Detection of COVID19 and Pneumonia using Chest X-ray Images

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Abstract

Utilizing concepts introduced in course ITCS-4152-5152 Computer Vision, the aim of this project is to detect Covid-19 and pneumonia in a person using their chest x ray images. We are planning to use a data set on kaggle that contains images classified as person with COVID-19, pneumonia and healthy. Using the same data set, we will make our own model that can achieve a high success rate by implementing newer ideas of our own and use it as our final presentation. The tech stack we decided on using is python, convolution neural network(cnn) and some pre-trained models on transfer learning such as resnet,inception and vgg. Lastly this model will be deployed on a platform to make it more usable.

1. Introduction

COVID-19 has been an outrageous virus since 2019. It was the cause of thousands of deaths and the global pandemic. It is a well known fact that COVID-19 virus targets the lungs and infects it. With advanced medical technologies along with RT-PCR test COVID-19 can also be detected using the x-ray of a chest just like pneumonia. We wanted to work on this kind of heath care project which will be beneficial in the future for this sector.

The data set taken from kaggle contains nearly 30,000 x-ray images of chest x-rays classified in 3 classes - pneumonia, COVID-19 and normal. We will train our model on this data set using train and validation sets. The aim of our project is that our model should correctly predict whether a person if effected by COVID-19/pneumonia or is healthy when given a chest x-ray image of that person.

We are planning to use deep learning to construct our chest x-ray detection model because of its excellent performance accuracy and rapid speed, we are looking forward to using deep convolutional neural networks for image classification. Additionally, we are planning to implement fundamental transfer learning principles in neural networks to ultimately output if a person is healthy or has any of the disease when given a new unseen chest x-ray image.

This projects proposes to embark our journey through computer vision with this same goal in mind. This is a huge undertaking, especially for our group considering this is our foremost approach towards applying the principles of computer vision. With that said we will be using Open CV to create a model with a relatively high success rate.

2. Proposed Tech Demo

This model will be deployed and demonstrated using a visual representation like a web page or application. Given the scenario with COVID 19 all around the world this project aims in aiding the medical and healthcare sector by helping in diagnosing COVID 19 as well as pneumonia in a patient more efficiently. Convolution Neural Network Layers (CNN) serve as the model's underlying architecture and are used to generate various layers. Additionally, libraries like Keras, TensorFlow, and Open CV are employed.

We will discuss the outcomes of our training and testing along with our approach to molding the model. We plan to document our process including both success and failures and communicate them through our final presentation. We are looking to achieve a high overall success rate above the 75 percentile range. With guidance from the course instruction, we hope to make a model that can be used effectively for other applications.

3. Research

Our model will aid healthcare providers in the detection and diagnosis of COVID-19/pneumonia. Detection based on symptoms is not always adequate. Many patients are asymptomatic yet are positive for COVID-19. Chemical testing is costly and slow. Diagnosis using chest x-ray images requires a specialist who has expert knowledge. A deep learning approach can solve these issues because it is fast, cheap, and potentially highly accurate.

The use of deep learning approaches for classifying medical imagery is extremely prevalent today. In addition to COVID-19 pnuemonia detection, deep learning is being used to detect many different types of cancer, cardiovascular disease, and more. There are several open-source convolutional neural network models that are available for commercial and research use. We can use these existing models as a starting point for creating our own custom model. We can also use these models as a benchmark when evaluating the results of our model. Some examples include ResNet, COVID-Net, and MobileNet. The communities around this code are highly active. Similar solutions for our specific problem already exist. For example, COVID-Net is an open-source deep convolutional neural network that was made specifically for the detection of COVID-19 using chest x-ray images.

The dataset used to train the COVID-Net model contains 13,975 chest x-ray images from approximately 13,870 patients. It contains images collected from several medical databases. The data is labeled as either normal, covid-pneumonia, or non-covid pneumonia. It is considered open access, and is licensed under the GNU Affero General Public License 3.0.

4. Academic Literature Review

Paper Title: A Deep Learning Approach for the Detection of COVID-19 from Chest X-Ray images using Convolutional Neural Networks

Authors: Aditya Saxena, Shamsheer Pal Singh

Researchers from the Birla Institute of Technology set out to develop a fast, accurate, and cheap tool for diagnosing viral pneumonia (caused by COVID-19). The team decided to take a deep learning approach to classify chest x-ray images as either “normal” or “COVID-19 (pneumonia)”. The current standard for analyzing medical images is Convoutional Neural Networks (CNNs). CNNs have shown remarkable results over the past decade. One CNN, CheXNet, even managed to perform better, on average, than four radiologists.

