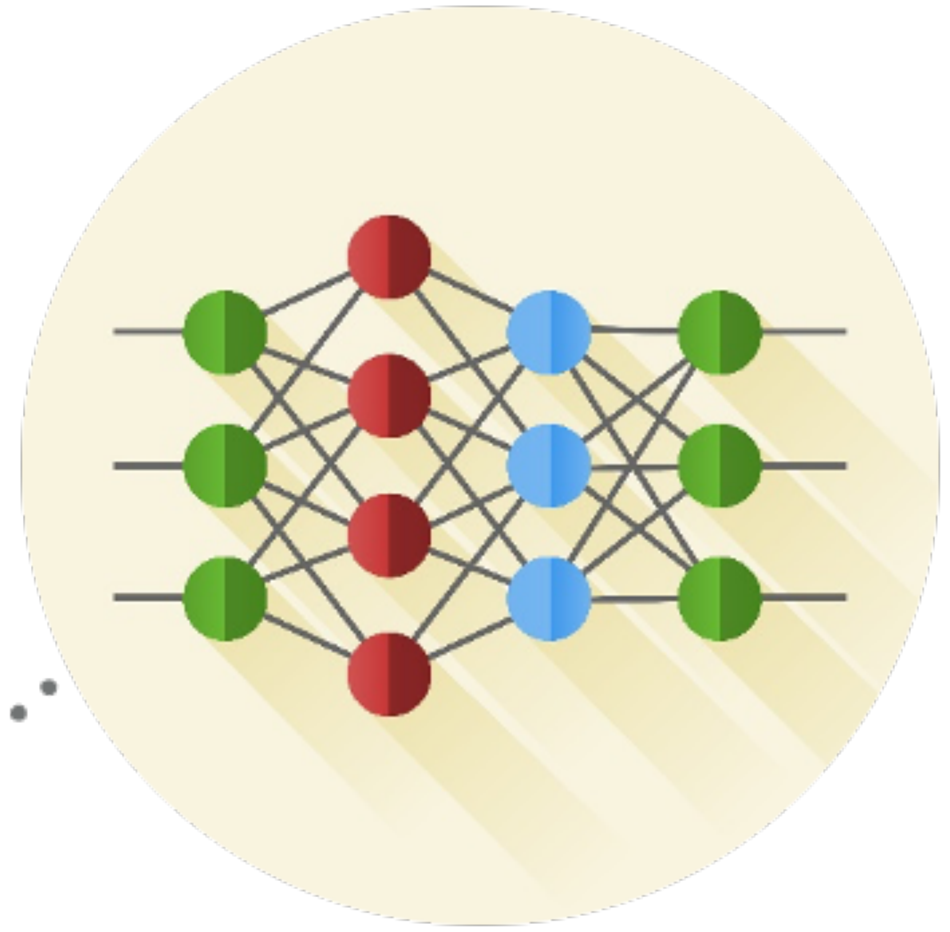
"#Houstonrescue 8518 Valley Forest Dr HTX 77078"

Toponym Resolution



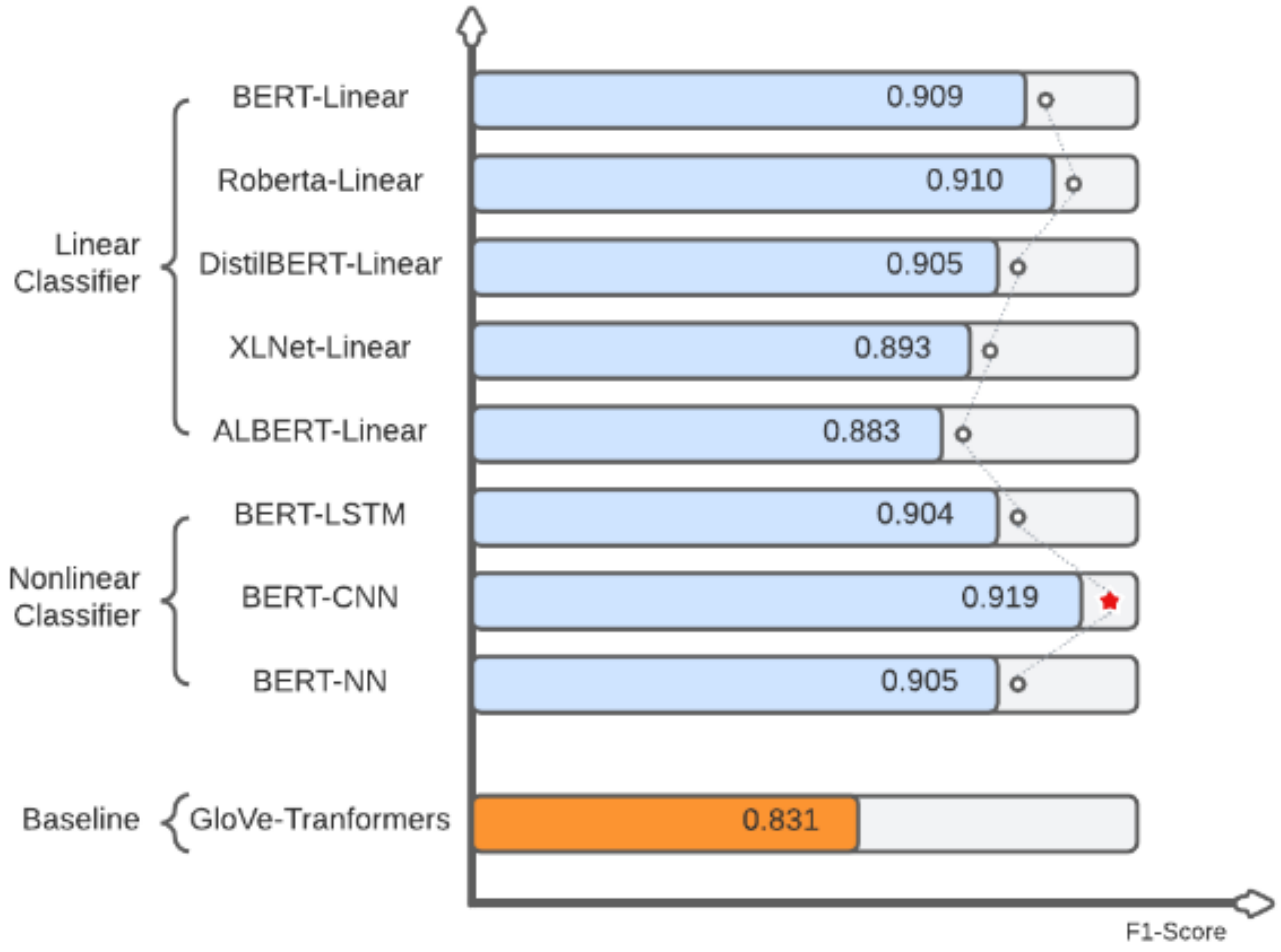
Mining Location-Based Disaster Information from Social Media

