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Intelligent predictions of Covid disease based on lung CT images using machine learning strategy

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ABSTRACT

Covid or Corona Virus, a term ruling the world from past two years and causes a huge destruction in all countries. One of the most important Covid disease identification method is Lung based Computed Tomography (CT) image scanning, in which it provides an effective disease identification means in clear manner. However, this Lung CT image based disease detection principles are complex to health care representatives and doctors to predict the Covid disease accurately. Several manual errors and medical flaws are raised day-by-day, so that a new systematic methodology is required to identify the Covid disease effectively with respect to machine learning principles. The machine learning principles are most popular to identify the respective disease efficiently as well as classify the disease in accurate manner without any time consumption. The infected portions of the chest are identified accurately and report to the respective person without any delay. In this paper, a new machine learning strategy is introduced called Hybrid Disease Detection Principle (HDDP), in which it is derived from the two classical machine learning algorithms called Convolutional Neural Network (CNN) and the AdaBoost Classifier. Both these algorithms are integrated together to produce a new strategy called HDDP, in which it process the lung CT image based on the machine learning factors such as pre-processing, feature extraction and classification. Based on these effective image processing strategies the proposed algorithm handles the CT images to predict the Covid disease and report to the respective user with proper accuracy ratio. This paper intends to provide effcient disease predictions as well as provide a sufficient support to medical people and patients in fine manner to assist them with modern classification algorithms.
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1. Introduction

In the year of 2019 December a crucial disease called Corona Virus under the family of SARS CoV2 infection is identified in Wuhan located in the country of China. Most of the countries does not know regarding the severity of this disease and not consider this as an important issue [1–3]. Because of this crucial affection and the destructions, all are getting shivered and The World Health Organization (WHO) announced an emergency regarding world health constrain on 30th January 2020 [4]. Around the period of end of April 2020, more than two lakhs and fifty thousand confirmed cases were identified in global manner and more than one lakhs seventy seven peoples are died for this disease [5]. Many different research scenarios are conducted to identify the nature and complexity of Covid disease and many countries are tied together to bring the medicine for this disease in serious manner. But within that period, this Covid disease spread around the world within few weeks of time in drastic manner and death ratio is increased day-by-day without any proper prediction possibilities. In practical, there are many ways available to identify the Covid disease based on several symptoms and nature. Over the starting 3 months of

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2020, the Corona virus disease outbreak has developed into a global health care disaster on a scale never seen before. Recognizing that early detection as well as continuous confinement of patients with Corona virus can significantly reduce disease spread, the use of Lung CT for patients suspected of having Corona virus has been recommended. The following figure, Fig. 1 shows the perception of Covid disease affected and unaffected images in clear manner.

Numerous studies have demonstrated that unenhanced lung CT seems to be more efficient than infectious genomic detection by utilizing medical transcriptase schemes for early identification of the sickness, but this process remains the standard method. When compared to lung CT, lung ultrasound is more favorable because it is a less expensive, reproducible, and non-ionizing radiation point of care technology. By use of lung ultrasound in patients suspected of having Corona Virus lowers the danger needed to manufacture unstable individuals to other scanners while also decreasing the risk of exposure to medical instruments and healthcare providers. This is essential in preventing clostridium order for that to happen to the virus's high contagiousness and although any use of lung ultrasound has increased massively over the last few decades, only a few studies have investigated the lung ultrasound results of individuals with Corona Virus. Thus, the goal of this study was to determine the lung ultrasound findings and their corresponding rates in people with Corona Virus, the link amongst lung ultrasound findings and the length of Corona Virus manifestations and the feasibility of utilizing lung ultrasound to determine the severity of Corona Virus. As compare to the lung ultrasound based scanning Scheme, all the technical experts are suggesting that the Lung CT image scanning is the best solution to identify the Corona virus in clear manner. So, that in this paper, a new methodology is designed with respect to the classical machine learning algorithms called Convolutional Neural Network (CNN) and the AdaBoost Classifier, in which it is called as Hybrid Disease Detection Principle (HDDP). This proposed algorithm HDDP identify the Covid disease with respect to Lung CT image scanning principle based on the machine learning procedures. The machine learning strategy is used in this paper to train the system with respect to lung CT image dataset downloaded from the public medium called Kaggle. Based on the training the efficiency of the approach is designed and the model is created according to that, in which it is helpful to identify the disease on testing scenarios. The live patient Lung CT image is input to the machine and it is considered to be the testing input for analyzing the disease in fine manner. The input testing image is cross-validated with the trained model and predicts the resulting features with proper accuracy as well as reporting that to the users without any time complexities. Presently, many researchers proposed several learning methodologies to identify the Covid disease based on radiological image screening [6,7]. Several supervised learning principles are utilized to manipulate these radiological images to identify the Corona Virus in crucial manner as well as the resultant features are so probabilistic to identify the disease. All these methodologies are producing the variations in results based on certain factors such as texture, size, position and more. Based on these factors the resulting scenario gets affected in numerous levels. So, that in this paper a new methodology is required to design to provide an intellectual way to predict the corona virus over lung CT images.

