Retinal Disease Classification Using Convolutional Neural Networks Algorithm

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Abstract: Although there is a striking demand for classifying retinal disease from Optical Coherence Tomography (OCT) images through the CNN (Convolutional Neural Network), its consummation seems to be impoverished whenever the input medical image contains the noise. The impulse noise, meaning the salt and pepper noise, is perceived as the most generic noise found in a grayscale image. Impulse noise has been identified as a very common shortcoming in the field of image processing. This paper proposed a novel technique for retinal disease classification using CNN from OCT image in noise exposure. Apart from this, seven OCT images (CNV, DME, DRUSEN, and NORMAL) were used to test. A novel filter technique has been applied to eliminate the noise that gives superb accuracy regarding Structural Similarity Index (SSIM). The prevalent filter is used to eliminate noise, which provides impoverished consummation as compared to this new technique implemented in this paper. The proposed algorithm is in three steps: the first step is to add noise in the test image. In the second step, apply a novel filter to remove the noise, and in the third step, Resnet 50 and VGG16 network is used to classify the disease. The proposed CNN ResNet 50 model utilizes to draw out distinct features of softmax & ReLU used to classify patients from their Optical Coherence Tomography (OCT) images into CNN fully connected layer. The experimental result showed that the proposed system achieved better performance by the accuracy of 98.73%.

Keywords: The Salt and Pepper Noises, Convolutional Neural Network (CNN), CNN VGG16 (Visual Geometry Group), CNN ResNet50 (Residual Network), Artificial Intelligence.

1. Introduction

In the image processing on digital images, when the digital image is sent to the receiver from the source, it starts containing impulse noise automatically, known as the salt and pepper noise. There are numerous noise sources except the transmission noises that range from electronic equipment noise, camera sensor noise, image light intensity noise, etc. Many researchers have developed various kinds of filters to deal with such noise. The image is initially given as an input through the image acquisition system (e.g., mobile DSLR, camera) in all standard image processing systems. Then it is fed to the computer. The computer connected with the software and storage for processing once it is transmitted using a wireless or wired medium and eventually displays upon the device.

There are numbers of methods utilized by researchers over recent years. Shams baboli et al. [1] suggest a method, which is called modified nonlinear filtering wherever the first image input is accepted and then symmetric trimmed median filter has been used; afterwards, a 3×3 sized window is taken in the last propped up median filter, which is applied to recuperate the noiseless image. A Neetha George et al. [2] depict the choroid segmentation system. In this paper, an initial OCT image has been taken, and a CNN algorithm has been implemented to avail the segmentation of intraretinal fluid (IRF) and choroid image. In this project, implementation complexity has been seen as a medium. Vineeta Das et al. [3] beget the ideation of standard 3D volume of OCT image to the automated diagnosis of OCT volume using the B-ScanCNN algorithm. It diagnosis the pathological symptoms from B-scan images. Ashkan Abbasi et al. [4] use multi-input fully-convolutional networks (MIFCN) algorithm on an average. The noisy image becomes an input, and its minimum and maximum pixel average are calculated to finally construct and get acquainted with the average of pure pixels. These three numbers of images are taken to experiment, and their noise ratio of peak signal, SSIM, is calculated. Mohamed Ramzy Ibrahim et al. [5] have propped up a Norm-VGG16 algorithm known as type-2. The authors have utilized a very large Labeled Optical Coherence Tomography (OCT) to execute the automatic RoI localization performance. The implementation of this Norm-VGG16 algorithm is more complicated and time-consuming.

2. Proposed Methodology

The proposed method follows three steps. The first step adding noise into the input image second step apply a filter on noisy image third step apply CNN and classify the disease. Figure 2 shows below the image as input, which remains in the matrix form and accumulates the image data within the J variable. Then the impulse noise is adjoined to the input image J, where it saves the image data in I variable., the number of columns and rows is calculated. Then standard deviation is applied into the image using utilizing loop. Filter Architecture consists of the input image, loop on r and c, input image's standard deviation, de-noised faces of the filtered image. CNN architecture consists of a resnet 50 and VGG16 CNN, OCT database, Softmax and ReLU activation functions. The application of CNN is made to the retinal disease recognition process, and the filtered image becomes refurbished. The noiseless image has been exposed eventually with SSIM value. Finally, retinal disease is recognized in different types.

