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Department of Computer Science and Engineering

15Z720 PROJECT WORK I

Report

GPU enabled CNN based COVID-19 HRCT Images Classifier

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Abstract

The ongoing COVID-19 pandemic has caused a bottleneck in the healthcare system around the world. The virus is highly contagious as it spreads through air droplets and person to person contact. The standard method of diagnosis for such viruses is the RT-PCR (Reverse Transcription-Polymerase Chain Reaction) method. However, there are numerous issues in using RT-PCR as it is prone to producing a large number of false-negative and false-positive results because of its low sensitivity and specificity. Also, there are a limited number of RT-PCR testing kits available. In this scenario, medical imaging such as X-ray and Computed Tomography (CT) of the lung of the patients can be used as an alternative tool to make the diagnosis, as the disease primarily targets the epithelial cells of the lung. As CT scanners are widely available, they are considered to be functional and practical diagnostic tools. Artificial intelligence (AI) technologies can be used to strengthen the power of imaging tools and help medical specialists in analyzing hundreds of CT images quickly. Deep learning provides state-of-the-art performance for detection, segmentation, classification, and prediction. Hence, deep learning offers a convenient tool for diagnosing and predicting the severity of lung infection in CT images for COVID-19 patients. The dataset is a collection of 150,000 to 200,000 high-resolution DICOM (Digital Imaging and Communication in Medicine) images of more than 400 patients from the Department of Radiology, PSG IMSR, Coimbatore.

Objective: Design and develop GPU enabled Convolutional Neural Network (CNN) based deep learning models for automated detection of the critical findings from CT scans, lung infection, and its pattern; percentage severity of lung infection.

Literature Survey

F. Pan et al. [1] used chest CT to assess the severity of lung involvement in coronavirus disease 2019 (COVID-19) and studied the changes in chest CT findings associated with COVID-19 from initial diagnosis until patient recovery. They concluded that in patients recovering from COVID-19 (without severe respiratory distress during the disease course), lung abnormalities on chest CT scans showed the greatest severity approximately ten days after the initial onset of symptoms.

Montagnon et al. [2] provide step-by-step practical guidance for conducting a project that involves deep learning in radiology, from defining specifications to deployment and scaling. Challenges including ethical considerations, cohorting, data collection, anonymization, and availability of expert annotations are discussed.

X. Li et al. [3] conducted a comprehensive comparison of various open-source parallel implementations of convolutional neural networks on GPUs over a wide range of parameter configurations, investigate potential performance bottlenecks, and point out several opportunities for further optimization. GPU computing model is very effective during CNN training where the computation is inherently parallel and involves a massive amount of floating-point operations, e.g., matrix and vector operations.

D. Strigl et al. [4] present the implementation of a framework for accelerating training and classification of arbitrary Convolutional Neural Networks (CNNs) on the GPU. They demonstrate the performance and scalability improvement that can be achieved by shifting the computation-intensive tasks of a CNN to the GPU.

Mohammad R[5] et al. propose a high-speed and accurate fully-automated method to detect COVID-19 from the patient's CT scan images using the ResNet50V2 network and a modified feature pyramid network.

Lessmann et al.[6] developed and validated an artificial intelligence (AI) system called CORADS-AI to score the likelihood and extent of pulmonary COVID-19 on chest CT scans using the CO-RADS and CT severity scoring systems.

Fei N [7] et al. develop a deep learning (DL)-based system for automatic segmentation and quantification of infection regions and the entire lung from chest CT scans. The DL-based segmentation employs the "VB-Net" neural network to segment COVID-19 infection regions in CT scans. The quantitative evaluation showed high accuracy for automatic infection region delineation, POI metrics.

A. A. Ardakani et al. [9] analyzed ten well-known convolutional neural networks to distinguish infection of COVID-19 from non-COVID-19 groups: AlexNet, VGG-16, VGG-19, SqueezeNet, GoogleNet, MobileNet-V2, ResNet-18, ResNet-50, ResNet-101, and Xception. Among all networks, they concluded that ResNet-101 and Xception achieved the best performance.

