Chest X-ray Pneumonia Classification (CNN)

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ABSTRACT Pneumonia is an inflammatory condition of the lungs and remains a significant global health issue. The aim of this project is to classify chest X-ray images for the presence of pneumonia using Convolutional Neural Networks (CNNs). The Convolutional Neural Network showed a promising accuracy of 90%.

KEYWORDS Binary Classification, Chest X-ray, Convolutional Neural Network (CNN), Deep Learning, Machine Learning, Pneumonia

I. INTRODUCTION

A. BACKGROUND INFORMATION

In 2021, pneumonia took approximately 2,180,000 lives worldwide [1]. Classifying patients for the presence of pneumonia is currently the responsibility of medical professionals. Employing machine learning methods for classification could provide a great point of reference for the person responsible for the diagnosis. Early identification of pneumonia is crucial for effective treatment, and X-rays are commonly used for this purpose. One of the biggest challenges is accurately determining the presence of the disease from X-ray images. Automatic recognition using machine learning can significantly speed up the process and potentially save hundreds of thousands of lives. Convolutional neural networks (CNNs), a type of neural network designed for visual data analysis, are particularly effective for this task.

B. PROBLEM FINDING

To further investigate the pneumonia problem, the "Large Dataset of Labeled Optical Coherence Tomography (OCT) and Chest X-Ray Images" [2] dataset was used for training and evaluating machine learning models, see Fig. 1.

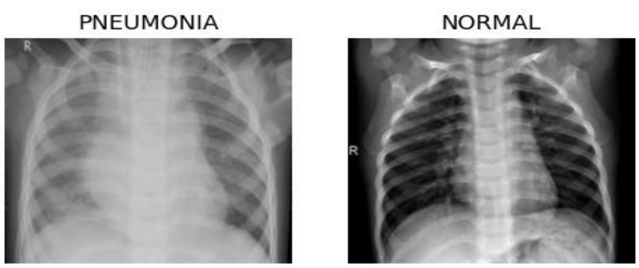

FIGURE 1. X-rays of infected and healthy lungs from the dataset [2]

II. IDEA FINDING

A. STATE OF THE ART

Current state-of-the-art solutions employ various CNN architectures. Some of the solutions proposed by Kaggle users KIMGOEUN13 [3] and MOHAMED ABDALLAH [4] achieved similar scores to our CNN. On the other hand, a more professional article that compares advanced usage of combinations of the most popular neural nets includes the outstanding VGG model with an AUC of approximately 99.1% and even a deep feature CNN with an AUC of 99.4% [5]. AUC, which stands for Area Under the Curve of the ROC – Receiver Operating Characteristic, is a measure of classification accuracy, see Fig. 2.

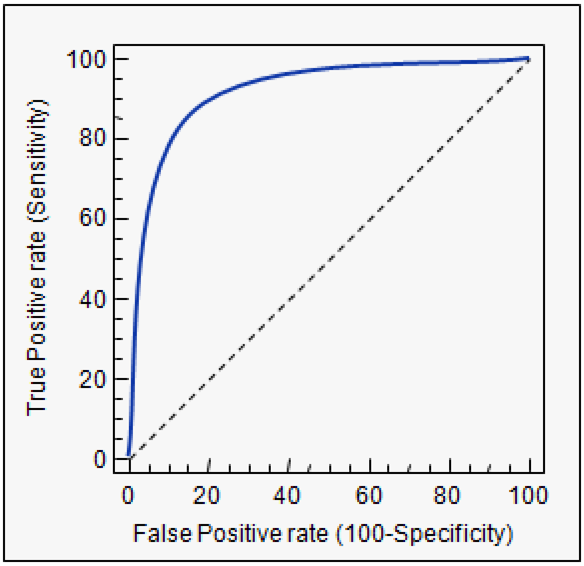

FIGURE 2. ROC - Receiver Operating Characteristic [6]

B. INNOVATIVE IDEAS

Data augmentation consisting of normalizing, flipping, rotating the images and weighing the classes. Combining CNN architecture with other classification models. These ideas can be helpful to detect pneumonia even more accurately, as this disease is still a big problem nowadays, see Fig. 3.

