KaCUDA

Pioneering Tomorrow's Energy Grids with AI-Powered Electricity and Settlement Detection

By Team SAT-D

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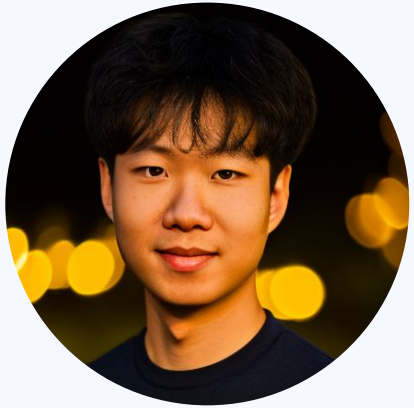
Meet the Team

Stephen Kakuda



Daniel Lan

Teresa Liang

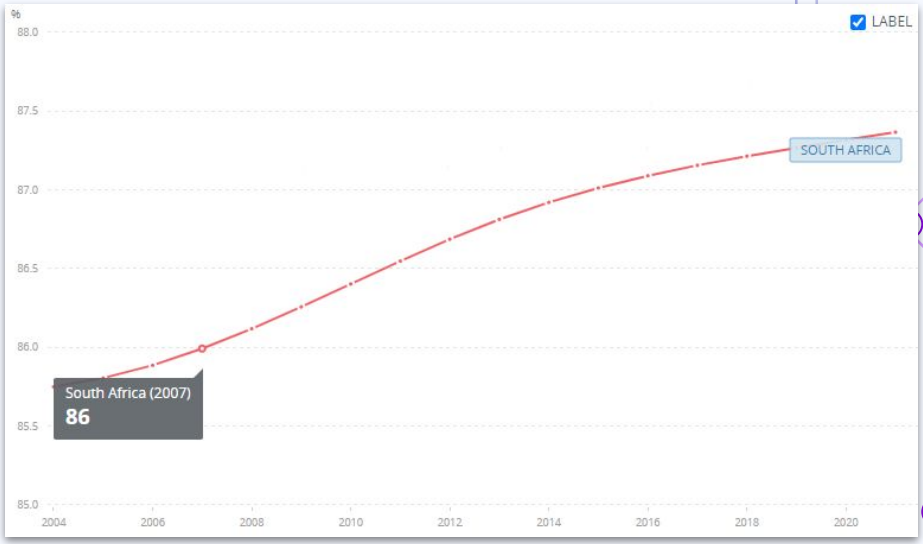
Aileen Mi

The Problem

- Electricity is a fundamental requirement for improving living standards and fostering economic growth
- Nearly 600 million people in South Africa do not have access to electricity

Why Is the Problem Significant?

- The South African population is increasing but electricity development is stagnating
  - Access to electricity decreased by 0.7% in 2023
- Land developers can prioritize human settlements with the largest populations and strong potential for rapid development



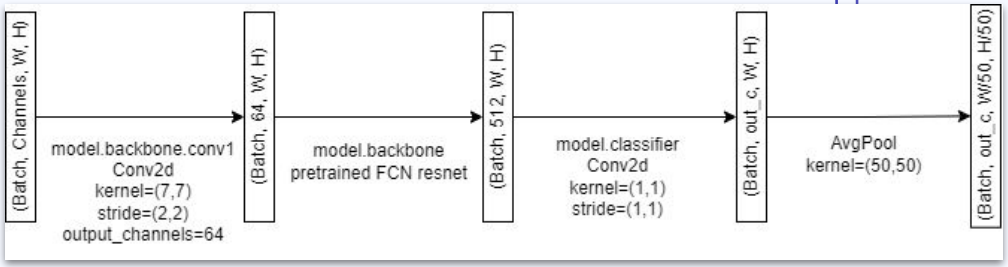
Access to electricity in South Africa from 2004 - 2023

Our Approach: Transfer Learning

If we can leverage computer vision to create a machine learning model to detect human settlements that do not have access to electricity, then we can enable future grid planning and renewable energy solutions.