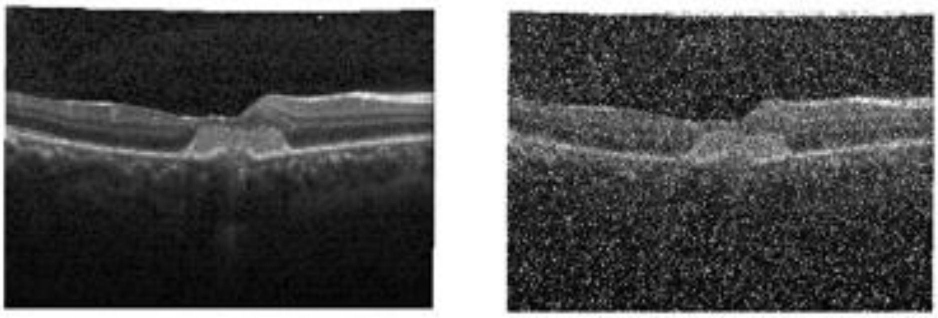

Fig 1. (a) Original Image (b) Noise Image

A. Noise Removal Approach

Fig 2 demonstrates the noise elimination flow diagram. The first step is to input the original image, and then impulse noise is supplemented to the input image using inbuilt functioning in Matlab. The inbuilt functioning's name is "imnoise", which is utilized to adjoin dissimilar kinds of noises (Gaussian, impulse noise, Poisson noise, Speckle noise, etc.) image. The next stage is finding the number of columns and rows in that image. As soon as the number of columns and rows is determined, the standard noise deviation has been calculated. The salt and pepper noise can be eliminated by implementing the noise pixel's standard deviation by utilising a loop. Once the filtered pixel is availed, it jumps toward the next stage. Otherwise, the procedure will get repeated until the filtered pixel is gained. In the final stage, once the filtered pixel is availed, it starts reconstructing the filtered image.

B. Convolutional Neural Network (CNN)

The Convolutional Neural Network (CNN) [6, 7, 14] has variant kinds of architectures based on the network layers, such as 18 layers, 101 layers, and 50 layers. In this paper, resnet50, a 50 layers-based CNN and VGG16 with ReLU/softmax activation functioning have been used. The resnet50 can train millions of images simultaneously and is also able to classify categories of thousands of objects simultaneously. The activation functioning is common of two kinds, such as nonlinear activation functions and linear activation functions [17-25]. The ReLU (Rectified Linear Unit) activations functions are a linear function based on pieces and assist in categorizing the image more precisely than the sigmoid function, softmax function [26-34].

