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Deep Neural Network based Abdominal Aortic Aneurysm Identification with PSO Optimization

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Abstract*: Converting the ongoing advancement of abdominal aortic aneurysm (AAA) development and rebuilding information for prescient treatment needs a significant and computational perspective demonstration system. Also abdominal aortic aneurysm is fatal and rupture hence an effective treatment is needed. The aim of this research work is to develop an algorithm that focuses on the accurate detection of the AAA image. In this proposed work, the input AAA images preprocessed to transform the RGB format into gray scale image using adaptive filter, also the pixels which are corrupted by noise is too determined. Then watershed segmentation is applied before extracting the highlighted feature from AAA images. The features of AAA are extracted by genetic algorithm. After the extraction, the best features are selected by using particle swarm optimization and finally for classification and recognition, deep neural network classifier is applied. The proposed system is appropriate to accomplish our aim in foreseeing the AAA progress and in figuring the propagation vulnerability. The performance of our system is measured using accuracy, precision, f-score and computation time are utilized. The comparative analysis of the outcomes showed the significant performance of the proposed approach over the existing SVM and CNN classifier.

Keywords*: Adaptive median filter, Watershed transform, Genetic based algorithm, Particle swarm optimization (PSO) and Deep Neural Network (DNN).

I. INTRODUCTION

Abdominal aortic aneurysm plays a main role in our body. It circulate the blood throughout the body. It becomes fatal if it ruptures. Its normally has a diameter of 2 cm. If it extends more than 3 cm it is said to be abdominal aortic aneurysm (AAA) [1], [2]. By using an ultrasound scan. It helps to determine the size of aneurysm [9]. It plays a significant factor in deciding on a course of treatment. It doesn't show any symptom until they become large therefore there is a need to be diagnosed as a result of screening or during a routine physical examination. Treatment depends on several factors such as size, position etc. If the aneurysm is found large a surgical intervention is needed.

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Researchers undergoes several approaches like deep learning and they used morphological and geometrical features for correct prediction [4]. But it doesn't made much effective. To overcome the problem, this proposed methodology focuses on high infalliable information. In this work, before performing watershed segmentation, The AAA image has to be converted to gray scale image and adaptive median filter is performed to find out the pixel which is affected by noise. To extract the feature from the segmented image, genetic algorithm is proposed. This algorithm is widely in use in many real time applications. It made a great boom in many medical related applications. Genetic algorithm is very good in predicting. Particle swarm optimization helps to figure out the best features among the extracted features. Finally to perform classification and recognition, DNN classifier is applied [12]. It helps to perform analogizing with the trained dataset. The platform used in this methodology is mat lab. A cohort of 20 data's were taken for analysis by using this methodology. This proposed algorithm and approaches provides a good accuracy as to our expected level and it's very facile to perform computation. By this proposed algorithm the achieved accuracy is 96.5%. It helps the clinicians and doctors to provide a better treatment plan for the patients who were affected by abdominal aortic aneurysm.

II. RELATED WORKS

Roy. D et al [2014] proposed finite element analysis of abdominal aortic aneurysms: geometrical and structural reconstruction with application of an anisotropic material model. A solid mechanics framework with the aim of modeling an anisotropic response of AAAs in a robust and straightforward way is proposed in this paper. A large deformation pattern and a folding behavior can be captured using the proposed model. The stress concentration factor is area, where the gradient of the radius is large due to the high stress. There is no specific anisotropic constitutive model for iliac arteries in AAA patient. Morariu, C. A. et al [2016] proposed sequential vs. batch machine-learning with evolutionary hyper parameter optimization for segmenting aortic dissection thrombus. In this paper, the feasibility of the process of segmentation of aortic dissections with thrombosed false lumen have been focused. Three profiles such as, one around the actual contour position, two at positions shifted inside have been computed during the training stage. In case of dissection-related thrombosis which affects aortic section more effectively than aneurysm, no proper solving method is discussed. Hahn, S et al [2019] proposed deep learning for recognition of Endoleak after endovascular abdominal aortic aneurysm repair.

In this paper, to identify the presence of Endoleak and localize the abdominal aortic aneurysm a cascaded deep neural network was proposed. To predict the axial slice by slice based on the Endoleak, binary cross entropy loss function is used to train the network. Using deep learning identifying the Endoleak is both difficult and novel task, and the small Endoleak have no specific efforts to remove.

Maeda, K et al [2017] discussed about comparison between open and endovascular repair for the treatment of juxtarenal abdominal aortic aneurysms: a single-center experience with midterm results. In this paper, for the treatment of juxta renal abdominal aortic aneurysm, rather than using EVAR (which often complicates the presence of short proximal neck OSR is used. The patients underwent OSR are mostly comparability young, hence they are not much suitable for the patients with high-risk and EVAR.

Lan, R.et al [2017] proposed medical image retrieval via histogram of compressed scattering coefficients. In this paper, the medical images has been analyzed using the deep learning technique which provides an interesting way to abstract the features of medical images in high level using the scattering transform. Various factors like the minimum, maximum, mean and variance's statistical analysis are provided. However, it takes more computational cost for obtaining the codebook which contains the large training and code word numbers.

