
AI-Driven Tuberculosis Detection Using VGG-16

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Abstract.

Tuberculosis (TB) is still among the most essential infectious diseases that require immediate and precise detection to decrease mortality rates. Traditional methods are usually lengthy and require expertise. This research proposes an automatic method for TB detection based on the VGG-16 convolutional neural network utilizing chest X-rays (CXR). The proposed framework is implemented with TensorFlow and Keras and trained on open-source data. The experiments showed an accuracy rate of 77.8%. Nevertheless, relatively poor precision and recall reveal certain issues, such as class imbalance. The proposed application also incorporates a convenient, user-friendly interface with Gradio, allowing for instant predictions of X-rays uploaded by users.

Keywords. Tuberculosis, Deep Learning, CNN, VGG-16, Chest X-ray, TensorFlow, AI Diagnosis.

1. INTRODUCTION

TB remains a major worldwide health issue that severely impacts regions with limited medical resources, where diagnosis is delayed and inaccurate. Standard detection ways such as sputum microscopy and chest radiographs are tends to be slow, time- consuming, often has a lack of accuracy, are prone to human error, and need specialized expertise. Limited diagnostic resources in several regions' slow treatment in many areas, or delays due to workforce and the importance of AI driven approaches.

This approach can improve the efficiency of diagnosis and also lower the dependency on highly skilled medical experts. Enabling timely treatment and better patient outcomes, it provides faster results. Furthermore, the system promotes global healthcare equality by offering reliable diagnostic support in underdeveloped and resource-limited regions. Overall, the importance of integrating deep learning with medical imaging to achieve intelligent, accurate, and accessible Tuberculosis detection is highlighted by this approach.

2. RELATED WORK

Tuberculosis detection primarily works to utilize the CAD methodologies that are based on handcrafted edge and texture-based image features. Despite some of the automation showing

the dependence on manual features, these methods lacked flexibility and accuracy across the datasets. The advent of deep learning has advanced medical imaging by enabling the direct feature learning from raw data, and the models are trained in a way that they automatically learn complex features from X-ray. CNN architectures such as ResNet, DenseNet, and VGG are greatly enhanced for the classification accuracy for the thoracic conditions. In the case of Rajpurkar et al. (2017) [1].

CheXNet by Rajpurkar et al. was a key breakthrough or a mark as a major milestone, a 121-layer convolutional neural network (CNNs) was created for pneumonia detection that proved the abilities of deep learning architectures in clinical imaging. Moving on to this framework, Jaeger et al. [2] executed an early TB screening model integrating preprocessing and classification, serving as a reference for later studies. Showkatian et al. [3] improved TB detection through refined CNN integration and magnified data preprocessing, enhancing disease identification accuracy. Capellan-Martin et al. [4] developed a deep model that is small in size as well as very accurate yet is applicable in the real-time situation.

Prasad et al. [5] conducted comparative research between traditional machine learning and modern deep learning-based models with transfer learning that provides high-performance.

Overall, these articles indicate that the development of the traditional CAD systems into the new deep-learned-based-approaches is rather clear, and the potential of AI in TB detection is present. The incorporation of effective design models, such as GPU-enhanced systems, VGG models, and B user-friendly interface creates the basis of the usability of the system to create correct, accessible, and scalable TB diagnostic models to be utilized in clinical and distant health care processes. One paper presents a DH-DSU-optimized U-Net model for effective lesion segmentation in WCE images. It combines multiple feature extraction methods and uses an improved DNN for classifying inflammatory, polypoid, and ulcer diseases. Results show the proposed approach outperforms several existing optimization-based models.