The dataset consisted of 13,975 chest x-ray images collected from five open-source repositories. To avoid overfitting, and to make the dataset larger, various physical transformations were performed such as cropping, flipping, zooming, and shifting. They also performed grayscale normalization to “reduce the effect of illumination’s differences”.

The unique functionality of a deep CNN is it performs feature extraction at multiple stages. After features are extracted using convolutional layers, pooling layers were used to extract combinations of features. Lastly, a fully connected layer uses the extracted features to classify each image. Dropout was used to add regularization, and batch normalization was used to prevent overfitting.

The proposed custom DCNN achieved an accuracy of 92.62±0.015%, outperforming existing models such as ResNet18, COVID-Net, and MobileNet-v2.

Paper Title: Comparison and Validation of Deep Learning Models for the Diagnosis of Pneumonia

Authors: Zhenjia Yue,Liangping Ma,and Runfeng Zhang

Pneumonia clinical image diagnosis requires the use of artificial intelligence.Convolutional neural networks (CNNs) have outperformed humans in terms of image identification, and artificial intelligence recognizes images very quickly.In order to classify these diseases in the dataset, Authors used five common network algorithms in studies and compared the results.

Based on the comparison, The authors used the Kaggle dataset, which included chest X-ray images for classification and included 5216 train and 624 test images, with pneumonia and normal as the two categories.Authors were able to improve MobileNet’s network structure and achieve a higher accuracy rate than other methods.Additionally, the expanded MobileNet network could be utilized in additional locations.

On a dataset consisting of X-ray images of lungs with pneumonia and normal lungs, the accuracy of five mainstream deep learning models is used to diagnose clinical data in this paper.Authors concentrated on MobileNet’s network structure as one of them due to its superior performance.The findings demonstrated that MobileNet’s accuracy is higher than that of the other network structures and that each of the five network structures is capable of recognizing pneumonia.In addition, there is insufficient use of artificial intelligence technology in the medical field, and the types of datasets in this field need to be expanded.

Paper Title: Chest X-ray image analysis and classification for COVID-19 pneumonia detection using Deep CNN

Author: Terry Gao

A new diagnosis platform based on a deep convolutional neural network (CNN) was developed in this study to speed up the discovery of COVID-19 disease mechanisms from X-ray images. This platform can help radiologists diagnose patients by separating COVID-19 pneumonia from non-COVID-19 pneumonia based on classification and analysis of chest X-ray images.The research idea is that a set of medical X-ray lung images—which include normal, infected with bacteria, and infected with viruses like COVID-19—is used to train a deep CNN that can tell the difference between noise and useful information. This CNN is then used to interpret new images by recognizing patterns in the individual images that indicate certain diseases like coronavirus infection.It mimics medical school, but the idea is that because it can learn from a much bigger number of images than any person, it could end up being more accurate.

The deep CNN is trained to look at the actual difference based on the presence of pneumonia and no other factors associated with pneumonia, so the training of the CNN needs to have no pneumonia and pneumonia representing X-rays that are alike in all other aspects that may influence how an X-ray looks.Approximately 400 chest X-ray pictures serve as testing samples (100 images for each class). A total of 100 chest X-ray pictures, including 50 images with COVID-19 infection, are utilized for validation.

This research created a deep CNN-based chest X-ray classifier to detect anomalies and extract textural aspects of the changed lung parenchyma that can be associated to particular signatures of the COVID-19 virus in order to hasten the discovery of disease causes. It mimics medical school in this way, but the assumption holds that because it can learn from a far greater collection of photos than any person, it has the advantages of being more accurate and speeding up the infection diagnosis process.

Paper Title: Deep Learning on Chest X-ray Images to Detect and Evaluate Pneumonia Cases at the Era of COVID-19

Authors: Karim Hammoudi, Halim Benhabiles, Mahmoud Melkemi, Fadi Dornaika, Ignacio Arganda-Carreras, Dominique Collard, Arnaud Scherpereel

In this paper the authors experimented with the chest X-ray pneumonia dataset and used tailored convolution neural network models to detect pneumonia in a person in the era of covid-19. The dataset is classified into 3 categories namely - normal, viral pneumonia and bacterial pneumonia. From this if a person has viral pneumonia then it is highly likely that they have covid-19. After that further RT-PCR tests can be done to confirm covid-19 infection. The tailored CNN models used in this experiment are namely - DenseNet169, VGG-19 and Inception ResNetV2 RNN.