Xin He et al.[10] benchmarked and compared the performance of a series of state-of-the-art 3D and 2D convolutional neural networks (CNNs). The results show that 3D CNNs outperform 2D CNNs in general. They designed an automated deep learning methodology to generate a lightweight deep learning model, MNas3DNet41 that achieves an accuracy of 87.14%, F1-score of 87.25%, and AUC of 0.957, which are on par with the best models made by AI experts.

Hardware requirements

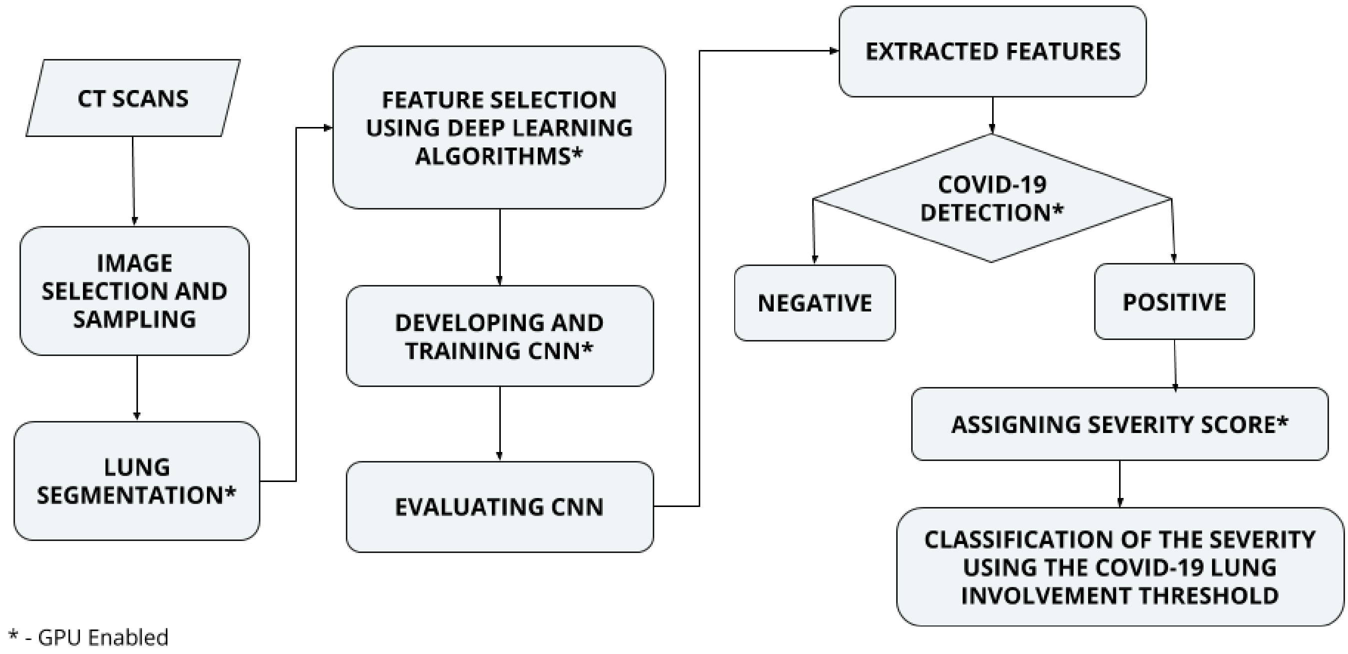
- Processor (CPU): Intel Core i3 (sixth generation or newer) or equivalent.
- Memory: 8 GB RAM