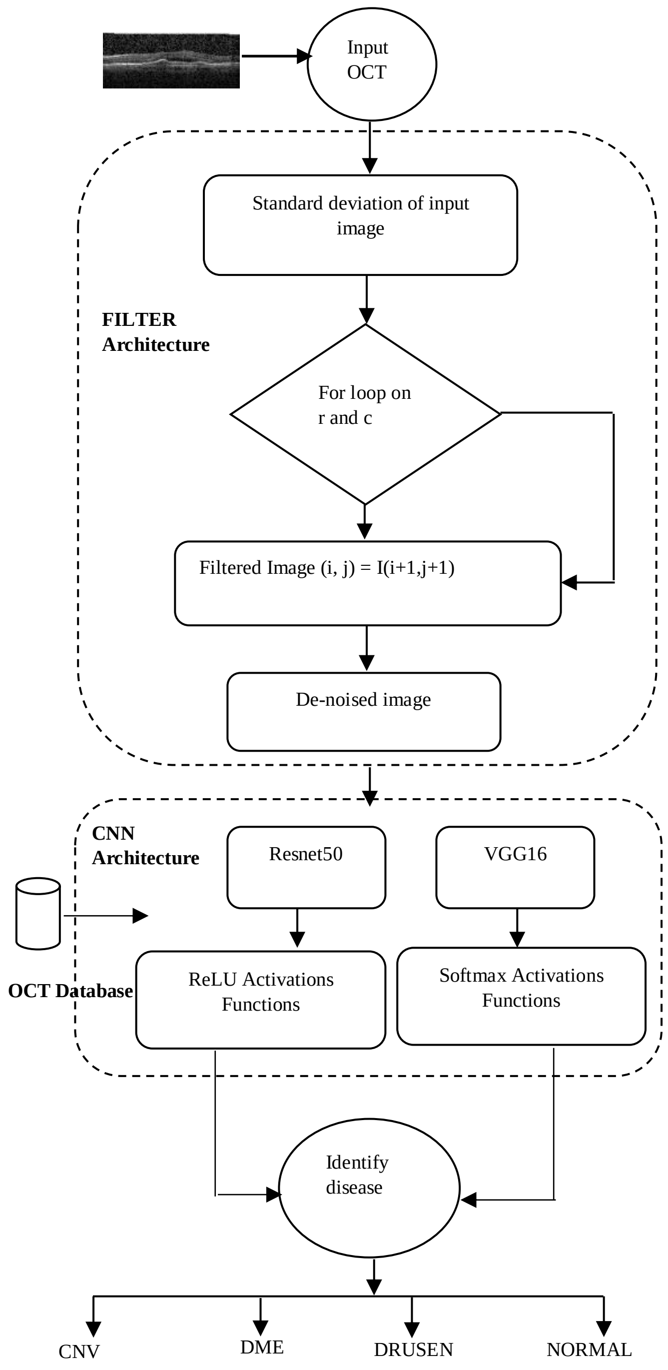

Fig. 2. Retinal Disease Recognition Flow Diagram

Proposed Algorithm

//Algorithm: Retinal Disease Recognition //

Step1: OCT Image has been used as an input in the matrix form, and the image data is stored in the J variable.
Step2: The Impulse noise is supplemented to the J input image and then safeguards the image data in the I variable. The zero data is the impulse noise that is adjoined in this stage.
Step 5: Calculating the number of columns and rows to apply standard deviation into the image using utilizing loop
Step 6: Apply Convolutional Neural Network for retinal disease classification.
Step 7: Finally, the retinal disease will be recognized.

C. Technical Requirements

The software and hardware remain as the fundamental essentialities of all paper that involve time and compensation. Requirements acknowledged in this paper include a 2.5GHz quad-core and i7 processor and based Windows 10 operating system with 8 GB RAM [35-47].

D. Dataset Generation

The dataset used to train and access the proposed retinal disease is made up of 108,312 images over 4,686 patient cases. The database consists of four categories (CNV, DME, DRUSEN, and NORMAL), of which choroidal neovascularization consist 37000 images diabetic macular oedema consist of 11000 images drusen consist of 8600 images and 51000 normal images [48-56]. This database is chosen because they are open source, and they are accessible to the public and researchers. The database link is given in the references [9].

3. Experimental Results

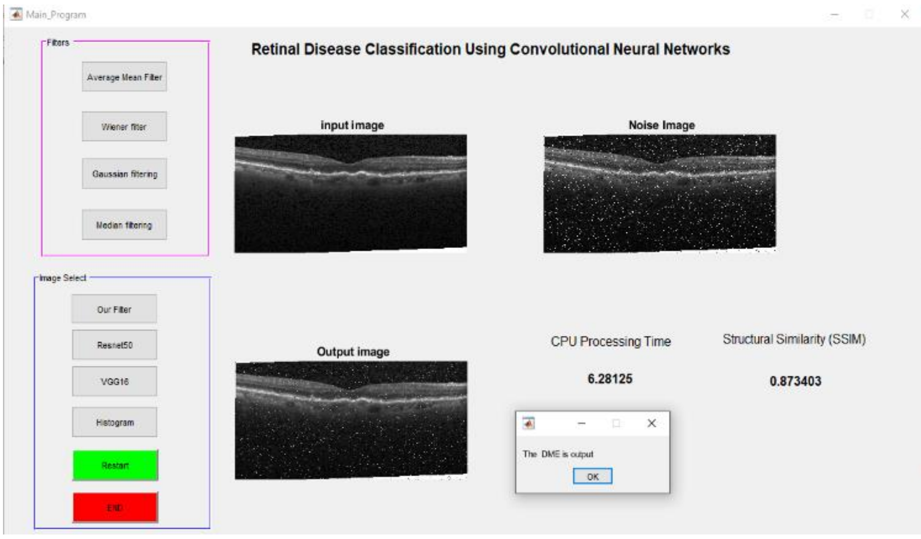

Fig. 3. Graphical User Interface of Retinal Disease Classification with Noise Removal Algorithm

