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A Novel Approach for Automatic Detection of the Coronavirus Disease from CT Images Using an Optimized Convolutional Neural Network

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Abstract: *To speed up the diagnosis of covid19 virus disease, an automatic automated approach for classifying computed tomography images of the chest is presented. The Automatic Detection Coronavirus Optimized Convolutional Neural Network (ADECOCNN) is a proposed convolutional neural network model for dividing infected, non-infected, and other pulmonary disease patients. The ADECO-CNN-optimized CNN model can categorise CT images with 99.99 % accuracy, 99.96 % sensitivity, 99.92 % precision, and 99.97 % specificity, according to extensive testing. CT imaging of the chest is highly recommended in the early detection of disease since it determines the amount and nature of the lesion. It also evaluates alterations that aren't obvious on X-rays of the chest. The shape, quantity, distribution, density, and accompanying symptoms of a lesion are all examined using CT imaging. Chest CT imaging can serve as a critical early warning indicator of being a COVID-19 carrier and can be extremely useful for patients who are experiencing any COVID-19-related symptoms.*

Keywords: Convolutional Neural Network (CNN), COVID, Computed Tomography (CT) Images, Deep Learning, etc.

I. INTRODUCTION

COVID-19 infection can induce significant pneumonia and can be fatal, similar to acute respiratory distress syndrome (ARDS) [2]. Fatigue, fever, and cough are common clinical symptoms; however, some people may be asymptomatic. Patients with severe cases of ARDS may require ICU or oxygen support therapy. Elevated C-reaction protein levels, lymphopenia, and erythrocyte sedimentation rate are used to diagnose SARS-Cov-2 cases in the lab. The genome of the SARS-Cov-2 virus was sequenced, allowing real-time tests termed reverse transcriptase polymerase chain reaction (RT-PCR) to be used as a diagnostic tool to stop the spread of the COVID-19 virus. Swabbed nucleic acid samples from a patient's throat, nose, and lower respiratory tract are used in an RT-PCR test [3].

Patients' anamnesis, etiological variables, symptoms, and medical imaging are all used to diagnose COVID-19 instances. Clinical sampling for nucleic acid testing is a trustworthy criterion, but it has certain drawbacks, including insufficient specimens, test kit shortages, laboratory errors, unequal detection technology, erroneous sampling, and technological issues [4]. Diagnostic test costs are also posing financial difficulties for both individuals and governments, particularly in nations with privatised health care. Due to difficulties in pathological diagnosis on nucleic acid testing, health care practitioners are exploring radiological scans as a diagnostic tool to detect COVID-19 patients. Radiologists have a critical role in the diagnosis and rapid identification of suspected illnesses, which is advantageous not only to the general public but also to the medical community.

1.1 Artificial Intelligence

Artificial intelligence (AI) is the simulation of human intelligence in robots that have been trained to think and act like humans. The phrase can also refer to any machine that demonstrates human-like characteristics like learning and problem-solving. Artificial intelligence (AI) refers to intelligence demonstrated by machines rather than natural intelligence expressed by humans or animals. Leading AI textbooks define the topic as the study of "intelligent agents," which are any systems that sense their surroundings and take actions to maximise their chances of attaining their objectives. Some popular reports use the phrase "artificial intelligence" to denote robots that simulate "cognitive" functions that humans connect with the human mind, such as "learning" and "problem solving," although this is a misapplication of the term rejected by major AI researchers.

The simulation of human intelligence processes by machines, particularly computer systems, is known as artificial intelligence. Expert systems, natural language processing, speech recognition, and machine vision are examples of AI applications.

Advanced web search engines, recommendation systems (like those used by YouTube, Amazon, and Netflix), understanding human speech (like Siri or Alexa), self-driving cars (like Tesla), and competing at the top levels in strategic gaming systems are all examples of AI uses (such as chess and Go), The AI effect is a phenomena that occurs when machines grow more proficient and jobs believed to require "intelligence" are often eliminated from the concept of AI. Optical character recognition, for example, is usually left out of AI discussions despite the fact that it has become a commonplace technique.

