EMERGENCY MANAGEMENT USE CASE

Research Title:	**Harnessing Big Data and Al to Augment Disaster Situational Awareness**
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Description:	Situational awareness before, during, and in the aftermath of disasters can promote proactive preparedness, prompt efficient disaster response, and rapid community recovery. The research uses social media, crowdsourced, and location-based mobile phone big data to enable disaster preparedness monitoring, as well as proactive community response and recovery tracking to augment situational awareness. Using this data in data analytics and machine learning approaches, the research enables automated mapping and information retrieval from social media, such as Twitter, crowdsourced data (such as 311 calls) and location-based big data and to extract insights to understand the extent of preparedness, the level of disaster impact, and the progress of community recovery. In particular, the research outcomes provide critical information such as the under-prepared, severely affected areas, and slow-recovery areas to inform emergency managers. With near real-time information and data-driven insights, emergency responders and public officials can take proactive actions and allocate resources in a timely manner.
When Applied:	The proposed Use Case can be applied **before, during, and in the aftermath of disasters**. Before disasters, the information retrieved can provide insights of population preparedness for impending disaster events. During disasters, the impact level of the affected areas can be revealed by analyzing population activity and crowdsourced data. In the aftermath of disasters, the insights facilitate proactive monitoring of recovery progress to identify areas in need for recovery support.
Who Applies:	The proposed Use Case can be applied by **emergency managers, first responders, and public officials** to reveal population preparedness, disaster impact, and community recovery. With the information, they can proactively make decisions to enhance the resilience of communities in the face of disasters. The situational awareness insights would also inform infrastructure owners and operators such a power and transportation agencies.
Disaster Type:	The proposed Use Case has been applied to natural disaster events such as hurricanes, flooding, and winter storm and their associated impacts such power outage, disrupted access to critical facilities, and transportation disruption.
Infrastructure Affected:	The situation awareness insights from the Use Case could be beneficial for the owners and operators of critical facilities (e.g., hospitals), power grid, and transportation infrastructure.
Industry Affected:	The situation awareness insights from the Use Case could be beneficial for the owners and operators of critical facilities (e.g., hospitals), power grid, and transportation infrastructure.
Where Applied:	The proposed Use Case applies to areas affected by natural hazards across the state. The research has been implemented in **flood-prone areas and areas that are vulnerable to natural disasters**. For the initial step, the Use Case will be applied to Harris County area. Nevertheless, the methods are applicable to all areas across the state.

Agency Affected:	In addition to **TDEM, Local agencies (city and county OEM)** who involve in decision-making processes during disaster response and recovery are the target users of the proposed Use Case. The insights from this Use Case can provide decision makers a data-driven approach to understand the preparedness, impact, and recovery progress of the Use Case areas.
VOAD Affected:	N/A
Who/What Affected:	The proposed Use Case can help **state and local emergency management agencies** by improving their disaster situation awareness based on harnessing community scale big data. Also, the insights of the impact levels of local communities can inform **disaster responders** to better understand the impact severity in different areas. By improving disaster situational awareness, this Use Case can improve the safety of **Texas residents**.
How Affected:	This Use Case could improve disaster situational awareness in three aspects: (1) proactive monitoring population preparedness prior to an impending disaster (e.g., Hurricane); (2) rapid mapping of disaster impacts and population relief needs; and (3) near-real-time recovery tracking to specify areas with recovery lag. These insights can improve resource allocation and prioritization of respective agencies and would lead to reduced impacts of disasters on people.
Timing of Application:	The proposed Use Case can be applied at **all phases of the disaster resilience cycle**, which includes preparation, response, recovery, and hazard mitigation. For the preparedness, the research results provide metrics such as the extent of preparedness to understand local preparation status. During response, the research results show the impact levels of communities caused by disasters and how populations react to disasters. In the aftermath of disasters, the research monitors community recovery, such as the trajectory of recovery across the impacted areas. These insights can also inform hazard mitigation plans and policies for future events.
Critical Points:	The research results provide critical insights regarding the status of preparedness, response, and recovery with quantitative measures. By harnessing heterogeneous community-scale big data and AI approaches, critical insights such as the spatio-temporal extent of preparedness, evacuation rate, mapping of social and physical impacts, and recovery trajectories can inform emergency managers, responders, and public officials to better allocate resources and prioritize actions. Besides, with the identified quantitative measures, the spatial distribution of disaster resilience capability can be examined, making it possible to incorporate equity consideration into community resilience processes. The information extracted from community-scale big data can augment situational awareness and promote equitable decisions/actions in different phases of the disaster resilience cycle.
What Benefit:	The benefit of adopting the research include: (1) Using social media and emerging big data to augment situational awareness: With the novel AI and data-driven approaches, the public and agencies can have better situational awareness of the upcoming disasters, which can improve the preparedness and resilience capability and mitigate disaster impacts. (2) Revealing areas and populations in need faster than the current approach: Instead of relying on agencies' surveys and inspections and residents' self-report, social media and location-based big data provide

