GEOspatial Artificial Intelligence (GEOAI) group
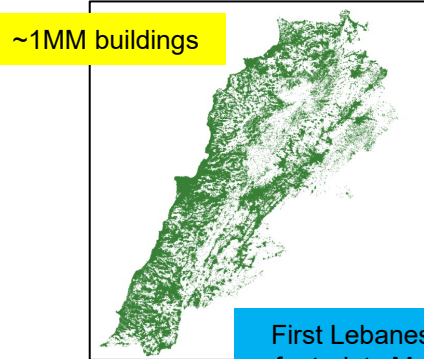
International Collaboration

- Lead: Dr. Ali J. Ghandour
- Established: April 2015
- Members: 32
- Webpage: https://geogroup.ai/
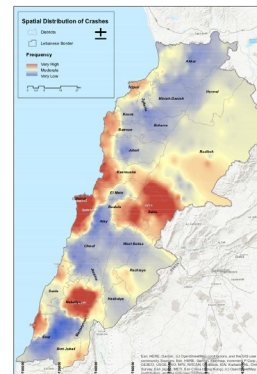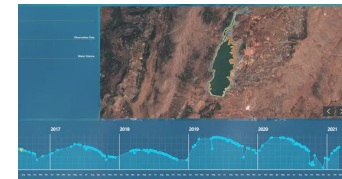
IMT Nord Europe
École Mines-Télécom
IMT-Université de Lille
CERI-SN

SORBONNE UNIVERSITÉ
ISIR

TECHNISCHE UNIVERSITÄT MÜNCHEN

Institut national de la recherche scientifique
INRS Quebec

UNIVERSITY OF TECHNOLOGY-IRAQ

Ongoing Projects

GeoUrban-AI Tool
~1MM buildings
First Lebanese footprints Map

Solar rooftop potential map
Number of Placed Panels : 45
Solar Potential : 30.4398(MWh/year)

Road Crashes Observatory
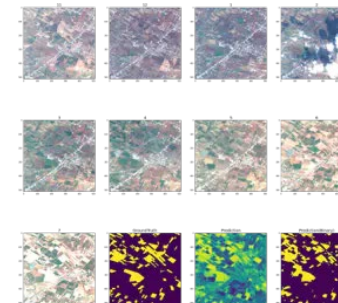Spatial Distribution of Crashes

Water Body Monitoring

Winter Wheat Monitoring

Waste-To-Energy

Background

- **GEOAI capitalizes on its:**
  - **long experience (~10 years)**
  - **large group (32 members)**
  - **know-how (deep learning, time-series imagery, in-house geotils python library)**
  - **credibility and visibility (publications in prestegious venues, mailing list, network)**

- **GEOAI offers: AI-based solutions for Earth Observation (EO)**

- **EO market value estimated to reach USD 700 Billion by 2030 [WEF and Deloitte]**

- **AI in EO market valued at USD 1.75 Billion in 2022 and projected to expand at 27.5% CAGR, reaching USD 35.90 Billion by 2030 [REF].**

Target Sects

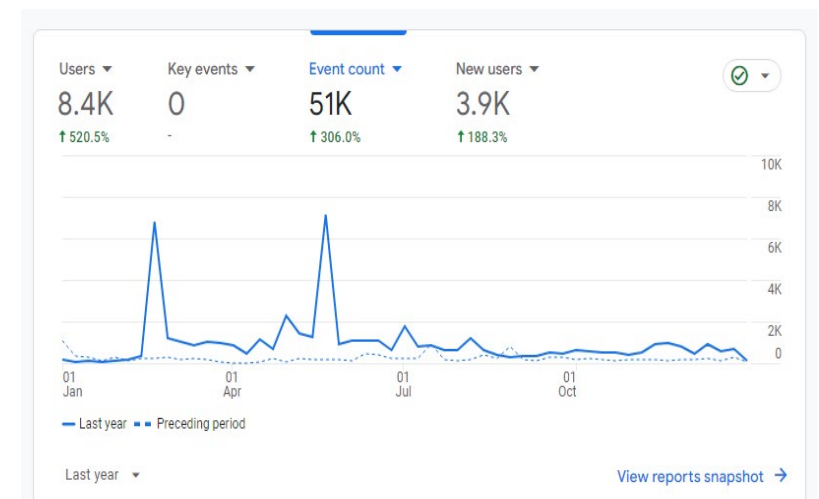- **Scene and Environment Monitoring:**
  - **Mining industry**
  - **Defense**
  - **Construction industry (Solar PV installers)**
  - **Telecom industry**
  - **Transportation industry**