Figure 3 demonstrates the GUI (Graphical User Interface) that is chiefly in use. The core purpose of using this GUI is to allow the program to be user friendly. GUI is adorned with nine buttons and two groups that have different purposes. The first group is adorned with four pushbuttons, demonstrates different noise removal filters. The second group is adorned with five pushbuttons. Using the first button user will input the image, and hence, it is named input image. As soon as the user chooses this input image, the application of the CNN algorithm starts, and the output image, the noise image, and the CPU (Central Processing Unit) time and SSIM will be shown through the GUI. The third button works in favour of histogram analyses, and it exposes two graphs. One is the genuine image histogram, and another is the graph for the output image histogram. The greenish button is used to restart the program while the reddish one for closing the program.

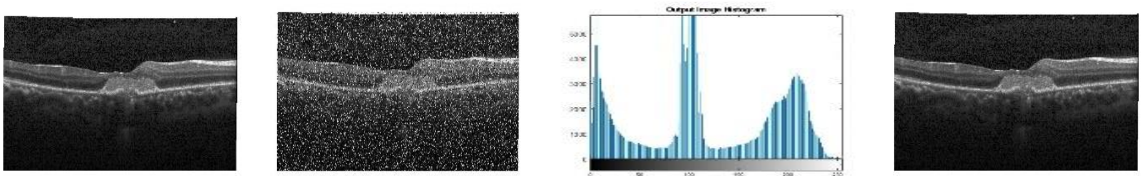

Fig. 4. (a) Original Input Image (b) Noise Image (c) Histogram Analysis (d) Output Image

In Figure 4, the first image is the original one that is used as input. The next one is the noise image which conveys the salt and pepper noise, and the third one is the output image's histogram. In the finishing part, the output image or the reconstructed image is shown. The digital image is represented through the histogram. The digital image of every pixel value on the bar conveys some specific difference in heights depending on every pixel value of the image. The histogram, furthermore, is advantageous for numerous purposes, including image compression technique, image enhancement and image segmentation techniques and so forth.