1.1. Dataset summary

In this paper, a general public Lung CT image dataset is acquired from Kaggle web source. This is an open source dataset download medium, in which it contains a vast set of information regarding multiple sources. From that this lung CT image dataset is acquired and it consists of more than 2000 lung CT images including 1340 Corona Virs affected images and the 660 normal images. These images are suitable for processing with machine learning concepts in fine manner without any complexities. All the images acquired from the dataset is in same structure and size, so that it is easy to process with digital image processing norms. The following figure, Fig. 2 illstrates the view of dataset images with normal and affected perceptions.

The following table, Table 1 contains a list of publicly available Corona Virus imaging datasets, the majority of that are diagnostic in nature, only with one dataset supplying differentiation labels.

1.2. Research contributions

The major contributions of this paper is summarized as follows.

(i) A novel Machine Learning approach is designed in hybrid manner with the help of two traditional powerful algorithms called Convolutional Neural Network (CNN) and AdaBoost Classification Logic. It is called as Hybrid Disease Detection Principle (HDDP).
(ii) To provide a sfficient support to medication industry to analyze the disease strcture and severity in correct manner with the help of HDDP in clear and accurate manner.

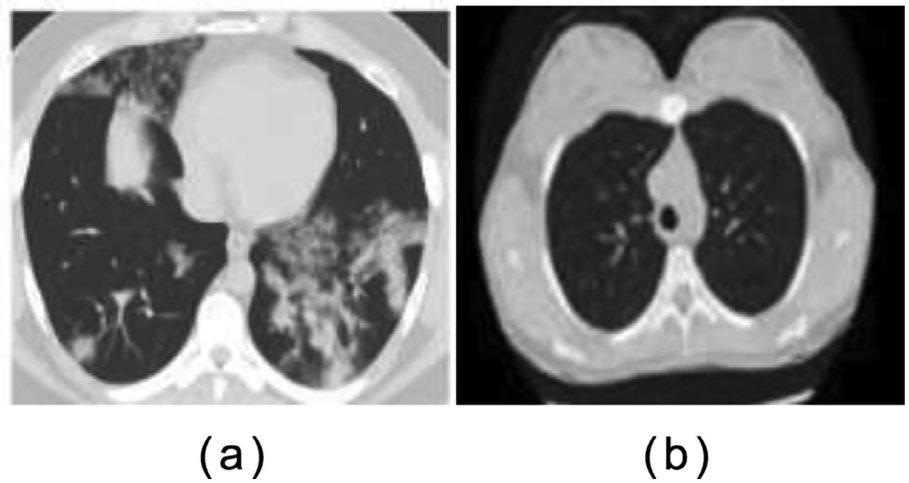

Fig. 1. Example of Covid Affected (a) and Unaffected (b) Lung CT Scan Images.

