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COVID-19 DETECTION USING CT SCANS AND X-RAY IMAGES BY DEEP LEARNING TECHNIQUES

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ABSTRACT

In the present pandemic, Coronavirus Disease 2019 (COVID-19) has created an extreme danger to human life due to the infection of the respiratory and lung tissue. The researchers find infection patterns on lung CT images for automatic diagnosis of COVID-19. Detecting COVID-19 is essential to decrease the patients' death risk. This study proposes a flow system to determine COVID-19 infections and detect, localise, and segment the lung using added tomography images. Perhaps the specialists' most extensively familiar and successful techniques are using CT and X-rays to break down the images of lungs for COVID-19. Deep learning procedures have recently been on an ascent and have changed many exploration applications. Particularly in the clinical area, picture informational collection includes chest X-ray, Lung CT Scan Image, and Brain MRI, giving promising outcomes and all-inclusive accuracy by utilising profound learning methods.

Keywords: COVID-19; Image Pre-processing, Tomography, Lung segmentation; and deep learning

I. Introduction

The recent coronavirus (COVID-19) pandemic is a dangerous virus disease spreading from China at the end of December 2019. The virus spreads all over the world. At present, final COVID-confirmed cases are around 19.5 million and over 4 million deaths [1]. It involves a huge family of viruses. It was declared a pandemic by the World Health Organization. Symptoms of COVID-19 virus disease, such as dry cough, sore throat, and fever, mainly affect the respiratory system [2]. The brooding time of COVID-19 varies from 1 to 14 days, with side effects developing in 3 to 7 days; the longest time frame can reach 24 days for the incubation period.

Early identification can reduce the transmission of COVID-19 infection. Initial Clinical testing RT-PCR conducted is well suited for early detection and collects swab specimens from the infected patients [3]. The test is manual and time-consuming; results take 2 or 3 days. Researchers prove that sometimes false-positive results are shown while proceeding with RT PCR testing. This test may not be helpful for a faster diagnosis of COVID-19. Speedy, accessible, reasonable, and low-cost spotting of COVID-19 is the main process to slow down the spread of COVID-19. Medical experts and researchers suggest other testing methods, such as X-ray imaging, ultrasound, and computed tomography.

X-rays are one of the most cost-effective ways to define lung infections, but do not show abnormalities in the earlier stage [4]. Ultrasound images have no side effects and are used in bedside patients. Also, the low cost generally does not detect lung lesions or abnormalities [5]. For these reasons, another imaging method is CT. It helps with early detection, observation, and disease evaluation, which can quickly identify lung infection problems and faster diagnosis of COVID-19. Clinicians analyse and predict virus disease based on the variations in CTs. Computer researchers develop an early detection tool for diagnosing COVID-19. Most researchers have recently used D.L. methods to find COVID-19 on CT images. Deep Learning algorithms using multiple layers of neurons can automatically generate the COVID-19 identification characteristics [10].

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a) ***The figure depicts the CT images of COVID-19-infected patients present in the lungs***
b) ***The figure depicts the CT images with Non COVID-19 patients present in the lungs***

Fig1: A comparison of normal and COVID-infected CT images.

The most enormous number of passing all around the world is COVID-19. The pace of the demise of COVID is the most astounding among all the other illnesses. Computer-aided diagnosis (CAD) frameworks were created to distinguish COVID early by utilising lung CT images. The primary focus is on distinguishing and identifying the lung images. The experts' most broadly recognisable and effective strategies are using CT and X-rays to stall the photos of lungs for COVID-19.

A combination of CT and X-ray images exclusively utilised for two main purposes:

- To expand the size of the dataset.
- Then, a chest X-ray contains low driving force in the underlying stages, but a CT sweep of the chest is helpful even before side effects; the two sorts, CT and X-ray, were utilised and recognise exactly the new features distinguished in the pictures.