Since its inception as an academic study in 1956, artificial intelligence has gone through multiple waves of optimism, disappointment, and funding cuts (known as a "AI winter"), followed by new approaches, success, and renewed investment. Throughout its history, AI research has explored and rejected a variety of methodologies, including mimicking the brain, modelling human problem solving, formal logic, massive knowledge libraries, and imitating animal behaviour. Highly mathematical statistical machine learning dominated the subject in the first decades of the twenty-first century, and this technique has proven highly successful, helping to tackle many tough problems in industry and academics.

The many sub-fields of AI research are based on specific aims and the application of certain techniques. Reasoning, knowledge representation, planning, learning, natural language processing, sensing, and the ability to move and manipulate objects are all conventional AI research goals. One of the field's long-term goals is general intelligence (the capacity to solve any problem). AI researchers use search and mathematical optimization, formal logic, artificial neural networks, and methods based on statistics, probability, and economics to solve these difficulties. Computer science, psychology, linguistics, philosophy, and a variety of other disciplines are all used in AI.

Human intelligence "can be so clearly described that a machine can be constructed to imitate it," according to the field's founders. This sparks philosophical debates about the mind and the ethics of building artificial intelligence that is human-like. Since antiquity, myth, fiction, and philosophy have all attempted to address these challenges.AI, with its vast potential and power, has also been suggested as an existential threat to humans in science fiction and futurology. Vendors have been trying to showcase how AI is used in their products and services as the hoopla surrounding AI has grown. Machine learning, for example, is frequently referred to as AI. For designing and training machine learning algorithms, AI necessitates the use of specialized hardware and software. Although there is no single programming language that is synonymous with AI, a few notable ones include Python, R, and Java.

1.2 Deep Learning

Deep learning, which is effectively a three-layer neural network, is a subset of machine learning. These neural networks attempt to mimic human brain function by allowing it to "learn" from massive volumes of data, but they fall far short of its capabilities. While a single-layer neural network can only make approximations, adding hidden layers can help to optimise and enhance accuracy. Deep learning is used in many artificial intelligence (AI) products and services to improve automation by performing analytical and physical tasks without the need for human intervention.

Deep learning technology is used in everyday products and services (such as digital assistants, voice-enabled TV remotes, and credit card fraud detection), as well as prospective developments (such as self-driving cars). Classes are described using terminology such as targets, labels, and categories. Classification predictive modelling is the process of estimating a mapping function from discrete input variables (X) to discrete output variables (y). In machine learning and statistics, classification is a supervised learning method in which a computer software learns from data input and then applies that learning to classify new observations.

This data set could be bi-class (for example, determining whether the person is male or female or whether the mail is spam or non-spam) or multi-class (for example, deciding whether the person is male or female or whether the mail is spam or non-spam) (for example, determining whether the person is male or female or whether the mail is spam or non-spam).

Examples include speech recognition, handwriting recognition, biometric identity, document classification, and other classification issues.

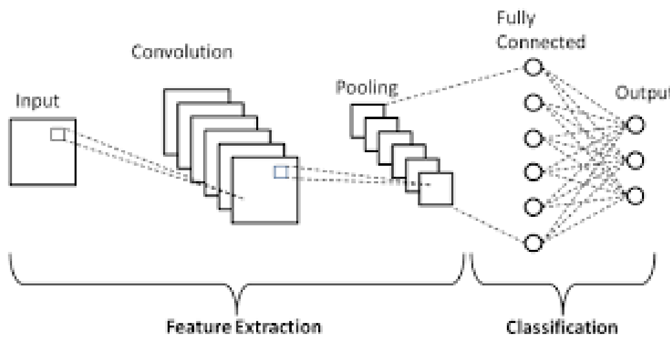

Figure 1: Convolutional Neural Network Process Flow

1.3 Convolutional Neural Network

In deep learning, a convolutional neural network (CNN/ConvNet) is a sort of deep neural network that is used to analyse visual imagery. Matrix multiplications come to mind when we think about neural networks, however this isn't the case with ConvNet. Convolution is a technique used in it. Convolution is a mathematical procedure that takes two functions and produces a third function that shows how the shape of one is modified by the other. Convolutional neural networks are made up of many layers of artificial neurons. Artificial neurons are mathematical functions that, like their biological counterparts, calculate the weighted sum of numerous inputs and output an activation value. When you input an image into a ConvNet, each layer develops several activation functions that are passed on to the next layer.

