ARTIFICIAL INTELLIGENCE FOR SAR (AI4SAR)

KEY MESSAGE

Rapid-revisit, high-resolution Synthetic Aperture Radar (SAR) is a big data problem with unique challenges. Unlike the traditional optical Earth Observation (EO) sensors, the preservation of complex electromagnetic phase information facilitates the observation of novel information from Earth, but also requires efficient memory and compute to process and mitigate residual artifacts.

The ability to analyze this type of data presents a steep learning curve for non-experts. For Artificial Intelligence/ Machine Learning (AI/ML) computer vision, there's the added challenge of leveraging the valuable complex information in deep learning frameworks intended for one-band (grayscale) or three-band (red, green and blue) information. All of these challenges are underscored by the cost consideration of implementation, compute, and time. So, the key contribution of this project is the discovery of a cost-effective approach to bridge the gap between the SAR-based EO and AI/ML domains.

OBJECTIVE

Harness the potential of AI/ML for EO with a focus on high-frequency and high-fidelity SAR data.

DATA READINESS

CHALLENGES

1. Big Earth data: Storing EO datasets in self-contained structures for ML models

2. Domain expertise: Dearth of ML Engineers and Data Scientists with EO knowledge

APPROACH

Open-source Python library for SAR-based ML applications

GitHub : icecube

Use the publicly available ICEYE sample dataset with the icecube toolkit:
Time-series stack of Strip SAR imagery

If you are a researcher or an application developer, you can submit a proposal to ESA to gain ESA-sponsored (free) ICEYE images for research and pre-operational application development.

READ MORE:
Sponsored SAR Data for Research

FORMAT TRANSLATION

CHALLENGE

External training data in geographic or projected map coordinate system (not in the language of SAR)

APPROACH

Reference system translation (Geo-to-SAR and SAR-to-Geo)

COST INEFFECTIVENESS

CHALLENGE

Expensive to find and consume SAR-based training datasets

APPROACH

SAR simulator that generates SAR-specific training datasets

DATA PECULIARITIES

CHALLENGE

Ambiguity in SAR images that impact the outcome of downstream applications

APPROACH

ML models that detect and suppress ambiguities

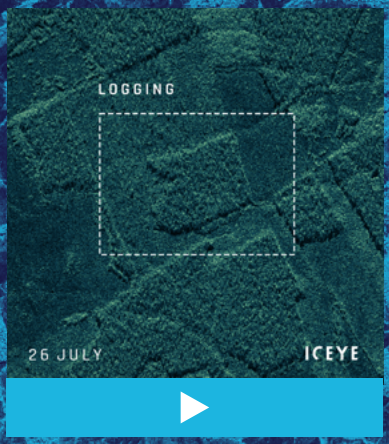
REAL-LIFE APPLICATIONS

CHALLENGE

Two environmental use cases that demonstrate the achievability of the objective

APPROACH

Deforestation and water-extent use cases

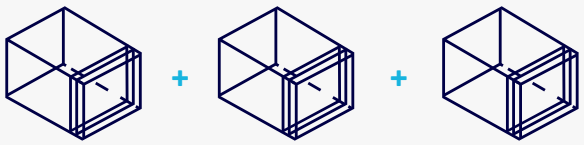


The animation showcases a stack of seven Strip images from one of ICEYE's one-day ground track repeat (GTR) orbit test sites. With repeat image intervals measured in hours instead of days, the question that the data answers is moving from 'was there deforestation?' to 'is deforestation happening right now?' Answering this question enables us to act while the site is still active instead of recording the damage done.

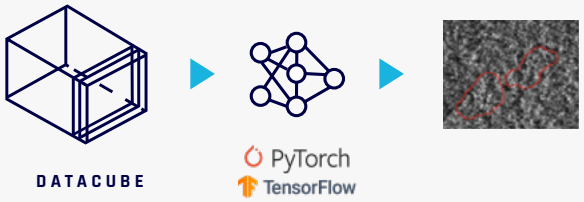
VISIT
AI4SAR PROJECT PAGE

USER CONFIGURATION

DATACUBE CREATION

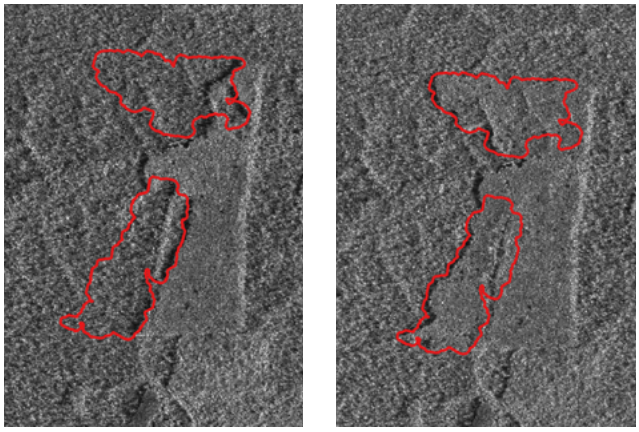


MACHINE LEARNING INTEGRATION

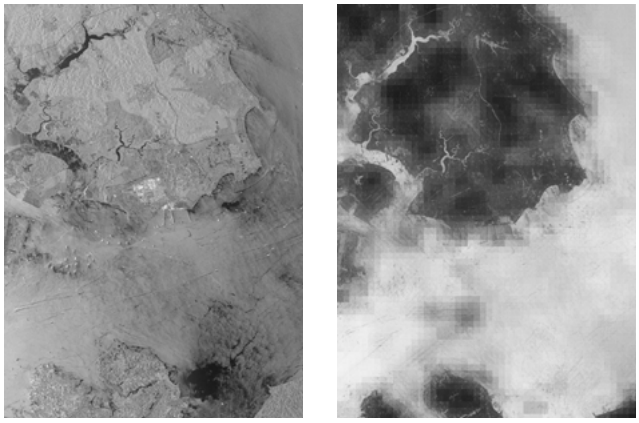


The diagram shows how the generated cubes fuse together with the ML pipeline for model training. This makes it easier for ML engineers to train ML models without worrying about the domain-specific knowledge of SAR.

GitHub: icecube



↑ *Large-scale deforestation in 2021. The image on the left is from late July and the one on the right is from early August.*



This image pair illustrates how the ML model predicts the water extent. The image on the left is an **ICEYE Strip image** of the Singapore Strait and the image on the right is the **Neural Network (NN) output probability**. The bright values in the image on the right indicate water.

We selected this use case to demonstrate some nonlinear behavior of water backscatter on large open waters. The wind is breaking the surface of the water, thereby making some areas appear bright and some very dark. The model can identify water in both cases, which means that it has learned more than a simple thresholding function.

BLOG

A five-part series that highlights the key facets of the AI4SAR project. While we prepare the last two blogs for publication, read these three blogs!

- Applying ML to rapid-revisit SAR
- Create time-series datacubes for supervised ML
- Spatially align a time-series stack of ICEYE SAR images

ABSTRACT

The AI4SAR project team submitted the following abstract to Living Planet Symposium 2022: *A Machine Learning Approach to Automatic Azimuth Ambiguity Filtering in SAR data.*

TECHNICAL FACT SHEET

SAR IMAGING MODE	Strip 3m resolution with a scene size of 30x50km Single Look Complex (SLC) Ground Range Detected (GRD) **Read more: https://www.iceye.com/sar-data/strip**
PROGRAMMING LANGUAGE	Python
OPEN-SOURCE LIBRARIES AND KEY ELEMENTS	PyTorch, Dask, Xarray (with built-in support for Zarr), NetCDF, ESA SNAP, and Docker Hub

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