The most general cause for a large number of deaths in the world is COVID-19. The death rate COVID disease is the most astounding among every other kind of disease. Many Computer-Aided Diagnosis (CAD) systems were developed using lung CT images to detect COVID-19 disease in its early stages. The CAD systems mainly concentrate on identifying and detecting lung nodules to introducing a deep learning method, namely Radial Restricted Boltzmann Machines with Functional Neural Network (R2BM-FNN), to reduce memory usage from a large set of training data and classify the COVID disease. Pre-processing is initially carried out for the input image using the Laplacian Gaussian filtering technique to make the image normalisation and enhance the image. The coefficient feature selection extracts the COVID feature from the segmentation image. In this proposed method, a neural network is used to train the neurons with the help of stochastic gradient descent. This proposed R2BM-FNN method results in classification accuracy, precision, sensitivity, specificity, and execution time to evaluate system performance.

II. Deep Learning for COVID Detection

Various approaches based on DL have been developed to diagnose COVID quickly. Classification, Segmentation, and prediction tasks are done with the DL approaches [9]. The researchers used various methods with clinicians to help identify COVID. These approaches have more efficacies and, further, proceed accurate results for identifying and diagnosing COVID and using classification models to identify the Coronavirus disease patients with deep layers. Segmentation defines the affected area in the lungs. Manual segmentation takes more time. Prediction identifies the risk of COVID-19 infection.

DL has reassured such strains by observing all the features during the learning step. In contrast to extricating features in a hand-planned way, DL advancing requires just a bunch of information with pre-processing, if essential, and decides the instructive portrayals in a self-trained manner. These days, the issue of features has moved from a human side to a PC side. So, researchers have used deep learning approaches at the human level to improve disease identification and detection. Deep learning in other real-life applications similarly provides exciting outcomes with reasonable accuracy for medical imaging. The PC helped examine rendering images, which has been an issue in the clinical imaging field. The new advances in AI, particularly in DL, have taken a large jump toward helping order, group, and evaluate designs in clinical images.

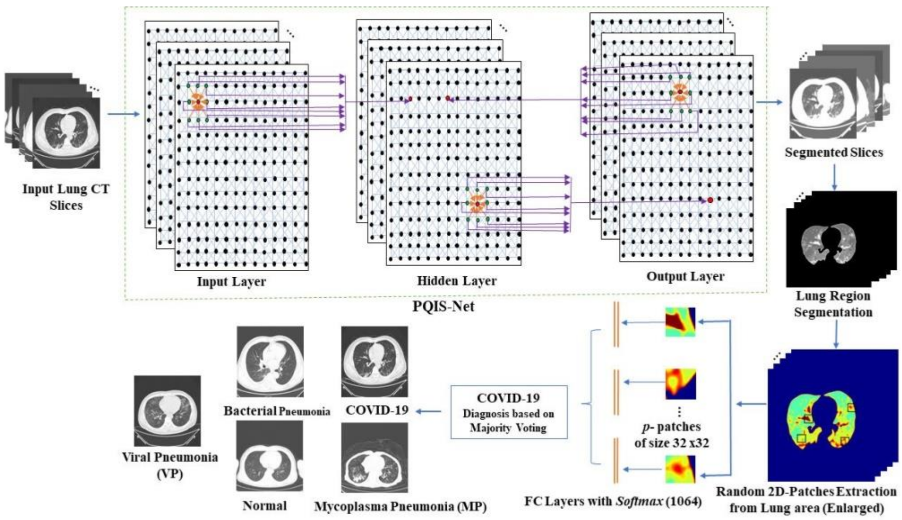


Figure 2: X-ray image prognosis

Experts are interestingly adding to clinical information investigation research that advances clinical. AI has been enormously applied to disengage the practical elements from image collections and arrange them for infection diagnosis. In COVID-19, human organ lungs get contaminated, and investigation on research relies upon Lung X-rays. Examine the COVID-19 image datasets from lung image investigation and arrive at any pragmatic result using the DL approach. To distinguish the Pneumonia cases from chest X-rays, CNN is applied with the 121-layered neural organisation.