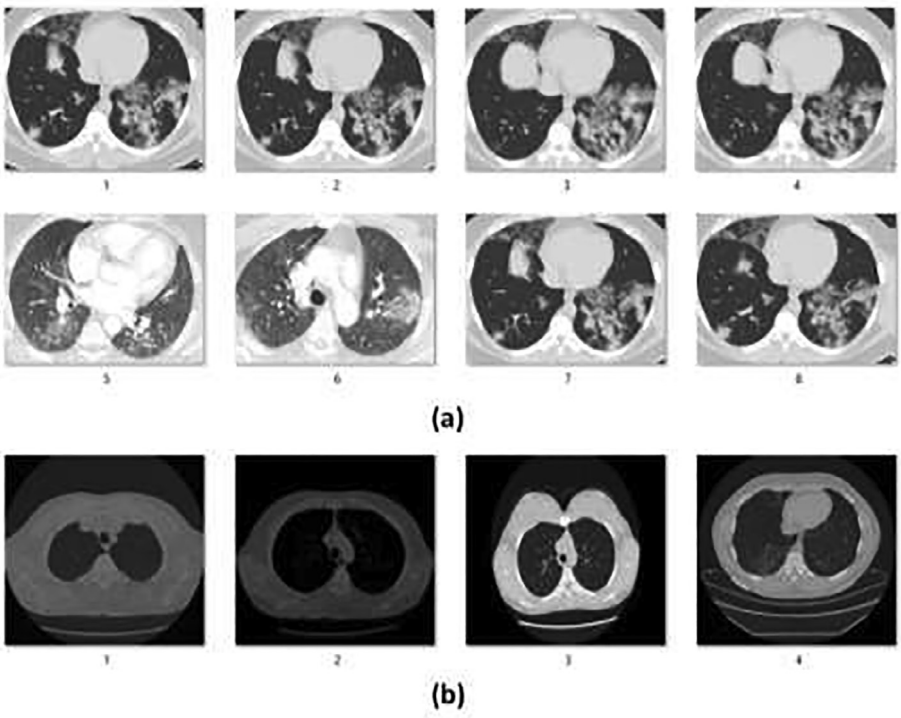

Fig. 2. Dataset Image Samples. (a) Covid Infected CT Images and (b) Normal Images.

Table 1
Publicly available Corona Virus imaging datasets.

Dataset Name	Mode	Affection/ Unaffection Ratio	Role
Corona Virus X-Ray Dataset [9]	Chest X-Ray	229/0	Assesment
Corona Virus Computer Tomography Dataset [10]	CT Images	20/0	Assesment
Corona Virus Computer Tomography Dataset [11]	CT Images	288/1000	Assesment
Corona Virus Radiographical Dataset [12]	Chest X-Ray	70/28	Assesment
Corona Virus Computer Tomography Segmentation Dataset [8]	Chest X-Ray	110/0	Segment

(iii) All the layers of the Convolutional Neural Network algorithm is considered and remove the last layer to moderate the logic of AdaBoost Classifier to improve the accuracy levels in fine manner as well as the prediction accracy is also improved based on this logical correction.
(iv) To build a robust prediction model with the consideration of both corona virus affected and unaffected scenarios based on the labels and the image acquired from the dataset gathered from the globally available public Lung CT image dataset downloaded from Kaggle.
(v) To improve the processing time by means of cross-validating the proposed HDDP model with the random dataset CT images and the resulting accuracy is verified in clear manner.

The rest of this paper describe regarding Related Study over section 2, further section of Section 3 illustrates the proposed system methodologies in detail with proper algorithm flow and the Section 4 illustrates the Result and Discussion portion of the paper and the final section, Section 5 illustrates the concept of Conclusion and Future Scope of the proposed paper. These all will be explained in detail over the further section summaries.

2. Related study

Hong et al., [13] 2020, proposed a paper related to identify the patients with Covid negative results with respect to the analysis of Lung CT images and the Reverse-Transcription Polymerase-Chain-Reaction. In this paper [13], the authors illustrated such as the goal of this study was to determine the utility of computed tomography in the assessment of corona virus disease, particularly in patients who initially tested negative for Reverse-Transcription Polymerase-Chain-Reaction. Between 19th January 2020 and 20th February 2020, individuals with corona virus were included. Within three days, all patients received chest CT and swab Reverse-Transcription Polymerase-Chain-Reaction assays. Patients were separated into two groups based on their first RTPCR findings: Covid-negative (7-patients) and Covid-Positive (fourteen patients). Both groups' imaging findings were documented and compared and 21 individuals with symptoms were assessed (9 Male Patients and 12 Female Patients within the age between 26 and 90 years). In our investigation [13], the majority of Corona Virus lesions were found in several lobes of around 67% and dual lungs of around 72%. Furthermore, 33 percent of patients showed additional lesions in the vicinity of the conduction of this study network. Among the additional lung CT findings were oxygen needs of around 57%, vasculature expansion of around 67% and pericardial effusion of around 19%. In comparison to the category with successful treatment of RTPCR outcomes, the grouping with pessimistic initial RTPCR findings had a lower prevalence of lung contraction on CT (p lesser than 0.05). A less bronchial contraction detected on lung CT, the increasing the chances of initial RTPCR findings being negative. Lung CT is critical for patients diagnosed with clinical suspicion of illness, particularly anyone with negative first RTPCR readings.