Software requirements

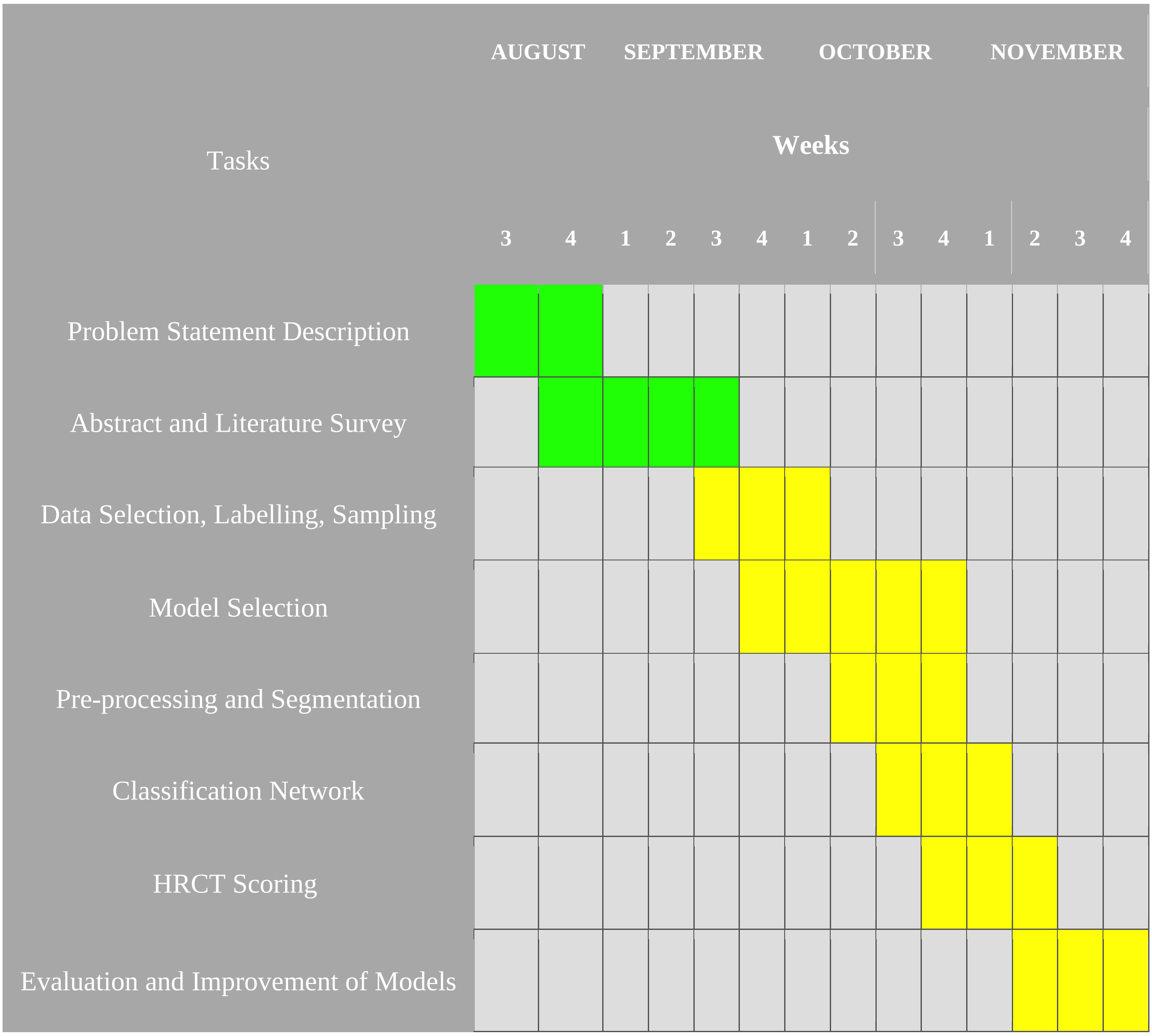
- Operating System: Windows 7 or later, macOS or Linux.
- Platform: Google Colab (provides free GPU).
- Language: Python 3
- Libraries: Tensorflow, Keras, Pytorch

Methodology and Flowchart

Segmentation is performed on the dataset initially to find the lung region and other specific patterns like ground-glass opacity in the CT scans. Segmented images are then used as inputs for classification, following which severity score is determined based on the percentage of lungs affected.



Timeline of activities



Completed   Planned to complete

Dataset

A dataset of 150,000 to 200,000 high-resolution DICOM (Digital Imaging and Communication in Medicine) images of more than 400 patients.

Source: Department of Radiology, PSG Institute of Medical Sciences and Research, Coimbatore.

References

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