The first layer usually extracts basic properties such as horizontal or diagonal edges. This data is sent on to the next layer, which is in charge of recognising more complex features such as corners and combinational edges. As we delve deeper into the network, we discover that it is capable of recognising increasingly more complex items such as objects, faces, and so on. Based on the activation map of the final convolution layer, the classification layer outputs a sequence of confidence ratings (numbers between 0 and 1) that indicate how likely the image is to belong to a "class."

1.4 Preparing the Dataset

This dataset was created in order to build models for Corona Virus Detection. It contains

- COVID Infected patient's CT Images.
- Patient's CT Images who are not infected by COVID.
- Images are in JPEG&PNG format

II. LITERATURE REVIEW

A literature review is a body of text that aims to review the critical points of current knowledge on and/or methodological approaches to a particular topic. It is secondary sources and discusses published information in a particular subject area and sometimes information in a particular subject area within a certain time period. Its ultimate goal is to bring the reader up to date with current literature on a topic and forms the basis for another goal, such as future research that may be needed in the area and precedes a research proposal and may be just a simple summary of sources. Usually, it has an organizational pattern and combines both summary and synthesis.

Fang et al. [8] conducted some studies and comparisons between the RT-PCR and the data gained from examining the chest CT images of 51 patients over the course of three days. When compared to RT-PCR at an early stage, Fang et al. [8] found that the effectiveness of a chest CT was higher, with 98 % versus 71 % having p 0.001 [8]. After performing the swab test on individuals who had negative RT-PCR findings but had specific features in their chest CT scans, the results were positive. Chest CT imaging can serve as a critical early warning indication of COVID-19 infection and can be extremely useful for patients who exhibit any suspected COVID-19 symptoms [9]. A number of deep learning algorithms have recently been developed to detect COVID-19 infection via radiographic images [10].

Zhang et al. [11] presented the anomaly detection approach to aid the radiologist in examining a large number of chest X-rays. With the use of a deep learning algorithm, *Li et al*. [12] were able to distinguish COVID-19 from other lung illnesses using CT images. Due to the heterogeneity in size, position, and texture of infections, COVID-19 infection detection utilising CT scans with good sensitivity and accuracy remains a difficult task.

Image patterns such as chest radiographs and chest CTs have recently been employed to detect COVID-19 [12].

Cohen et al. [13] created a dataset based on the COVID-19 public X-ray and CT scan image collection. They gathered around 125 photos from various websites and magazines online. For the categorization of COVID-19 cases utilising X-rays, they used four pretrained CNN models (ResNet18, AlesNet, SqueezNet, and DenseNet201) and enhanced images. With 98 % accuracy and 96 % sensitivity, SqueezNet came out on top.

In [22], a new deep learning model called CLSTM was introduced for predicting the remaining useful life. Segmentation is a pre-processing method used to obtain the region of interest, which is a lesion or diseased region, from radiological images.

Shan et al. [23] used their suggested model, a three-dimensional convolutional neural model termed VB-Net, to conduct autonomous segmentation of entire lungs and infected areas using CT images. The dataset they used in their experiment isn't available to the general public. For training, they employed 249 infected patients and 300 fresh patients for testing. Their suggested model predicts the volume, shape, and proportion of infection while also auto contouring the infected area.

III. PROPOSED SYSTEM

The CNN has been widely used in a variety of image classification applications and is regarded as a very powerful technique. It has gotten a lot of interest in a lot of different areas, including image identification, image analysis, object detection, and computer vision jobs. The CNN efficiently pulls features from images, and its hierarchical nature allows it to deal with images dynamically. Each convolution stage results in a new "convolved" image comprising features derived from the previous step.

Let an image be represented as I (x, y), and f(x, y) represents the filter that is used, then the resulting transformation is

$$y(i,j) = (I,f)(x,y) = \sum_{-\infty}^{\infty} \sum_{-\infty}^{\infty} I(x-u, y-v) f(u,v)$$

The rectified linear unit (ReLu) is used as an activation function, with a sophisticated feature mapping connecting each layer's output and input. The ReLu is a linear function that returns a zero result when given positive input values.

