

<p align="center">FORM 2</p> <p align="center">THE PATENTS ACT 1970 (39 OF 1970) & THE PATENT RULES 2003</p> <p align="center">COMPLETE SPECIFICATION</p> <p align="center">(SEE SECTIONS 10 & RULE 13)</p>																							
<p>1. TITLE OF THE INVENTION</p> <p>“SARS-COV-2 PRESENCE CLASSIFICATION VIA CHEST RADIOGRAPH”</p>																							
<p>2. APPLICANTS (S)</p> <table border="1"> <thead> <tr> <th>NAME</th> <th>NATIONALITY</th> <th>ADDRESS</th> </tr> </thead> <tbody> <tr> <td>Nikhil Lamba</td> <td>Indian</td> <td>SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana</td> </tr> <tr> <td>Dr. Ajay Sharma</td> <td>Indian</td> <td>SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana</td> </tr> <tr> <td>Dr. Surjeet Dalal</td> <td>Indian</td> <td>SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana</td> </tr> <tr> <td>Dr. Neeraj Dahiya</td> <td>Indian</td> <td>SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana</td> </tr> <tr> <td>Dr. Sanjay Kumar</td> <td>Indian</td> <td>SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana</td> </tr> <tr> <td>Dr. Vivek Jaglan</td> <td>Indian</td> <td>DPG Institute of Technology & Management, Near Hero Honda, behind Marble Market, Sector 34, Gurugram, Haryana 122001</td> </tr> </tbody> </table>			NAME	NATIONALITY	ADDRESS	Nikhil Lamba	Indian	SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana	Dr. Ajay Sharma	Indian	SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana	Dr. Surjeet Dalal	Indian	SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana	Dr. Neeraj Dahiya	Indian	SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana	Dr. Sanjay Kumar	Indian	SRM University, Delhi-NCR, Sonipat. Plot No. 39, Rajiv Gandhi Education City, PS Rai, Sonipat, Haryana	Dr. Vivek Jaglan	Indian	DPG Institute of Technology & Management, Near Hero Honda, behind Marble Market, Sector 34, Gurugram, Haryana 122001
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<p>3. PREAMBLE TO THE DESCRIPTION</p> <p>COMPLETE SPECIFICATION</p> <p>The following specification particularly describes the invention and the manner in which it is to be performed</p>																							

SARS-COV-2 PRESENCE CLASSIFICATION VIA CHEST RADIOGRAPH

TECHNICAL FIELD

[0001] This invention is in the field of automated detection of diseases via medical imaging. This is for the detection of SARS-COV-2 and pneumonia (pneumonia is taken into consideration as some of the symptoms are similar), as now a second wave is on rise in countries like India and is affecting the lives of people. This invention is made in the concern of helping people and doctors to flatten the curve by fast detection of coronavirus cases using Chest X-Ray only. Artificial intelligence is helping a lot in such domains where detection is necessary at a very fast speed, here convolutional neural network is used for training the chest X-Ray images and classification of coronavirus, pneumonia and normal cases.

BACKGROUND

[0002] Background description includes information that may be useful in understanding the present disclosure. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed subject matter, or that any publication specifically or implicitly referenced is prior art.

[0003] From the last couple of years computer aided detection (CAD) is benefitting a lot to healthcare domain by its applications of automatic detection of diseases by the use of artificial intelligence and hence saving a lot of time..

[0004] CAD technology is used in many areas of healthcare like:-

- It helps in the dental domain by providing accuracy during the time of insertion as per the requirement.
- It provides assistance to doctors for finding fractures in x-ray.
- It helps in handling large workflows by providing an automated system like in the present situation of pandemic.

CAD systems are so efficient specifically in radiology that these are used to confirm the review made by radiologists after examining a patient in some cases.

[0005] All the countries are trying really hard for dealing with such a situation of global emergency by making vaccines and imposing lockdowns to prevent the spread. This invention is the contribution for such efforts and the concept is to make a

system for the classification of coronavirus, pneumonia and normal patients for the quick detection of infection inside lungs with the help of convolutional neural networks as algorithm for the formation of such computer aided **detection system**.

OBJECTS OF THE DISCLOSURE

[0006] Some of the objects of the present disclosure, which at least one embodiment herein satisfy, are listed here in below.

[0007] The main objective of this invention is to provide the remoteway for efficient diagnosis of infection caused by SARS-COV-2 in lungs by use of chest X-Ray and so doesn't require to wait for hours for the final result and also doesn't require much effort.