Language Models

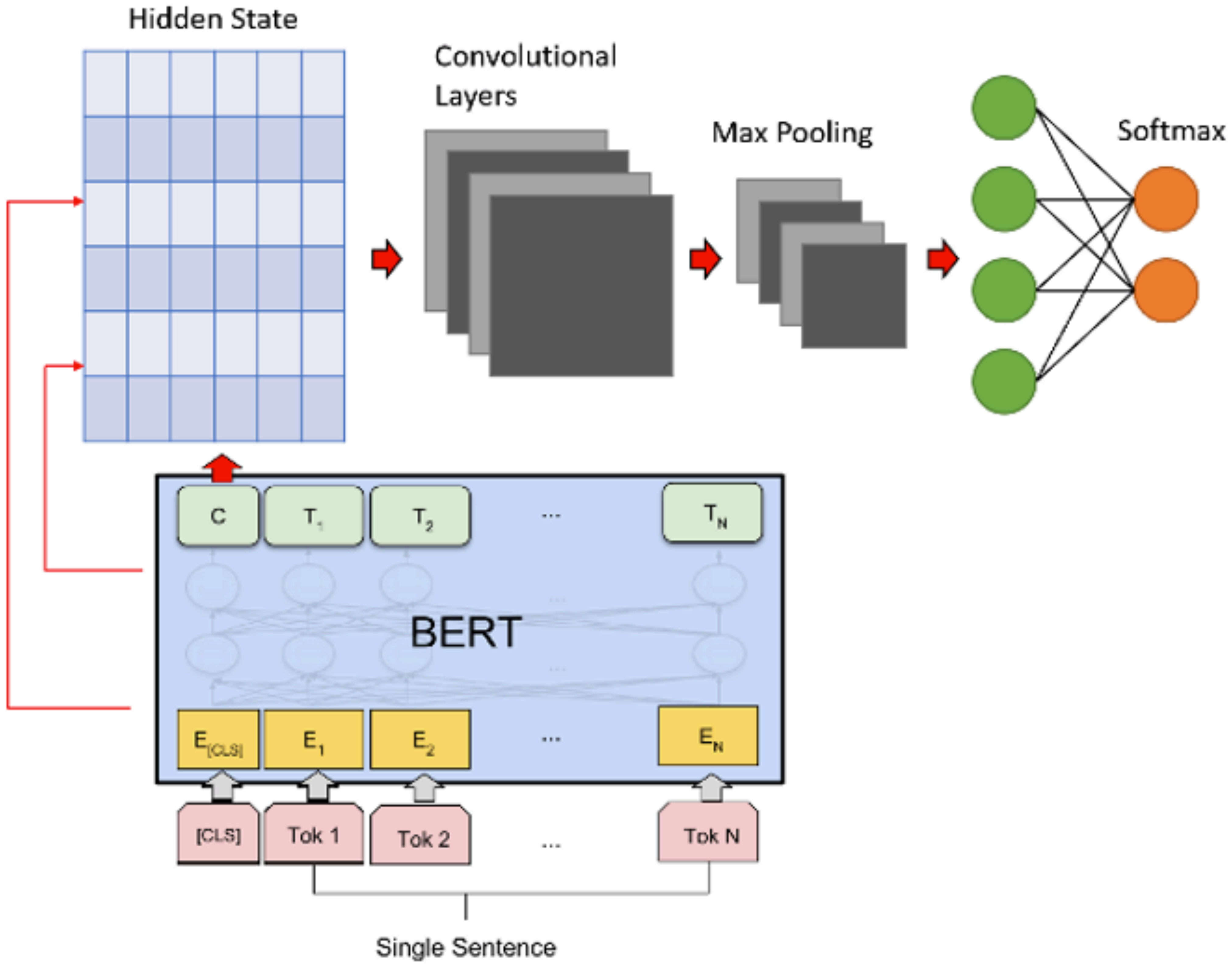


DNN

Intelligent Classifier



Model Performance

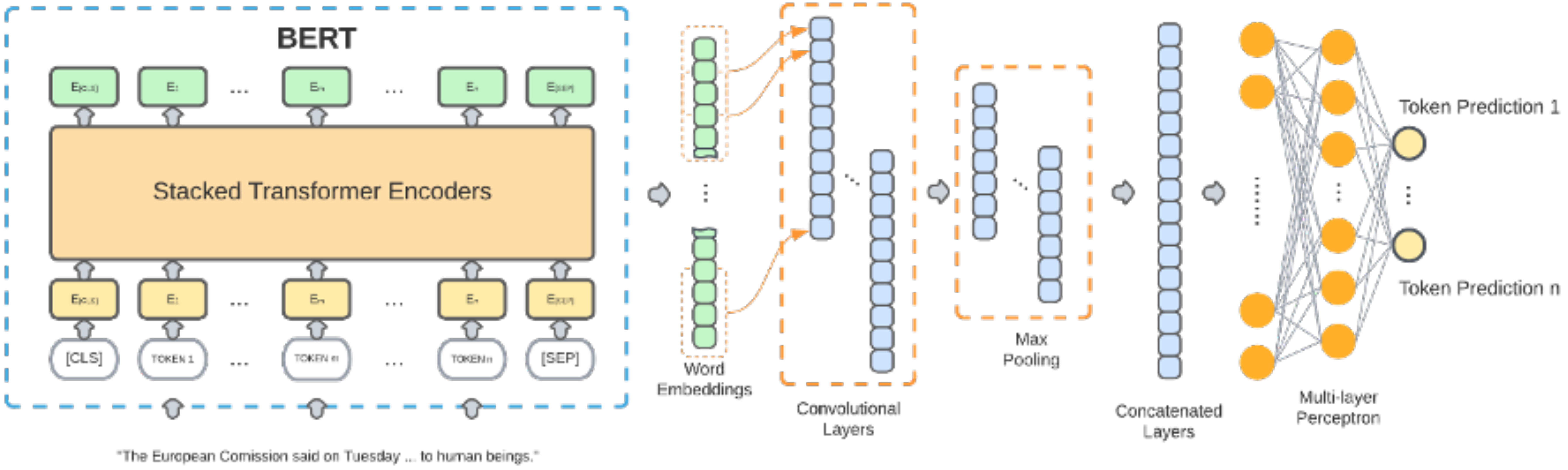


Optimal Model: BERT-CNN

Zhou, B., Zou, L., Mostafavi, A., Lin, B., Yang, M., Gharaibeh, N., Cai, H., Abedin, J. and Mandal, D., 2022. VictimFinder: Harvesting rescue requests in disaster response from social media with BERT. *Computers, Environment and Urban Systems*, *95*, p.101824.