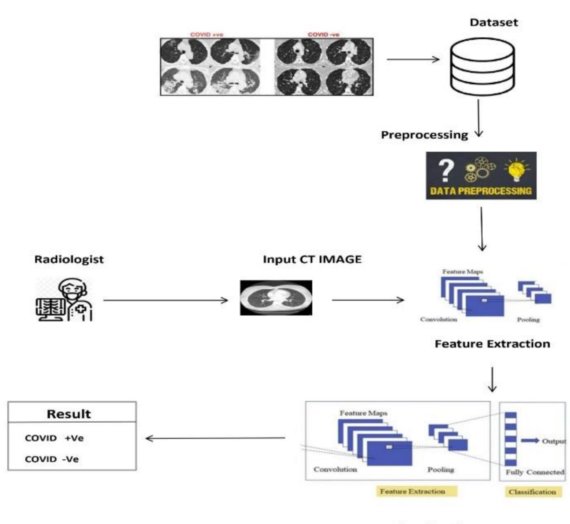

Figure 2: System Architecture of Proposed Model

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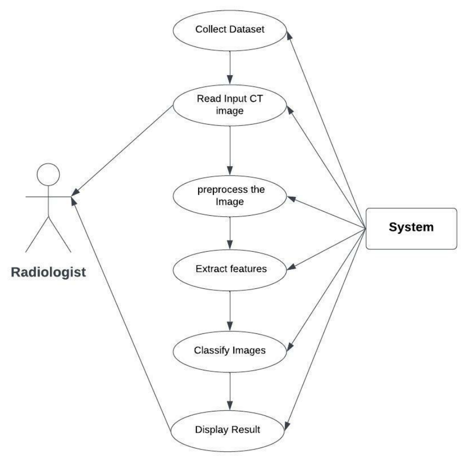

Figure 3: Use Case Diagram of the Proposed System

Use case diagrams are considered for high level requirement analysis of a system. So, when the requirements of a system are analysed, the functionalities are captured in use cases. So, it can say that uses cases are nothing but the system functionalities written in an organized manner.

IV. MODULE DESCRIPTION

Proposed System Modules

- Dataset Collection
- Pre-processing
- Feature Extraction
- Classification

Dataset Collection

Dataset contains the CT scan images of COVID-19 positive and negative patients. The experiment's data source [26] can be found at A single SARS-COV-2 CT-Scan file contains CT pictures from a number of different patients. It contains 1252 CT pictures from patients who tested positive for SARS-CoV-2 (referred to as COVID +ve) and 1230 CT images from patients who did not test positive for SARS-CoV-2 (referred to as COVID -ve). A total of 2482 CT images make up the complete dataset. Figure 4(a) depicts COVID +ve cases with infectious patches in the lungs, while Figure 4(b) depicts COVID- ve cases without infection (b).

The images in the aforementioned dataset were acquired from patients in hospitals in the Brazilian metropolis of Sao Paulo. The major goal of this dataset was to assist researchers in developing and fine-tuning artificial intelligence algorithms for determining whether or not a person has been infected with COVID-19 simply by looking at their CT pictures.

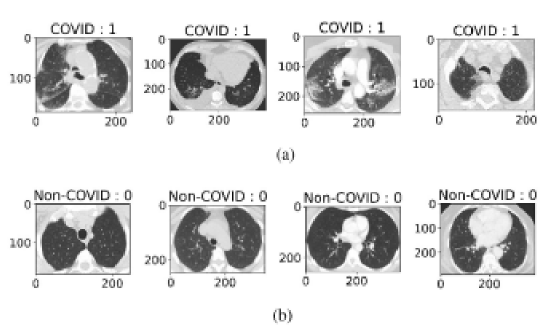

Figure 4: CT images of COVID +ve and COVID −ve cases. (a) COVID +ve Images. (b) COVID −ve Images.

