EUROSAT LAND COVER CLASSIFICATION

INFO6147-Deep learning with python

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ABSTRACT

- The project represent a deep learning-approach to classify satellite image into various land cover types using the RGB version of the EuroSAT dataset.
- A ResNet-50 convolutional neural network, pretrained on the ImageNet was fine-tuned over 27,000mRGB sentinel-s Images of 10 different classes like River, Industrial, Residential, Agricultural and so on.
- The model enhanced high accuracy through data argumentation, normalization and optimized training.
- To enhance the interpretability, GRAD-CAM was integrated to visualize class-specific regions influenced on the model's prediction.
- A user-friendly web interface developed using Streamlit developed via ngrok.

Introduction

- The main object of the project is to build a CNN-based classifier(ResNet-50) to accurately label the land covers from the satellite images.
- The dataset contains over 27000 labeled satellite images of 10 land cover types.
- ResNet-50 trained on ImageNet has been used as the CNN
- To improve the transparency, GRAD-CAM was used to generate visual heatmaps
- Visual heatmap shows which part of an image the model focused on during its prediction.
- It was wrapped in a user-friendly streamlit web application making it easy to upload an image and view the prediction along with the heatmap.

Methodology

Dataset Selection

- Dataset source: https://zenodo.org/records/7711810#.ZAm3k-zMKEA
- Dataset contains 27,000 images of 10 classes.
- RGB version of EuroSAT has been used for this project.
- It contains R,G,B frequency bands encoded as JPEG images.

Data preprocessing

- Image resizing: Resized all images into 224*224 pixels(resNet-50 input)
- Tensor conversion and ImageNet standard normalization for the better regularization and the performance of the model.
- Train-validation split (80%-20%)
- Loaded the data for both training and validation with batches of 32.

Model selection and architecture

- Model selection: ResNet-50
- Why ResNet-50

Deep 50-layer architecture

Proven performance in image classification, object detection and transfer learning

It extract rich spatial features from EuroSAT satellite images

- Model architecture:

Initial layers(1*conv2d layers)

16 bottle neck blocks each has 3 conv layers

Final layer which is replaced with output size=10

- Relu has been added to introduce non-linearity after each convolutional layers
- BatchNorm2d also added to stabilize the training.

Model Training

- Training and evaluation have been done for fine-tuned ResNet-50 model on the EuroSAT dataset.
- Model is trained using CrossEntropyLoss and optimized via SGD with learning rate of 0.001 over 5 epochs.
- Evaluated the performance using validation accuracy and training loss and validation loss.
- A separate prediction function has been added to predict the confidence score
- Softmax function was used to convert the raw scores into probability distribution across all classes.

Evaluation

To evaluate the performance of the model, accuracy has been calculated.

Epoch 1:

Loss: 1.8022

Training Accuracy: 50.9%

Validation Accuracy: 69.5%

Epoch 2:

Loss: 0.9513

Training Accuracy: 77.2%

Validation Accuracy: 84.3%

Epoch 3:

Loss: 0.5725

Training Accuracy: 85.2%

Validation Accuracy: 85.9%

- **Epoch 4**:

  Loss: 0.4003

  Training Accuracy: 88.9%

  Validation Accuracy: 92.0%

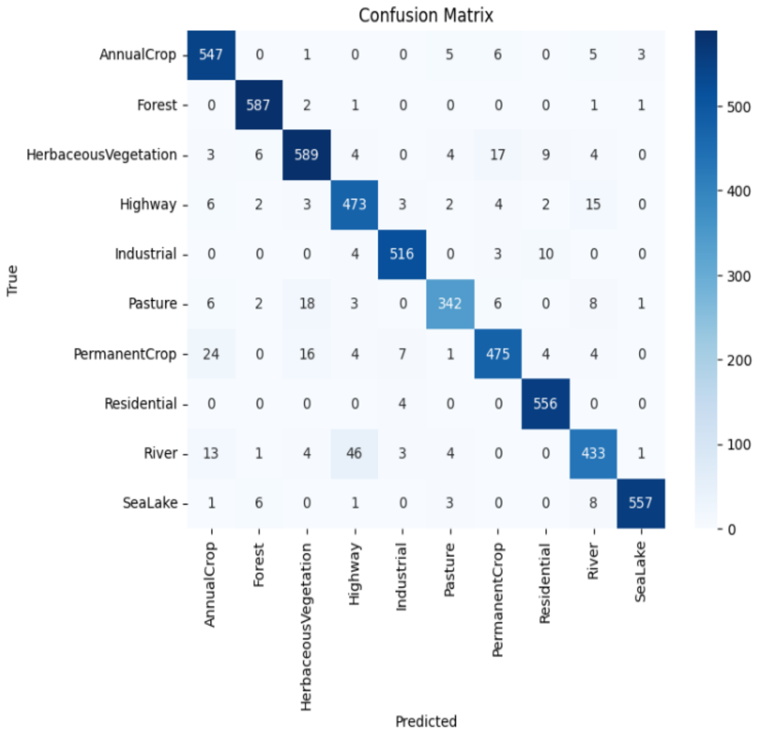
- **Epoch 5**:

  Loss: 0.3144

  Training Accuracy: 90.7%

  Validation Accuracy: 93.9%

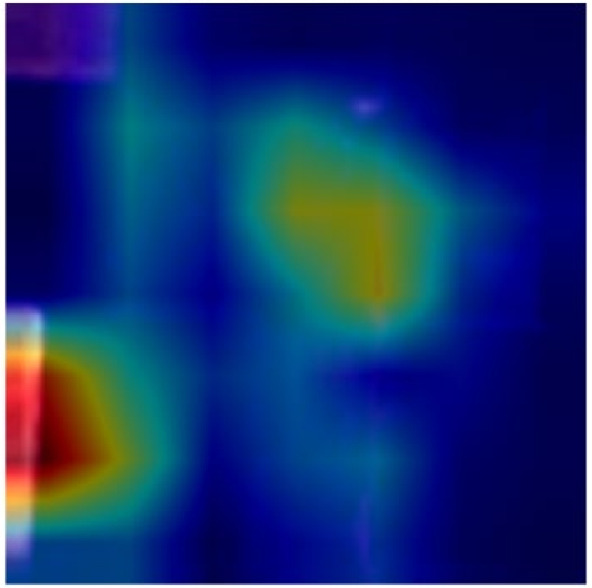
- The model shows steady improvement in both training and validation accuracy
- The accuracy reached to 93.9% from 69.5%.



Confusion matrix

- Confusion matrix indicates that the ResNet model exceptionally well in classifying land cover from EuroSAT dataset.
- Categories like forest, herbaceous vegetation, Sea lake and residential are classified with high accuracy
- However, model struggles to classify categories Such as river, pasture due to visual similarity.

GRAD-CAM Feature map



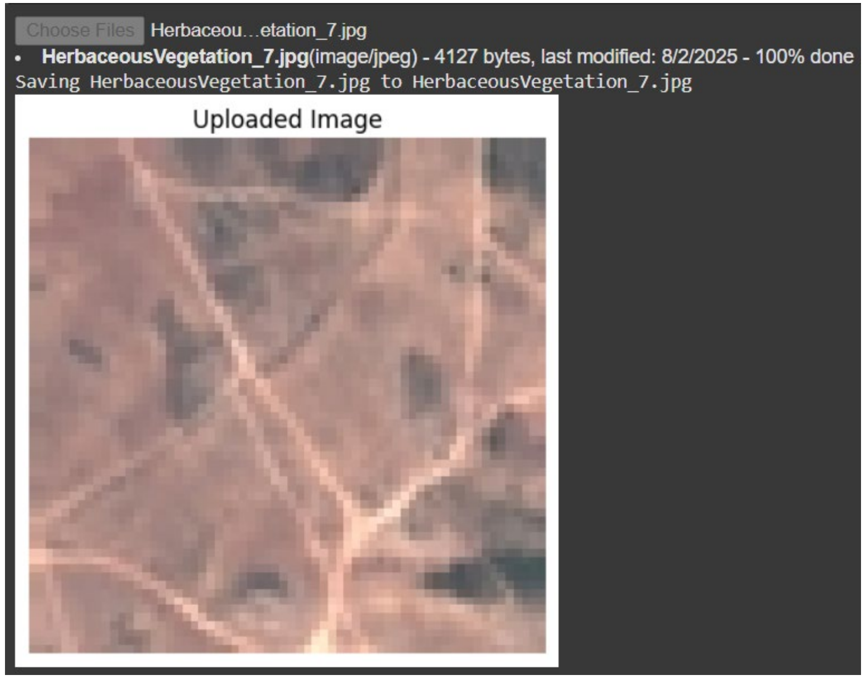
- The figure shows the GRAD-CAM(gradient Gradient-weighted class

