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COVID-19 detection based on deep learning and artificial bee colony

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ABSTRACT

COVID-19 has become a great challenge to the whole world, as it has infected and killed millions of people and affected the different fields of our life due to its rapid ability to spread. In this paper, the COVID-19 patient's recognition technique utilized the deep learning, and An artificial bee colony is intended to be applied. Deep learning was implemented to provides the features from X-ray images, while the artificial bee colony algorithm used to refine these features by selecting the best features. The multilayer perceptron classifier has been utilized in the classification stage. The experiments carried out on the standard dataset with/without different other daises such as MERS, SARS, and ARDS as well as COVID-19(+) referred that the proposed work provided high recognition rates with high reduction in the number of deep learning features.

Keywords: COVID-19, Deep learning, Artificial bee colony, Recognition technique, The Multilayer perceptron classifier.

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1. Introduction

The name of coronavirus is referring to CoV virions relative to the external appearance in which spike projections from the virus, the membrane gives the appears in the shape of crown or corona in Latin [1, 2]. A coronavirus is a group of extremely various single-strand with the positive-sense RNA genome [3]. The length of this virus ranges from 26 to 32 kilobases [4]. The RNA of the coronaviruses is divided into different exclusive genera, which are gamma, delta beta and alpha, in which both beta and alpha infect human beings. The COVID-19 has a contrasting coronavirus-specific nucleic acid sequence from identified coronavirus varieties. It is comparable to some of the coronaviruses recognized in bats [5]. Coronaviruses are a substantial, large circle of relatives of viruses that would lead to many ailments, beginning from bloodless as much as greater severe sicknesses of the same as an intense severe breathing syndrome-SARS-COV along with the center East breathing syndrome-MERS-COV,that reasons extreme respiration diseases. These viruses are common in diverse classes of animals, involving cattle, camels, bats, cats as well as humans. Infrequently, animal Coronavirus can pass on a disease to persons and then spread out among people [6]. Between 2002 and 2003, SARS outbroke in China, and this fact had changed when coronavirus of animal infected the human there. After a few months, It turned into a global pandemic with 8,000 cases, and the fatalities were 774. MERS-CoV was detected first at Kingdom of Saudi Arabia in 2012 and had been accountable for 858 death cases from September 2012 to November 2019. It marked the highest deaths in Saudi Arabia [7-9]. Both SARS-CoV in addition to MERS-CoV probably started in bats, and genetically multiple coronaviruses that can be related to those viruses, and they were determined in the bat's overall world [10]. Since the end of Dec 2019, there were patients who suffered from pneumonia with unknown aetiology regarded at Huanan seafood market in Wuhan town, China, and from there it was started spreading all over the world [11]. Virological screening refers that the causative agent of this pneumonia is a novel coronavirus named (COVID-19). COVID-19 stands for an acute devastating respiratory virus principally exhibiting as pneumonia [12, 13]. The apparent symptoms of COVID-19 are dry cough, fever, develop difficulty of breathing and tiredness. Several cases may have pains and aches, diarrhea and sore throat [14-17]. In general, these symptoms start mild at the beginning, and the impact of the disease