Transfer Learning Model for Semantic Segmentation

We take a pre-trained neural network (ResNet 101) and fine-tune it on our dataset to produce labels for individual regions in satellite images



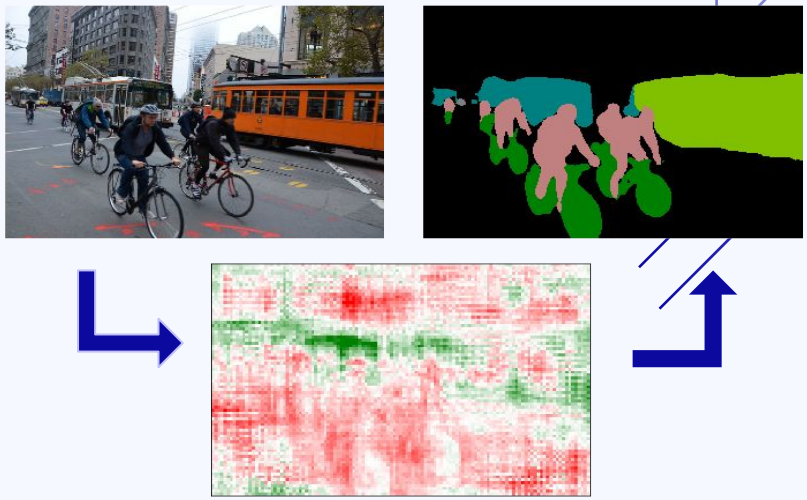
Transfer Resnet 101 Pipeline

Our Approach: Explainable AI

If we can interpret the layers in our machine learning model and generate visual explanations of its decisions, then we can better comprehend and trust its results.

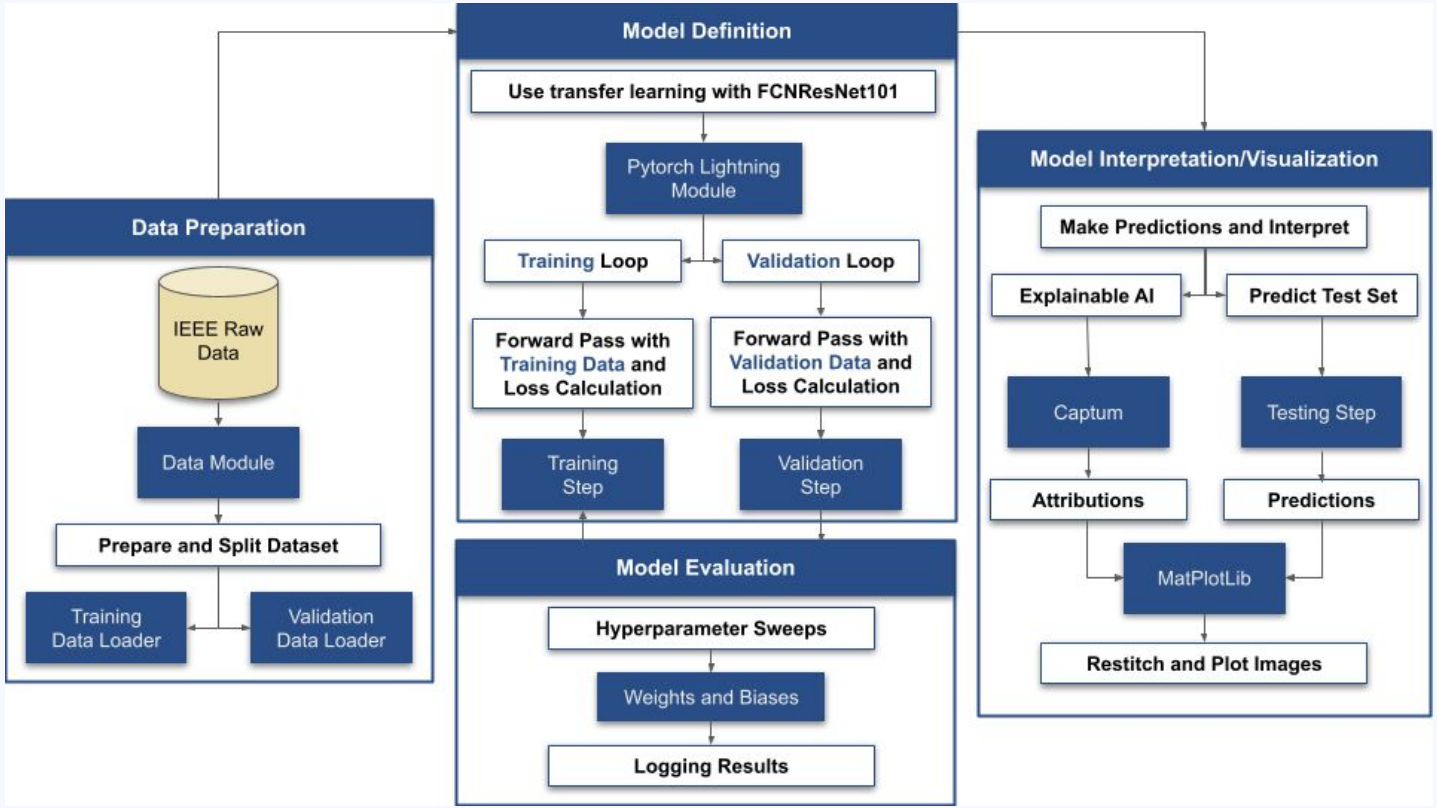
Layer Gradient-weighted Class Activation Mapping

