SOLUTION SHOWCASE

UNIVERSITY OF COPENHAGEN

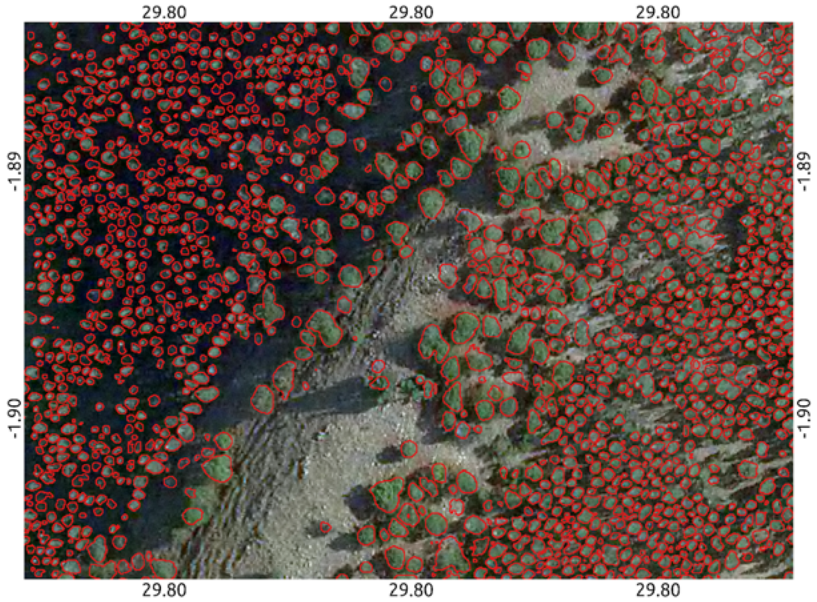
Mapping Tree Ecosystems with GPUs

> *"The neural network built for this project used 32 million trainable parameters. By using NVIDIA GPUs over a CPU approach, we were able to speed up training by ~1,000X. This allowed us to train and evaluate the system on large amounts of data. We know the NVIDIA team well, and work closely with them for valuable support, software and services in our research projects."*
>
> —**Michael Egesborg,** Service Delivery Manager, University of Copenhagen

Trees provide a multitude of services to the ecosystem. This includes carbon storage and food sources, and they play a crucial role in supporting the biodiversity of flora, fauna, insects and animals.

Most public interest relating to the earth's trees is devoted to forests alone, so trees that exist outside of forests are not well-documented. Individual trees are of particular importance in drylands, which cover about 40 percent of earth's landmass, due to the lack of large closed-canopy forests in these areas.

The University of Copenhagen (UCPH) is using deep learning models to monitor ecosystem properties, for example the number of trees, at a global scale to explore their role in mitigating climate change, environmental degradation and poverty.



UNIVERSITY OF COPENHAGEN

University of Copenhagen uses NVIDIA GPUs to train deep learning models to identify trees outside of forests (TOF)

DOMAIN

- Geoscience

CHALLENGE

- Trees outside forests are not well-documented, but have a crucial role in biodiversity.
- Huge variability in tree and shrub appearance, and climatic conditions

RESULTS

- Using satellite imagery 1.3 million square kilometers were analysed in the West African drylands, where 1.8 billion trees were mapped outside of a traditional forest
- Using GPUs delivered ~1,000X faster results than a CPU approach
- Previous studies predicted 0% canopy cover, UCPH found it to be 3%, and a tree density of 13.4 trees per hectare
- This approach will change the way global ecosystems are monitored, modeled and managed

NVIDIA Solution

With high resolution satellite images from 1.3 million square kilometers of West African drylands, UCPH were able to map the location and size of 1.8 billion trees and their respective canopy cover using deep learning models.