3. METHODOLOGY

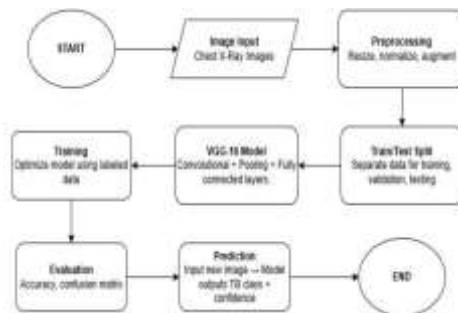


Fig. 3.1. Tuberculosis Detection Pipeline

TB is a serious bacterial disease that, for the most part, affects the lungs and demands timely detection for effective treatment. A deep learning model based on VGG16 is proposed for automated tuberculosis detection from chest X-ray images. The system is based on binary classification for TB-positive and TB-negative classes for chest X-ray images. Various preprocessing and augmentation methods are used for effective learning by the model. A web-based interactive system was also integrated for real-time prediction from uploaded images. The proposed framework demonstrates the possibility of AI-based TB detection in

real-world environments. A cost-effective diagnostic system was proposed for TB detection using Google Colab, TensorFlow, and Keras.

The general framework of the proposed approach for TB detection system is illustrated in **Figure 1**. As shown in the diagram, the process initiates with the input of CXR images, which are then subjected to necessary preprocessing steps such as normalization, augmentation, and resizing. The dataset is then classified into training, validation, and testing before passing through the VGG16 CNNs for feature identification along with categorization. The model is trained and optimized using labeled datasets, and the trained model is thereafter evaluated using accuracy metrics, ROC AUC, and a confusion matrix. Finally, the system provides instant diagnostic predictions, allowing new X-ray images to be analysed and classified as TB-positive or negative, along with the accuracy.

The presumed TB detection model automatically sorts CXR images into TB-positive or TB-negative classes. It is used in deep CNN particularly VGG16 architecture. The network has a layered design with fully connected stages, convolutional, and pooling. This structure helps in capturing low-level and high-level features of the lungs. As a result, it can detect the changes that are associated with TB infection

Before training, the image data went through several preprocessing steps that included resizing, normalization, random rotations, flips, and brightness and pixel adjustments to achieve better generalization and control overfitting. A user-oriented Gradio interface was integrated to simplify deployment, allowing direct upload of X-ray images for instant diagnostic predictions via the web. Although the framework supports transfer learning with pretrained CNNs, this implementation trains VGG16 from the ground up to extract features that are specifically relevant to tuberculosis pathology.

4. RESULT AND DISCUSSIONS

The model has achieved a total accuracy of 77.8, the preciseness = 14.9, recall = 7.1, and F1-score = 9.6 that detects Tuberculosis. It has accurately chosen the majority of the Normal images, i.e., (643/700), but with a poor sensitivity and a high specificity in terms of Tuberculosis cases (10/140). Therefore, this indicated lack of dataset balance and additional optimization to be made. Trained on the curated CXR dataset, the VGG16- based model demonstrated high competencies in distinguishing between the TB-positive and normal CXR. The reduction of the computational time was achieved without reducing the image resolution in the course of training. Random rotations and horizontal flips are data augmentation techniques that increase the ability of the model to generalize and retain high performance of unseen data depicted with assessed, unseen CXR images.

These results suggest that the VGG16 network successfully learns and identifies important radiographic patterns for TB detection, showing strong accuracy with both high sensitivity and specificity. Using the Gradio web interface, users are allowed to submit CXR images and direct prediction results of the trained model is more convenient and real-time clinical practices.

5. CONCLUSION

The study of this project concludes how the project actually works and reaches its goal. The correct use of VGG16 in order to understand and detect TB. It is seen how deep learning enhances TB detection and diagnosis using CXR images. The model learned well from the

images and could correctly tell the difference between TB and normal cases. Data augmentation methods, such as flipping as well as image rotation, has helped a lot in the case of model accuracy as well as its ability to work with new data. Some errors occurred with unclear or low-quality X-rays, which suggests that better image enhancement techniques could improve results further. A simple Gradio interface/app is also made where the doctors can upload an X-ray and instantly see if it shows “Tuberculosis-positive”. This system is mainly developed in order to help hospitals save time, reduce doctors' workload, and make Tuberculosis screening easier even in places with fewer medical experts

6. REFERENCES

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Biographies



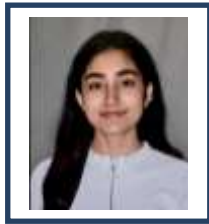
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