The majority of the models were prepared using CT scan images. They are similarly additionally efficient and are not open at numerous medical clinics. All types of health diseases have a few frameworks connected with their spread, which are commonly non-straight. A wide assortment of research has been done utilising CNN, specifically in clinical investigation. We have offered to expand the current procedures for evaluating COVID-19 patients' X-ray image information.

Deep Learning algorithms handle large volumes of data and produce accurate results. It established a model for showing the coronavirus-affected person in an earlier stage. Deep Learning Technology uses CNN models to analyse the chest CT scans of how the virus disease affected humans [21]. The algorithm Deep Convolutional Neural Network (DCNN) can be used to learn the imaging characteristics of the patients affected by COVID-19. Deep Learning Architectures such as AlexNet [13], VGG16 [24], VGG19 [24], GoogLeNet [19], ResNet18 [24], ResNet50 [22], ShuffleNet [25] are the efficient networks used for early identification of COVID using Computer Tomography images.

Table: Comparison table represents the deep learning algorithm-based COVID classification approaches

Model	No. of CT images	Description	Accuracy (%)
ResNet[11]	Total:618 COVID:219 Pneumonia:224 Normal:175	A Residual Network (ResNet) built with various layers looks like a pyramidal structure.	86.70
DenseNet121[12]	Total:757 COVID:360 Non-COVID:397	Accurately performs where the infected areas are present in the lungs.	84.07

AlexNet[13]	Total:7500 COVID:2500 Lung tumour:2500 Normal:2500	Classify high dimensional convolutional features with less time.	98.25
EfficientNet[10]	Total:3294 COVID:1601 Normal: 1693	Compound scaling method-based architecture was built.	87.68
DCNN14]	Total:1065 COVID:325 Pneumonia:740	Multiple units can be defined. The hierarchy structure of the class can be represented.	85.20
GoogLeNet[19]	Total:746 COVID:349 Normal:397	Kernel sizes and inception layers were obtained in this model. Reduce the dimensional size and computational cost.	91.72
DRE-Net[20]	Total:1282 COVID:777 Pneumonia:505	Define the top-K information image details of the lungs and diagnose higher-level predictions.	86.00

III. Review of Literature

In the present years, DL learning has advanced in clinical image segmentation, which has created general diagnostic apparatuses because of the representation of features. An abundance of DL networks has been utilised for the programmed location of COVID-19 pneumonia lung CT volumes and have revealed great precision.

S. No	Title/Year	Author	Advantages	Disadvantages
1.	COVID-19 CT Image Synthesis With a Conditional Generative Adversarial Network (2020).	Yifan Jiang, Han Chen; Murray Loew	CT image methodology gives a contingent generative network that can successfully create superior grade and sensible COVID-19 CT pictures for DL-based clinical imaging undertakings for division and characterisation.	In this approach, CT image segmentation requires well-labelled data, which is labour-intensive. These problems mean

				that the COVID-19 CT data collection process can be difficult and time-consuming.
2. .	Adaptive Feature Selection Guided Deep Forest for COVID-19 Classification With Chest CT (2020).	Liang Sun; Zhanhao Mo; Fuhua Yan	The author proposes the Adaptive Feature Selection directed Deep Forest (AFS-DF) strategy given the prepared DL model to lessen the overt repetitiveness of elements. The component choice could be adaptively consolidated with the COVID-19 arrangement model.	This approach doesn't provide accurate results, and it takes more time.
3	A Basic Concept of Image Classification for Covid-19 Patients Using Chest CT Scan and Convolutional Neural Network (2020).	Irma Permata Sari; Widodo; Murien Nugraheni	Convolutional Neural Networks (CNN) produce spatial trademarks from pictures, which is extremely speedy for picture classification.	This algorithm didn't identify the accurate classification for lung CT images.
4	Prediction of COVID-19 Using Genetic Deep Learning	R. G. Babukarthik; V. Ananth	It is prepared to group them between COVID-19 and typical pictures without extricating features. It demonstrates that the	This algorithm didn't provide a proper classification