  activation mapping) feature map of class0(annual crop).
- It highlights the important regions in the image that the ResNet

  focused on while making predictions.
- The Red/yellow areas represent the regions with high influence on

  prediction
- Blue areas indicate the low contribution to the classification

Results



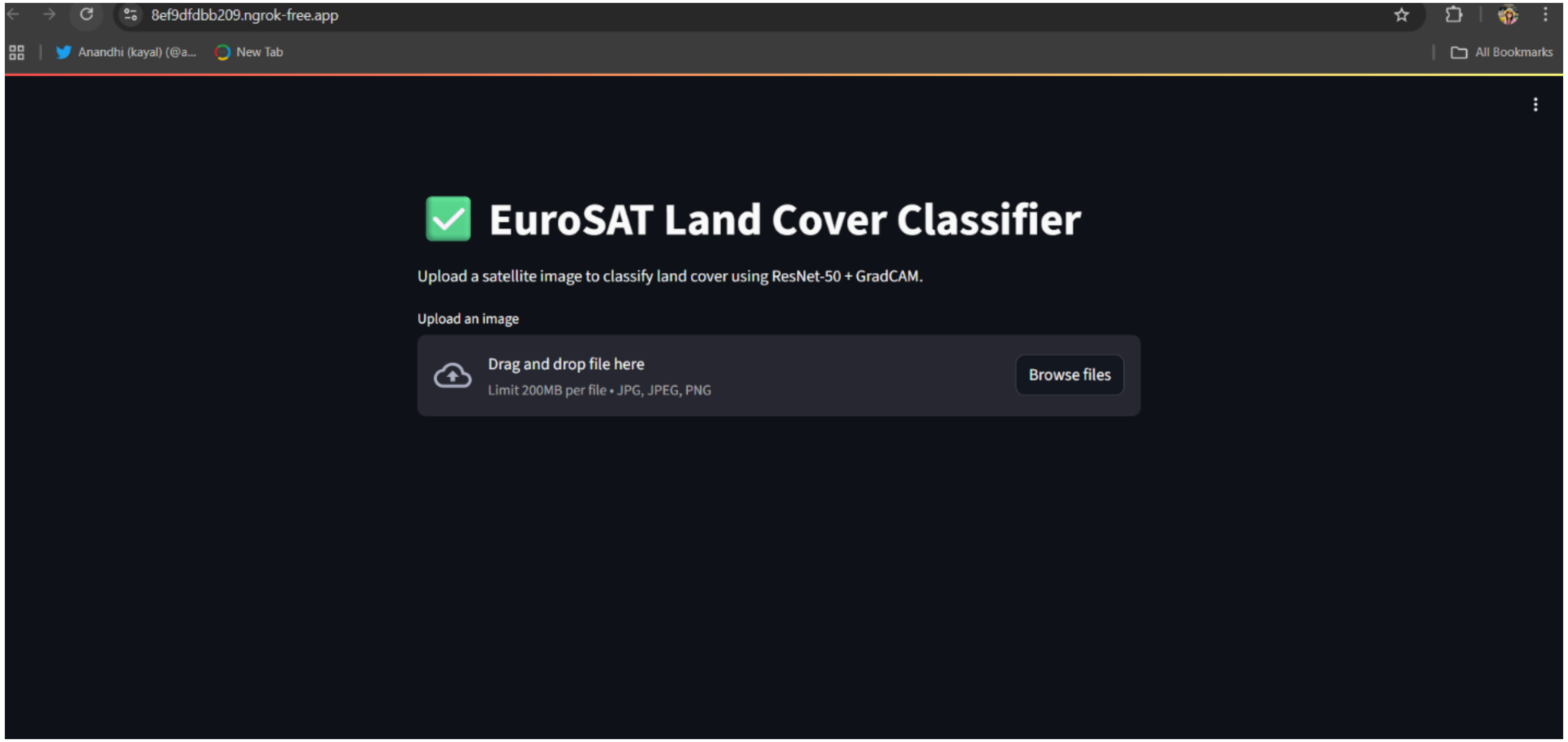
- To enable the real-time predictions, an image upload feature was implemented.
- Using the upload menu, user can upload the satellite image directly.
- Results the immediate visual feedback to the user.
- Also Predicted label and its corresponding confidence score have been printed using predict_resnet()

