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Deep CNN-WCA and FLICM image segmentation for automatic detection and classification of COVID-19 Diseases

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ABSTRACT

COVID-19 is the leading cause for unknown deaths in men in age 60 to 90 and also women in same age group. Now a days the all age groups are also affected by COVID-19 diseases. Diagnosis of COVID-19 diseases is a very important part in its treatment. A prime reason behind an increase in the number of cancer patients worldwide is the ignorance of people towards treatment in its early stages. This research work proposes a novel Fuzzy Local Information C Means (FLICM) segmentation technique for detection of tissues from COVID-19 image that can inform the radiologist and doctor about the details of diseased tissues. This segmentation technique include noise removal and sharpening of the image along with basic morphological functions, erosion and dilation, to obtain the background. The segmented images are applied to the proposed Deep CNN-WCA (Convolutional neural network with water cycle algorithm) classification of the type of diseased tissues for visual localization. Further the

classification results will be compared with the existing conventional CNN with back propagation model.

1. Introduction

Coronaviruses are a huge family of viruses which causes illness related to common cold to more severe diseases such as “Middle East Respiratory Syndrome (MERS)” and “Severe Acute Respiratory Syndrome (SARS)”. According to the research “SARS-CoV and MERS-CoV” originated in bats, and it is named as SARS-CoV-2(COVID 19). “SARS-CoV” then spread from infected civets to people, while” MERS-CoV” spreads from infected dromedary camels to people. According to the report of WHO[1], the COVID-19 affects drastically in the countries such as Italy, Spain and Iran, US, Germany [2-5] directly. Ethiopia also affected by CORONA-19, but the cases registered as per the source is much less as compared to other country cases. The patients are admitted to hospitals has to go through the process of X-Ray of chest and lungs to identify about the virus, but it is difficult for the doctors to get information from the images of chest and lungs.
Cai et al. [6] proposed the fast “generalized FCM algorithm (FGFCM)” with a local similarity measure new for both noise reduction and “detail-preservation” for image segmentation. The “noise detection (NDFCM)”[8], proposed for segmentation in which the trade-off parameter is tuned by measuring local variance of grey levels. Motivated by this, in this research work, we improve the FCM algorithm, and propose a significantly fast and robust algorithm for image segmentation. The proposed algorithm can achieve good segmentation results for a variety of images with a low computational cost, yet achieve a high segmentation precision. CNN (Convolutional neural network)[9] for classification of the breast densities by utilizing the Breast . Recently Asmaa Abbas et al.(2020)[10] proposed a deep CNN, called “Decompose, Transfer, and Compose (DeTraC)”, for the classification of COVID-19 chest X-ray images. And obtained an accuracy of 95.12% .Dilbag Singh et al(2020)[11] proposed “multi-objective differential evolution–based convolutional neural networks” for classification. Tulin Ozturk et al.,(2020)[12] proposed a new model for automatic COVID-19 detection using raw chest X-ray images and to provide accurate diagnostics for binary classification “(COVID vs. No-Findings)” and multi-class classification “(COVID vs. No-Findings vs. Pneumonia)” and obtained classification accuracy of 98.08% for binary classes and 87.02% for multi-class cases. The recent mention papers were not proposed any segmentation technique, motivated by this, we are proposing a novel FLICM segmentation and Deep CNN-WCA model for classification of COVID 19 diseases.
The rest of the paper divided as follows : Section -2 presents the FLICM segmentation, research implementation diagram, proposed Deep CNN +WCA hybrid model for classification, section-3 presents the results of segmentation and classification, section-4 presents the related discussions to the results and at last the section -5 presents the conclusion and references.

2. Materials and methods

A. Methodology

The research work follows the following steps: (i) The COVID-19 X-Ray images collected and segmented by the novel FLICM algorithm, Further (ii) the segmented images are fed as input to the proposed Deep CNN-WCA for the classification of the diseases. In the third stage (iii) the weights of the fully connected layers to be updated utilizing WCA algorithm. In the fourth stage (iv) The results of the classification comparison the models are presented. The research flow diagram indicates the step by step accomplishment of the research work. Further the block diagram shows the flow of algorithm application for detection and classification of COVID-19 mentioned in Fig.1.