This XAI technique calculates the gradients of the target we want to explain flowing into a convolutional layer to produce a heatmap highlighting the important regions in the image with respect to that target



Layer GradCAM Visualization

ML Pipeline


Data Preparation
IEEE Raw Data
Data Module
Prepare and Split Dataset
Training Data Loader
Validation Data Loader
Model Definition
Use transfer learning with FCNResNet101
Pytorch Lightning Module
Training Loop
Validation Loop
Forward Pass with Training Data and Loss Calculation
Forward Pass with Validation Data and Loss Calculation
Training Step
Validation Step
Model Evaluation
Hyperparameter Sweeps
Weights and Biases
Logging Results
Model Interpretation/Visualization
Make Predictions and Interpret
Explainable AI
Predict Test Set
Captum
Testing Step
Attributions
Predictions
MatPlotLib
Restitch and Plot Images

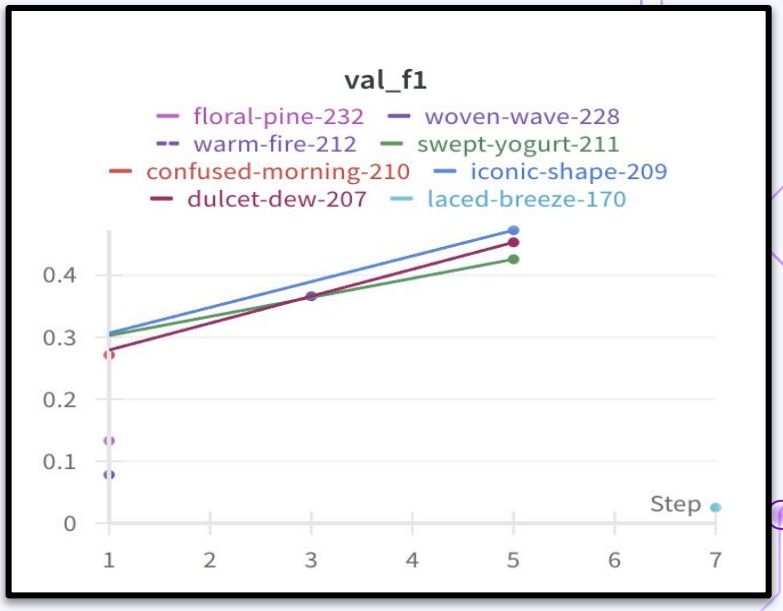
Model Demo

Baseline Models

