BIO-CXRNET: A Robust Multimodal Stacking Machine Learning Technique for Mortality Risk Prediction of COVID-19 Patients using Chest X-Ray Images and Clinical Data

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INTRODUCTION

A machine learning framework using Chest X-ray images and clinical data was used to predict severity and mortality risk in COVID-19 patients. The study used 25 biomarkers and CXR images to predict the risk in 930 COVID-19 patients in Italy during the first wave of the pandemic. The proposed multimodal stacking technique improved the accuracy by 6% in comparison to the CXR image or clinical data alone and was able to predict the death probability of high-risk patients

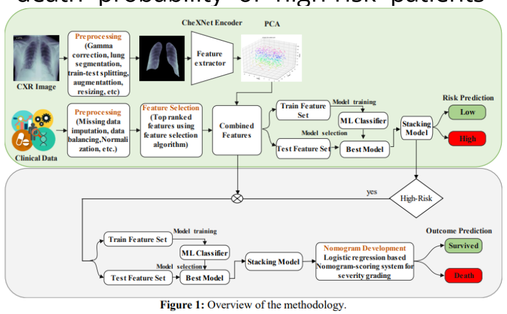

Figure 1: Overview of the methodology.

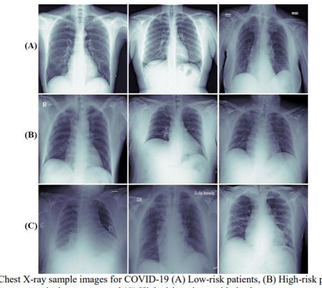

Figure 2: Chest X-ray sample images for COVID-19 (A) Low-risk patients, (B) High-risk patients with survival outcomes, and (C) High-risk patients with death outcomes.

METHODOLOGY

The study conducted two investigations: the first using a multimodal approach with CXR images and clinical data to predict the severity risk of COVID-19 patients, and the second analyzing high-risk patients' data to predict the death outcome using the stacking model from CXR images and clinical biomarkers. The study used a pre-trained deep CNN model, PCA, feature selection algorithms, and nomograms to develop these models. The study used a dataset of 930 COVID-19 patients from six Italian hospitals, including CXR images and clinical data obtained at admission during the first wave of the pandemic. The dataset contained 42.6% low-risk patients and 57.4% high-risk patients, with a mortality rate of 31.8% among the high-risk group.

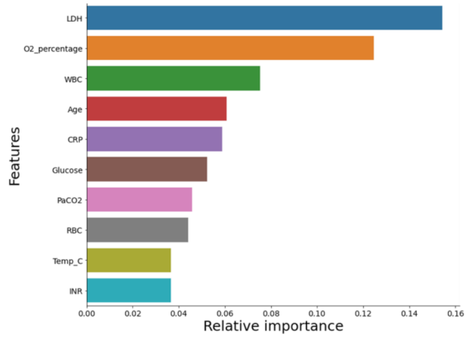

Figure 4: Top ten features selected using the random forest feature selection technique.

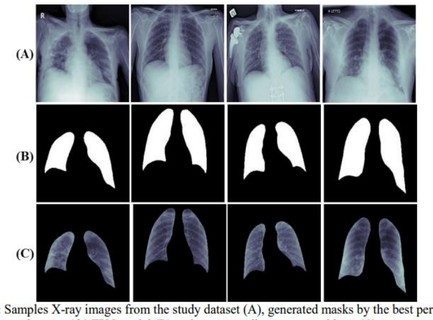

Figure 3: Samples X-ray images from the study dataset (A), generated masks by the best performi densenet121 FPN model (B) and corresponding segmented lung (C).

CONCLUSION

The study proposed a multimodal approach that combines CXR images and clinical data to predict the severity and mortality risk of COVID-19 patients. The proposed method achieved high sensitivity in detecting low and high-risk patients and accurately predicted the likelihood of death in high-risk individuals using a nomogram-based approach. The model can be useful for optimizing patient stratification management and minimizing mortality rates, but further validation is required in large-scale multicenter and multi-country prospective studies.

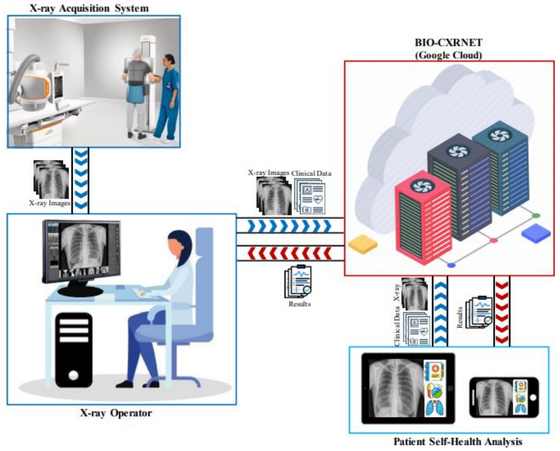

Figure 5: COVID-19 severity risk detection tool using web application framework.

DISCUSSION

This work presents a multimodal system that combines CXR images and clinical data to predict the risk and potential outcomes of COVID-19 patients. The multimodal approach outperformed individual modality in both risk group stratification and outcome prediction, with an accuracy of 89.03% and 92.3%, respectively. The results reported in this work showed superior performance compared to some of the state-of-the-art performance reported in the literature.

Rahman, T., Chowdhury, M., Khandakar, A., Mahbub, Z., Hossain, M., Alhatou, A., . . . Hossain, M. (2022, June 15). BIO-CXRNET: A robust multimodal stacking machine learning technique for mortality risk prediction of COVID-19 patients using chest X-ray images and clinical data. Retrieved May 5, 2023, from https://arxiv.org/abs/2206.07595