B. FLICM Segmentation

The FLICM segmentation plays a vital role in segmentation.it removes rician noise from the images and smoothen the images. Let the N sample data given by $X = \{x_1, x_2, x_3 ......x_N\}$. "Fuzzy C Means"[18] algorithm the cost function minimized as :

$$J_m = \sum_{k=1}^{N} \sum_{i=1}^{c} u_{ik}^m \|x_k - v_i\|^2 \tag{1}$$

Where "v_i is the cluster center, m is fuzziness coefficient, u_{ik} is membership matrix," x_k is the gray value of the k^{th} pixel.

According to the "FLICM [8], the fuzzy facto" is given by

$$G_{kv} = \sum_{\substack{r \in N_v \\ v \neq r}} \frac{1}{d_{vr} + 1} (1 - u_{kr})^m \|x_r - v_k\|^2 \tag{2}$$

Now the "new cost function" is given by

$$J_s = \sum_{t=1}^{c} \sum_{l=1}^{q} \gamma_l u_{il}^m (\xi_l - v_t)^2 + \exp(G_{kv}) \tag{3}$$

C. Proposed Deep CNN-WCA Model

The deep CNN-WCA is proposed to reduce the computational time of conventional CNN. We are proposing the WCA(Water cycle algorithm) to optimize the weights of CNN due to the robustness of the optimization capability as compared to accelerated particle swarm optimization, genetic algorithm etc. The water cycle algorithm is a complex mathematical calculation free algorithm based on the process of water cycle in rivers and streams flow in the ocean which permits a search agent to be transposed around the desired solution. Understanding the metaheuristic nature of the algorithms, we are motivated to hybrid the WCA algorithm with CNN to improve the performance of CNN and considered to apply for COVID-19 images for classification. Basically the Deep CNN is modelled with back propagation algorithm for weight optimization. Due to complex mathematical calculation and backward propagation from last layer to first layer during weight optimization consume

larger time for classification. To avoid such situation, we are motivated to hybrid WCA with CNN model for weight optimization.
The Fig.2 below shown is the part of the proposed AI based CNN-SCA model. In this model the weights of the fully connected layer is optimized with a novel water cycle algorithm (WCA) model to improve the performance of Deep CNN.

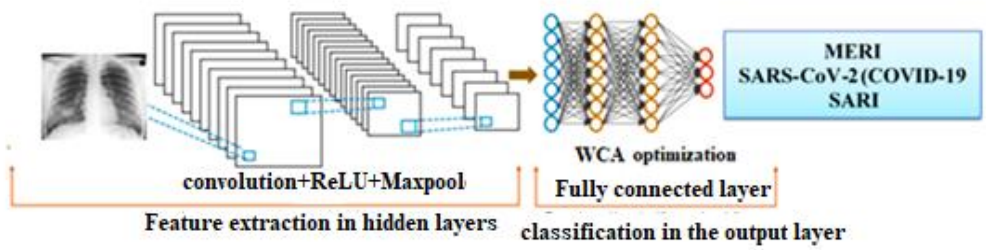

Fig.2 Deep CNN-WCA model for COVID-19 Classification

The classification model will classify the different categories of diseases such as pneumonia (SARS-CoV-2), severe acute respiratory infection (SARI), MERI (Middle East respiratory Infection) etc.

D. Water Cycle Algorithm (WCA) Optimization
WCA is a population based stochastic optimization technique inspired by river, sea and stream flow. WCA [13]uses a to search feasible region of the function space. The "water cycle algorithm (WCA)" clones the flow of streams and rivers in the direction of the sea and imitative by the view of process of water cycle. The WCA has not been used previously by the researchers for COVID-19 images. In this research work, we are proposing to apply the WCA in the fully connected layer to update the weights for improvement of the performance of conventional CNN model.
The updated positions for "streams" and "rivers" have been evaluated as follows.