Gozes et al., [14] 2020, proposed a paper related to an explosive growth cycle of artificial intelligence based Covid-19 disease identification using Deep Learning principles based on Lung CT image analysis. In this paper [14], the authors illustrated such as: Construct an automated lung CT image processing tools based on artificial intelligence for the recognition, characterization and surveillance of Corona virus; illustrate that these systems can distinguish corona virus infected patients from non-infected persons. Numerous worldwide datasets were added, including those from Covid disease infected areas in China. A method is offered [14], in which it combines strong 2-d and 3-d deep learning techniques with clinical understanding by changing and extending existing AI models. A repeated prospective trials are conducted to test the system's efficacy in detecting probable Corona Virus thoracic lung CT characteristics and the disease progression in each person over the period using a three – dimensional review and the respective Covid assessment. The research evaluates 157 patients from the country of China and USA). Corona virus affected vs unaffected cases per lung CT investigations had an accuracy of 95 percent on databases of Chinese sovereignty and Covid affected patients. For Corona virus patient time report, the process variable offers measurement methods of minor opacities and visualization of bigger opacities in the form of a slice based map or a three – dimensional display. The proposed [14] Corona score quantifies illness changes over time and this initial investigation, which is already being replicated to a broader population, shows that induce significant Intelligence over image processing techniques may obtain significant performance in identifying Corona virus and estimating as well as quantifying illness severity.

Tang et al., [15] 2020, proposed a paper related to the corona virus illness intensity evaluation in 2019 behavior relates data obtained through lung CT images. In this paper [15], the authors illustrated such as Lung CT image is a well acknowledged as a critical tool for determining the severity of corona virus infection and a s the percentage of Covid patients grows, human intensity evaluation is now a time-consuming task that may result in treatment delays. Automatic severity evaluation of corona virus using lung CT scans and exploration of frequency and intensity aspects from the generated evaluation framework utilizing machine learning. Lung CT images of 176 individuals [15] with confirmed corona virus infection are utilized to determine 63 statistical characteristics, including the infection density of the entire lung and indeed the percentage of field transparency regions. On the basis of statistical characteristics, a Random-Forest classifier is constructed to determine the severity. The Random Forest model calculates the impact of each measurable model trained on its link to the frequency of corona virus. The Random Forest model performs well in 3-fold classification model, with a true positive rate of 93.3%, a true negative rate of 74.5%, an accuracy of 87.5% and an area under the receiver operating characteristic of 91%. The resulting significance of predicted values indicates that the quantity and percentage of affected regions are strongly correlated with the severity of Covid disease and that the statistical characteristics estimated from the chest cavity are more associated with the severity evaluation than those calculated from the left lung. Systematic severity classification of Corona Virus infection is possible using the Random Forest based approach and the outcome is encouraging. Numerous quantitative indicators were identified that may be indicative of the frequency of corona virus. Moreover researchers are proposing various protocols in the field of healthcare[16–21] and vehicle communication[22–28] to protect the information exchanged among various devices to devices. Some researchers are providing various techniques for image privacy[29–33] and IoT based application[34–38].

2.1. Methodologies

In this paper, a new hybrid algorithm is designed with respect to the identification of Covid virus using Lung CT images. The traditional classification based machine learning principles called Convolutional Neural Network and the AdaBoost Classification algorithms are integrated together to form a new algorithm called Hybrid Disease Detection Principle (HDDP). This proposed approach of HDDP provides an efficient prediction model to identify the Covid diseases in terms of accuracy enhancements and time considerations. The most common Kaggle based Lung CT image dataset is acquired to process the proposed approach, in which it contains a set of affected and non-affected images in nature to build a robust model. The last layer of the Convolutional Neural Network is traced and removed by using the dropout function as well as replace the last layer by means of AdaBoost Classifier by using the fitting logic. Once the last layer is fitted with the AdaBoost classifier the prediction accuracy is improved and the classification ability of the proposed approach is enhanced, because the functionality of two algorithms are merged together to provide a proper filtration logic to attain good outcome as a result.

