NATIONAL SECURITY SCIENCES

GeoAI

For Mapping and Monitoring

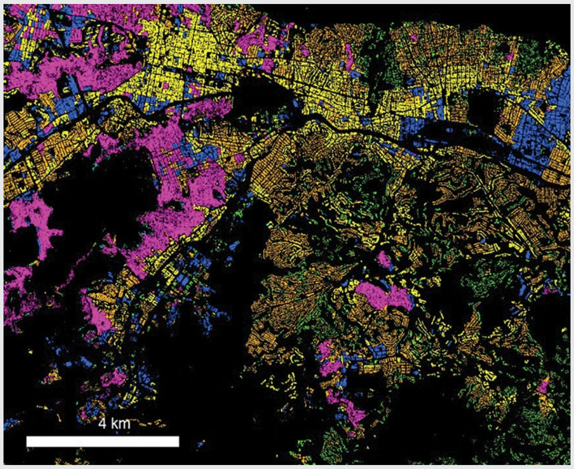
Through advances in artificial intelligence, Oak Ridge National Laboratory is transforming geospatial analytic methods in support of information exploitation and dissemination into geospatial intelligence (GEOINT) foundational data layers.

With core strengths in machine learning for high-performance computing, geoassurance, probabilistic reasoning, and spatio-temporal analytics, we are developing geospatial artificial intelligence (GeoAI) methods focused on several key research areas:

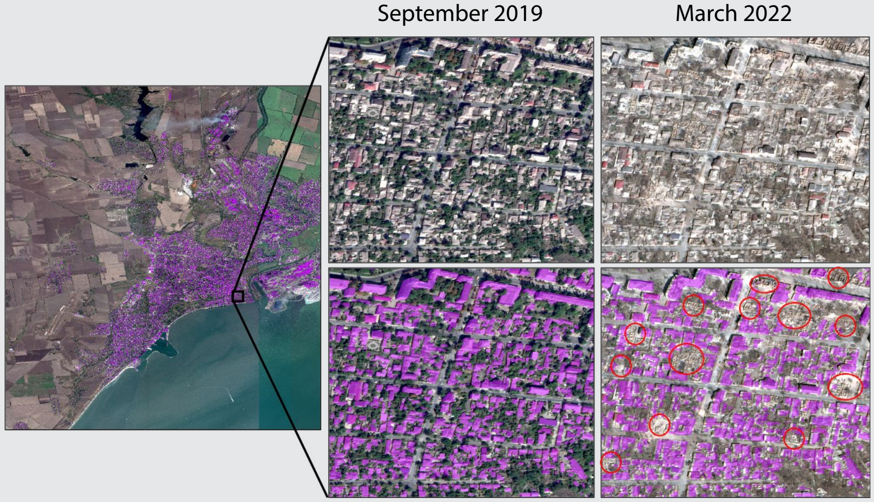
- ***Spatio-temporal Analytics for Global Data***—Integrating global datasets and applying advanced analytics to identify trends, patterns, anomalies, and changes in national landscapes
- ***Settlement Characterization***—Exploiting overhead imagery to develop scalable ways to characterize socioeconomic neighborhoods for economic stimulus, unstructured settlement mapping, population distribution studies, and more
- ***Automated Feature Extraction***—Employing machine learning, computer vision, and high-performance computing to automate the creation of foundational data layers for building footprints, road networks, solar panels, and more at scale
- ***Population Dynamics***—Applying Bayesian learning approaches to estimate building occupancy at varying times of day and night across a variety of sociocultural environments, improving urban planning, emergency management, and disaster response
- ***Gravity Mapping***—Adapting AI techniques to produce high-resolution gravity maps on a global scale to support navigation systems, early detection of potential earthquakes, and measurement of changes in water patterns

ORNL's groundbreaking GeoAI capabilities are foundational to the Lab's research and mission applications in critical infrastructure resilience, human security, and disaster recovery.

Our scientists and engineers have developed new methodologies and adapted existing techniques in new ways to advance scientific solutions across a wide range of domains, including:



Detected building footprints with socioeconomic neighborhood delineations.



Changes detected in March 2022 imagery.

To expand our impact on national security and humanitarian missions, we are enhancing our GeoAI capabilities through a variety of R&D efforts, including:

- Generalizing and scaling GeoAI imagery across a range of geographic, temporal, cultural, and sensor conditions—with increasingly finer and more accurate feature extraction across a range of applications.
- Reducing the need for large training sample sizes by:
  - » improving sampling strategies
  - » using human-computer collaborations to accelerate sample collection
  - » deploying deep learning architectures that are less susceptible to statistical "noise" from random data variations

- Engaging a variety of AI strategies, such as reinforcement learning and adversarial learning, to discover the underlying distribution of unseen data and to learn in an unstructured environment, increasing extensibility and flexibility in AI and machine learning.
- Leveraging deep feature learning to advance computer vision performance and extract features of interest such as buildings, roads, and sociocultural regions at scale.
- Developing Bayesian systems that learn population dynamics from open-source data and explicitly capture uncertainty from multiple sources, producing operational systems that learn and improve population estimates in real time.
- Advancing GeoAI models that integrate multi-sourced and multimodality data including imagery, open-source text, points of interest, crowd-sourced maps, and traditional survey data.
- Enhancing and supplementing traditional physical models with GeoAI approaches, such as parameterizing and understanding physics-based geomatic models.

CONTACT | Dalton Lunga | GeoAI Group Leader | lungadd@ornl.gov | 865-574-8444

Oak Ridge National Laboratory is managed by UT-Battelle LLC for the US Department of Energy

2022-G00695

Oak Ridge National Laboratory

U.S. Department of Energy | Office of Science

NATIONAL SECURITY SCIENCES