$$Y_{Stream(i,j)}(L+1) = \xi\vec{X}_{Stream(i,j)}(L) + rand\left(Y_{Sea(i,j)}(L) - Y_{Stream(i,j)}(L)\right)$$
$$Y_{Stream(i,j)}(L+1) = \xi\vec{X}_{Stream(i,j)}(n) + rand\left(Y_{River(i,j)}(L) - Y_{Stream(i,j)}(L)\right)$$
$$Y_{River(i,j)}(L+1) = \xi\vec{X}_{River(i,j)}(n) + rand\left(Y_{Sea(i,j)}(L) - Y_{River(i,j)}(L)\right) \quad (4)$$

Where $\psi = \left(1 - \frac{j}{L}\right)$ is the controlling parameter

Pseudo code: WCA-Deep CCN Algorithm implementation

1. Initializing random position and velocity vectors.
2. Initialize the WCA parameters $\lambda,\psi_{sr},\psi_{pop}$
3. fitness function evaluation based on y_{ij}
4.%optimization loop
5.for i=1:L
6. for j=1:M
8. update WCA parameter
9. update $Y_{Sea(i,j)}$ and $Y_{Stream(i,j)}$ and $Y_{River(i,j)}$ to obtain fitness
10. update eqn (4)
11. end for the loop i
12. end for the loop j
13.Continue until convergence

E. Covid-19 dataset details

As per the National Institute for Allergy and Infectious (NIAID) "[https:// www. niaid. nih. gov/ diseases-conditions/covid-19]" a novel coronavirus, "SARS-CoV-2, was recognised as the cause of an outbreak" of viral pneumonia in "Wuhan, China". As per the Coronavirus Notification note on COVID-19 Situational Update till 2020 December , there are nearly ten million confirmed cases. We will collect nearly 2,200 images of X-Ray image data for chest and lungs for our research. Further, from Kaggle dataset[19], 5000 images are collected for the testing and training. A total of 5000 X-Ray Images will be given as input to the Deep CNN- WCA model for classification.

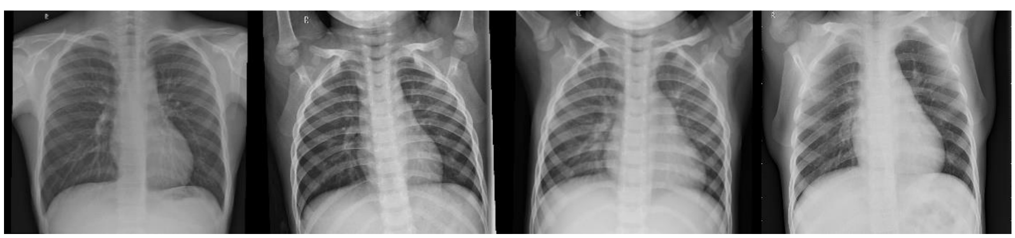

Fig.3 Normal covid-19 Chest images of four cases (Patients)

Fig.4 Pneumonia COVID-19 chest images of four cases (Patients)

