AdeNet: Deep learning architecture that identifies damaged electrical insulators in power lines

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presented by

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Outlines

- Introduction
- Related work
- Proposed Approach
- Methodology and Experimental Design
- Results and Discussion
- Conclusion

INTRODUCTION

- Power line insulators change over time because they are continuously exposed to the weather
- identifying damaged insulators is a critical safety task
- Automatically detecting anomalies in image data has a broad range of applications
- Training data for such tasks is often unbalanced

INTRODUCTION

- **Anomaly Detection**

  Finding unusual patterns in data

- **Class Imbalance**

  Data is skewed

RELATED WORKS

- AnoGAN
- L2 and SSIM Autoencoder
- CNN Feature Dictionary
- GMM-Based Texture Inspection Model
- Variation Autoencoder.

PROPOSED APPROACH

- Shallow learning - Udat
  - Udat [28] works by first extracting a large set of 2841 numerical image content descriptors from raw pixels and transforming the raw pixels
- Deep learning: In deep learning, multiple layers of mini-algorithms, called neurons, work together to draw complex conclusions.
  - EfficientNetB7
  - VGG19
  - ResNet-101

DATASET OVERVIEW

Table 1. Number of samples of damaged and undamaged insulators in the dataset.

Dataset	Damaged	Undamaged	#images
Train + Validation	1417	2836	1484
Test	290	835	212

Fig. 2. An example of a power line image.

METHODOLOGY AND EXPERIMENTAL DESIGN

AdeNet is a deep learning architecture implemented with three layers of CNNs, each with batch normalization, maxpooling, and ReLU with no dropout.

One fully connected layer comes before the softmax layer.

It contains the initial fully convolutional layer with 32 filters. We always used kernel size 3×3 as is standard for modern networks. The trained model size was 1.3MB with 102,082 trainable parameters and 448 non-trainable parameters.

RESULTS AND DISCUSSION

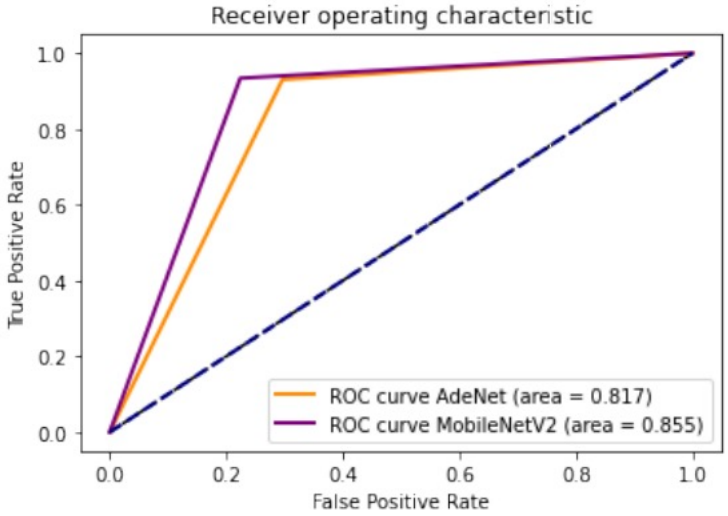

Fig. 5. Model comparison of the ROC curve on insulator dataset

	Size (MB)	Trainable parameters
MobileNetv2	5.7	398, 690
AdeNet	1.3	102,082

RESULTS AND DISCUSSION

Table 8. Classification accuracy, F1, precision, recall, and ROC area under the curve when using different methods on test data (average of 5 folds cross validation).