The DenseNet169 model gave the highest accuracy of 97.97 for bacterial pneumonia followed by 96.62 for viral pneumonia and 92.57 for normal pneumonia. Overall all the models have shown good accuracy of above 84 which is above average. The inceptionnet model has even shown least number of false negatives meaning it is the most reliable of all models for accurate detection of pneumonia during the times of COVID-19.

Paper Title: Applied Computer Vision on 2-Dimensional Lung X-Ray Images for Assisted Medical Diagnosis of Pneumonia

Authors: Ralph Joseph S.D. Ligueran, Manuel Luis C. Delos Santos, Ronaldo S. Tinio, Emmanuel H. Valencia

This work focuses on the field of artificial intelligence named as computer vision for the analysis of the 2-D lung X-Ray images for diagnosis of pneumonia. A convolutions neural network algorithm was implemented in the process of performing the analysis of the lung X-rag images. A flask- based web application was developed on the x-ray's images for the detection of pneumonia. Convolutional neural networks work with pattern identification and detection, a technique called transfer learning was implemented to train the neural networks for the detection of patterns. Medical images such as scanning, x-rays are generally very well versed with the detection and diagnosis of certain diseases. Using convolutional neural networks on these image/x-rays related to analysis of diseases work well and accurate results are given out. Training datasets were obtained from Kaggle, an open-source research community owned by Google LLC. The dataset used is entitled "Chest X-ray Images for Pneumonia Detection with Deep Learning" published by Tolga Dincer (2020), a data scientist from Connecticut, United States.

In this study, a machine learning model file with an h5 file extension contains all the data relevant to the analysis of the image. Kernel matrices containing the pattern to be detected are stored in the h5 file. A Python application built on top of the Flask framework was created for online deployment in order to implement the image analyzer and use the h5 knowledge base file that was made for the detection of common pneumonia. The virtual machine and cloud storage were all hosted by PythonAnywhere, a cloud server that is compatible with Python. The front-end is composed of HTML CSS-coded web pages. The back end is created using the Python-coded Flask framework, and the storage is where the h5 file and image storage directory are located. A dense layer, a flattened layer, and five blocks of feature extraction layers made up the bulk of the VGG-16 algorithm. The feature extraction layer's blocks are made up of Cov2D and MaxPooling2D stages. Convolutional processing can be applied to photos using the computational function ov2D. In order to reduce the size of the matrix, the computational function MaxPooling2D finds the largest value within each partition. The matrices will go through two rounds of Cov2D for the feature extraction layers of blocks 1 and 2 and one stage of MaxPooling2D. The matrices will go through three steps of Cov2D and one stage of MaxPooling2D for blocks 3, 4, and 5 TESTING: - Using a quantitative approach and statistical techniques, a confirmatory test was carried out to evaluate the accuracy and efficiency of the built web application. Five trials were used in the confirmatory test's experimental design. This method involved performing a confirmatory test five times with five randomly and independently chosen test datasets. A sample of 100 2-dimensional lung x-ray pictures was taken from the open-source dataset for each trial. A statistical method called as Simple Random Sampling without Replacement was used for the selection procedure (SRSWOR).

CONCLUSION: -The development of the h5 knowledge base successfully demonstrated the capability of the CNN algorithm implementation for machine learning to produce patterns based on an examination of open source datasets. The web application's successful implementation and deployment to the cloud server demonstrated the viability of deploying such a system on such a platform. The experimental results demonstrated the excellent accuracy of the analysis, demonstrating that, when used under the guidance of medical professionals, it may be utilized to identify common pneumonia.

Paper Title: Literature Review for Pneumonia Classification Using Deep Learning from Chest X-ray Images During COVID-19

Authors: Abdullahi Umar Ibrahim 1, Mehmet Ozsoz 1, Sertan Serte 2, Fadi Al-Turjman 3, Polycarp Shizawaliyi Yakoi 4

Abstract: -A common and important examination form used for suspected coronavirus cases is chest X-ray imaging (CXR) (COVID-19). Due to its accessibility, affordability, and quick turnaround times, CXR imaging is preferred in locations with severe damage or scarce resources. However, these tests might reduce the effectiveness of pandemic control and prevention because of COVID-19's rapid dissemination. Due to their cutting-edge performance in the interpretation of visual data and a vast variety of medical images, artificial intelligence techniques like deep learning offer intriguing choices for autonomous diagnosis.

Convolutional neural networks (CNNs) are commonly used for medical imaging; they have various architectures and applications. A CNN model known as Decompose, Transfer, and Compose (DeTraC) for the classification of COVID-19 using chest X-ray images. The study utilized multiple datasets acquired from different hospitals around the world.