	Convolutional Neural Network (GDCNN) (2020).	Krishna Adiga; G. Sambasivam	strategy performs better than other exchange learning methods using the Genetic Deep Learning Convolutional Neural Network (GDCNN).	result, and the author doesn't focus on image segmentation.
5	Efficient and Effective Training of COVID-19 Classification Networks With Self-Supervised Dual-Track Learning to Rank (2020).	Yuexiang Li, Dong Wei; Jiawei Chen	The author proposes an original methodology for compelling preparation of COVID-19 characterisation networks utilising a few COVID-19 CT tests and anachieve of negative examples. An original self-managed gaining strategy is proposed to separate features from the COVID-19 and negative examples.	This approach, which effectively utilises the existing archive of non-COVID-19 data (the negative samples) in severe class imbalance, is another challenge.
6	Auto-Diagnosis of COVID-19 Using Lung CT Images With Semi-Supervised Shallow Learning Network (2021)	Debanjan Konar; Bijaya K. Panigrahi; Siddhartha Bhattacharyya	A random patch-based grouping for Parallel Quantum-Inspired Self-regulated Network (PQIS-Net) segments is fused at the recommended semi-managed shallow neural organisation system arrangement layers. Intensive tests have been conducted using three freely accessible informational indexes, one for simple division assignments and the other for arrangement.	This method can't provide proper classification results.

7	Lung Lesion Localization of COVID-19 From Chest CT Image: A Novel Weakly Supervised Learning Method (2021)	Ziduo Yang; Lu Zhao; Shuyu Wu	A weekly managed COVID-19 restriction in the Generative Adversarial Network (GAN) suggested a technique match procedure to work with created pictures by directing the generator to catch the intricate surface of chest CT pictures.	This method of supervised CT images of COVID-19 pneumonia requires voxel-based annotations for training, which takes much time and effort.
8	JCS: An Explainable COVID-19 Diagnosis System by Joint Classification and Segmentation (2021).	Yu-Huan Wu; Shang-Hua Gao; Jie Mei	The Joint Classification and Segmentation (JCS) framework performs constant and logical COVID-19 chest CT findings. To prepare the JCS framework, we must develop an enormous scope of the COVID-19 Classification and Segmentation (COVID-CS) dataset. The proposed JCS conclusion framework is extremely effective for COVID-19 order and division.	It takes more time during classification and segmentation and didn't work well.
9	COVID-19 Automatic Diagnosis with Radiographic Imaging: Explainable Attention	Wenqi Shi; Li Tong; Yu anda Zhu	The author proposes a Deformable Attention Module (DAM) to strengthen contamination areas and compress the noise in immaterial regions with an extended gathering field. Additionally, by	This algorithm doesn't provide accurate results, and it takes more time.

	Transfer Deep Neural Networks (2021).		consolidating fundamental data into unique information, consideration information moves from an educator organisation to an understudy network through a picture combination module. Prepared with educator networks mutually, the understudy branch with weighted thick availability can zero in on unpredictably model sore regions to learn discriminative elements and further develop network execution.	
10	COVID-19 Chest CT Image Segmentation Network by Multi-Scale Fusion and Enhancement Operations (2021).	Qingsen Yan; Bo Wang; Dong Gong	The author proposes a custom Convolutional Neural Network (CNN) for segmenting chest CT pictures with COVID-19. It includes various blocks that adaptively change the elements' worldwide properties for fragmenting COVID-19 disease. The proposed FV block can improve the capacity of element portrayal successfully and adaptively for different cases.	This strategy's clinical picture division technique can't accomplish acceptable execution.