- **AI-based Satellite Imaging for <u>Agriculture Market</u>:**
  - **INGO (FAO, AOAD, ..)**
  - **Agribusiness**
  - **Agri-Analytics**
  - **Soil Quality (Pesticides, Fertilizers, ..)**
  - **Value: USD 785.3 Million market by 2028 [REF]**

Target Sectors – *cont.*

- **MRV for GHG emissions/Climate Change:**
  - ○ **Ministries and local governments**
  - ○ **Oil & Gas industry**
  - ○ **Waste Management industry**
  - ○ **Livestock**
  - ○ **Value: USD 3.28 Billion in 2022 [REF]**

NEWSLETTER

GEOAI Newsletter

Major achievements and updates from the GEOAI group at the Lebanese National Center for Remote Sensing - CNRS.

By **Ali J. GHANDOUR**
Associate Researcher at the National Center for Remot...

Published monthly
930 subscribers

Performance overview

Delivered to		Deliverability rate	
1,664	View contacts	97.03%	Excellent
Opens		Open rate	
790	View contacts	47.48%	Excellent
Clicks		Click-through rate	
182	View contacts	10.94%	Excellent

Users	Key events	Event count	New users	
8.4K	0	51K	3.9K	
↑ 520.5%	-	↑ 306.0%	↑ 188.3%	

Last year — Preceding period

Last year

View reports snapshot →

Multi-Modality Foundation Models

Scope

- **Description:** Foundation/Unification models are gaining huge momentum nowadays; moving from task-specific models to multi-task models.
- **Advantages:** <u>Multi-Modality</u>: Optical, SAR, Multi-Spectral, Hyper-Spectral, Text (Vison-Language Models), Video, LiDAR, ..
<u>Complex Use Cases</u>: Image-Text Retrieval, Image Captioning, Visual Grounding, VQA, Text-Image Generation, and many more complex tasks..

The large storage tank

Dam on the left

Airplane at the bottom right

Tennis court on the upper left

What could have happened based on the current scene?

Based on the current scene in the image, it is possible that a hurricane or severe weather event caused significant damage to the buildings and infrastructure in the area. The person walking through the debris-covered area suggests that they are inspecting the damage caused by the disaster. The presence of palm trees indicates that the location may be in a tropical or sub-tropical region, which can be more susceptible to hurricanes and other natural disasters.

References

- A. J. Ghandour, H. Moughnieh, M. Zahweh, H. Nasrallah, M. Shukor, C. Nattero, and P. Campanella, "Efficient adaptation of Foundation Models for Visual Grounding Remote Sensing task", in 51th EGU General Assembly 2024, April 14 - April 19, 2024, Vienna, Austria.

Urban Map Extraction Tool
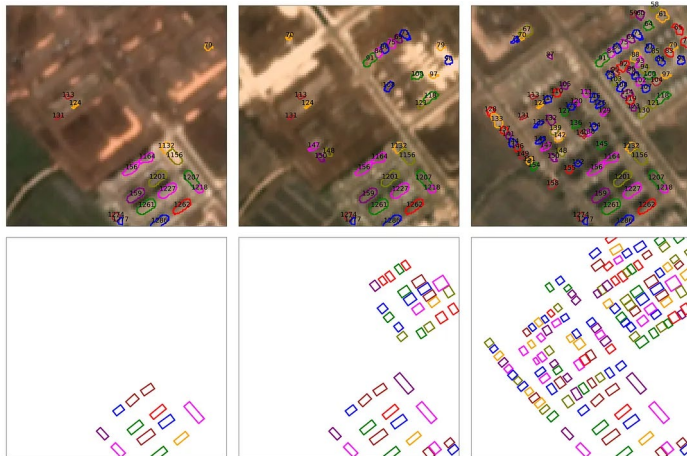
Scope

- **Description:** Automated pipeline to produce national/regional buildings' footprints map using single/time-series imagery using deep learning methods.
- **Advantages:** Buildings' instance segmentation in dense scenarios and slum areas using wide-range resolution (2cm up to 10 m) satellite/aerial imagery.
- **Quality Assurance:** High pixel and object-wise performance, up-to 80.9% F1-score.

