EMERGENCY MANAGEMENT USE CASE

Research Title:	**Automated Rapid Building Damage Assessment using Satellite Imagery**
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Description:	With the growing number of disasters and limitations in the number of trained human personnel to perform on-the-ground damage assessments, rapid and automated assessment of building damages is a critical in the aftermath of disasters is critical to expedite emergency response and resources allocation. The use of artificial intelligence on satellite imagery provides near real-time, high-coverage information and offers opportunities to inform large-scale post-disaster building damage assessment. The research developed and applied computer vision techniques to assess and classify building damages using pre- and post-disaster satellite imagery. The research outcomes show that the developed method can effectively detect damaged buildings and classify their damage levels by using high-resolution satellite imagery. The model and its outputs can inform emergency responders and decision makers of the locations of highly impacted buildings for source allocation of disaster response and recovery planning.
When Applied:	The proposed Use Case can be applied **in the aftermath of disasters** to provide automated rapid and high-coverage information on building damage levels at a large scale. The assessment results can inform decision-making for resource and rescue allocations and recovery planning. In addition, the damage estimation can be understood with the building damage assessment results.
Who Applies:	The proposed Use Case can be applied by **emergency managers, first responders, and public officials** to understand building damage levels of Use Case areas. With the rapid and automated approach, the assessment of building damages is expedited for more efficient resource allocation. In addition, large-scale building damage assessment results provide them opportunities to understand the damage status of entire impacted areas.
Disaster Type:	The proposed Use Case has been applied to **natural disaster events such as hurricanes, earthquakes and flooding** to assess building damage levels. Although different types of disasters may result in different damages, the research has shown that the developed method can effectively identify and classify building damages with high-resolution satellite imagery.
Infrastructure Affected:	The proposed Use Case applies to different kinds of buildings including but not limited to houses, condos, schools, and factories. Especially, the buildings providing essential services and supporting disaster responses may need additional attention. The developed method identifies buildings and assesses building damage levels based on the comparison of pre- and post-disaster satellite imagery.
Industry Affected:	Any areas with buildings can use the proposed Use Case to identify and classify damages. The proposed Use Case, for instance, can be applied to understand the damage to critical facilities such as schools and fire stations.
Where Applied:	The computer vision model developed in the research was trained on several datasets with more than six types of natural disaster around the world, including Hurricane Harvey in Harris County and Hurricane Ida in Orleans Parish. The assessment results from the model show promising results of damage assessments and classifications. Therefore, The proposed Use Case can be applied to the areas having building damages caused by natural disasters.

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 an overall understanding of building damage levels 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 providing computer vision-based information for rapid damage and impact assessment using satellite imagery. Also, the trained models can offer reliable property damage classification in an automated way to inform **disaster responders** to better understand the impact severity in different areas. By incorporating the research for disaster response and source allocation, this Use Case can expedite resource allocation and response/recovery progress of **Texas residents**.
How Affected:	This Use Case could improve disaster response and recovery capability in two aspects: (1) automated rapid building damage assessment to identify impact areas, and (2) reliable damage classification to reveal damage severity of buildings across the impacted area. These insights can improve resource allocation and prioritization of respective agencies and would result in expediting recovery progress for the impacted areas.
Timing of Application:	The proposed Use Case can be applied during **disaster response and recovery phases**. During response, the research results identify the impacted and damaged buildings caused by disasters and inform rescue actions for first responders. In the aftermath of disasters, the research provides building damage level information to help estimate disaster impacts and allocate resource effectively. These insights can also inform hazard mitigation plans and policies for future events.
Critical Points:	The research results provide critical insights of damaged building identifications and damage level classifications. By using satellite imagery, these critical insights can be obtained promptly with an automated approach. With these insights, emergency managers, responders, and public officials can better allocate resources and prioritize on-the-ground damage inspections.
What Benefit:	The benefit of applying the propose Use Case is to expedite and automate building damage assessments and thus reduce the time and labor force needed. For example, the research shows the capability to identify and classify damaged buildings and specify the minimum number of properties that need field inspection in order to be able to supplement the satellite imagery data without the need for inspecting all properties. In other words, the proposed Use Case not only provides a rapid and automated building damage classification insight, it also reduces the need for field inspection of all damaged properties by specifying the number and location of damaged properties. Accordingly, the approach will significantly improve the speed and accuracy of damage assessment and enables FEMA and other local and public agencies to expedite claim processing and allocate resources in a rapid, efficient and equitable manner.
Where Used:	The computer vision model developed in the research was trained on several datasets with more than six types of natural disaster around the world, including Hurricane Harvey in Harris County and Hurricane Ida in Orleans Parish. The model can be used across the state.
Additional Research:	N/A
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:	Kaur, N., Lee, C., Mahdavi, A. & Mostafavi, A. (2022). Large-scale Building Damage Assessment using a Novel Hierarchical Transformer Architecture on Satellite Images. *arXiv*. https://doi.org/10.48550/arXiv.2208.02205
What Risks:	No major risk.
Partner Agencies/Jurisdictions:	Local OEM offices such the Harris County OEM.
Advantages of Satellite Imagery:	While aerial imagery (captured by UAV and drones) can capture more details about buildings' conditions due to lower flying altitudes than satellite imagery, it requires extensive local planning and provides a smaller area of building coverage than satellite imagery. Satellite imagery, which provides near real-time and high-coverage information, offers opportunities to assist in large-scale post-disaster building damage assessments have shown that by leveraging satellite imagery and deep learning, the process of damage assessments can be accelerated with the generation of high-quality building footprints and damage-level classification for each building.

Research with a Technology Component Should Respond to the Following Questions

Research Requested:	This research was informed by the need identified by the research team during interactions with various emergency managers at federal, state, and local level regarding the importance of rapid building damage assessment.
Why Better:	Rapid and automated damage assessment of buildings and infrastructure in the aftermath of disasters is critical to expedite emergency response and resources allocations. Damage assessments done by ground crews can be time-consuming and labor-intensive. The proposed Use Case leverages satellite imagery for rapid automated building damage assessments. The satellite imagery is usually available within 2 days after an event. Hence, the proposed approach could yield reliable property building damage estimates within 2-3 days. This a significant improvement compared with the current approach (field inspection of all properties) that take several months.
Reliability:	The technology implements computer vision algorithms on cloud by using satellite imagery from satellite imagery providers. Hence, the technology is reliable and classifies building damages with high accuracy.
Support Needed:	The technology implements computer vision algorithms on cloud by using satellite imagery from satellite imagery providers. Hence, potential support may be needed to ensure the accessibility of the input images and output results 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 method and to work with the model outputs.

Public Accountability:	The satellite imagery is collected from different providers such as Apollo mapping, under its data agreement requirements.

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.