increases gradually. The people who suffer from chronic such as blood pressure, diabetes, heart and lung problems, and cancer are at advanced hazard of developing a severe disease [18]. Evaluating the clinical symptoms and Comprehensive laboratory examinations should be demanded to confirm the diagnosis of COVID-19 [19]. The standard diagnostic procedure is to employ RT-PCR (real-time polymerase chain reaction) to isolate and reveal the samples of viral nucleotides from gotten specimens by bronchoalveolar lavage, nasopharyngeal swab, oropharyngeal swab, or tracheal aspirate [20]. Current diagnostic approaches to identifying the COVID19 virus have limitations. In the early time of illness, the RT-PCR examination is holding a low sensitivity. Computed Tomography (CT) of the chest suggests low specificity and high sensitivity [21, 22]. This low specificity may additionally come out from the factor that it is considerably hard to identify the traces of COVID-19 from any other sickness on chest CT. [23, 24]. Fei et al. have developed an automatic segmentation system of each lung and infection positions by means of chest CT based on deep learning techniques [25]. CT scan of the chest is one of the essential techniques, and it has been utilized to diagnose pneumonia. Artificial Intelligence (AI) based automated CT image analysis tools have been developed to detect, quantify, and monitoring of COVID-19 to distinguish the cases with viruses from those who are disease-free [26]. An automatic framework has been advanced for detecting COVID-19 using chest CT [27]. Based on the deep learning pattern, the COVID-19 detection neural network (COVNet) has been developed for extracting the observed features from chest CT examinations to detect COVID-19. The deep-learning has feasibility for detecting and recognize the COVID-19 from community-acquired pneumonia and other non-pneumonic lung sicknesses via the chest CT. They identify both COVID-19 and community-acquired pneumonia on chest CT. To increase the accuracy and the speed of diagnosing the virus, there is a need to develop the new COVID-19 test kits. Consequently, it is important to perform an automatic detection system as a diagnosis COVID-19. In the study by Ali Narin et al., they have purposed three various techniques to detect the patient who is infected with COVID-19 pneumonia using chest X-ray radiographs, based on convolutional neural network-based patterns, which are ResNet50, InceptionV3 and InceptionResNetV2. From the results of their study, it shows that the highest classification performance of the pre-trained is ResNet50 pattern, which gives 98% of accuracy among the other suggested techniques (97% accuracy for InceptionV3 while the Inception-ResNetV2 afford only 87% accuracy) [28]. In order to select the most acceptable classification model, a performance investigation has been done. Experimental findings have shown that, in conjunction with the SVM classifier, the concatenated deep function-based CNN models show better performance with an accuracy of 98.3% for discriminating COVID-19 testers when compared to the other approaches [29]. Prabira Kumar Sethy and Santi Kumari Behera have projected the X-ray images based on deep features and SVM for the detection of coronavirus. For this, nine pre-trained CNN model has been extracted and passed to SVM classifier independently. For determining the finest classification pattern, statistical study is carried out. The classification pattern, i.e., ResNet50 plus SVM statistically provides better results when compared to the other eight models [30], by means of automatic machine learning approach for composition investigation of Chest CT scans for doubted COVID-19 cases to complement in effect test RT-PCR lab. It could offer a dependable system regarding the analysis and diagnosis in critical cases where the PCR test is not conclusive enough particularly in pre-symptomatic patients [31].
In this article we have projected an effective COVID-19 detection technique using deep learning and artificial Bee Colony (ABC) algorithm. The novelty of the proposed technique is utilizing the ABC algorithm to select distinct features that leads to increase the detection accuracy as well as it leads to minimize the complexity of the classification stage by reducing the large number of the features provided by deep learning.

2. Feature extraction using deep learning

The deep learning model which utilized in this work is VGG-16. The VGG-16 consist of different layers, namely: fully connected layers, activation layers, max pooling layers, and convolutional layers. The VGG-16 contains 21 layers but only 16 weight layers. These layers are 5 Max Pooling layers, 3 dense layers, and 13 convolutional layers. In the proposed technique, the feature maps provided by last convolutional layer have been adopted. These features are fed into the next stage feature selection using ABC.

3. Artificial bee colony (ABC)

The ABC is a feature selection algorithm which motivated by the intelligent trait of the honey bee's behavior through its searching about the food. Using the ABC algorithm leads to select distinct features as well as it leads

to reduce the complexity therefore the ABC utilized in numerous image processing application such as disease diagnosis [32], pattern classification [33], clustering [34], symbolic regression [35], biometric [36], iris segmentation [37] etic. The mechanism of the ABC algorithm works based on considering the source of food as a solution in the solution domain as well as the fitness represented by the amount of the collected nectar. The bees in ABC algorithm can be divided into 3 categories, specifically active bees, onlookers bees, and the scouts bees. The role of employed bees is collecting the nectar. While the onlookers bee's role is waiting the employed bees to return. The role of scouts bees is searching for sources of the food randomly. the ABC algorithm can be explained as follows [38]:

1) initiate ABC algorithm by randomly selecting of population size, solutions, limit, and maximum cycle number.
2) Initialize the FSM by assigning the information for each food source.
3) repeat
   A. forward the bees which responsible of collecting nectar (employed bees) to food source.
   B. dependent on the knowledge of employed bees forward the bees which responsible of waiting the employed bees to return (onlookers bee's) to best food.
   C. search new food's source by the bees which responsible of searching for sources of the food randomly (the scout bees to).
   D. save the track of the better source of food until (maximum number of the cycles).

The steps of a, b, and c are repeated many times up to the maximum number of the cycles.

4. Multilayer perceptron classifier (MLP) classifier

The MLP classifier has distinct characteristics such as the suitability training for small-scale problems, suitability for online implementation, and simplicity. The ability of MLP of supervised training leads to successfully utilizes it in different applications for classification with any degree of accuracy and nonlinear function approximation. The 1-of-C coding can be used for construing MLP classifier for a C - class problem [39]. In this case the MLP classifier produce C outputs in which every output belongs to one class. The *cth* output yc, of MLP classifier with one hidden layer presented as [40]:

$$y_c = f_o(\sum_{j=0}^{M_H} w_{cj} f_h(\sum_{i=0}^{M_I} w_{ji} x_i)) \qquad (1)$$

The logistic function (*fo*) can be represented as follows:[40]

$$f_o(\emptyset) = \frac{1}{1 + e^{-K\emptyset}} \qquad (2)$$

5. The proposed method

The proposed technique exploits the distinct traits of deep learning to provide attractive features about the X-ray images as well as it utilizes the intelligent behavior of bees in order to select the effect features and reduce the number of the features that fed to classification stage. In the classification stage the MPL has been employed to distinguish the COVID-19 X-ray images. The following steps summarizing the proposed technique:
1) Resize the chest X-ray images into 224 X 224 pixels.
2) Extract the features from chest X-ray images by means of deep learning. For this reason, we have used CNN -VGG 16 model Which means providing N-4096 features where N refer to the number of the total chest X-ray images.
3) Select better features: for this purpose, ABC has been used to discard the or feature this means that the best features only used in the next stage, furthermore, decreasing the number of the features leads to reduce the

complexity of the classification stage. Figure 1 illustrates the feature extraction and selection in the proposed technique.

4) perform the classification process and make the final discoing. In this stage the MPL utilized

Figure 2 demonstrate the presented method's block diagram. The training chest X-ray images are undergoing the same steps that carried out on the test chest X-ray images.

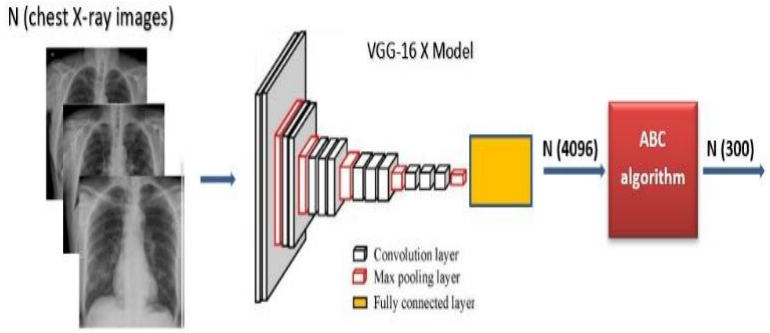

Figure 1. The features extraction and selection of the proposed technique.