Use Cases

- Regularly update buildings' rooftop map without relying on traditional photogrammetry and surveying methods. Proposed architecture relies on advanced augmentation techniques to overcome dataset scarcity, which is often the case in developing countries.
- Urban agglomeration using time-series imagery, including buildings tracking and change detection.
- Accepts GeoTIFF, JP2 and ECW rasters.
- Roads Network & Vehicular segmentation

References

- H. Nasrallah, A. Samhat, C. Nattero and A. J. Ghandour, "'Automated National Urban Map Extraction", in 44th IGARSS July 2024, Athens, Greece [**Online Demo**].
- A. Mayladan, H. Nasrallah, H. Moughnieh, M. Shukor and A. J. Ghandour, "Zero-Shot Refinement of Buildings' Segmentation Models using SAM", in 5th International ECRS, Nov 2023.
- H. Nasrallah, M. Shukor and A. J. Ghandour, "Sci-Net: Scale Invariant Model for Buildings Segmentation from Aerial Imagery", in SVIP Journal, 2023.

Buildings' Damage Assessment (BDA) Tool

Pre-Image (06-10-2023) : 1951 Total Buildings
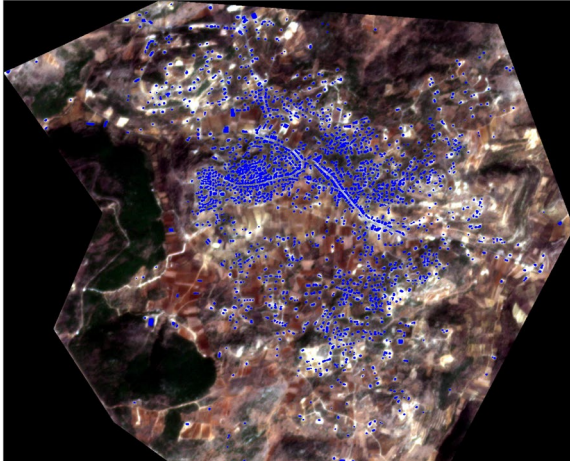
Post-Image (01-06-2024) : 849 Damaged Buildings
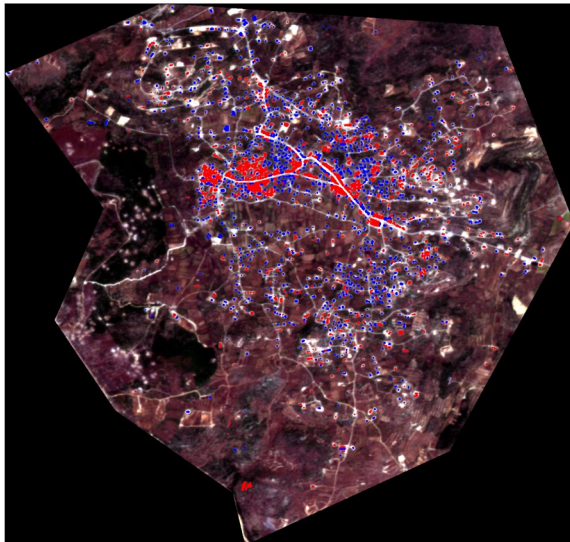
Scope

- **Description: Buildings classification into damaged/not-damaged using Optical and SAR imagery.**
- **Advantages: Detects several damage type and relies on pre/post or post-event images only.**
- **Quality Assurance: Fast convergence and high accuracy score up to 85.3% using wide-range resolution (sub-meter up to 10 m).**

Use Cases

- Considering current global conflicts and natural disasters, such as the Ukrainian conflict, 2023 Gaza War, the 2023 Turkey–Syria earthquake, and Libya's Derna flood, **a damaged building is defined (in this scope) as a partly or wholly demolished building that might result from armed conflicts, earthquakes, tornadoes or hurricanes.**
- Damaged area survey is crucial for first responders, and also in the early reconstruction phase.
- Future plans to add 4 quantization level of damage severity.

References

- A. J. Ghandour et. al "Buildings' Classification using VH Resolution Satellite Imagery", in ECRS 2023.
- A. J. Ghandour and A. Jezzini, "Post-War Building Damage Detection", in ECRS 2018.