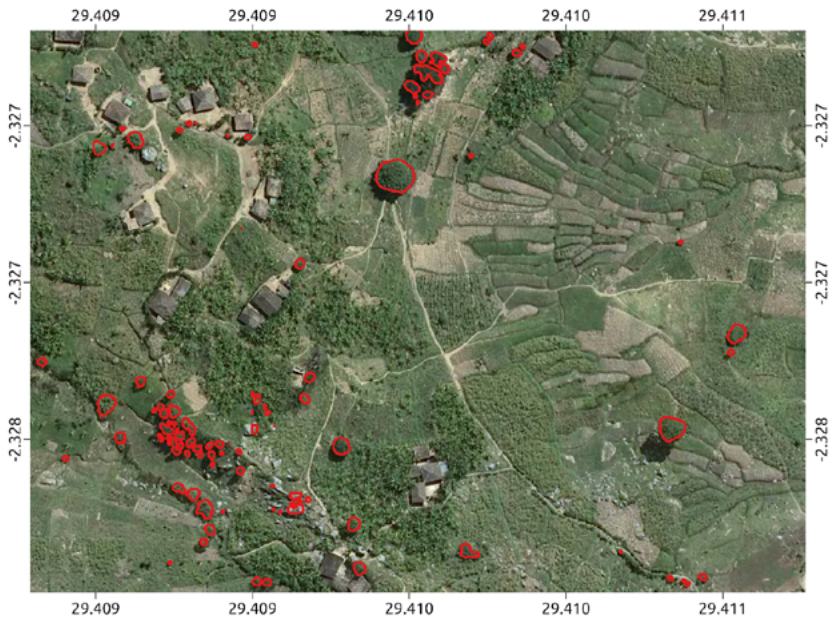
Dryland trees and shrubs can be particularly challenging to identify due to the high variability in their appearance and in the climatic conditions over such large areas.

For this task, UCPH researchers used orthorectified, pan-sharpened satellite images containing the panchromatic band and the normalized difference vegetation index (NDVI). The images were taken during the dry season, to capture photosynthetically active woody plants with high NDVI values.

Within the selected area, UCPH researchers manually labeled 90K individual trees in the satellite images, covering a range of environmental and climatic conditions along a north-south gradient.

This data was then used to train a fully-convolutional neural network. To evaluate the performance, UCPH compared the results with the data from field studies conducted in the same area, and found high correlation in both the count of trees and the overall canopy cover ($r^2 = 0.89$).

In comparison to using a CPU, the NVIDIA GPUs used in this project sped up training by a factor of approximately 1,000. The GPUs were essential for training the neural network, which contained more than 32 million trainable parameters. These significant time savings meant researchers could tune the model's hyper-parameters to achieve performance on par with the field studies.



Results

UCPH's system gave the first accurate measurement of individual trees in the West African Sahara and Sahel zone. It was found that the number of trees – but not necessarily the carbon stock (the amount of carbon that has been taken from the atmosphere and is now stored within the forest ecosystem) – is higher than expected.

Using this information, UCPH could study the effect of various factors such as mean annual rainfall, soil type, land use and proximity to human settlement on the distribution of individual trees.

Earlier studies had predicted 0 percent canopy cover in the majority of this area, but UCPH instead found that the tree density and canopy cover gradually increases depending on levels of rainfall.

NVIDIA TECHNOLOGY USED

- NVIDIA® DGX™ A100 PCI and HGX cards
- NVIDIA RTX™ 8000

TREE DENSITY BY RAINFALL			
HYPER-ARID AREAS (<150mm rainfall)	**ARID AREAS** (150 - 300mm rainfall)	**SEMI-ARID AREAS** (300 - 600mm rainfall)	**SUB-HUMID AREAS** (600 - 1000mm rainfall)
0.7 Trees per hectare	**9.9** Trees per hectare	**30.1** Trees per hectare	**47** Trees per hectare

UCPH's analysis is now being extended to map individual trees in large parts of the world and predict the carbon stocks for the whole Sahara, Sahel and Sudanian Zones of Africa. This approach will no doubt drive fundamental changes in how global terrestrial ecosystems are monitored, modeled and managed.

About University of Copenhagen www.ai.ku.dk

The University of Copenhagen (UCPH) was founded in 1479, and today hosts 37,500 students and 9,000 employees. The University is highly ranked, where nine Nobel Prizes and a Turing Award have been awarded to researchers at UCPH. The departments involved in this project collaborate in the SCIENCE AI Centre, which fosters excellence in AI research at the Faculty of Science at UCPH with an emphasis on interdisciplinary collaborations.

Brandt, M., Tucker, C.J., Kariryaa, A. et al.
An unexpectedly large count of trees in the West African Sahara and Sahel.
Nature 587, 78–82 (2020).

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