[0008] Other objective is to tackle the future situations that are possible from different strains coming like delta version,etc. of this virus.

[0009] Other objective is to provide the explainable output that shows the doctor which region of the lungs is infected so medical treatment can be customized varying from patient to patient.

[0010] Other objective is to make workload of the doctors as less as possible so to diagnose the patients coming in large numbers.

[0011] Other objective is to make the patients understand their present lungs condition like how much they are corona infected, how much pneumonia infected and how much they are normal ,again utilizing the predictions only for this explanation.

[0012] Other objective is to help the government agencies, labs to handle the large queue of patients by quick diagnosis that is possible with this invention and so knowing by number of patients from a region either to impose strictness or not.

[0013]. Other objective is to make the users of this invention aware of their respiratory organs' health even after the strain so not getting infected again and somehow diagnosed infected but at very mild as per this invention they can isolate themselves and work on their immunity.

[0014] Last objective is to contribute parallely to the global efforts that scientists, researchers are doing to handle this situation of global pandemic and make it end soon.

SUMMARY

- [0015] Various objects, features, aspects, and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.
- [0016] First cases of Covid-19(SARS-Cov-2) were found in China, at the end of 2019. Now the cases are present in almost the whole world. WHO (world health organization) declared this situation an emergency in January, 2020. Since then researchers started finding ways to detect the presence of this virus in humans with the help of CT scans, chest X-Ray, RTPCR test, etc. and WHO declared RTPCR test as standard for Covid-19. Before making RTPCR a standard test radiologists were using CT scans and chest X-Rays to detect the Covid-19 cases. This was done by radiologists as some patterns were found in these radiographs of positive patients like:- ground glass opacities(GGO), pleural thickening, etc. and these patterns were visible in radiographs.
- [0017] Government also started taking huge moves not to let the curve rise and started making people aware about the seriousness of this disease by deploying some apps like Aarogya Setu launched by Indian Government that helped for the cause it was made, this global pandemic situation slowed down all the infrastructure of countries when countries started recovering then studies were made that showed the mutation in this SARS-Cov-2 virus and this time it was more dangerous than of previous. Now it was not even detected in RTPCR test. Then doctors shifted to the detection method as chest X-Ray and CT Scans and the reason why it is detected in these radiographs is those patterns that it is showing even in this mutation.
- [0018] So, in this invention these patterns are the major concern of detection of the novel coronavirus and for the creation of such system convolutional neural networks are used that have shown really impressive progress in the field of medical imaging for detection of pneumonia, edema, etc. diseases and even outperformed the radiologists. So, this kind of quickness and accuracy is required in the present situation of a pandemic so as to decrease the workload of doctors and nurses. Hence, those patients that require more attention can be provided with the same and the requirement of hospital beds and ventilators can be decreased. The

classification category of pneumonia is also included as some symptoms shown by Covid-19 patients and pneumonia patients were somewhat similar.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The illustrated embodiments of the subject matter will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout. The following description is intended only by way of example, and simply illustrates certain selected embodiments of devices, systems, and methods that are consistent with the subject matter as claimed herein, wherein:

[0020] This invention unrolls the potential of Artificial intelligence in remote diagnosis of the lungs infection using just chest X-ray and this diagnosis method does play an important role in the present condition. To understand the invention, please have a look on Figure 1 which is self-explanatory; and

[0021] Figure 2 shows the whole process flow of the invention first of all chest x-ray image is provided to the model that will preprocess the image and converts it into 224x224 dimensions dimensions as per model is trained on.

[0022] The accuracy increases here as again utilizing the features and concatenating them as per from distinct layers shown in Figure 3.

DETAILED DESCRIPTION

[0019] The detailed description of various exemplary embodiments of the disclosure is described herein with reference to the accompanying drawings. It should be noted that the embodiments are described herein in such details as to clearly communicate the disclosure. However, the amount of details provided herein is not intended to limit the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure as defined by the appended claims.

[0020] It is also to be understood that various arrangements may be devised that, although not explicitly described or shown herein, embody the principles of the present disclosure. Moreover, all statements herein reciting principles, aspects, and embodiments of the present disclosure, as well as specific examples, are intended to encompass equivalents thereof.