2.1.1. Image pre-processing

The image pre-processing logic is the most important feature of the Digital Image Processing scheme, in which it cross verify the input image and change the size as well as proportions of the respective image to proceed further. The pre-processing logic applied over the proposed approach of HDDP to resize the image into common pixel standard as 256x256. The resized image is converted into grayscale format for processing that in more accurate manner as well as the image binarization logic is purely dependent on this image pre-processing procedure. The following equation is utilized to pre-process the image with full intensity and edge oriented considerations.

$$\boldsymbol{P(i)} = \boldsymbol{Image}_{(x,y)} + \sum_{i=1}^{n} \left(\boldsymbol{X_i.S} \frac{\boldsymbol{Image(i)}}{256\boldsymbol{x}256} + \boldsymbol{Y_i} \frac{\boldsymbol{RGB}}{\boldsymbol{GS}} \right) \quad (1)$$

Where the above procedure is used to convert the image into common format to process further, in which the P(i) indicates the procedure for processing all images available into the Lung CT image dataset, S indicates the Size of the image, GS indicates the Gray Scale nature, X and Y are the image proportions.

2.1.2. Image binarization and segmentation

This particular approach is more important to process the image in fine manner, in which the process of image binarization extracts the foreground portion of the image and separates the background. So, that the foreground portion is clear enough to process further. This procedure pictorize the lng CT image in more clear manner as well as the Segmentation process allows the binarized image to extract further. The extracted portion is replicated to the next process and the foreground portion is filtered from the background by using this segmentation process respectively. This binarization process identifies the background and foreground portion of the input image, in which the segmentation process extracts the foreground separately from the image. This is achieved by using the following equation.

$$\int_{i=1}^{n} \boldsymbol{Image(i)}\{\mathrm{Bx,y} - \mathrm{Fx,y}\} \quad (2)$$

Where $\boldsymbol{i_S^B}$ indicates the image binarization and segmentation function, i is an integer variable for lopping the dataset images from 1 to n, $\boldsymbol{B^{x,y}}$ indicates the background portion of the image and the $\boldsymbol{F^{x,y}}$ indicates the foreground portion of the image.

2.1.3. Image convolution and filtration

The image convolution function is utilized in this approach to optimize the processed image in fine manner for further processing. The filtration logic is used to filter the noise oriented things presented into the image. In this approach, two different categories of filtrations are utilized such as edge based filtration and region based filtration. In edge based filtering procedure, the system considers the input image boundaries and the region based filtering procedure considers the image inner region to filter for noises presented into it and if the related noises are present into the image that will be removed by using this filtration logics. The image noises are the major cause to raise the prediction failures and based on such problem the prediction accuracy drops out. The following equations are helpful to identify the noise levels over the images and remove that in intense manner by means of identifying the weight factors associated with the respective images.

$$\text{EFilter} \leftarrow \sum \text{E(x, y)}((\boldsymbol{I}(\boldsymbol{i})+1)^{1-\boldsymbol{n}}.\frac{\boldsymbol{P}(\boldsymbol{x},\boldsymbol{y})}{\boldsymbol{I}(\boldsymbol{i})}+\frac{\boldsymbol{P}(\boldsymbol{x},\boldsymbol{y})}{\boldsymbol{I}(\boldsymbol{i}+1)}+\cdots \tag{3}$$

$$\text{RFilter} \leftarrow (\boldsymbol{R}(\boldsymbol{i}))^{\boldsymbol{x}\boldsymbol{y}}.\frac{1}{\boldsymbol{Pix}(\boldsymbol{i})}+\frac{2}{\boldsymbol{Pix}(\boldsymbol{i}+1)}+\cdots \tag{4}$$

Where E_{Filter} and R_{Filter} indicate the respective edge and region filter function variables, I indicate the respective image; E indicates Edge and R indicates the Region portions respectively.

2.1.4. Disease classification

The proposed approach of HDDP utilizes the classical Convolutional Neural Network procedures to classify the Covid lung CT images as well as in addition with that the AdaBoost classification logic is included over the approach to process the prediction analysis in fine manner. The classification principle is used to extract the content of the filtered region and process that accordingly based on the weight factors of the affected region in the CT image. The affected portions are identified and cross-validated with the existing trained mode created on dataset training phase and report the classified outcome with proper accuracy estimations. The acquired outcome from this classification phase is the final result and the prediction accuracy is estimated based on the score matching function, in which it identify the resulting accuracy in fine manner with proper proportions. The following equation is utilized to classify the images in fine manner.

$$\text{C} \leftarrow \sum_{\boldsymbol{i}=1}^{\boldsymbol{n}} .\boldsymbol{I}(\boldsymbol{i})\frac{\boldsymbol{x}}{\boldsymbol{y}}(\boldsymbol{\alpha}\pm\boldsymbol{\beta}).\boldsymbol{W}(\boldsymbol{x},\boldsymbol{y}) \tag{5}$$

Where C indicates the classification variable, I indicate the respective image, $\boldsymbol{\alpha}$indicate the image region and $\boldsymbol{\beta}$indicate the boundary of the image. Based on the weight factor W the processing accuracy is attained.