Intelligent Toponym Recognition

Model	Precision	Recall	F1-score
Stanford NER (broad location)	0.729	0.440	0.548
SpaCy NER (broad location)	0.461	0.304	0.366
BiLSTM-CRF	0.703	0.600	0.649
DM_NLP	0.729	0.680	0.703
NeuroTPR	0.787	0.678	0.728
TopoBERT	**0.898**	**0.835**	**0.865**

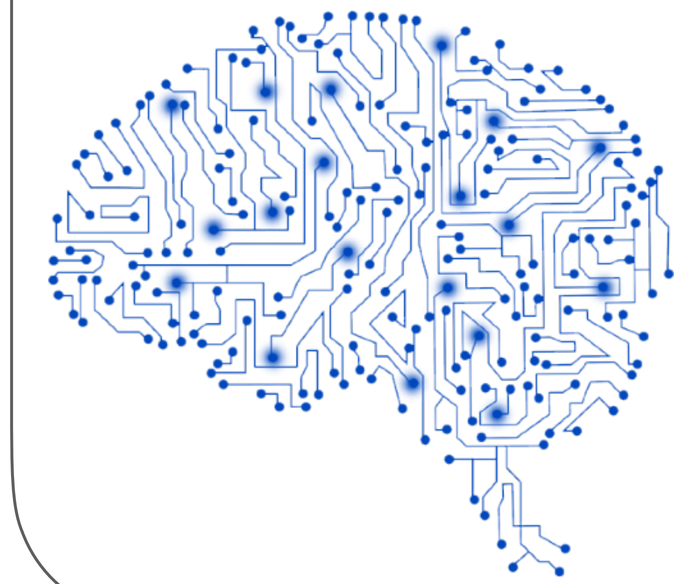


Optimal Model: BERT-CNN1D

Zhou, B., Zou, L., Hu, Y., Qiang, Y., Goldberg, D. 2022.
TopoBERT: A Plug and Play Toponym Recognition Module Harnessing Fine-tuned BERT. (Under Review)

Mining Disaster/Location Information from Social Media with AI

Classifier
BERT-CNN



Toponym Recognition
TopoBERT

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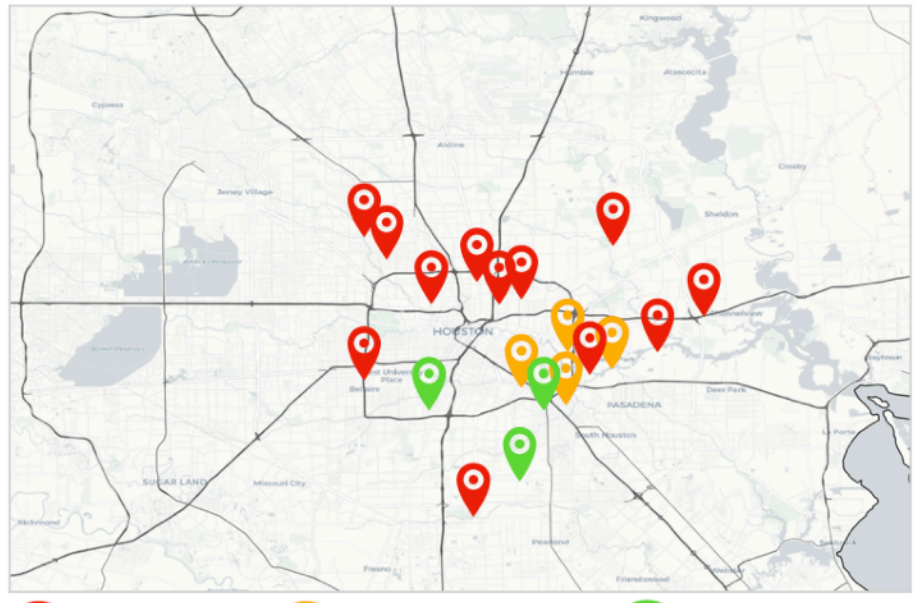
Toponym Resolution
Google API



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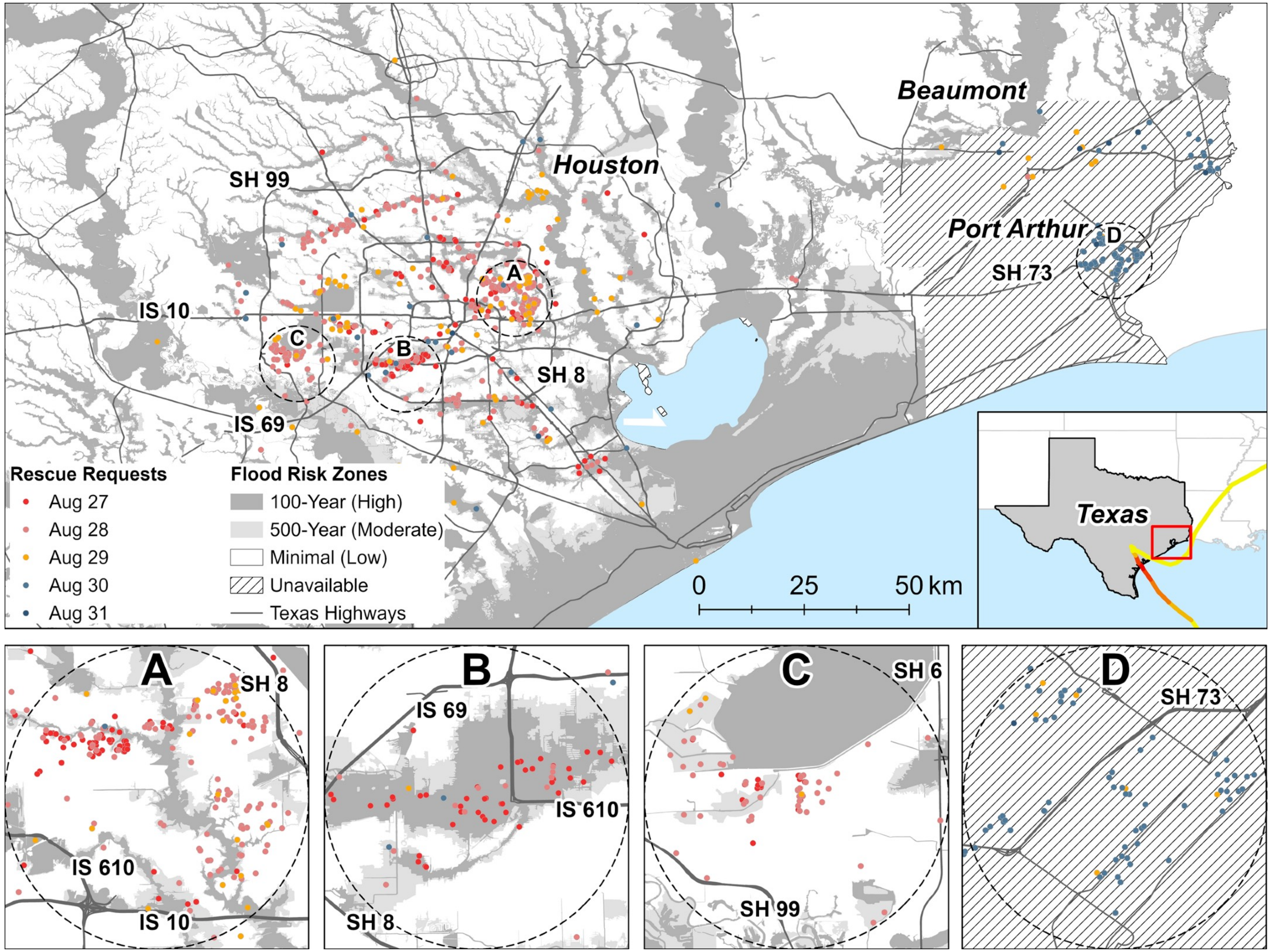
Social Media in Disaster Response: Emergency Rescue