Deep Learning: -Deep learning (DL) is a branch of machine learning (ML), a subset of artificial intelligence (AI) inspired by the makeup of the human brain. It is termed as a sub-field of ML that works similarly to the biology of human brains by taking data and processing the data through neural networks. Transfer learning (TL) has provided an easier approach to quickly retrain neural networks on datasets with high accuracy.

We use the AlexNet model which is a deep learning model which uses rectified linear unit (ReLu) in place of the Sigmoid function which is used in traditional neural networks. It contains five convolution (CONV) blocks or layers with convolutional filter size 3×3 without padding and 2×2 window size of the max pooling operation. The last three layers are two fully connected layers (FCL) and the output layer.

The AlexNet model's typical input size is 227 by 227 by 3. The model has eight layers in total, five of which are convolutional layers and three of which are completely connected. Convolution, pooling, and normalization are the three procedures that make up the first two convolutional layers. In contrast to conventional machine learning, which employs Tanh and sigmoid functions, AlexNet uses ReLU as an activation function. ReLU turns negative values into zeros and aids in the modeling of non-linear functions.

The workflow of the proposed method is shown below-

The datasets are divided into two: 70

For multiclass dataset, before we train the whole classes, we examine the performance of the model based on three-way classification (COVID-19, bacterial pneumonia, and healthy) to see how the model will perform before integrating non-COVID-19 viral pneumonia.

We used Matlab loaded on a personal computer with a 64-bit window, 8 GB of Random Access Memory (RAM), an Intel ® Core i7-3537U, and a Graphics Processing Unit for training datasets (GPU). 30

Three factors are taken into account to assess how well the trained models perform: accuracy, sensitivity, and specificity. The ratio of correctly categorized photos to all images is known as accuracy. It is also known as the sum of sensitivity and specificity. The most popular method for assessing the performance of models using true positives (TP), true negatives (TN), false positives (FP), and false negatives is the confusion matrix (FN). The number of samples that each model correctly classifies as positive cases or the number of cases that are genuinely positive (i.e., pneumonia-related) are referred to as the TPs.

Conclusion: - The models were trained based on two binary classes and multiclass (three and four classes). For two binary classifications, each of COVID-19, non-COVID-19 viral pneumonia, and bacterial pneumonia are classified along with healthy CXR images. For multiclass, the models are trained based on (1) three-way classification (COVID-19, bacterial pneumonia, and healthy CXR images) and (2) four-way classification (COVID-19, non-COVID-19 viral pneumonia and bacterial pneumonia and healthy CXR images). The models were evaluated based on accuracy, sensitivity, and specificity. However, the result has shown that for the classification of non-COVID-19 viral pneumonia and healthy datasets, the model achieved 94.43

The higher performance achieved for classification of COVID-19 pneumonia and non-COVID-19 viral pneumonia and COVID-19 pneumonia with healthy CXR images has shown that computer-aided detection approach can be used as an alternative or a confirmatory approach against

RT-PCR method which has shown to be less sensitive, time consuming, and laborious. One of the limitations of this research is the fact that we used a small dataset of COVID-19 pneumonia.

5. Data Collection

The COVIDx CRX-3 dataset will be used to train the model. COVIDx is a publicly available, open-access benchmark dataset comprised of 29,986 chest X-ray images from 16,648 patients. The images are labeled as one of three classes: no pneumonia/non-COVID-19 pneumonia/COVID-19 pneumonia. Approximately 55% of the training images are classified as COVID-19 pneumonia, 18.5% are non-COVID-19 pneumonia, and 26.5% are normal. The testing split contains 400 professionally annotated images. 50% of the testing images are classified as COVID-19 pneumonia, 25% are non-COVID-19 pneumonia, and 25% are normal.

The creators of COVIDx compiled the dataset from several publicly available sources. These sources include Actualmed COVID-19 Chest X-ray Dataset Initiative, COVID-19 Radiography Database - Version 3, RSNA International COVID-19 Open Radiology Database, and more. Updated as recently as 06/02/2022, COVIDx was the clear choice for our model due to the large number of samples and labels that are specific to our problem.

6. Modeling

6.1. Literature Review

Based on our research, it was clear the foremost strategy for this kind of medical image classification is the use of Deep Convolutional Neural Networks. Approaches involving pre-trained models and custom models both showed promise, so we set out to explore both options. For our pre-trained models, we chose ResNet18 and VGG16 because they performed well based on the literature we reviewed, and AlexNet because we wanted to try something new that did not show up in our research.