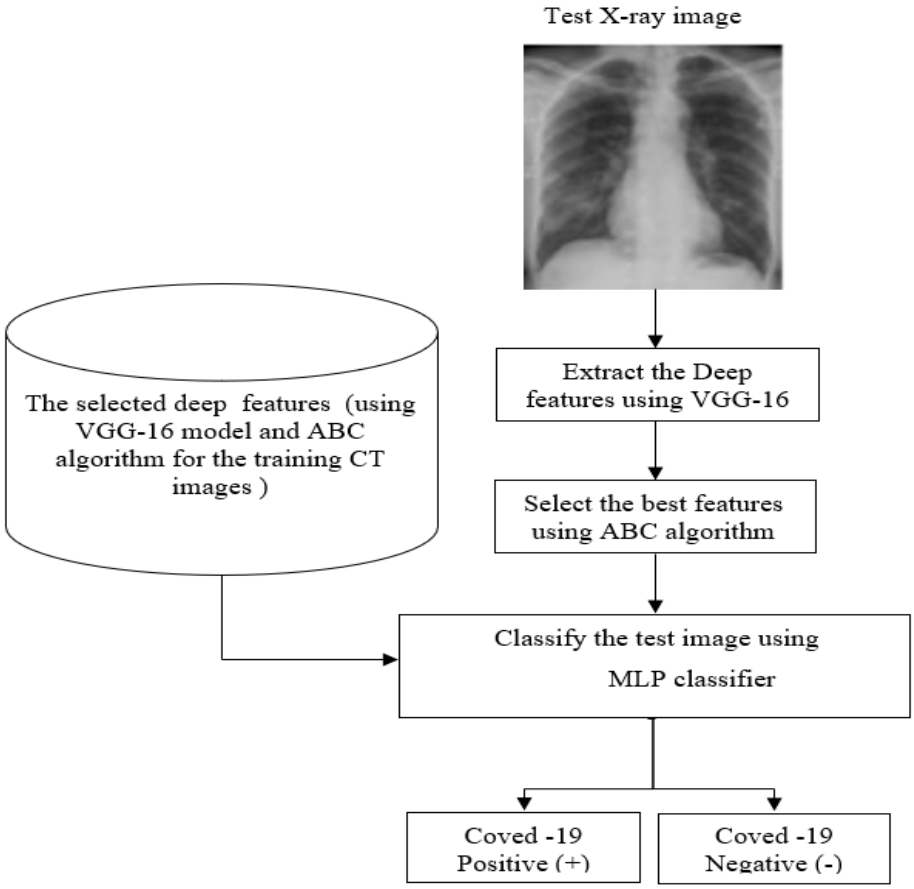

Figure 2. Proposed method's block diagram

6. The used database

In this work, two datasets have been utilized. The first dataset has 200 COVID-19(+) chest X-ray images and 200 COVID-19(-) chest X-ray images. The COVID-19(+) chest X-ray images are provided in GitHub repository shared by the postdoctoral fellow at University of Montreal, Dr. J. Cohen [29]. The COVID-19(-) are the chest X-ray images of pneumonia provided by Kaggle repository [30]. The COVID-19(+) preclude ARDS, SARS, and MERS. The second dataset has 200 X-ray images of COVID-19(+), including ARDS, SARS, and MERS. In addition, 200 COVID-19(-) chest X-ray images provided by Open-i repository [31].

7. Experimental analysis

The presented work has been assessed and demonstrated. Two grows of experiments carried out on the above-mentioned dataset using different CNN models which such as VGG-16, VGG-19, and AlexNet. For this purpose, 3 experiments have carried out, in these experiments we have taken five different numbers of the selected features using ABC algorithm, namely 100 200 300 400 500. In these experiments we have divided the utilized dataset into test and training with ratio 25:75. The Tables 1, 2, and 3 reported the results of the implementation of the proposed method based on VGG-16, VGG-19, and AlexNet respectively.