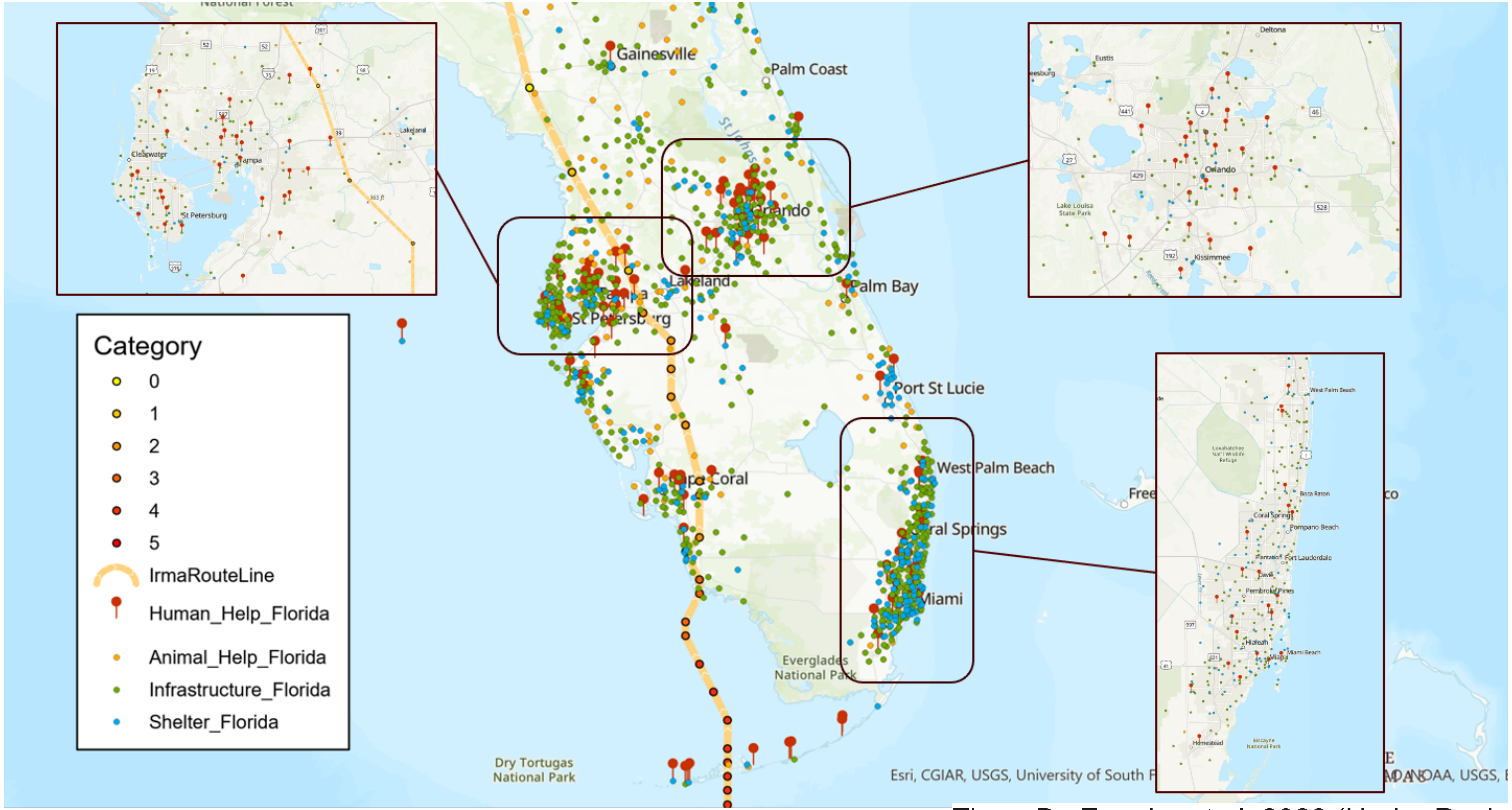
- 41.38% of rescue requests on Twitter were sent from minimal flood risk zones defined by FEMA
- Communities with high rescue request rates were below-average elevations, received more rainfall, and had more socially vulnerable populations



Zou et al. 2021. Social Media for Emergency Rescue: An Analysis of Rescue Requests on Twitter during Hurricane Harvey. *arXiv preprint arXiv:2111.07187*.