[0021] The terminology used herein is for the purpose of describing particular

embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises”, “comprising”, “includes” and/or “including,” when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

[0022] It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two figures shown in succession may, in fact, be executed concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0023] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It will be further understood that terms, e.g., those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0024] This invention's motive is to create the accessibility of the deep learning application for remote diagnosis of coronavirus, pneumonia and normal patients with the help of their chest x-ray.

The figure explains the overview of invention, at first user will upload the chest x-ray and the system will send it to the algorithm's part where it will be analysing the picture of x-ray and then it predicts as per given input, the prediction will contain three parts with percentage of each i.e., coronavirus, normal and pneumonia:

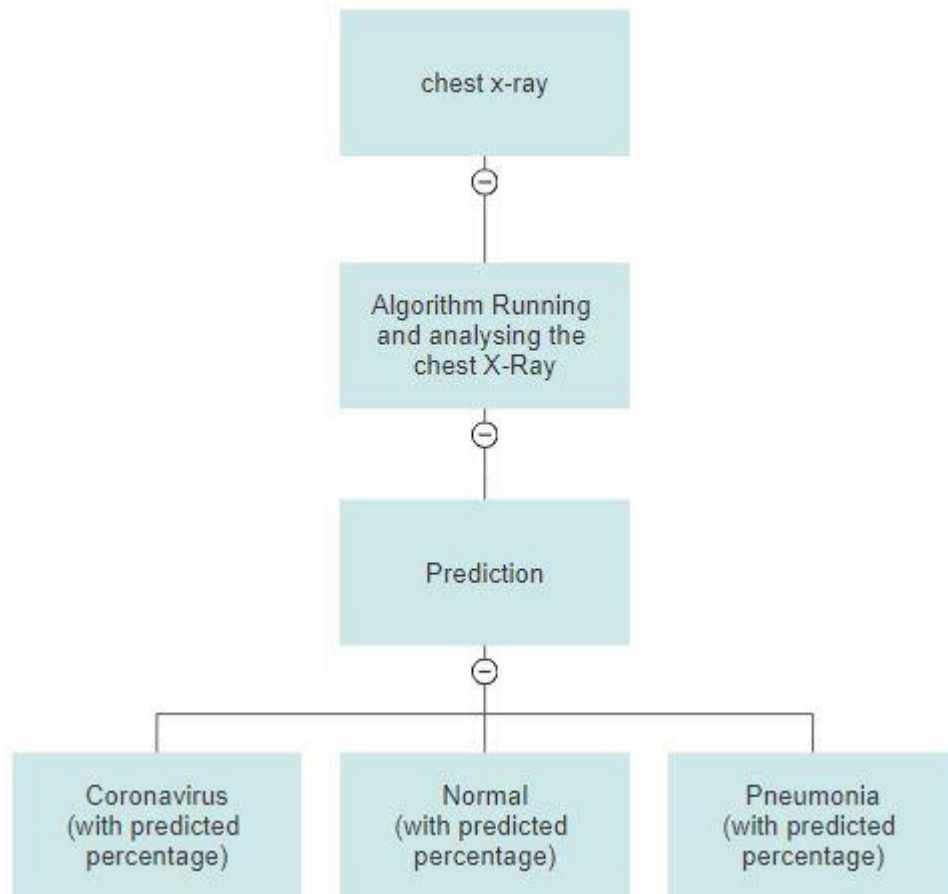


Fig1. Overview of the invention

Great amount of images are required for such applications in the medical field but are not always available. The main reason can be given as of cost and as well as followed by workload of experts in radiology in such time of pandemic as they are not able to provide labels for these many images. And also in this time of emergency we are not having a lot of images of patient's chest x-ray. There is a need for transfer learning reflected by these issues as training of model being much better and accurate by use of this approach on even small datasets. So, for increasing the present amount of images data augmentation techniques are used in this invention and hence making these many images that can be trained by this transfer learning approach and giving high accuracies.