C. MAIN IDEA SELECTION AND JUSTIFICATION

After the initial test, the idea of combining CNN architecture with other classification models lead to lower accuracy which made data augmentation the main focus.

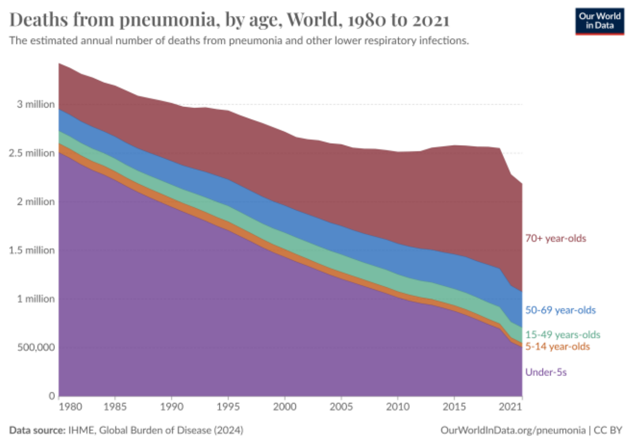

FIGURE 3. **Deaths from pneumonia, by age, World, 1980 to 2021 [1]**

III. SOLUTION IMPLEMENTATION

A. TECHNICAL DETAILS

Before training the CNN, image transformations, including resizing, flipping, and rotation, are applied to augment the training data and enhance the model's generalization capabilities. Class weights are used to mitigate class imbalance effects, ensuring equal training representation and preventing biases. Network weight initialization with specified mean and standard deviation enhances convergence efficiency and avoids gradient-related issues.

The CNN architecture is composed of three blocks, each containing a convolutional layer, batch normalization, and max pooling to extract important features from the images. These features are then passed to four blocks, each consisting of a fully connected linear layer and dropout to prevent overfitting. Finally, one neuron with a sigmoid activation function is used to decide whether a patient has pneumonia or is perfectly healthy. The activation function used in our model is ReLU. The whole architecture can be seen in Fig. 4.

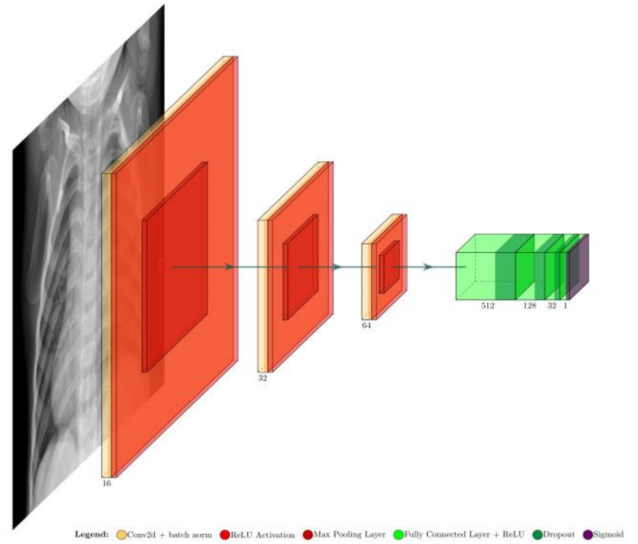

FIGURE 4. **Final CNN architecture**

IV. WAYS OF VERIFICATION

In the case of machine learning, verifying whether a model is effective is based on test data evaluation and a trade-off between bias and variance during training. The CNN was verified on the test dataset, achieving 90% accuracy, which is a great score that could undoubtedly help a medical professional. Team members responsible for the performance and stability of the neural network ensured that learning rates were chosen according to the pace of convergence.