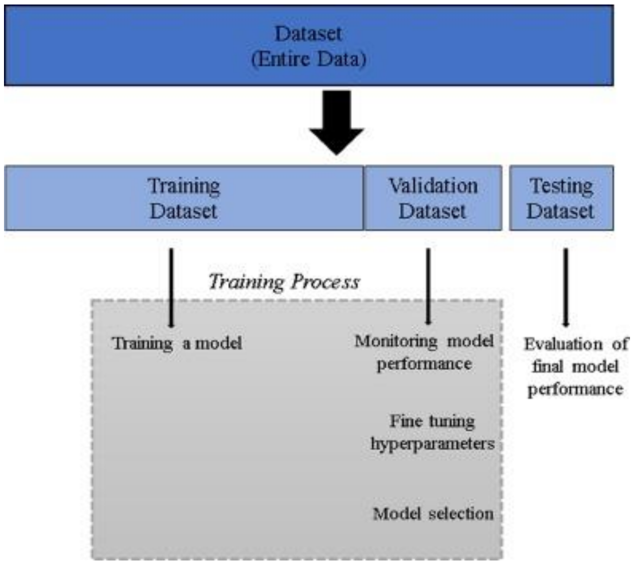
IV. Dataset

Deep learning requires a large amount of data for the model to be trained efficiently and accurately. The data available in the dataset are split into three sets:

i) Training dataset

ii) Validation dataset

iii) Test dataset.



The training dataset was divided into two parts: 20% was used to validate the already-built model, and 80% was used to make the model. The test dataset was used to assess the created model's actual performance after training without exposing it to it. 80% of the training data was split into five subsets for fivefold cross-validation. Chest X-ray scan images were used in the test or train sets, but not both, without lossy compression. The dataset was divided into 80% training and 20% testing to validate the developed model.