Learning	Classifiers	Acc	F1	Precision	Recall	ROC Area
Shallow	Random Forest	0.79	0.64	0.79	0.62	0.82
Shallow	Random Tree	0.69	0.60	0.60	0.60	0.60
Shallow	Naive Bayes	0.56	0.56	0.64	0.67	0.76
Shallow	MultiLayer Perceptron	0.77	0.69	0.69	0.68	0.79
Shallow	Support Vector Machine	0.72	0.65	0.65	0.66	0.66
Deep	MobileNetV2 + 10 epochs	0.82	0.72	0.77	0.71	0.73
Deep	MobileNetV2 + 20 epochs	0.70	0.63	0.76	0.70	0.71
Deep	AdeNet + 10 epochs	0.86	0.81	0.85	0.80	0.80
Deep	**AdeNet + 20 epochs**	**0.89**	**0.84**	**0.87**	**0.83**	**0.83**

RESULTS AND DISCUSSION

Table 2. Confusion matrix for Random Forest on test set

	Predicted Damaged	Predicted Undamaged
Actually Damaged	11	279
Actually Undamaged	2	833

Table 3. Confusion matrix for MobileNetV2 after 20 epochs for test set

	Predicted Damaged	Predicted Undamaged
Actually Damaged	991	459
Actually Undamaged	1063	3112

Table 6. Confusion matrix for AdeNet after 20 epochs for test set

	Predicted Damaged	Predicted Undamaged
Actually Damaged	1026	424
Actually Undamaged	213	3962

QUALITATIVE RESULTS

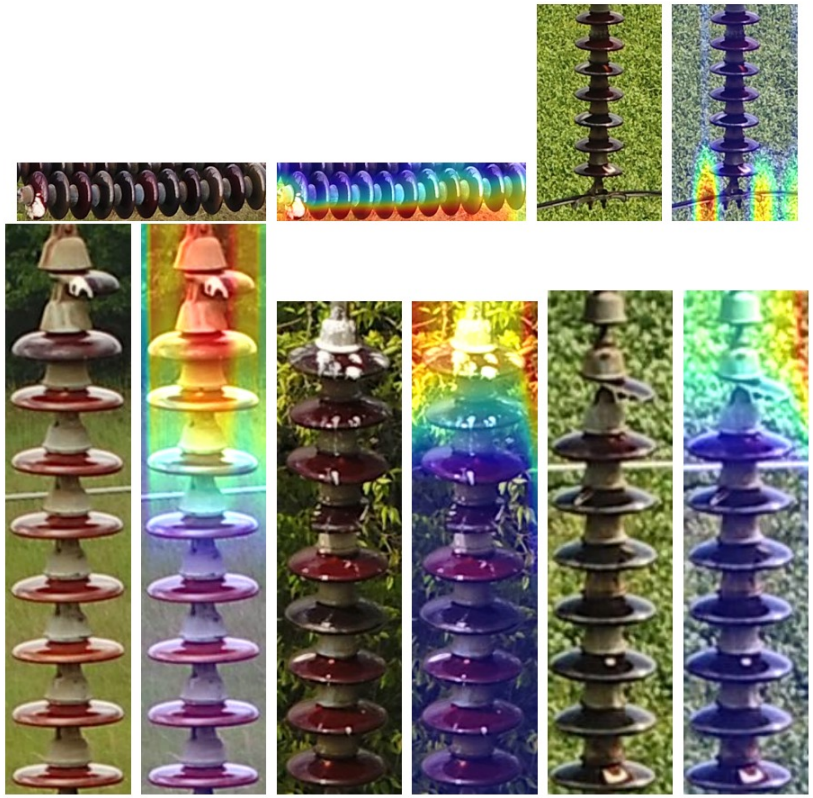

Fig. 6. Grad-CAM heatmap visualizations

CONCLUSION

- We addressed the task of detecting damaged electrical insulators in power line images

- The new architecture, AdeNet, based on a deep convolutional neural network has the advantage of requiring little energy, allowing it to be used on low-energy devices like UAVs

- In comparing the proposed method and other solutions, including shallow learning, we found that deep learning outperforms shallow learning architectures.

IMPLEMENTATION CODE

https://github.com/demolakstate/AdeNet-Deep-Learning-Architecture.git

THANK YOU FOR LISTENING

QUESTIONS