V. CONCLUSIONS AND PERSPECTIVES

Summing it all up, the project initially utilized some ordinary CNNs, but there was room for improvement. Pre-trained models such as VGG16, ResNet, and MobileNet resulted in better accuracies but had an inevitable tendency to overfit due to the number of parameters, making them too complex. Considering this, a new CNN was created, blending ideas from both simple and pre-trained models. One drawback of this new CNN is the volatility observed in Fig. 5. However, this could be explained by the fact that the loss measurements were taken once per epoch, potentially accounting for the irregularity. Despite this, the CNN's performance on the test set, as seen in Fig. 6, suggests it does not have any obvious flaws, achieving similar metrics to the best models on Kaggle. This CNN, with some additional upgrades, could potentially be used in clinical settings to assist radiologists in detecting pneumonia from chest X-rays more efficiently.

FIGURE 5. **Training and validation losses for final CNN architecture**

	precision	recall	f1-score	support
0	0.88	0.84	0.86	234
1	0.91	0.93	0.92	390
accuracy			0.90	624
macro avg	0.89	0.89	0.89	624
weighted avg	0.90	0.90	0.90	624

FIGURE 6. **Classification metric for final CNN architecture**

APPENDIX

Considered CNN architecture available in Google Colab: https://colab.research.google.com/drive/1oNKDFvAEDcCcr5orESSfWXttY_dwglYK?usp=sharing

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AUTHOR BIOS AND CONTRIBUTIONS

I. HRYNIEWICZ was born in Lodz in 2003 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

As the project coordinator, I arranged and facilitated meetings. My responsibilities included coding tasks such as loading and preprocessing data, experimenting with various solutions, and constructing Convolutional Neural Networks. I also evaluated the performance of these networks and selected the optimal model based on specific metrics. Additionally, I revised presentations and authored the project report. This role required a blend of technical expertise and organizational skills to ensure the project's success.

H. WOŁODKIEWICZ was born in Lodz in 2003 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

My duties included coding tasks such as data loading, preprocessing, exploring various methodologies, and developing Convolutional Neural Networks. I conducted performance evaluations of these networks and selected the most effective model based on established metrics. Additionally, I revised presentations and authored the project report. This role required a combination of technical expertise and organizational proficiency to ensure the project's successful execution.

Z. AMBROŻEWICZ was born in Gorzów Wielkopolski in 2003 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

I played an active role in preparing presentations, collaborating closely with my peers to ensure their quality and coherence. I also conducted research to support our work and took on supervisory responsibilities, ensuring that tasks were evenly distributed and that every team member had the opportunity to contribute their strengths. Throughout the project, I assisted with group supervision to maintain a cohesive and productive team environment.

E. BERNARD was born in Lodz in 2003 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

I actively participated in the creation of the first presentation, collaborating with my peers to ensure its quality and coherence. Additionally, I took on a supervisory role for the second presentation, ensuring that the workload was evenly distributed among all group members and that everyone had the opportunity to contribute their strengths.

N. STĘPIEŃ was born in Lodz in 1997 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

In the project, I was responsible for presenting the progress of our code. I delivered presentations that explained the team's current achievements, the challenges we encountered, and our plans for the next stages of the work.

K. KOC was born in Lodz in 2004 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

I took a part in presenting on the first presentation with the assigned tasks, I created a scheme for the second presentation and created some slides also presenting my part on the in class presentation number two, while creating the presentations I always tried to distribute the amount of work equally to let teammates do the best job they could do.

M. FLORCZYK was born in Lodz in 2004 and since 2022 has been enrolled at Lodz University of Technology, majoring in Mathematical Methods in Data Analysis.

During my recent presentation, I showcased the code we developed for our project. The presentation included an overview of the project's objectives, a walkthrough of the key sections of the code, and explanations of the logic implemented. I used visual aids like screenshots and code snippets to illustrate the process and outcomes The presentation aimed to clearly convey the work we accomplished and provide a solid understanding of our coding efforts.