Table 1. The accuracy of the proposed method using VGG-16 model

Number of the selected features	First dataset	Second dataset
100	95.7	93
200	97	95.2
300	98.1	97.5
400	96.5	92.9
500	96.3	91.5

Table 2. The accuracy of the proposed method using VGG-19 model

Number of the selected features	Accuracy on first dataset %	Accuracy on Second dataset %
100	95.6	94.3
200	97	95.9
300	97	96.2
400	95	94
500	93.8	94

Table 3. The accuracy of the proposed method using AlexNet model

Number of the selected features	Accuracy on first dataset %	Accuracy on Second dataset %
100	91.6	91.1
200	94.3	94
300	95.5	95.0
400	93.2	92.7
500	93.0	92

The maximum recognition rates are 98.1, 97, and 95.5 % achieved by the proposed method under using the deep learning models GVV-16, GVV-19, and AlexNet respectively on the first dataset. While the maximum recognition rates achieved on second dataset using the above mention deep learning models are %97.5, %96.2, and %95.0 respectively. The analysis these results refers that the maximum recognition rates achieved using 300 features selected by ABC algorithm from 4096 features provided by deep learning models. Also, the performance of GVV-16 model is slightly better than the performance of GVV-19 model, while their performance outperforms the performance of AlexNet model. Furthermore, the accuracy on first dataset is slightly better than the accuracy on second dataset because that the second dataset contains ARDS, SARS, and MERS as well as the COVID-19(+). Figure 3 illustrate the recognition rate of the presented work on the two used datasets.

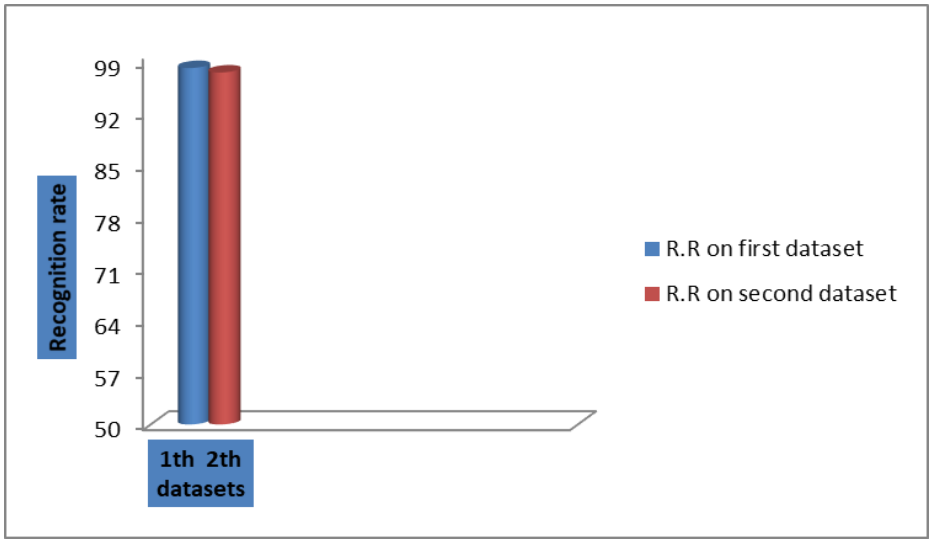

Figure. 3 The recognition rate of the presented work under the utilized datasets

8. Conclusion

The proposed work presented COVID-19 recognition technique based on ABC procedure and deep learning. The role of ABC algorithm is to select distinct features which extracted the deep learning used to provide the features, while the ABC algorithm used to select distinct features which leads to minimize the complexity of the classification stage. The experimental analysis reported the following conclusions:

1. Using the ABC algorithm leads to select attractive features and discarding the passive features which have negative impact on the accuracy of the recognition process. The particle experiments prove that the best number of the selected features provided by ABC algorithm is 300 out of 4096 features extracted by deep learning model.
2. The performance of GVV-16 model is slightly better than the performance of GVV-19 model, while their performance outperforms the performance of Alex Net model.
3. The recognition accuracy under first dataset is somewhat superior to the recognition accuracy under the second dataset because that the second dataset contains ARDS, SARS, and MERS as well as the COVID-19(+).

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