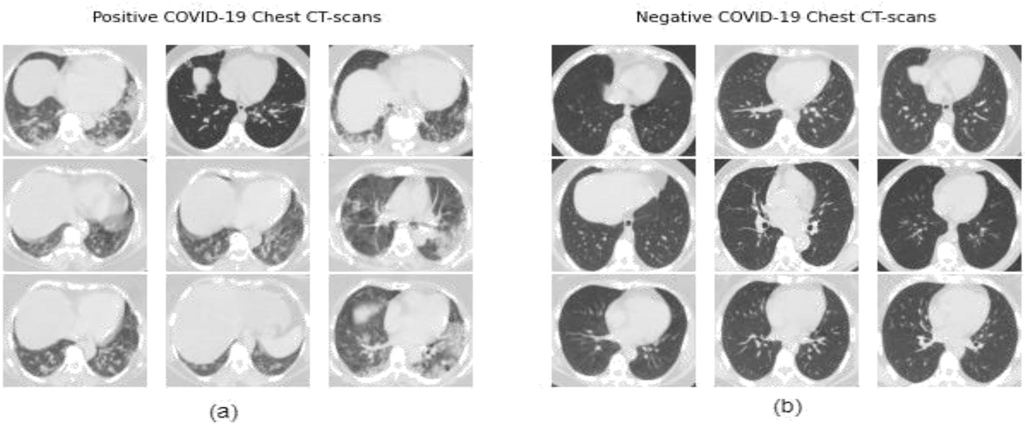


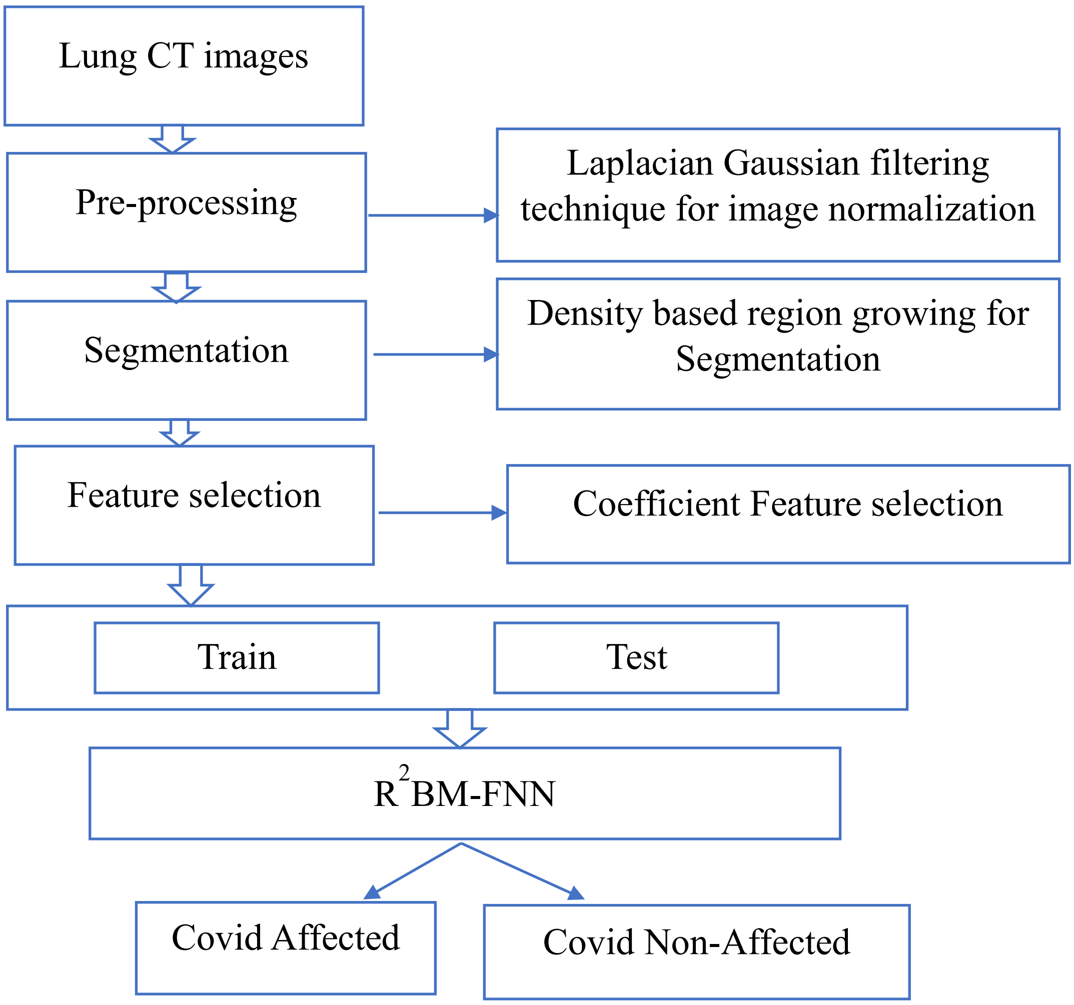
Figure 2. Sample images:

a) Positive COVID-19 Chest CT-scans b) Negative COVID–19 Chest CT-scans.

COVID-19 identification using lung CT images in the future. (Angelov et al., 2020), The dataset is divided into two categories: COVID and non-COVID. The patient information was gathered using CT scans from Brazilian hospitals. It is available at https://www.kaggle.com/plameneduardo/sarscov2-ctscan-dataset. The total number of CT scan images used is 2481. SAR-CoV-2 CT-scan dataset includes 1229 CT scans fit to COVID-19(-ve) patients and 1252 CT scans of COVID-19 (+ve) patients. Sample CT scan pictures of the lungs from the dataset are shown in Figure 1. 20% has been used for testing and 80% for training.

V. Methodology

This paper introduces a DL methodology, Radial Restricted Boltzmann Machines with Functional Neural Networks (R2BM-FNN). It reduces memory usage from a large training data set and classifies the COVID-19 disease. Initially, the first step is pre-processing the input data using the Laplacian Gaussian filtering technique to make scaling and improve the image quality. The coefficient feature selection extracts the COVID feature from the segmentation image. This method trains the neurons with the help of stochastic gradient descent.