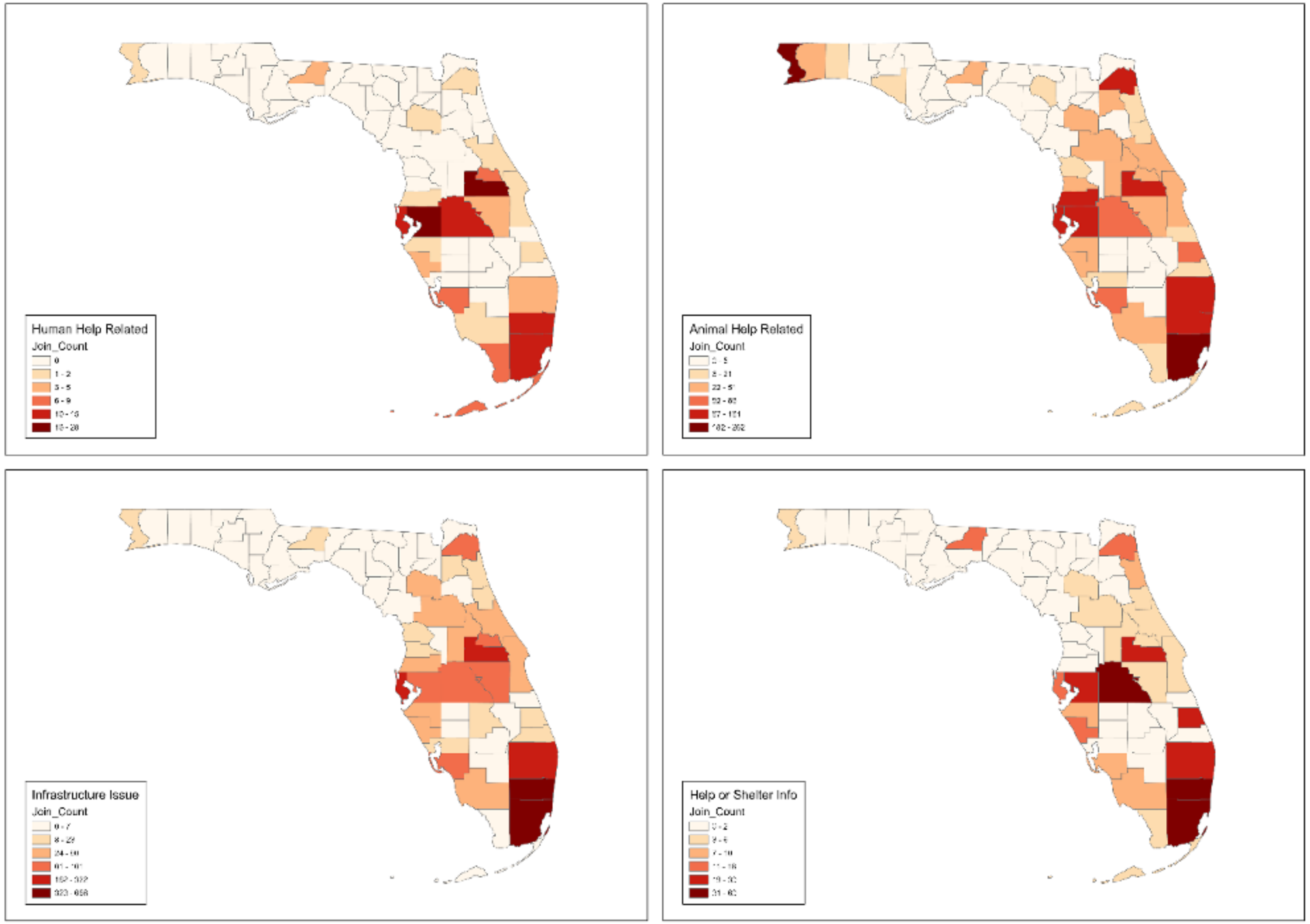
Social Media in Disaster Response

Social Media in Disaster Response: 2017 Hurricane Irma



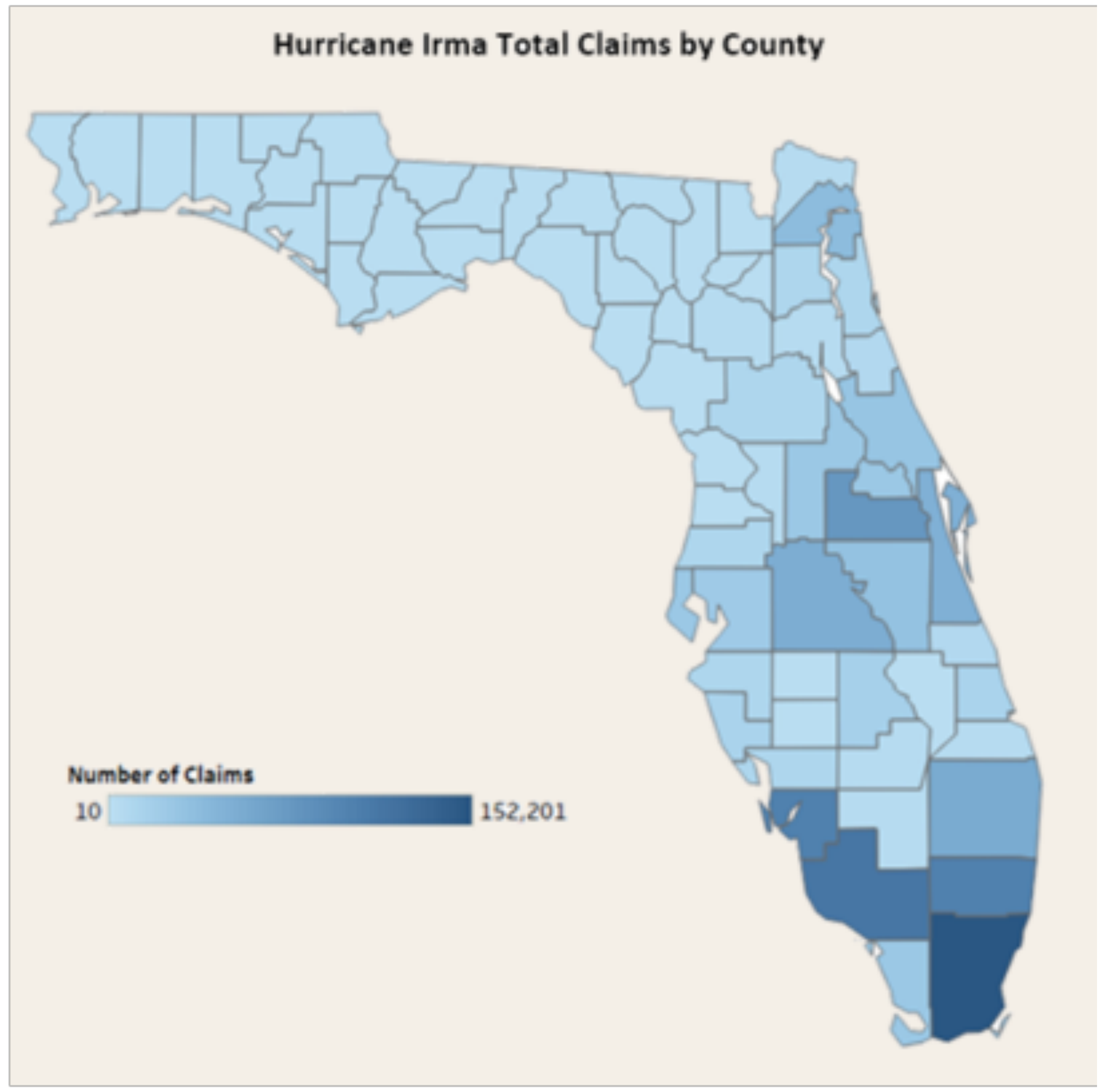
Zhou, B., Zou, L., et al. 2022 (Under Review)

Social Media in Disaster Response: Damage Estimation



Damage Assessment based on Infrastructure Malfunction Reports on Social Media:
R-square = **0.64**

Number of Claims



Zhou, B., Zou, L., et al. 2022 (Under Review)