Integration with GPT-4o

- To enhance the interpretability along with the resNet-50 prediction, GPT-40's multi-model capabilities were integrated into this project.
- A custom function converts the uploaded satellite image into a base64 format and send to GPT-4o via API along with the prompt asking the model to classify the image.
- Returns a response with its prediction.

Streamlit web application integration

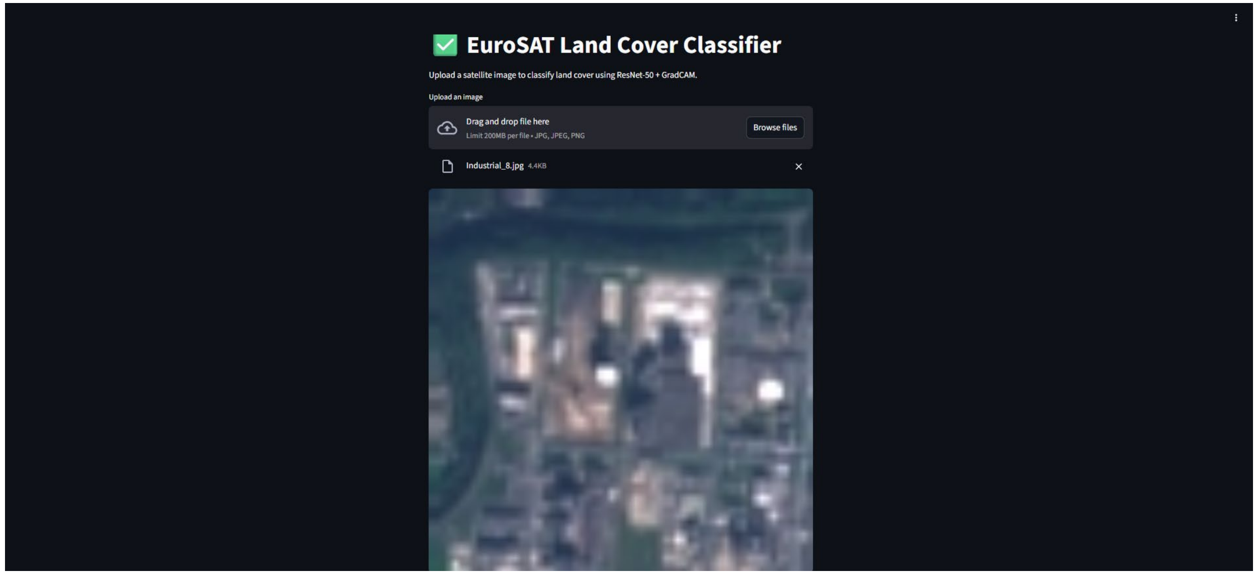
- To make the classification model accessible and interactive, a web application was developed using streamlit.
- The entire setup is wrapped inside a streamlit interface with user friendly prompt.
- When the user upload an image, it results the sample images that has been uploaded , predict the output along with the confidence score and heatmap.