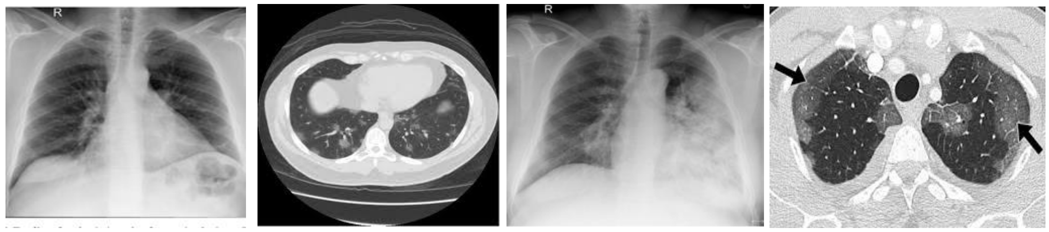

Fig.5 MERIS images of chest and lungs

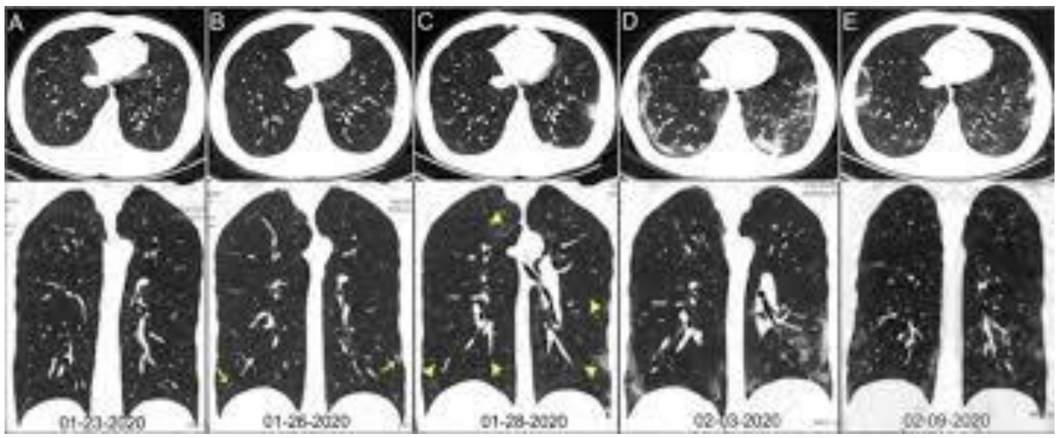

Fig.6 SARIS Images of chest and lungs

We emphasized the statistical significance of these measures for the purpose of detection and classification of COVID-19 diseases also. The Fig.6 data has been collected from public hospitals of São Paulo – Brazil from March 15 to April 15, 2020. Fig.3 to Fig.5 has been collected from the Kaggle dataset [19] Results

