Convolutional Clarity: Accurate, Reliable, Explainable CNNs by Evaluating the Impact of Data Augmentation on Chest X-Ray Pneumonia Classification

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Pneumonia, an infection of the lungs where air sacs fill with fluid, causes 2.5 million annual deaths and is the leading cause of death in children under five. From scratch, we developed a convolutional neural network (CNN) for multi-class classification using ChestX-Ray images of COVID, pulmonary edema, pneumonia, and normal cases with ~16,000 publicly available images. While we focused on pneumonia, the model can distinguish all four classes. Real-world adaptation of artificial intelligence for medical diagnosis has been slow due to the “black box” nature of models. Our project aims to achieve an 1) accurate, 2) reliable, and 3) explainable model for doctors. For accuracy, the CNN achieved >80% accuracy on test images (comparable to or exceeding human-level performance). Training took ~3.5 hours, but predictions only took milliseconds each. We augmented our training data through rotation, zoom, shifts, contrast, and horizontal flips. We use confusion matrices to show overall accuracies. For reliability, we tested the robustness by evaluating predictions after we modified test images with brightness, contrast, sharpness, and noise (and plotted with bar graphs). Since x-rays can vary in output from factors like contrast or image resolution, this is crucial for determining real-world applications. For explainability, the exhibitor devised a “red box test”, dividing images into ninths to analyze how each section affected the model’s outputs. We also used a more traditional method of saliency maps to highlight pixels most important to predictions. As a demonstration, the project includes an example of the exhibitor’s personal case of pneumonia. Results give a fast, accurate, and explainable model that can support medical diagnosis.

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