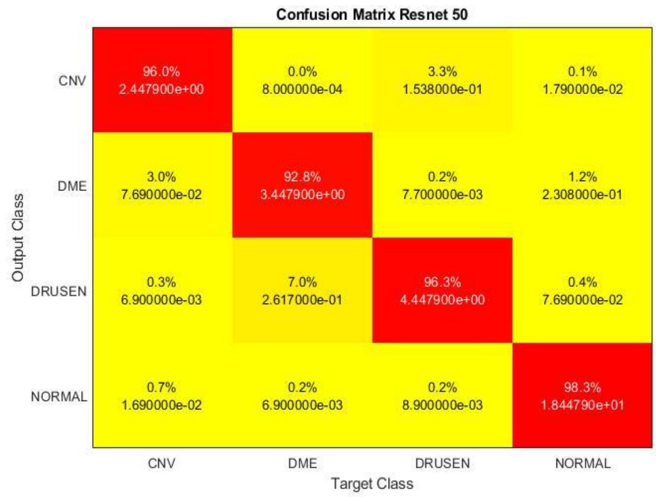

Fig. 5. CNN Resnet50 Confusion Matrix

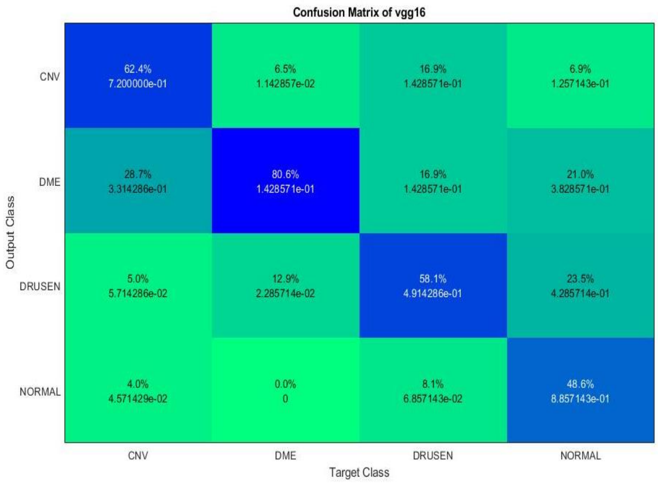

Fig. 6. CNN VGG16 Confusion Matrix

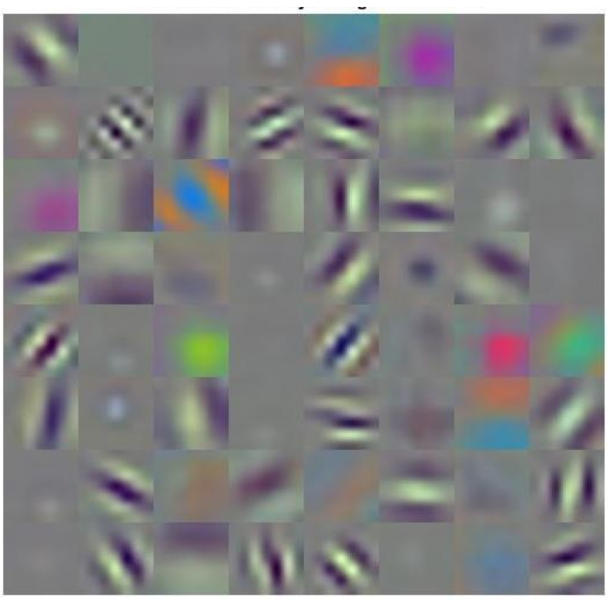

Fig. 7. First Convolutional Layer Weights ResNet-50

Fig. 8. First Convolutional Layer Weights VGG16

In Figure 5, a CNN confusion matrix depicts the overall performance of the CNN in the matrix form.

Table I. Comparison of the Filter with different Input

Input Image	SSIM	CPU processing time	Row(r)	Column(c)
CNV	**0.9812**	**6.0**	**1024**	**1024**
DME	**0.9746**	**3.3**	**317**	**325**
DRUSEN	**0.9703**	**9.6**	**512**	**512**
NORMAL	**0.9729**	**2.64**	**1517**	**325**

In table no. II, the proposed algorithm's result analysis has been discussed in which 7 input images are taken for experimental purpose. These are standard test image utilized in plenty of papers and are usually found easily. The first column represents the SSIM in which the image of the cartoon demonstrates the highest consummation, and the baboon image demonstrates the lowest consummation. The next column represents the computer's CPU's required processing time in second. This processing time relies upon different hardware used in different computers. Two next columns that follow these columns identify the number of generic columns and rows prevalent in the image.

Table II. Performance Comparison

Publication	Technique	CPU processing time	Accuracy
Mojahed D et al. [10] [2020]	Convolutional Neural Network	**120**	92.4%
Soichiro Kuwayama et al. [11] [2020]	Convolutional Neural Network	**140**	96 %
Shi F, al. [12] [2020]	Random Forest method	**137**	87.9%
Proposed paper	Novel filter and ResNet-50 and VGG16	**50**	98.73%.

The above Performance comparison Table I1.describes the comparison of the proposed technique with various other technique adopted for retinal disease classification. The above table concludes that the proposed technique is robust and efficient for retinal disease classification.

4. Conclusion

The renowned retinal disease from Optical Coherence Tomography (OCT) images process is performed through CNN Resnet50 and VGG16. A novel noise elimination mechanism and modified CNN activation function such as Relu and Softmax has been implemented to enhance CNN's efficiency. OCT image was given as the input, and then an impulse filter was applied to finally implement the CNN. The result has been more precise and accurate because of applying the impulse filter. This paper has used retinal disease recognition with a novel salt and pepper noise elimination mechanism and further compares the result using the existing old salt and pepper noise elimination mechanism like Average Median Filter, Median filter, Gaussian filter. The eventual outcome demonstrates that the novel filter is more consummate than the Median filter, Gaussian filter, and Average Median filter that have been shown in table 2. The proposed algorithm consumes a significantly short time for processing as well, as compared to other prevalent algorithms.

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