- The particular locale developing strategy and the thickness-based developing technique to section the lungs from the chest CT filter picture have been contrasted.
- The coefficient includes the choice to remove the COVID-19 highlight from the division picture. An ordered network is utilised from the portioned lung region to arrange the connected illnesses, utilising a fix-by-fix preparation and derivation, after which an official choice is made.
- The info neurons prepare the CT filter picture from division information using the Stochastic Gradient Descent method.
- Everyone assessed the information and secret neurons.

i) Image Pre-processing

Image processing is a way to make some image changes to an improved image or extract relevant information. Here, we use the Laplacian Gaussian filtering technique for image normalisation. It is a 2-D isotropic piece of the second spatial subordinate—it features areas of fast intensity variety and is utilised for edge identification. The strategy is consistently applied to first be smoothened, approximating a Gaussian smoothing channel to less noise. The administrator regularly takes a solitary dim-level picture as a commitment and produces another dark-level picture as efficiency.

ii) Image Segmentation

In this process, region development is a locale-based plan that determines a pixel-based picture division strategy. It contains the determination of essential points. This technique notices adjoining starting point pixels and manages whether to add the pixel neighbours to the respective regions. This further iterated general clustering algorithms. Segmentation of image intends to isolate the locales. Some other strategies, for example, thresholding, accomplish this objective by noticing the limits between locales given breaks in dim scale or shading properties. The locale developing is to pick a bunch of seed focuses. Seed point choice is developed based on some client rules. The region starts as the specific area of these seeds. They are grown from these seed focuses to together focuses contingent upon a regional basis. Then, at that point, the locales are developed at the beginning of the rule; the data itself is critical. The rule was a pixel intensity threshold value; an image histogram would be useful, as one could involve it to restrict an appropriate threshold for the region participation measure.

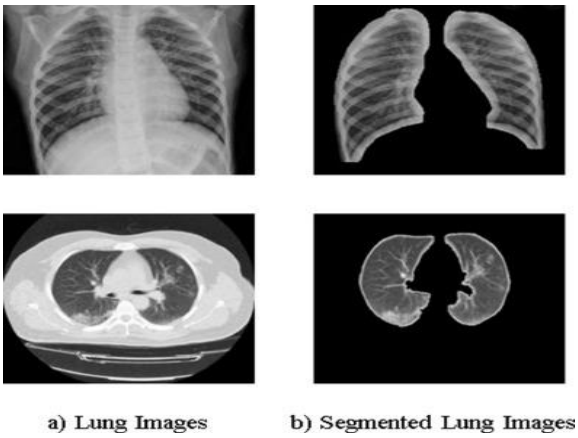


Fig 3: Image Segmentation Samples

iii) Feature Selection

The determination of features eliminates the number of information factors that are involved in analysis development. It is expected to diminish the quantity of info factors to minimise the framework's computational expense and to improve the model's overall performance. It decreases the strain of a model and makes it simpler. The accuracy of a model is chosen for the subset. This strategy is examined in three stages: screening, positioning and choosing. Screening disposes of irrelevant and testing indicators and records or cases, for example, with too many missing qualities or indicators with something over the top or too little variety to be useful. The use of Ranking sorts remaining indicators and assigns status positions. Choosing arranges the subset of highlights by rationing just the main indicators.

VI. RBM (Restricted Boltzmann Machines)-FNN (Functional Neural Network)

Boltzmann Machines is an unlabeled deep learning model. In this, nodes are associated with every other node. It is not a deterministic DL model; however, it is a stochastic DL model. It represents the persuaded framework—two kinds of nodes: machine-visible and hidden nodes. Visible nodes refer to measure, whereas hidden nodes can't quantify. If the nodes are divergent, RBM considers them equivalent and fills them in as one framework. The working information is taken into RBM, and the framework's weights are utilised consequently. It assists us with perceiving the deviations by finding out if the learning framework works in standard circumstances.

