Pneumonia Detection from Chest X-Rays using Convolutional Neural Networks (CNNs)

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1.1 Introduction

Pneumonia is a potentially life-threatening respiratory condition caused by infection that inflames the air sacs in one or both lungs.

Early diagnosis and treatment are critical in reducing morbidity and mortality. Traditionally, diagnosis is based on physical examination and chest X-rays interpreted by radiologists. However, this process can be time-consuming, subjective, and limited in regions with fewer medical professionals.

Computer Vision, combined with deep learning, offers an opportunity to automate pneumonia detection from chest X-rays. This project aims to develop a deep learning model capable of accurately identifying pneumonia from chest X-ray images.

1.2 Problem Statement

This project targets the automatic detection of pneumonia from chest X-ray images using deep learning. The challenges include distinguishing between pneumonia and normal lung conditions, managing limited labeled data, and ensuring robustness across diverse patient profiles.

Objectives of the Project:

- To acquire and preprocess a labeled dataset of chest X-ray images.
- To build a CNN-based model for binary classification (Pneumonia vs. Normal)
- To evaluate the model's performance using standard metrics.
- To identify strengths and limitations of the approach in clinical contexts.

2.1 Dataset

We used the Chest X-Ray Images (Pneumonia) dataset provided by Kaggle, containing over 5,800 X-ray images divided into training, validation, and test sets. Each image is categorized as either 'PNEUMONIA' or 'NORMAL'. Images were resized to 224x224 pixels. Preprocessing included grayscale conversion, normalization, and data augmentation (rotation, flipping, zooming) to enhance generalization.

Preprocessing Steps:

Preprocessing included grayscale conversion, normalization, and data augmentation (rotation, flipping, zooming) to enhance generalization.

2.2 Approach / Algorithm

A Convolutional Neural Network (CNN) was developed for this binary classification task. The architecture consists of:

- Multiple convolutional layers with ReLU activation
- MaxPooling layers for spatial downsampling
- Dropout layers for regularization
- Fully connected layers for final prediction

The final output uses a Sigmoid activation function to predict binary class probability. The model was compiled using binary cross-entropy loss and optimized with the Adam optimizer.

3.1 Experimental Setup

- **Hardware Used:** HP Pavilion with Ryzen 5 CPU and 16GB RAM
- **Software:** Python 3.10, TensorFlow, OpenCV, Jupyter Notebook
- **Evaluation Metrics:** Accuracy, Precision, Recall, F1-score

3.2 Results

The model achieved:

- **Training Accuracy:** ~98%
- **Validation Accuracy:** ~96%
- **Test Accuracy:** ~94%
- **Precision & Recall:** Above 93% on test data

Visualizations of training and validation accuracy/loss trends, along with confusion matrix and ROC curve, will be included to demonstrate performance.

3.3 Discussion

The CNN model showed strong performance in detecting pneumonia, highlighting the effectiveness of deep learning in medical image analysis. However, performance may vary based on patient diversity and X-ray quality. Further testing on external datasets and integration with clinical workflows is recommended. Challenges faced included managing data imbalance and ensuring interpretability for medical professionals.

4.1 Conclusion

We developed a deep learning-based CNN model to detect pneumonia from chest X-ray images. The model demonstrated high accuracy and reliability, achieving its goal of assisting early diagnosis. This approach shows promise in augmenting radiological decision-making, especially in resource-constrained settings.

4.2 Future Work

- Integrate Grad-CAM for visual explanation of model predictions.
- Extend the model to multi-class classification (e.g., viral vs. bacterial pneumonia).
- Validate performance using real hospital datasets and deploy as a clinical decision support tool.

References

1. PyTorch Documentation : https://pytorch.org/docs/stable/index.html
2. Kaggle Pneumonia Chest X-Ray Dataset : https://www.kaggle.com/
3. OpenCV Docs – https://docs.opencv.org