	opportunities to monitor the interaction among the population, infrastructure, and disasters and to identify vulnerable areas for resource allocations in a faster manner. (3) Responding to the needs proactively: Disaster response agencies can identify areas with less preparedness and greater impact by incorporating insights from social media and location-based big data, which help decision-makers respond proactively to the needs. (4) Gaining public trust on emergency response: Proactive and equitable disaster responses can help gain public trust on emergency management agencies' decisions during disasters.
Where Used:	The research has been implemented and tested on Hurricane Harvey (2017), Hurricane Ida (2021), Winter Storm Uri (2021) to understand the impact of floods, damaging winds, and power outages.
Additional Research:	No
Additional Information:	The published papers of the research behind the Use Case are listed below in Original Research. Besides, the UrbanResilience.AI Lab website (https://www.urbanresilience.ai/) provides additional information regarding scientific and technological approaches to improve community disaster resilience.
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Original Research:	Li, B., Mostafavi, A. Location intelligence reveals the extent, timing, and spatial variation of hurricane preparedness. *Sci Rep* **12**, 16121 (2022). https://doi.org/10.1038/s41598-022-20571-3 Lee, CC., Chou, C. & Mostafavi, A. Specifying evacuation return and home-switch stability during short-term disaster recovery using location-based data. *Sci Rep* **12**, 15987 (2022). Fan, C., Jiang, Y., & Mostafavi, A. (2020). Social sensing in disaster city digital twin: Integrated textual–visual–geo framework for situational awareness during built environment disruptions. Journal of Management in Engineering, 36(3), 04020002. Lee, CC., Maron, M. & Mostafavi, A. Community-scale big data reveals disparate impacts of the Texas winter storm of 2021 and its managed power outage. *Humanit Soc Sci Commun* **9**, 335 (2022). Yuan, F., Fan, C., Farahmand, H., Coleman, N., Esmalian, A., Lee, C. C., ... & Mostafavi, A. (2022). Smart flood resilience: Harnessing community-scale big data for predictive flood risk monitoring, rapid impact assessment, and situational awareness. *Environmental Research: Infrastructure and Sustainability*, *2*(2), 025006. Fan, C., Wu, F., & Mostafavi, A. (2020). A hybrid machine learning pipeline for automated mapping of events and locations from social media in disasters. IEEE Access, 8, 10478-10490.
What Risks:	No major risks.
Partner Agencies/Jurisdictions:	Local OEM offices such the Harris County OEM.

Quantitative Measures:	The quantitative measures identified in the research include (1) the extent of preparedness, (2) the extent of preparedness proactivity, (3) the extent of disaster impacts, (4) the duration of impact, (5) evacuation rate, (6) home relocation rate, and (7) the duration of recovery. The research identifies and uses these measures to quantify the extent, timing, and spatial variation of different phases of disaster responses.

Research with a Technology Component Should Respond to the Following Questions

Research Requested:	The research on improving situation awareness has been identified through engagement with emergency managers over the past several years.
Why Better:	The current approaches to disaster situation awareness have significant lags in providing the insights needed to inform the response and recovery decisions and actions. Also, the exiting approaches lack the required spatial resolution. The data analytics methods and quantitative measures from the research in this Use Case provide timely and proactive insights when the insights are needed and at fine spatial resolutions (e.g., recovery monitoring at the census tract level).
Reliability:	The technology implements data analytics algorithms on cloud by harnessing community-scale big data from Internet platforms. Hence, the technology is reliable.
Support Needed:	The technology implements data analytics algorithms on cloud by harnessing community-scale big data from Internet platforms. Hence, potential support may be needed to ensure the output is accessible to users through reliable power and internet connection.
Citizen Impact:	The end users of the technology are emergency managers, responders, and public officials. No negative impact on citizens is anticipated.
Training Required:	A moderate level of training would be required to understand the data behind the methods and work with the data analytics dashboards.
Public Accountability:	The social media data is collected from publicly available social media sources. All location-based data is collected from anonymized devices of users who have opted in to provide access to their location data anonymously for research purposes through a CCPA (California Consumer Privacy Act)- and GDPR (General Data Protection Regulation)-compliant framework.

Please Note: Questions or suggestions regarding the Use Case Template may be directed to Dr. MacGregor Stephenson at the Texas Division of Emergency Management at macgregor.stephenson@tdem.texas.gov.