3. Results and discussions

The proposed approach called Hybrid Disease Detection Principle is practically proven by using this following resulting summary, in which the approach is purely following the machine learning principles with respect to training and testing laws. The dataset acquired from the Kaggle is extracted fully and the images are processed based on the methodologies described over the previous section, Section-III. The resulting processes are experimentally developed by using the powerful Digital Image Processing code development tool called MATLAB and the resulting performance is far better. The accuracy over predictions and the processing nature is fine as well as the following illustrations will prove that in practical manner. The following figure, Fig. 3 illustrates the perception of input lung CT image in clear manner.

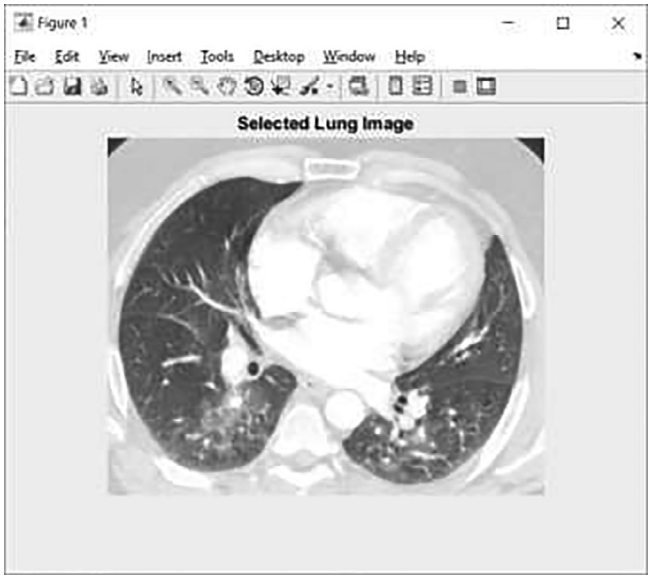

Fig. 3. Input Lung CT Image.

The following figure, Fig. 4(a) illustrates the RGB color extraction process of the image acquired for testing and the figure, Fig. 4(b) illustrates the redefined image perception of the input, in which it is redefined by the size of 256×256.

The following figure, Fig. 5 illustrates the image binarization perception of the proposed approach called Hybrid Disease Detection Principle, in which it extracts the foreground portion of the lung CT image from the actual background. This process assists to attain more accuracy as well as the prediction improvements.

The following figure, Fig. 6 illustrates the classification principle of the image, in which it classifies the affected portion in clear manner. So, that the predictions can be easily made and the resulting factors produced around 97% accuracy ratio as an outcome.

4. Conclusion and future scope

In this paper, a novel Corona Virus detection principle is designed based on the lung CT images, in which it utilizes the classical machine learning based image classification principles called CNN and AdaBoost classifier logics. Improved provisions are provided by this proposed approach to attain high prediction accuracy and classification accuracy. This proposed logic provides an efficient processing nature to filter the image in dual manner with respect to edge and region based filtrations. And the resulting accuracy levels are enhanced by means of this proposed classification logic called HDDP, in which the resulting accuracy is 97%. The resulting section shows the proper proof for classification, in which the figure, Fig. 6 illustrates that in clear manner. The resulting section figure, Figs. 4 and 5 shows the color extraction and redefinition principles as well as the binarization procedures in clear manner with practical outcome proof. For all this approach is more significant to predict the Corona Virus in fine manner with proper classification strategies.

In future, the work can further be enhanced by means of adding deep learning principles to provide more features to the proposed algorithm HDDP as well as the deep learning principles improve the time constraints and better processing ability to the approach.

Fig. 4. (a) RGB Extraction and (b) Image Redefinition.

Fig. 5. Binarization.

Fig. 6. Classification.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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