CNN-based Model for Pneumonia Disease Detection

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DSAI 308 Deep Learning

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May 2025

Indroduction

My project is a simple Convolutional Neural Network (CNN) with 5 layers built with TensorFlow/Keras, used to train a deep learning model to have images of lung x-rays as input and detect whether this patient has pneumonia. For improving the transparency and interpretability of the model's prediction, there are some explainability techniques applied, including LIME and a confusion matrix.

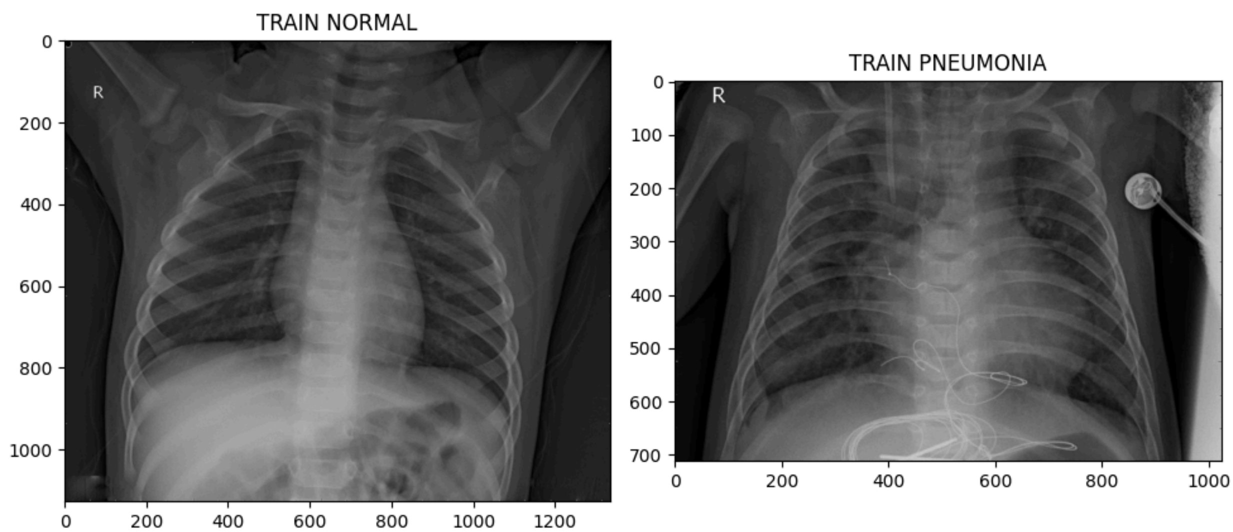

Fig 1. Plot samples from the dataset

Methodology

Custom CNN

A sequential CNN model includes:

- Input shape (150, 150, 3)
- Convolutional layers:
  - 4 Conv2D layers + MaxPooling2D layers with increasing filters (32 -> 64 -> 128 -> 128)
- Flatten layer: converts 2D features to 1D vector
- Dense layers:
  - One hidden dense layer with the ReLU activation function.
  - Final output layer with Sigmoid activation function for binary classification.
- DropOut: 0.5 to reduce overfitting
- Early Stopping
- Evaluation Metrics: Accuracy, AUC Precision and Recall

Explainable AI (XAI) techniques

For the XAI techniques, we used the LIME tool, which provides local explanations for individual image predictions by highlighting the most used region in the image with the yellow colour.

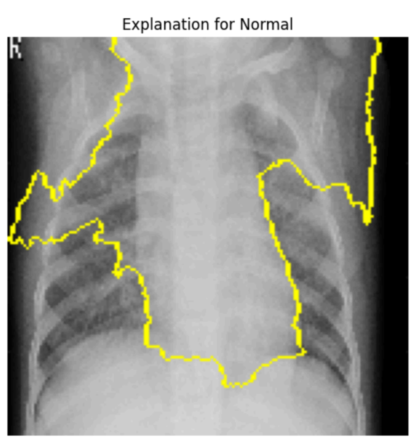

Fig 2. LIME

Challenges

The greatest challenge was data unbalancing, so we used the dataGen function, which selects images to share in the training.