6.2. Experimentation

In order to build a custom model from scratch, we first took inspiration from the architecture of pretrained models and custom models that showed up in our research. Once we had a starting point, we experimented with different pre-processing options, hyperparameters, and architectures. We kept track of what seemed to be increasing/decreasing model performance. Here is an extensive lise of the options we calibrated to optimize accuracy: data augmentation (horizontal flip), zero-centering, batch size, image size, learning rate, learning rate decay, optimizer algorithm, number of epochs, number of convolutional layers, number of max pool layers, kernel sizes, stride lengths, padding amount, number of filters, batch normalization layers, number and position of dropout layers, dropout rate, activation functions, number of fully connected layers, number of input/output neurons,

The final custom model is the culmination of our intuition-based experimentation involving all of these factors.

6.3. Pre-processing

All training and testing images were randomly shuffled, resized, normalized from [-1, 1], zero-centered, and grouped into mini-batches.

6.4. Hyperparameters

- Learning rate = 0.005
- Learning decays by a factor of 0.1 every 7 epochs
- Batch size = 64
- Image size = 128x128
- Epochs = 15
- Loss function: Cross-Entropy Loss
- Optimizer: Stochastic Gradient Descent

6.5. Architecture

Input: 128x128 Grayscale Images

Convolutional Layers:

Layer	Neurons/ Filters	Filter Size	Stride	Padding	Activation Function
Conv 1	32	5x5	1	0	ReLU
Max Pool 1	-	8x8	4	0	-
Conv 2	64	5x5	1	2	ReLU
Max Pool 2	-	2x2	2	0	-
Conv 3	64	5x5	1	2	ReLU
Max Pool 3	-	2x2	2	0	-
Dropout 1	Rate = 0.5				

Fully-connected Layers:

Layer	Input Size	Output Size
Linear 1	3136	3

6.6. Results

Model	Peak Test Accuracy	Train Accuracy
Custom	94.01%	92.90%
Fine-Tuned ResNet18	88.28%	99.93%
Fine-Tuned VGG-16	88.28%	97.58%
Fine-Tuned AlexNet	84.64%	93.21%
ResNet18 as Feature Extractor	79.69%	82.98%
AlexNet as Feature Extractor	66.93%	73.10%
VGG-16 as Feature Extractor	60.67%	69.70%

7. Conclusion

Detection of COVID19 and Pneumonia using Chest X-ray Images is a reservoir of wisdom, built on the basis of the accumulated experience and knowledge of the institution. Nurturing and building this model and involving teamwork for achieving classroom excellence is thus emerging as a big challenge for students, as they prepare to vault to the next level of organizational evolution moving from managing educational workload to becoming professional employees in companies or towards starting up their own firms. In this context the following factors become more relevant.

- Building systematic approaches to gather, share, retrieve knowledge.
- Encouraging people to be creative and innovative.

7.0.1 Job Expectation

In the 20th century the primary reasons to work in the corporation was adequate economic compensation and status. In fact, a persons social status and acceptance have been generally linked to the amount of wealth amassed and type of organisation one worked for. In the context of 21st century, with its Hi-tech and intelligent environment, people will be looking for something more than the satisfaction of materialistic and hedonistic needs. With all the technological superiority and control over nature the biggest mystery and challenge for human beings will be to understand themselves and develop their potential talents and capacities. At the workplace, people will increasingly look for personal, professional and spiritual growth. People will like to work in organizations where there is sense of meaning and inspiration, which is possible through computer vision. Our project has led us to consciously seek to psychologize, spiritualise and humanize our learnings so that people get the opportunity to self-actualize and self transform.

Team work is the basic building block for channelizing collective energy and empowering people. Working in a team on this project has us realize that we are comfortable about interacting, sharing and moving together for organizational excellence. Individuals may not have solutions for complex situations and problems but teams do have. Quality Action Teams, Quality Improvement Programs are some of the forums for team working. Right climate is created to harness the dormant potential of the individuals as well as teams by taking care of the following factors.

- Create forums where the team can bond together.
- Re-direct the normal competitive energies outward and towards killing competitions
- Reward collaboration
- Emphasize the higher goal

7.0.2 Team involvement and Participation

The thrust on meaningful interaction with the teammates through established forums of participation have been augmented and efforts made to formulate frameworks of joint consultation to step up the level of interaction and buildup.According to Keith Davis,"Participation is a mental and emotional involvement of an employee in a group situation which encourages him to contribute to group goals and share responsibility in them. It is an important part of human relations because it offers an enormous potential for higher productivity, improved satisfaction and creative thinking. Individually, the contribution provided by each of our teammates has been submitted in the circulated peer review form.

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