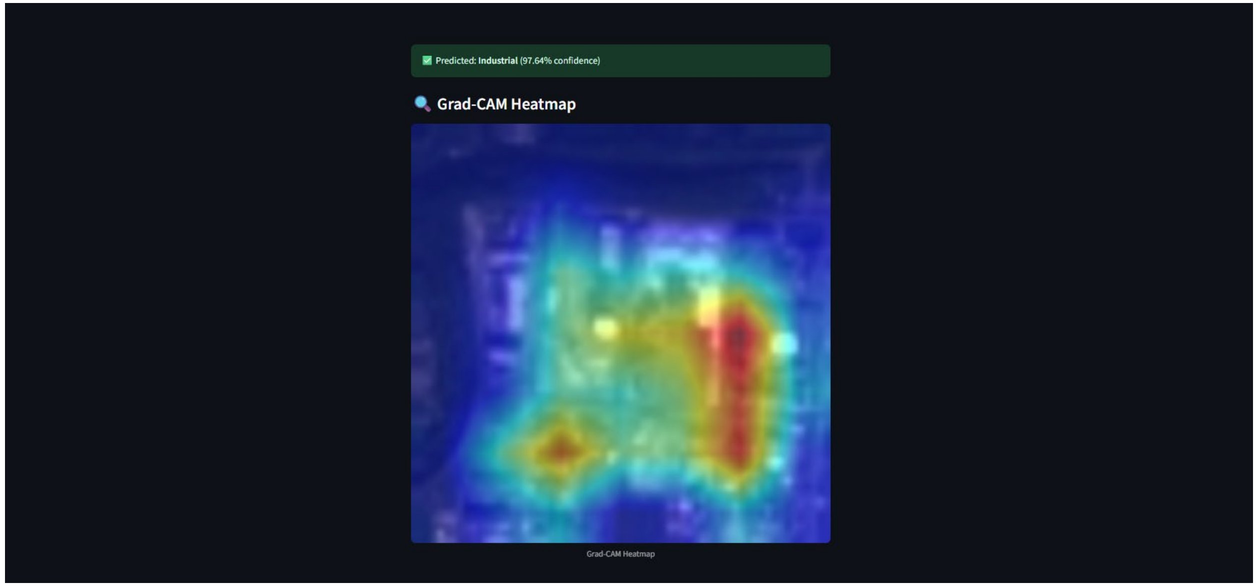


8ef9dfdbb209.ngrok-free.app
Anandhi (kayal) (@a...
New Tab
All Bookmarks
EuroSAT Land Cover Classifier
Upload a satellite image to classify land cover using ResNet-50 + GradCAM.
Upload an image
Drag and drop file here
Limit 200MB per file • JPG, JPEG, PNG
Browse files

These figures show the uploaded image via upload option and showing its prediction.

and the heatmap of the image





Conclusion

- The project successfully demonstrated the power of deep learning, specifically ResNet-50 in automating land cover classification using satellite imagery.
- ResNet-50 model achieved high classification accuracy with validation accuracy of 93% by the final epoch.
- The model effectively distinguished between 10 different land cover types.
- To enhance the interpretability, GRAD-CAM was integrated to visualize the heatmap of the images.
- The heatmaps help users to understand which part of the image influenced the model's prediction.
- Integrated with GPT-4o can understand the different response from the models.
- The entire system was deployed in a streamlit web UI, allowing users to upload their own satellite images, receive the predictions and view the GRAD-CAM images from a browser.
- In summary, the project illustrates a full pipeline from training to deployment, highlighting how a deep learning can classify the images from the satellite.

Questions?


thank you