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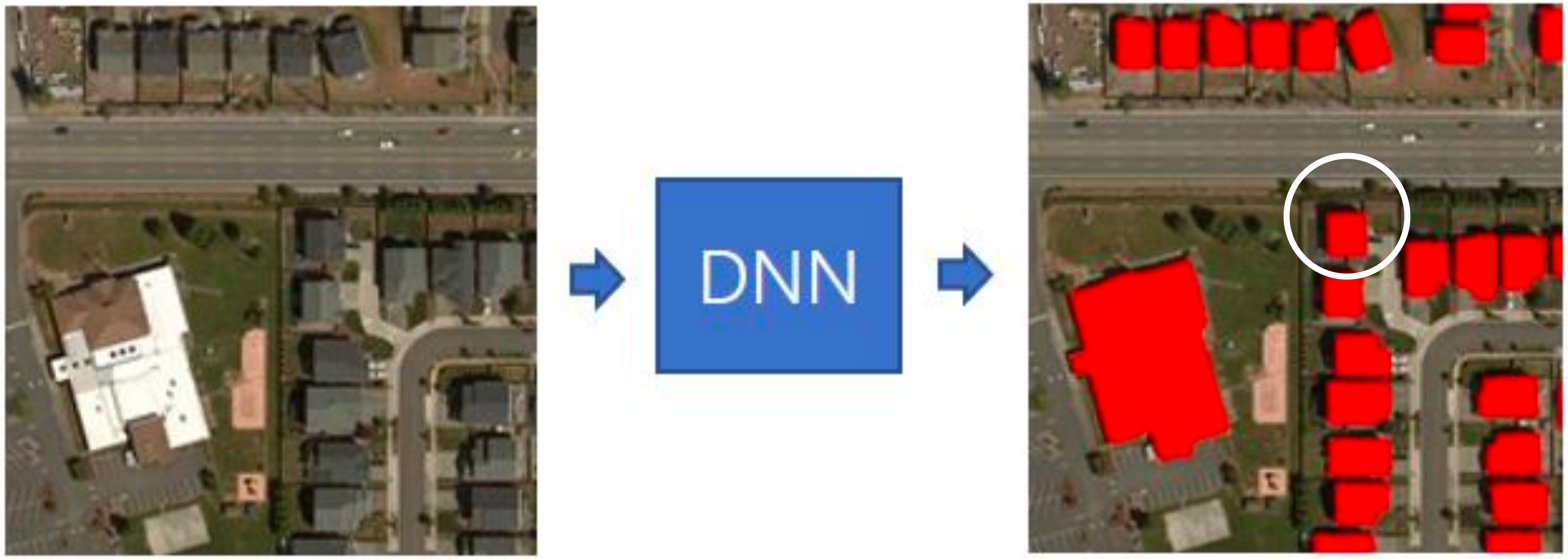
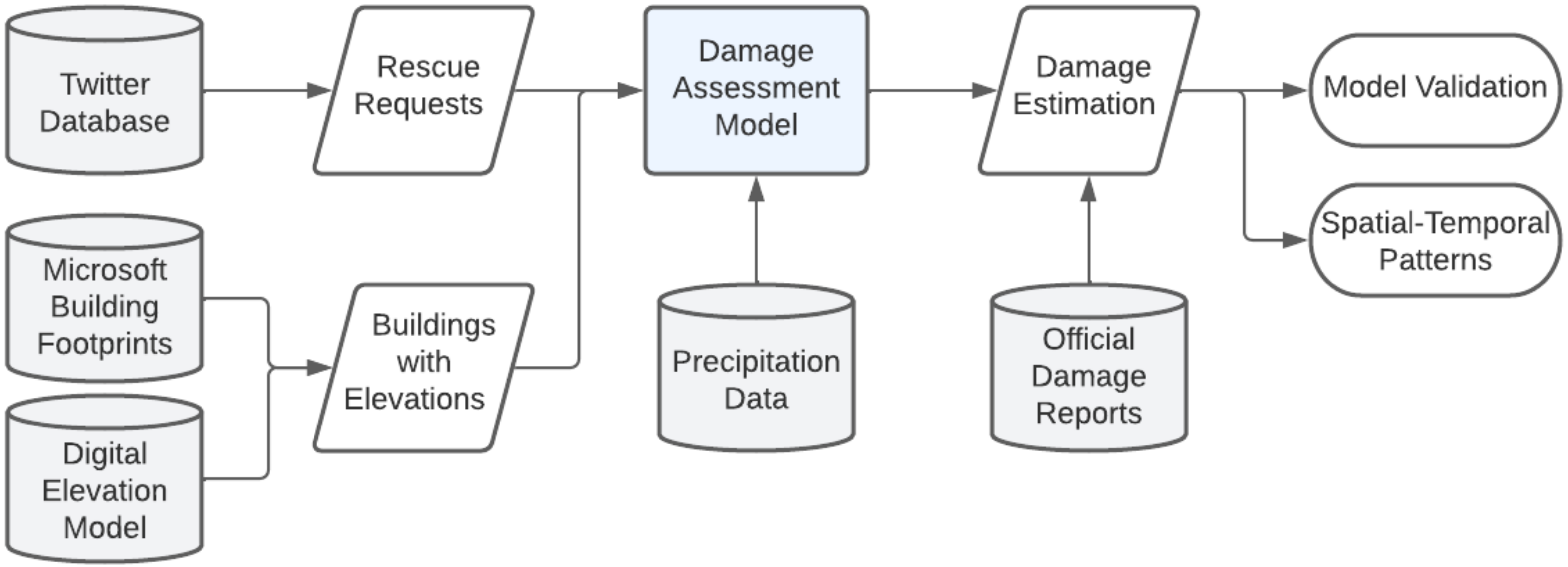
Use Bias in Social Media

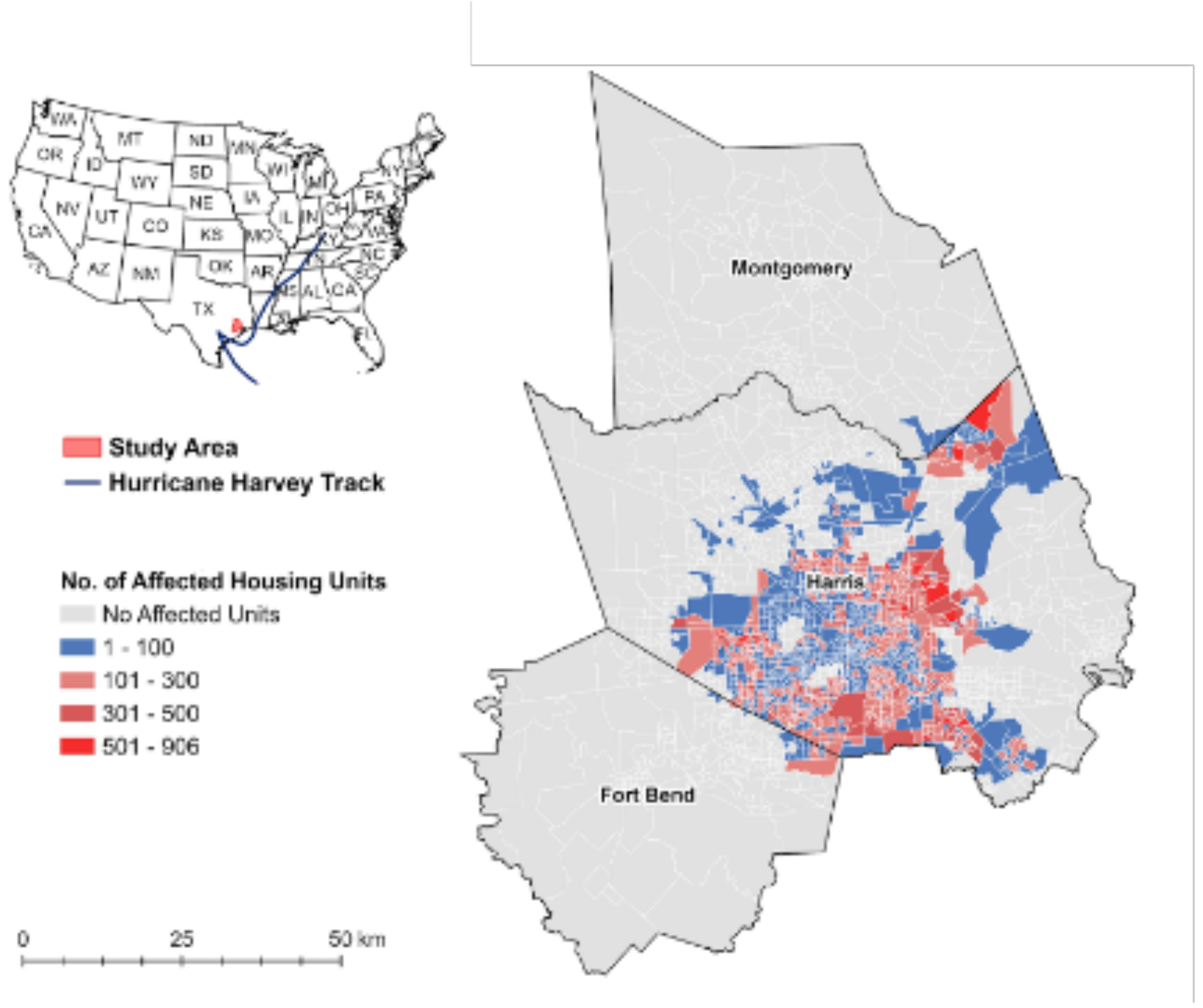
$$flooded_i = \begin{cases} 1, & elevation_i + rainfall_i \geq elevation_0 + rainfall_0 \\ 0, & else \end{cases}$$