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Data Pre-processing

The actions taken to format images before they are used by model training and inference are known as mage pre-processing. This covers resizing, orienting, and colour corrections, among other things. Image augmentation is the process of manipulating photos to create different versions of the same material in order to provide the model with more training examples. Randomly changing the orientation, brightness, or scale of an input image, for example, need a model that considers how an image topic appears in a number of conditions. While image pre-processing processes are applied to both training and test sets, image augmentation alterations are only applied to training data. Because the features produced directly from CT images had varying intensities and grey scales, data pre-processing was required before such pictures were fed into the classifier. Standardization and normalization are two data pre-processing procedures. Features in normalization are calculated as

where x^i are normalized features extracted from feature x^i , x^i min are minimum feature values, and x^i max are maximum feature values.

$$\hat{x}^i = \frac{x^i - x^i_{\min}}{x^i_{\max} - x^i_{\min}} \quad i = 1, 2, \ldots K$$

Preprocessing Steps

By eliminating noise from CT images, all images are preprocessed to appropriately extract lesion locations.

The four steps of preprocessing are as follows.

1. As seen in Fig. 4, all of the CT images were of varying intensities and sizes (a). As shown in Fig. 4, all photos were first converted to a fixed size by lowering the dimensions to 100 x 100 3 before training (b).
2. For edge detection, a filter with values ([0,1, 0], [1, 6, 1], [0, 1, 0]) is used.Figure 4 depicts images with edges (c).
3. Finally, the luma component values are recovered by transforming the RGB image to YUV in the third phase. Because luminance is more significant than colour, the resolution of U (blue projection) and V (red projection) is reduced, while the resolution of Y is maintained at full resolution, as illustrated in Figure. 4. (d).
4. The intensity values are then equalized in the last stage by converting the YUV image back to RGB and smoothing the edges and equalizing the histogram, as illustrated in Fig. 4. (e).

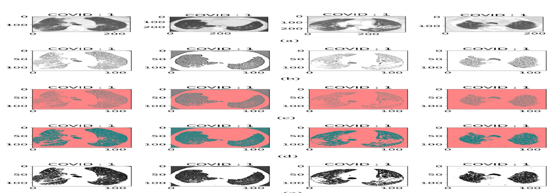


Figure 4: Four Steps of Preprocessing

(a) CT scan images without preprocessing. (b) Detection of edges. (c) BGR-image to YUV-image conversion. (d) Equalization of image intensity. (e) YUV-image to BGR image conversion.

Feature Extraction

To extract potential features, the CNN uses several convolutions and pooling layers in the initial stage. By using the max pooling layer, the retrieved features' spatial size is reduced. The pooling layer also aids in the reduction of over fitting. The maximum values are considered in the max pooling layer, while the average values are considered in the average pooling layer from the feature map created after the convolutional process. Stride is a term used to describe the space between image pixels during pooling. A new "convolved" image is created after each convolution stage, comprising features retrieved from the previous step.

Suppose an image is represented by I(x, y), and the filter is represented by f(x, y), then the transformation is

$$y(i,j)=(I,f)(x,y)=\sum_{-\infty}^{\infty}\sum_{-\infty}^{\infty} I(x-u,y-v)\,f(u,v).$$

The rectified linear unit (ReLu) is used as an activation function, with a sophisticated feature mapping connecting each layer's output and input. The ReLu is a linear function that returns a zero result when given positive input values.

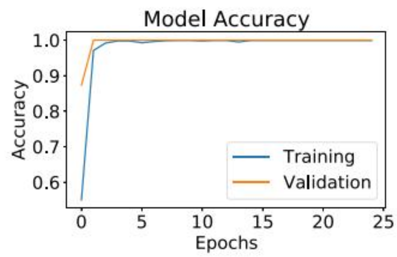
V. CLASSIFICATION

By producing a single long feature vector and passing it to the dense fully connected layer, the flatten layer converts the input into a one-dimensional array. Dense layers use extracted properties of an image acquired from convolutional layers to do classification. Typically, the activation function of the dropout layer decreases the feature map and minimises overfitting. Different weights are assigned to completely connected layers in each row, requiring different computational capabilities.