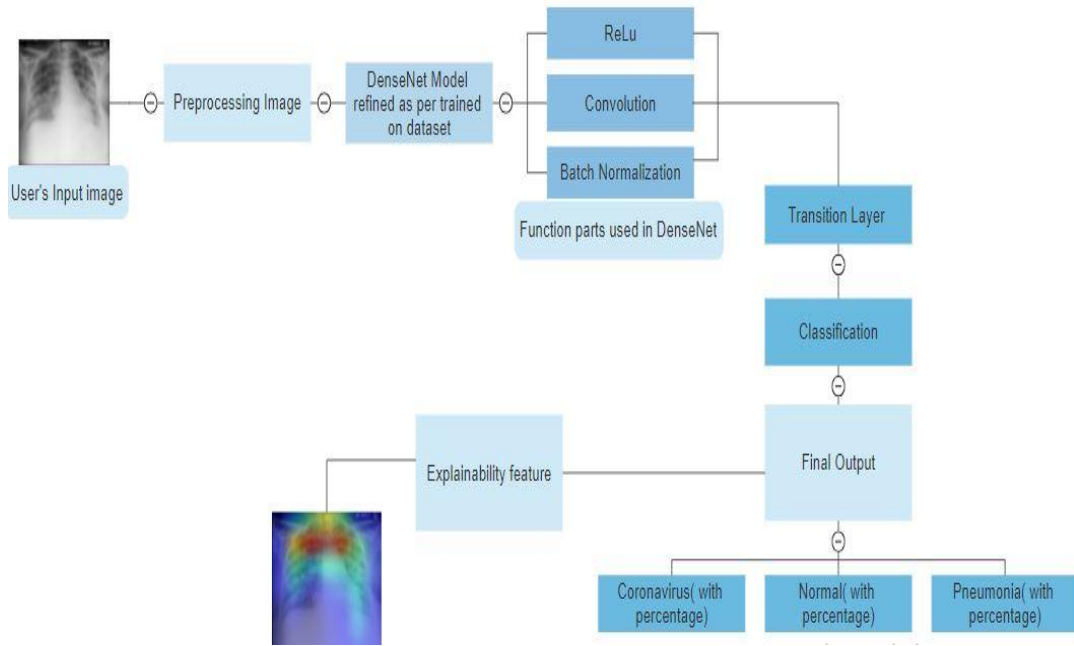


Fig 2. Detailed Description of the process

Fig 2 shows the whole process flow of the invention first of all chest x-ray image is provided to the model that will preprocess the image and converts it into 224x224 dimensions as per model is trained on ,then, it will take the preprocessed image and processes it through many hidden layers and that is then transferred to transition layer then to classification from where the final output is made containing three categories coronavirus (covid), normal and pneumonia and also the explain ability feature also works and provides the detailed output that can be taken into consideration by the person who wants to get diagnosed and this image is self-explanatory with respect to the output of percentages of three categories, doctors also can take this explainable image with percentages predicted as the final output of the model and diagnose that particular patient. This explainability feature is added in the invention to make anyone understand about which region the person's lungs are infected or because of which part the patient needs to be taken into consideration for either covid positive, pneumonia infected or is normal.