Crop Monitoring & Field Delineation

Scope

- **Description: Provide farmers with timely alerts to take targeted actions on various crop-related (Wheat & Potato) issues, including water stress, disease outbreaks and pest infestations in specific field patches.**
- **Advantages: Continuous monitoring using Sentinel 1 and 2 to detect early signs of crop stress and anomalies.**
- **Quality Assurance: Using transformer-based models with 84.9% F1-score on regions in Lebanon and Europe.**

Use Cases

- Field Delineation
- Crop Type Identification
- Crop Yield Estimation
- Crop Damage Monitoring such as water stress, irregular growth or diseases
- Grain Bins Mapping

References

- GEOAI group ranked 4th in the "NASA Harvest Field Boundary Detection Challenge" out of 730 participants [**Source Code**]
- M. Zahweh, H. Nasrallah, M. Shukor, G. Faour and A. J. Ghandour, "Empirical Study of PEFT techniques for Winter Wheat Segmentation", in 5th International ECRS, Nov 2023.
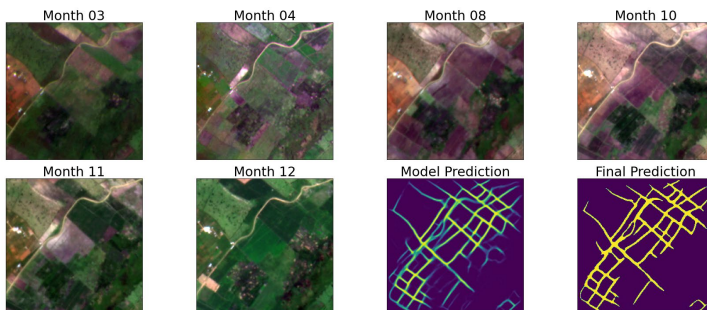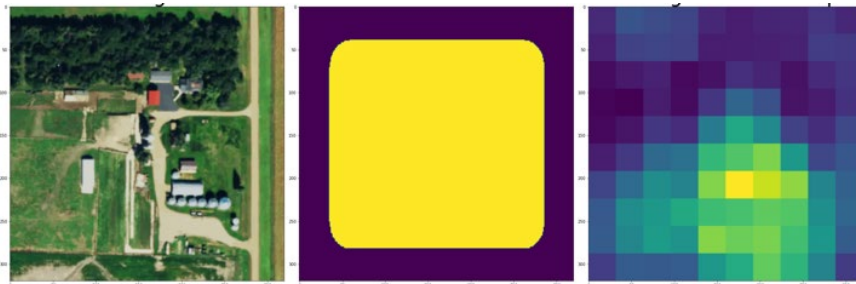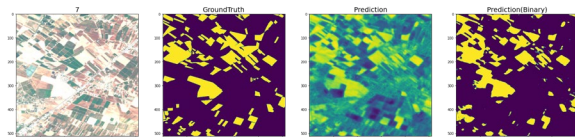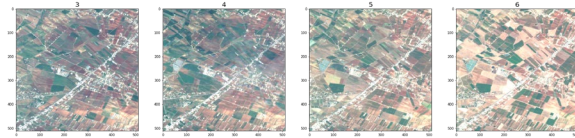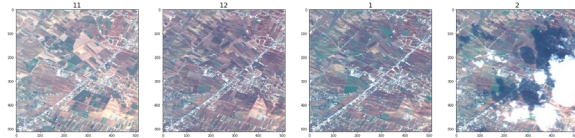
GHG Emissions Monitoring

Scope

- **Description:** Methane and Carbon Plumes Detection from Satellite Imagery using Multi-Modality AI techniques.
- **Advantages:** Leverages Sentinel-2 and PRISMA data to detect methane emissions with high spatial resolution and frequent revisit times.
- **Quality Assurance:** Uses multiple metrics such as SNR, ROC, AUC, and F1-score. Model output is fine-tuned using actual ground truth data to enhance the accuracy of methane emission estimates.