F. Segmented Results

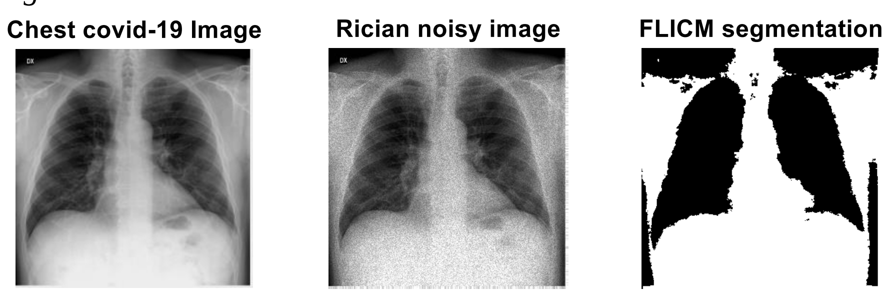

Fig.7 Segmented results for Pneumonia COVID-19

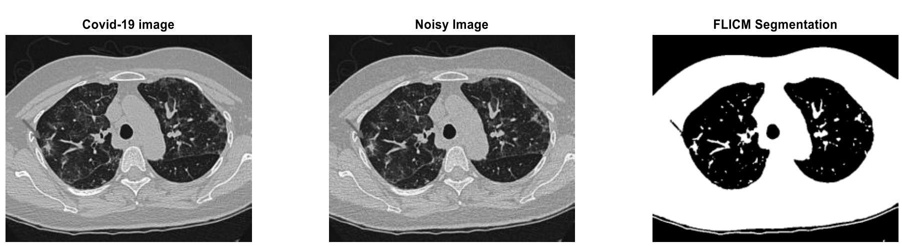

Fig.8 Segmented results for MERIS images COVID-19

G. Classification results

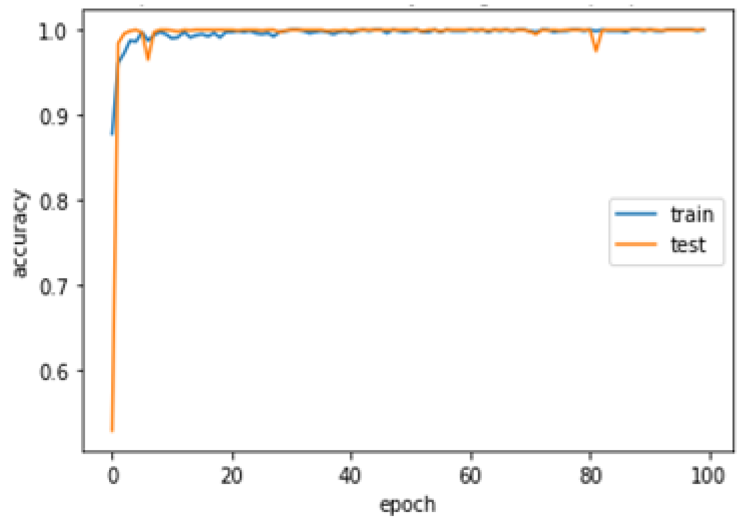

Fig.9 Classification results for images COVID-19 by using WCA+DCCN

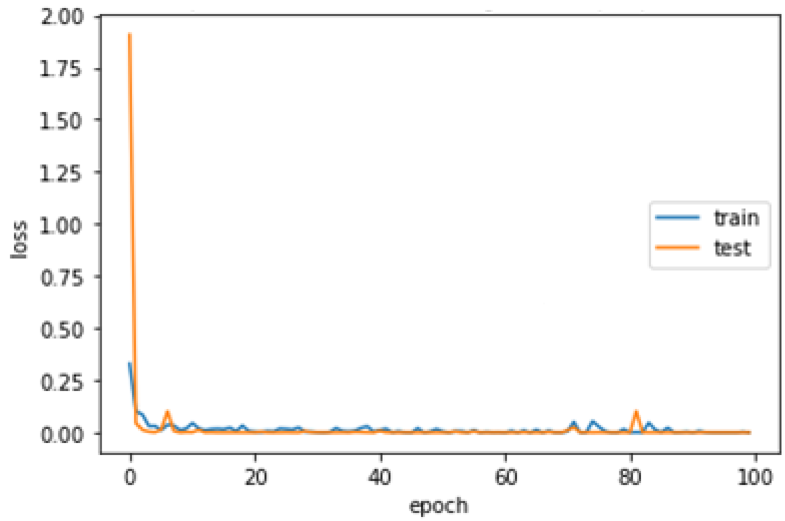

Fig.10 Loss results for images COVID-19 using WCA+DCCN

H. Performance evaluation

	No.of Images	**Elapsed time (seconds)**		**Accuracy in %**	
Models		**Training**	**Test**	**Training**	**Test**
Deep CNN +WCA	5000	19.8947	16.2145	98.71	98.11
Deep CNN+ Back propagation	5000	27.3926	25.2983	98.21	96.92

3. Discussion

Fig.7 and Fig.8 shows the segmentation results for the chest images having Pneumonia and MERIS. It is observed that the infected areas are detected from the images prominently, but still there is some haziness of the images are available due to the X-ray images. Fig.9 shows the training and testing of the results. There are a total of 5000 images are considered for training and testing. The model DCCN is optimized with WCA algorithm. Out of which 80% of the images are considered for the training and 20% of the images are considered for testing. It is observed that the training accuracy is 98.71 % and testing accuracy is 98.11%. A total of 100 epochs are considered with a GPU system with 6GB.Fig.10 shows the loss incurred during training and testing. It is observed that the loss in testing is less which is shown at 80th epoch. The proposed model out performs in comparision to Deep CNN with back propagation optimization. The training and testing accuracies are presented in Table-1.

4. Conclusion

This paper shows an automatic detection by utilizing the FLICM segmentation techniques for covid-19 images. The detection of infected regions are shown in the segmentation results. the segmentation accuracy is observed as 97.12%. The classification has been done by the proposed Deep CNN model with WCA training. The WCA algorithm has been applied in the on fully connected layer for optimization of weights. The proposed DCNN+WCA model has obtained an accuracy of 98.71 % which is larger than the conventional DCCN with back propagation. From the result, it is found that the proposed WCA+DCNN model outperforms in classification and computational time. The Deep CNN with Sine cosine algorithm, harmony search can also be applied in the fully connected layer to improve the performance of conventional CNN models.

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