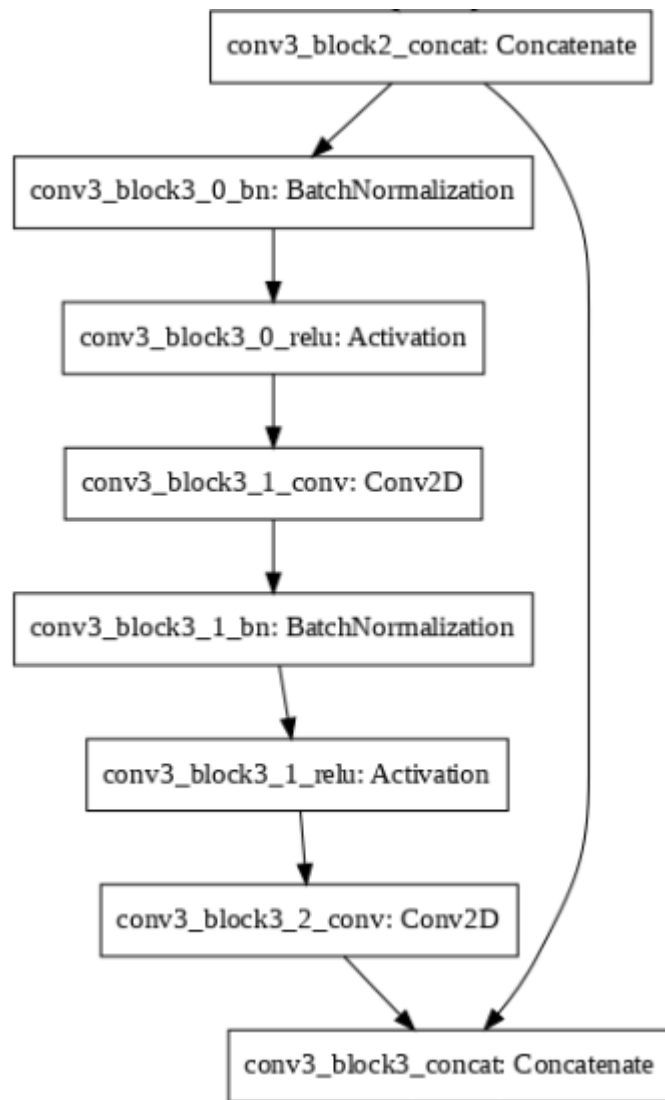


Fig 3. Concatenation and other functions present in architecture

The densenet architecture is chosen for the transfer learning approach in this case because of many reasons. The flow of connection between layers in this architecture is really different, in this, features from previous layers are taken and given to upcoming layers. The advantage here with compared to other architectures like VGG, Resnets is that it requires less number of parameters. The flow of connection in this architecture also makes the task of training much simple. The accuracy increases here as again utilizing the features and concatenating them as per from distinct layers shown in Fig3. Here, there is a function used that includes different actions: rectified linear unit(ReLU), batch normalization(BN), convolution function.

ReLU is used here the reasons may be noted as, it is linear function used as activation function in many neural architectures as it gives nice results for training purposes. It does not provide output as almost 0 value, if it is, then it outputs as 0 exact. BN is used here as densenet is really deep neural network architecture and it also requires a lot of epochs to

get it trained on the dataset, but, here BN plays an important role in decreasing these epoch counts. The function of pooling is done by the transition layers and these are the layers that are present between dense blocks.

We claim:

1. A deep learning based method to detect the presence of covid-19 infection in patient's lungs x-ray. We dedicate this invention for the remote diagnosis of the infection caused by this virus in human's lungs, this invention can be used by doctor or by patient.
2. It just takes input a chest X-Ray of a patient and process it with the densely connected neural network architecture used, it gives output as the percentage of findings among the categories used for training i.e., covid, pneumonia and normal.
3. Deep transfer learning is used to transfer the knowledge of densenet to our dataset, here it is shown that there is no need of writing convolution neural network algorithm from scratch, as it will somehow get trained on limited features of the dataset and we require the most features from the dataset that can be done possibly by densely connected neural network.
4. Densenet is chosen here due to its feature of reduction of parameters and using the concatenation method(as shown in Fig3) for reusing the features from previous blocks. By doing so densenet is making our objective of this invention possible of getting most features with as much lesser parameters as possible.
5. The interaction of this web app is deployed with flask and provides a simple GUI for user, in which user have to just click on choose [to upload the chest x-ray image] and then click on predict to get the findings that are predicted by the model.
6. The modified dense convolutional neural network architecture is trained using 2 Tesla V100 GPUs running on the cloud and distributing work as per algorithm written and took some hours to complete the execution, but the web application so created doesn't require any special kind of GPUs or complex CPU hardware, it just needs a browser and a local storage on the gadget from which user needs the chest x-ray to be diagnosed.
7. The explainability is also made of each diagnosed chest x-ray that the user provides as an input so that patients can be made clear about the regions of infection and

also making it faster for the doctors to manage their workloads. The part of explainability is not provided as an input with each chest x-ray during training of the dataset.

8. This invention is having the potential to be used even after the current emergency situation and can be used further to diagnose remotely if someone get infected with covid-19, pneumonia or is normal. The F1 score of the model is 98.7 that is the harmonic mean of precision and recall.

Dated this 26th day of June, 2021



Nikhil Lamba



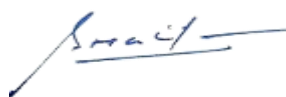
Dr. Ajay Sharma



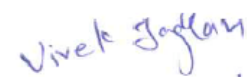
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To,

The Controller of Patents

The Patent Office, at Delhi

ABSTRACT

SARS-COV-2 PRESENCE CLASSIFICATION VIA CHEST RADIOGRAPH

This invention unrolls the potential of Artificial intelligence in remote diagnosis of the lungs infection using just chest X-ray and this diagnosis method does play an important role in the present condition where many people are having smart gadgets around them that can run the application and get the diagnosed results instantly, the micro framework so used made it very simple to make use of the app. Dense architecture of the convolutional neural network so modified here is trained on the three categories and all the images taken for training are frontal chest X-Ray that made the process less complex. The user has to upload the chest x-ray and the model gives output within couple of seconds. This application can also play a vital role in decreasing the queue around hospitals.

[[TO BE PUBLISHED WITH FIG. 1]]