Use Cases

- **Government Agencies:** Regulatory bodies for environmental compliance and climate change mitigation.
- **Waste Management Companies:** Operators of landfills and waste treatment facilities that need to monitor and report methane emissions frequently and accurately.
- **Environmental NGOs and Research Institutions:** Organizations and research institutions focused on climate change and greenhouse gas emissions.
- **Oil and Gas Companies:** Companies involved in the extraction, processing, and transportation of fossil fuels, which are significant sources of methane emissions.
- **Livestock and Agricultural Sector:** Farms and agricultural businesses that generate methane emissions from livestock and manure management.
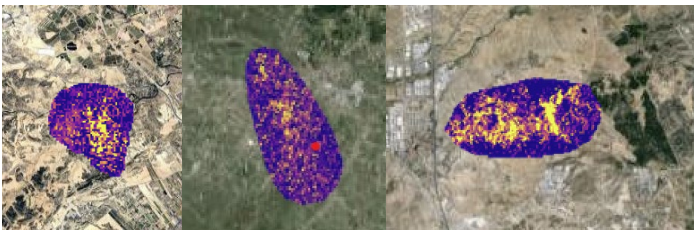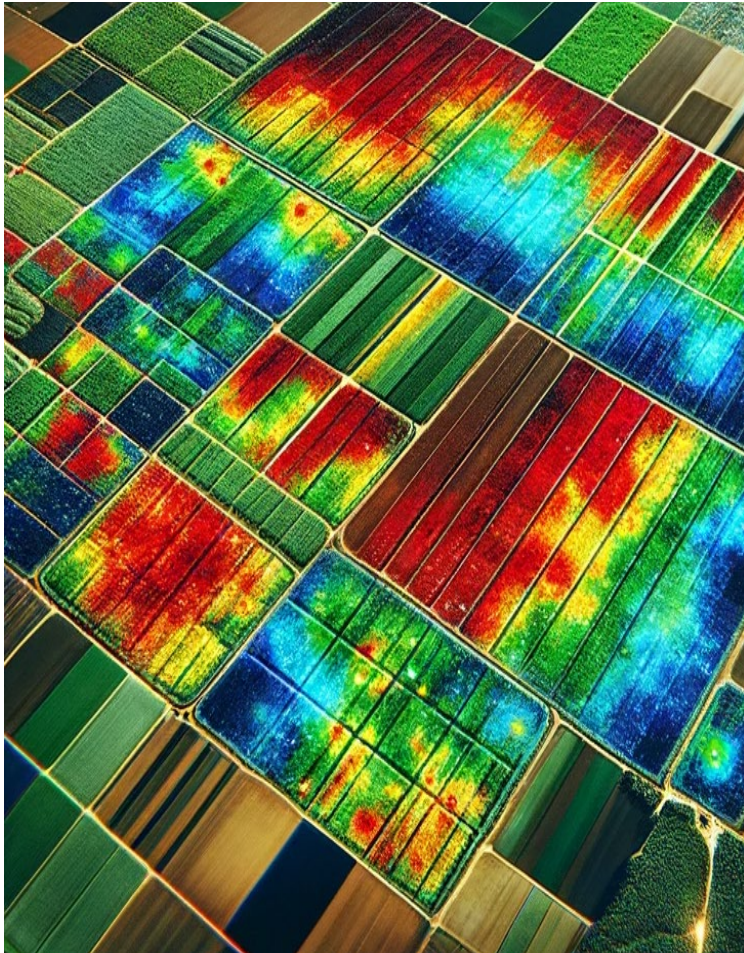
Soil Quality Monitoring

Scope

- **Description:** Soil Nutrients Detection System Using Satellite Imagery in Multi-Modality AI techniques.
- **Advantages:** Utilizes advanced multispectral satellite imagery to evaluate soil nutrient levels, enabling precise agricultural planning, sustainable land management and reduction of unnecessary use of fertilizers.
- **Quality Assurance:** Implements comprehensive metrics including NDVI, Soil Adjusted Vegetation Index (SAVI), and RMSE. The model can be further calibrated with soil samples to ensure high accuracy in nutrient detection.

Use Cases

- **Government Agencies:** Agencies tasked with agricultural policy-making, soil conservation, and land management.
- **Agribusinesses:** Large-scale farming enterprises that require detailed soil health information to optimize crop production and reduce fertilizer usage.
- **Environmental NGOs and Research Institutions:** Bodies focusing on sustainable agriculture, soil health research, and aquifer protection
- **Farmers and Agricultural Cooperatives:** Individual farmers and cooperatives seeking to enhance crop yields and soil health through targeted nutrient management.

Other Uses Cases

Use Cases

- Water-body monitoring (50+ Y time-series), including water volume, surface temperature and water quality indices (autonomously updated) [**Dashboard**].
- Solar Rooftop Potential Estimation using specific PVout for every geographical roof location, in addition to PV panels mapping.
- Geopose estimation from single imagery: buildings height and inclination
- Participated in FloodNet competition, xView2 and many others..
- XAI4EO