Microsoft Building Footprints Data: https://github.com/microsoft/USBuildingFootprints

Use Bias in Social Media





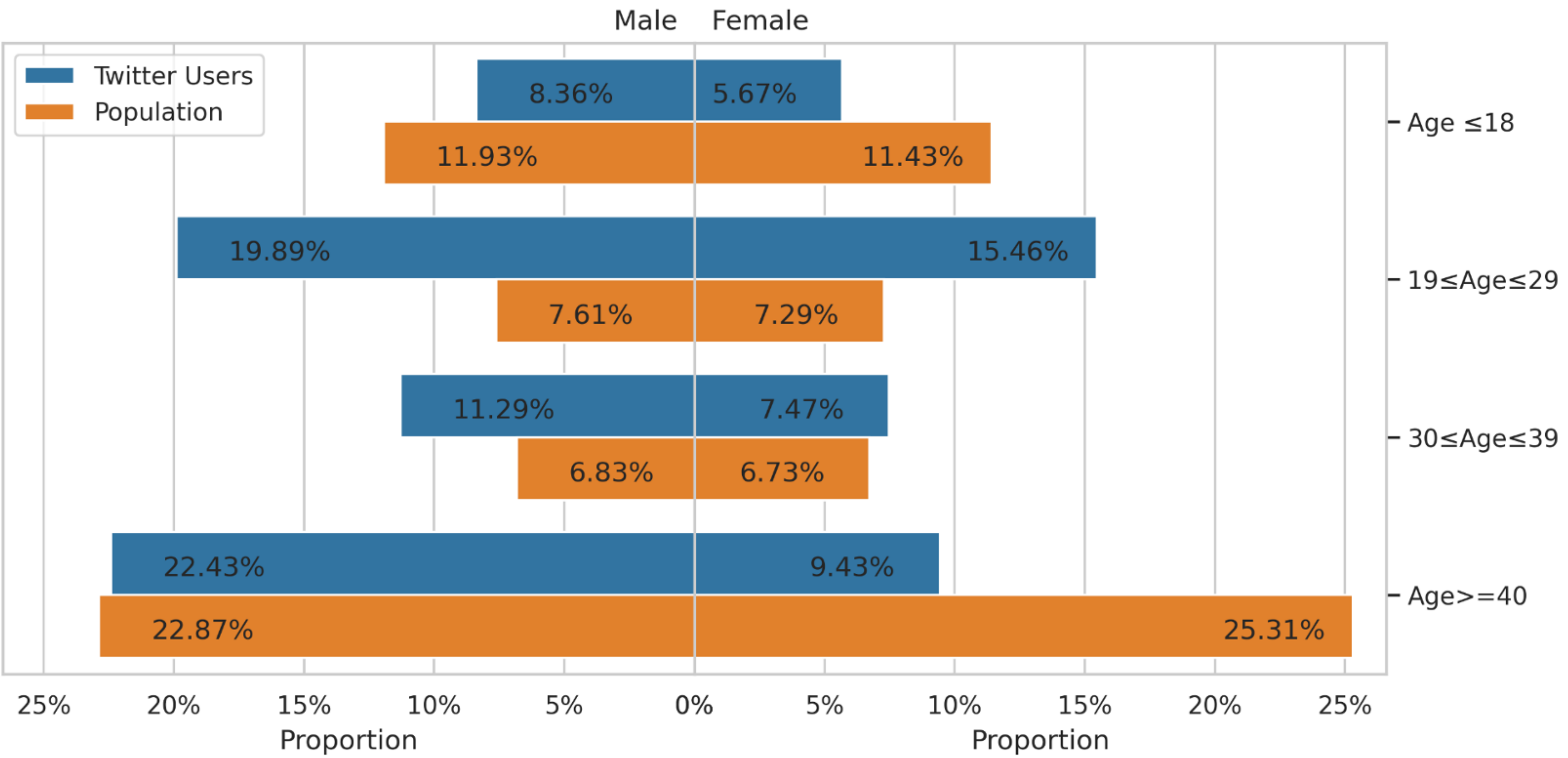
(1) The estimated affected households highly agree with the official damage report.

(2) The model performs better in communities closer to the locations of people requesting rescue or reporting damage on social media

(3) The developed model reveals overlooked communities in official damage reports.