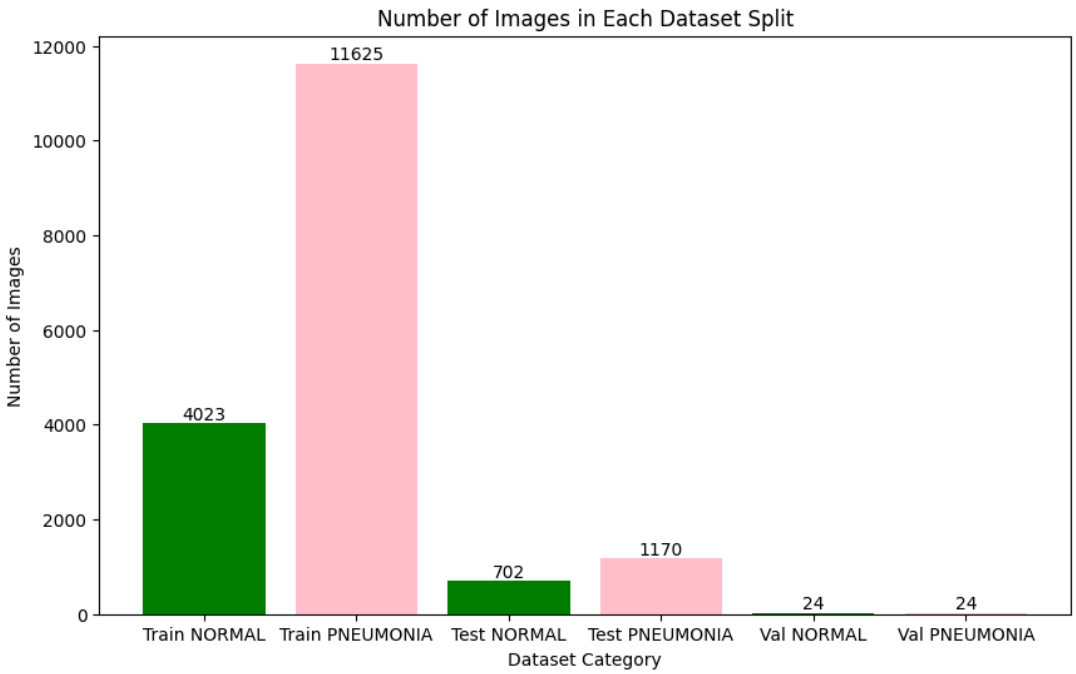

Fig 3. Showing an imbalance in data

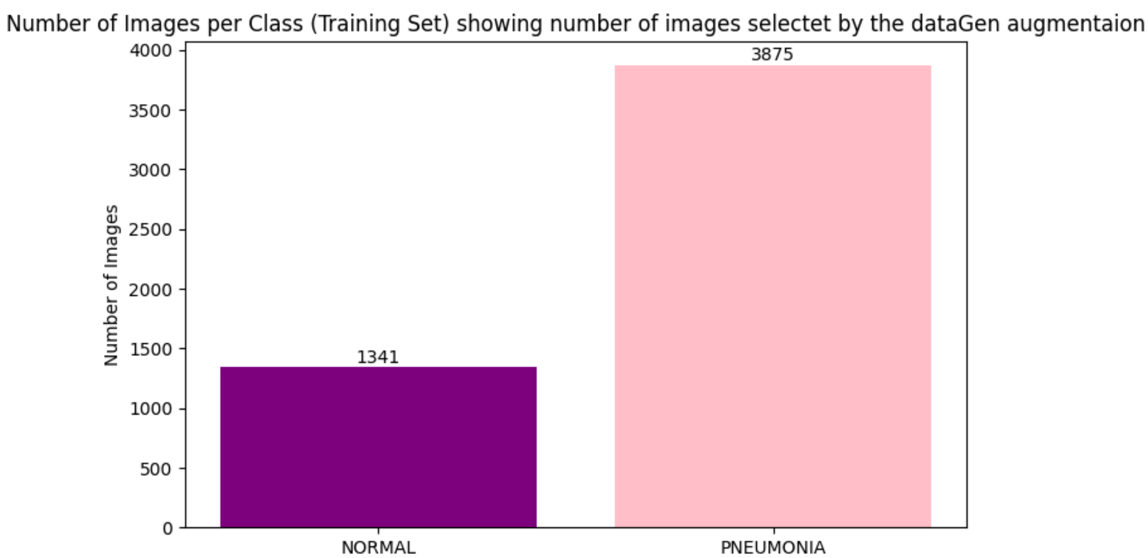

Fig 4. Showing the number of images selected with the dataGen function

Results

The model shows 96% accuracy with a very good classification tested by the confusion matrix and classification report.

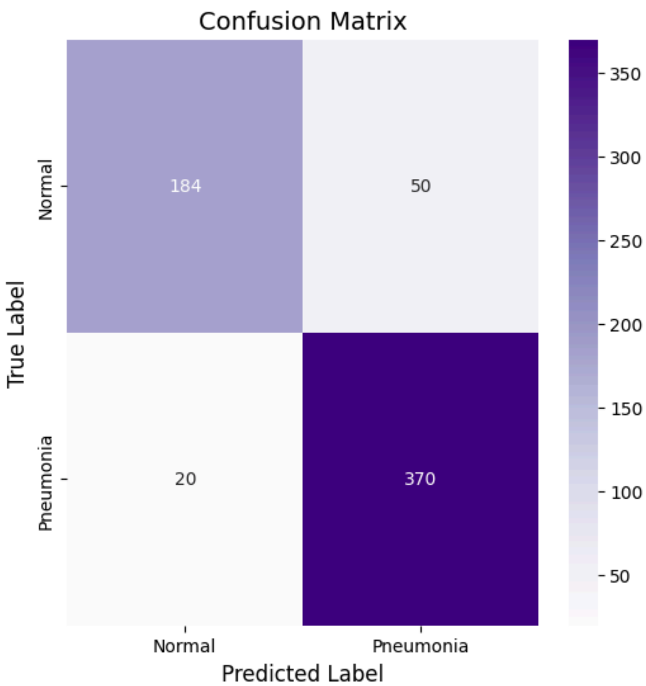

Fig 5. Confusion Matrix

Classification Report:

	precision	recall	f1-score	support
Normal	0.90	0.79	0.84	234
Pneumonia	0.88	0.95	0.91	390
accuracy			0.89	624
macro avg	0.89	0.87	0.88	624
weighted avg	0.89	0.89	0.89	624

Fig 6. Classification report

Comparison

POC	**CNN-based (my model)**	**CNN and deep learning [2]**
Dataset	5,863 chest X-ray images (anterior-posterior) were selected from retrospective cohorts of pediatric patients of one to five years from Guangzhou Women and Children's Medical Centre, Guangzhou. All chest X-ray imaging was performed as part of the patients' routine clinical care.(from kaggle) [1]	5,856 pediatric CXR images from Guangzhou Women and Children's Medical Centre (from Kaggle).
Model input	150× 150× 3	224×224×3
Model architecture	A custom CNN model: ● Built **from scratch** ● Uses **dropout outside convolutional layers** ● Includes normalization and ReLU activations. ● Ends with a dense layer and a sigmoid output	A custom CNN model, inspired by VGG: ● Built **from scratch** ● Uses **dropout inside convolutional layers** (novel idea) ● Includes batch normalization and ReLU activations ● Ends with multiple dense layers and a Softmax output
Batch size	32	16
Epochs	30	Up to 150

output	Binary classification	Binary classification
Accuracy	90.81%	97.3%
XAI	Yes, LIME	No

References

1. "Chest X-Ray images (Pneumonia)," *Kaggle*, Mar. 24, 2018. https://www.kaggle.com/datasets/paultimothymooney/chest-xray-pneumonia/data

2. P. Szepesi and L. Szilágyi, "Detection of pneumonia using convolutional neural networks and deep learning," *Journal of Applied Biomedicine*, vol. 42, no. 3, pp. 1012–1022, Jul. 2022, doi: 10.1016/j.bbe.2022.08.001.