In the last layer of dense layers, sigmoid is used to predict the final output. The standard sigmoid function is S

$$S(t) = \frac{1}{1+e^{-t}}.$$

Figure 5.1: Accuracy Graph



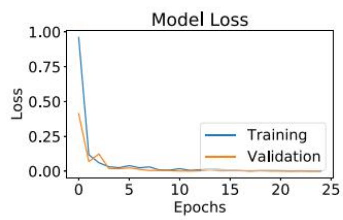


Figure 5.2: Loss Graph

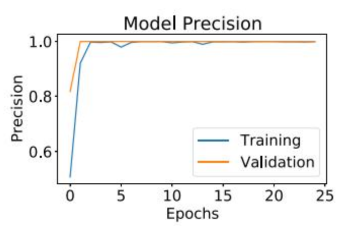


Figure 5.3: Precision Graph

ADECO-CNN Model Experimental Evaluation

```
y_val_pred=model.predict(x_val)
y_val_pred=np.argmax(y_val_pred,axis=1)
print(classification_report(y_val_pred,y_val))
```

```
              precision    recall  f1-score   support

           0       1.00      0.99      1.00       110
           1       0.99      1.00      1.00       121

    accuracy                           1.00       231
   macro avg       1.00      1.00      1.00       231
weighted avg       1.00      1.00      1.00       231
```

Figure 5.4: Classification Report for the Validation Dataset

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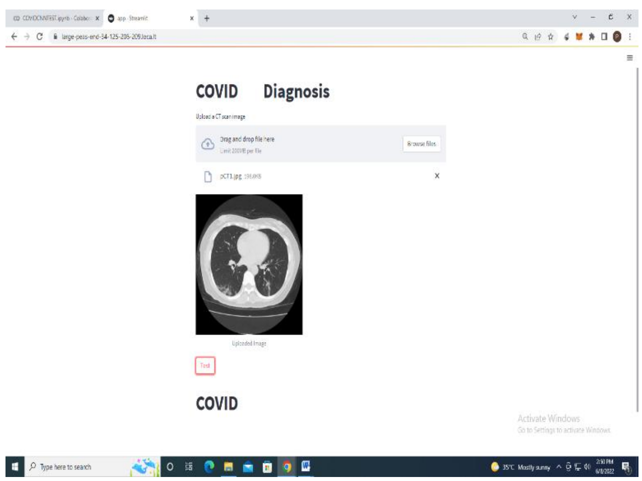
```
[27] accuracy_score(y_pred,y_test)

     1.0
```

Figure 5.5: Accuracy Score

```
[28] print(classification_report(y_pred,y_test))

              precision    recall  f1-score   support

           0       1.00      1.00      1.00        55
           1       1.00      1.00      1.00        73

    accuracy                           1.00       128
   macro avg       1.00      1.00      1.00       128
weighted avg       1.00      1.00      1.00       128
```

Figure 5.6: Classification Report for the Test Dataset

Case 1: COVID Positive



Case 2: COVID Negative

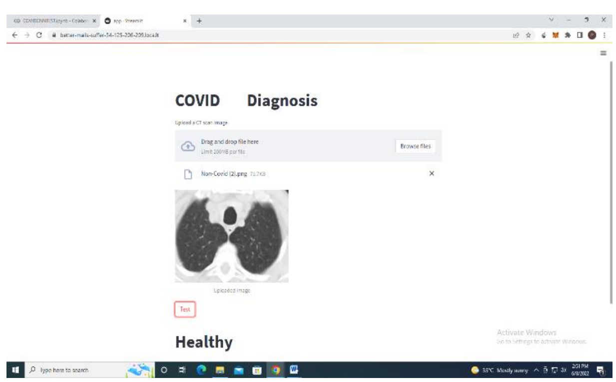


Figure 6: Output by the Proposed System

VI. CONCLUSION

This article developed a new classification model that can be used to predict COVID disease using only chest CT data. After four preparation stages, chest CT images from the COVID dataset were standardised. The CT-image dataset was

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then divided into two parts: a test set and a training set. After that, the training set was used to categorise COVID infected patients and create a model. To avoid over fitting and assure generalizability, fivefold cross validation was used.

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