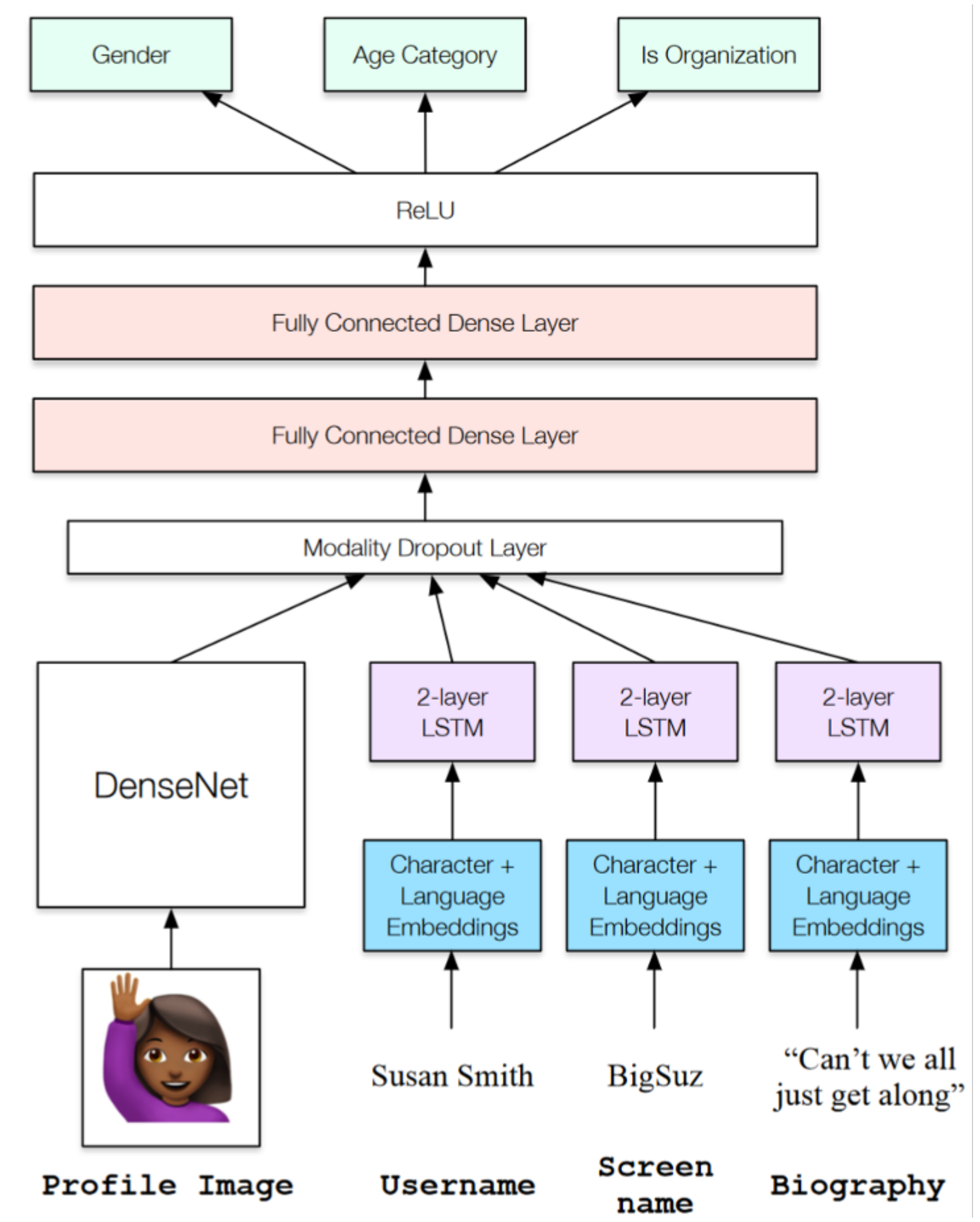
Zou et al. 2022

User Demographic Bias in Social Media



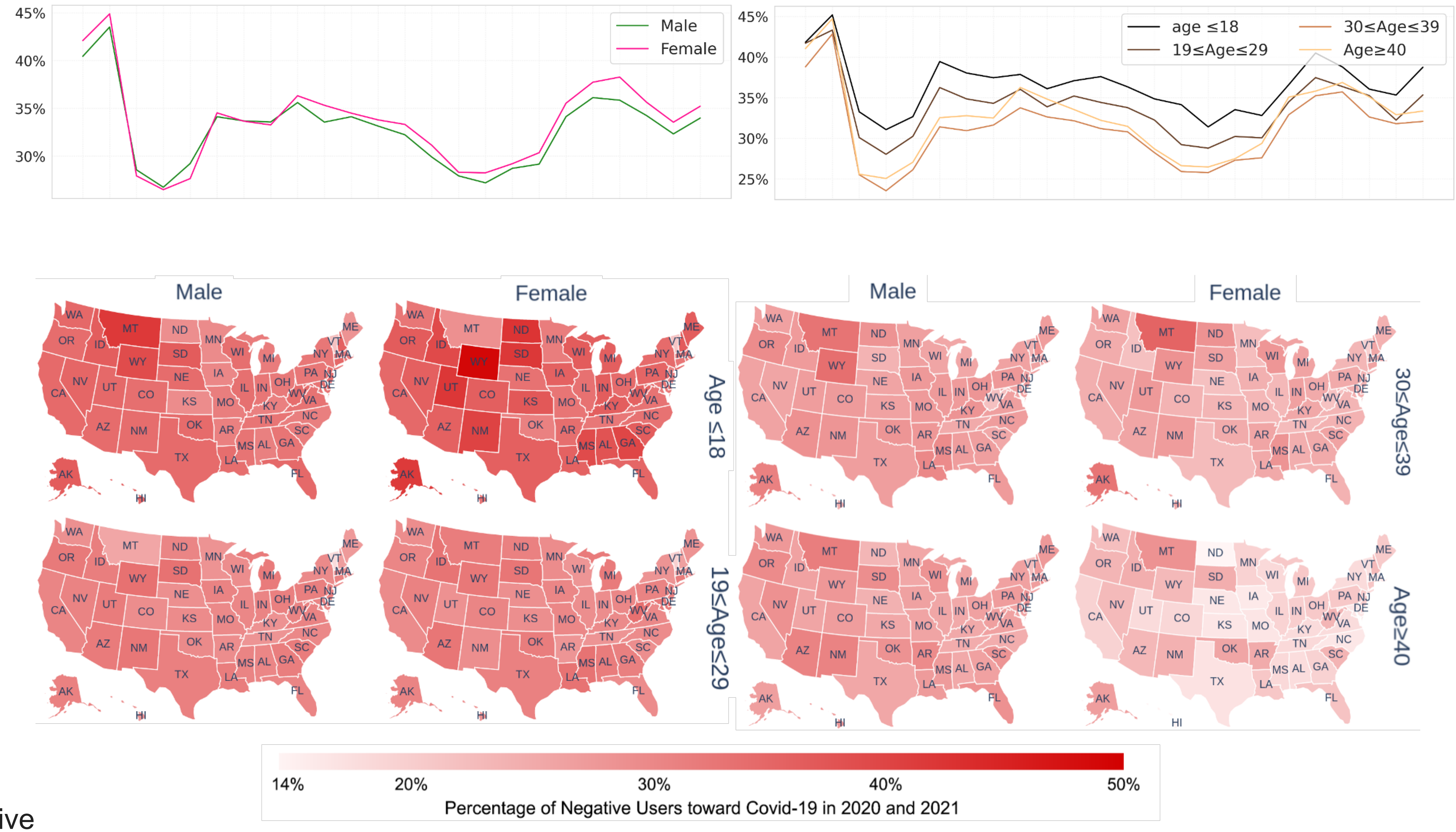
User Demographic Bias in Social Media

M3 Model



Wang, Zijian, et al. "Demographic inference and representative population estimates from multilingual social media data." *The world wide web conference*. 2019.

COVID-19 Sentiment Scores by Demographics in the U.S.



Lin, Zou, et al. AutoCarto 2022

Responsible Spatial Thinking for a Resilient Future!

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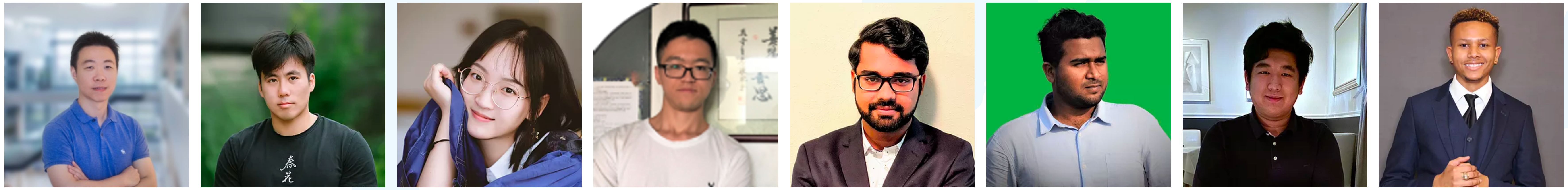
GEAR Lab Website: https://www.geoearlab.com/



***NSF-HDBE (Award #: 1931301)**: Reducing the Human Impacts of Flash Floods - Development of Microdata and Causal Model to Inform Mitigation and Preparedness*
***TAMU PRISE Program**: Leveraging Geospatial Big Data and Artificial Intelligence (AI) to Enhance Disaster Resilience in Vulnerable Communities*
***TAMIDS Data Source Development Program**: Revealing Social and Governmental Responses to COVID-19 through Geospatial Big Data*