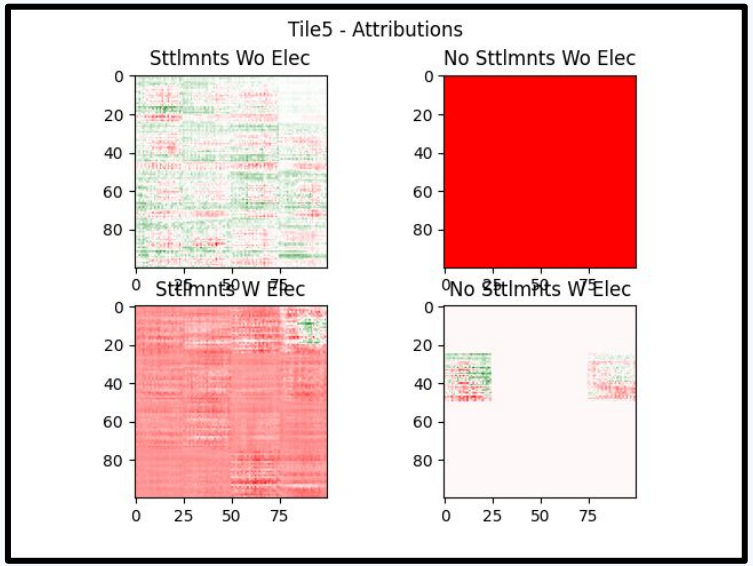
Model	Validation Accuracy
Segmentation CNN	31.26%
FNCResnet Transfer	36.61%
U-Net	42.58%

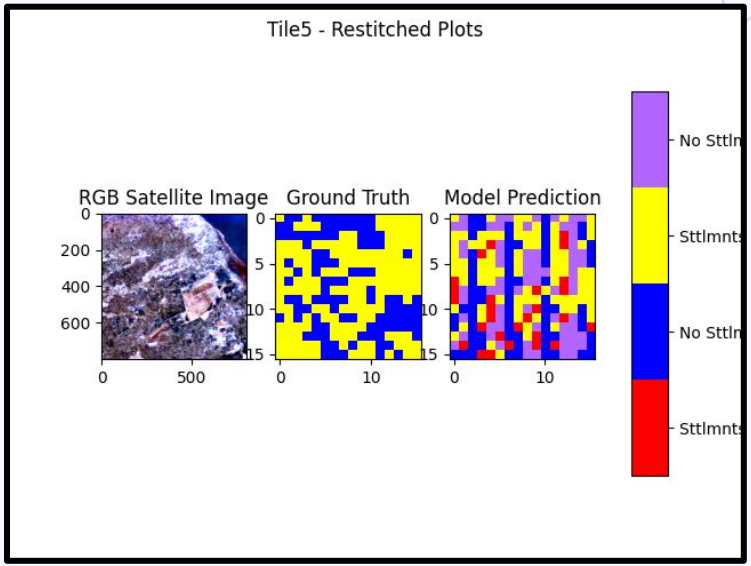
Deep Learning Model

Model	Validation Accuracy
Transfer Learning w/ Captum	59.97%



Our Results





less important for prediction ⟷ more important for prediction

So What?

- Advanced Model Architectures
- PyTorch Lightning and Automated Hyperparameter Tuning
- Comprehensive Evaluation Metrics (XAI)
- Remote Sensing Data Focus

Our Impact

Enhances Living Standards and Economic Opportunities

- Efficiently identifies unelectrified areas
- Guides targeted electrification planning efforts
- Provides data-driven development policies

Acknowledgements

- **Dataset** - 2021 IEEE GRSS Data Fusion Contest: Track DSE, Detection of Settlements without Electricity
- **Software Tools** - Pytorch, Captum
- **People**
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