VII. Implementation of the proposed method

The COVID-19 disease is analysed from the lung CT picture using the Radial

Restricted Boltzmann Machines with Functional Neural Network (R2BM-FNN) technique. This method is used to Classify the COVID-19 virus from a CT scan, and it is an unsupervised learning method with a reduced training rate. The samples are used for pre-processing and segmentation. There, dividing the lung and cavity locales was finished. After the segmentation, a few boundaries are decided to prepare the classifier training. Further, it is processed in the Gaussian channel and transferred to the Laplacian Gaussian channel to reduce noise and enhance the image's quality. Segmentation of the lungs is taken from the chest CT images. The threshold needs to be set to find the differentiation of pixel intensity of the area of the lung present in the chest CT images.

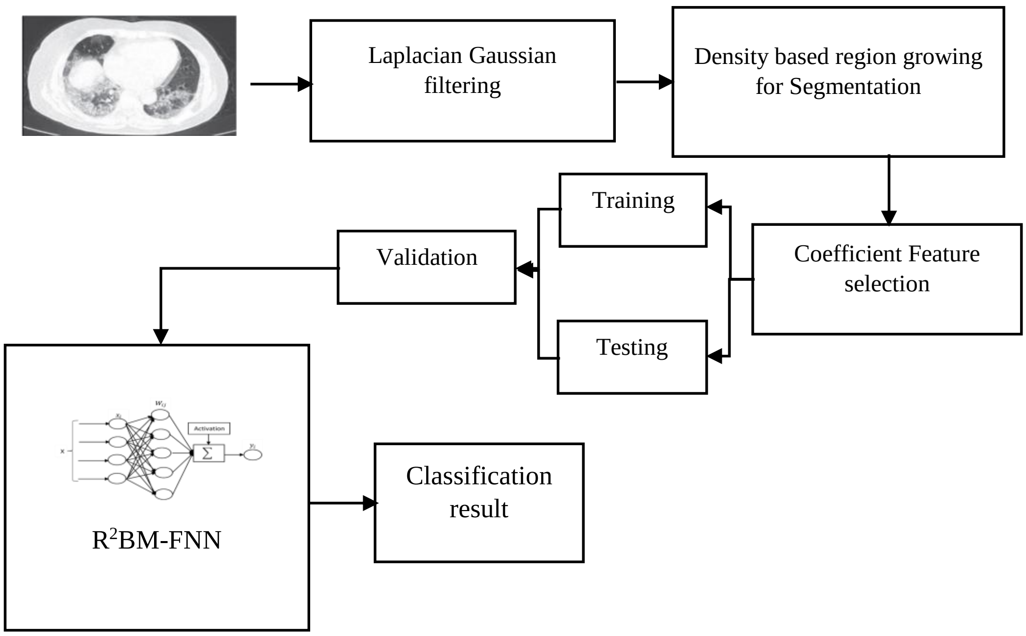


Figure 3: Overall Methodology Diagram

The above technique has been differentiated with a density-based region growing technique to separate the lungs from the chest CT images—the coefficient feature selection to extract the COVID feature from the segmentation image. A classification network is used from the segmented lung area to organise the identified diseases using the training patch-by-patch, inference, and final selection. The input neurons train the CT scan image from segmentation data with the help of Stochastic Gradient Descent. The input weights are evaluated, and the error estimate updates the hidden neuron.

VIII. Conclusion

The proposed deep learning method effectively develops a prediction model using various classification techniques to predict the COVID-19 disease and performance in prediction. The density-based region growing technique improves image segmentation and transparent information about lung regions. Using CT lung image features, we determine which classification model is most useful for helping doctors forecast the risk of COVID disease. To increase classification accuracy, we next use the suitable classification method Radial Restricted Boltzmann deep learning model to develop a prediction model. The excepted result is CT images affected or non-affected. The proposed classification's three-stage results are early detection, moderate, and severe. Also, we get the performances to form our deliverables: Classification accuracy, Sensitivity, Specificity, False rate, &Time Complexity.

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