III. PROPOSED METHODOLOGY

In this proposed methodology, as size and position is significant for the doctors to provide a better treatment plan. The main objective of this proposed methodology is to enhance the accuracy. In preprocessing, adaptive median filter is applied to determine the pixel which are affected by noise. Before performing segmentation in AAA image, the original image has to be converted to gray scale image. Segmentation is the process of splitting the image into homogenous region. It's a challenging task. Segmentation is done by using watershed transform. It perform operation by using distance transform, gradient method and marker extraction. After performing segmentation, features are extracted by using genetic algorithm. By designing an effective fitness function, it generates high accuracy in classification. Particle swarm optimization is applied to select the best feature. Finally DNN classifier is applied for classification. It span across two or more layers and it is iterated for 3 times to generate a high accurate result.

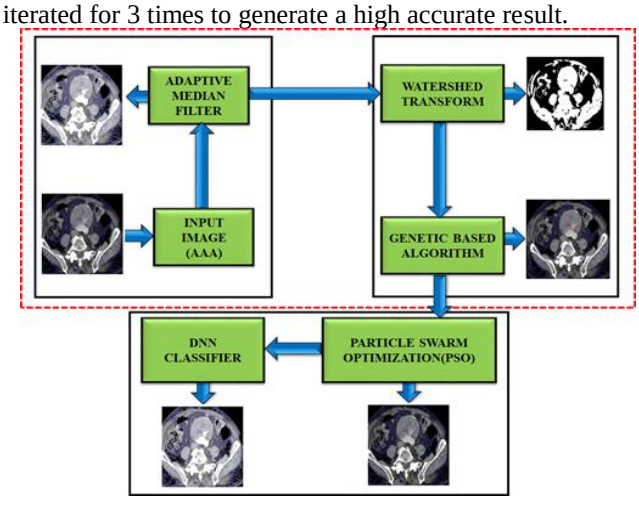

Fig 1: Block diagram of proposed methodology

IV. ADAPTIVE MEDIAN FILTER:

It helps to determine the pixel in an image which has been corrupted by impulsive noise. It classifies pixels as noise by analogizing with each pixel in an image. It's a proficient model to enhance the quality of image. In adaptive median filtering, new algorithm has been proposed to preserve sharpness and to find out the size of the impulsive noise. This filter is measured in terms of signal to noise ratio and time efficiency. In adaptive median filter, in first iteration it detects the position of corrupted noisy pixel. The binary value 0 and 1 is used to find out the noisy pixel. 0 indicates the pixel is good and 1 represents the noisy pixel. This filter removes the entire noise pixel.

Let $I_{i,j}$ represents the pixel of noisy image, I_{min} represents the minimum pixel value and I_{max} indicates the maximum pixel value.

STEP1:

If $I_{min} < I_{med} < I_{max,}$ then the median value is not an impulse, so it moves to step 2 to detect if the current pixel is an impulse.

Else the size of the window gets maximum and step 1 is iterated until the median value is not an impulse so the algorithm goes to step2; or the maximum window size is reached.

STEP2:

If $I_{min} < I_{i,j} < I_{max,}$ then the current pixel value is not an impulse, so the filtered pixel of an image remains unchanged.

Else the pixel value of an image is either equal to I_{max} or $I_{min.}$ The filtered pixel of an image is assigned as median value from step 1.

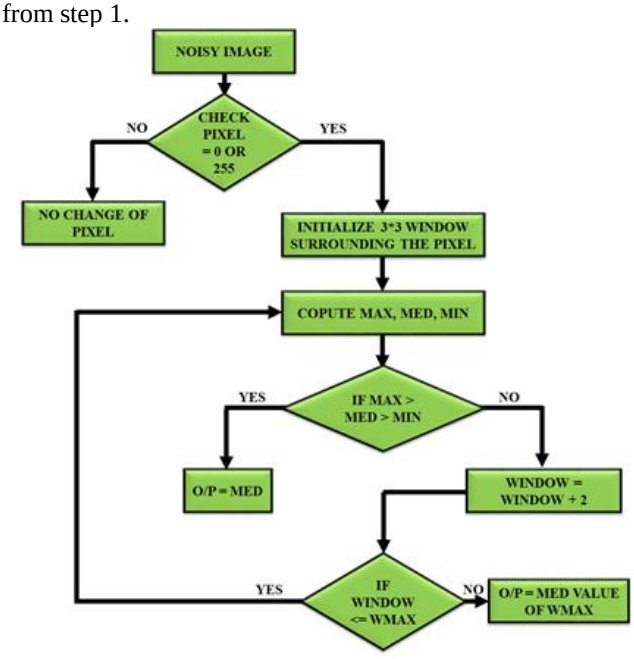

Fig 2: Flowchart for adaptive median filter

4.1 Segmentation By Using Watershed Transform:

It's the most challenging task in image processing. Its function is to divide an initial AAA image into homogenous region. This transform cannot be applied to the obtained image directly. The image has to be converted to gray scale image to apply this transform. Image segmentation algorithm depends upon the two characteristics discontinuity and similarity.

Watershed transform is the mathematical morphological method based on region processing. The basic concept of watershed includes three basic notions,

(1) Minima

(2) Catchment basin: The point which forms an interior gradient region is called watershed lines.

(3) Watershed lines: By splitting different catchment basin it forms crest lines which is called watershed lines.

In watershed transform, the bright area of image is considered as high altitude and dark areas is considered as low altitude. Watershed transform is a simple intuitive method and it perform computation in a faster way. Watershed transform is implemented by using three methods.

(1) Distance transform method

(2) Gradient method and

(3) Marker extraction method.

Distance transform:

It has been applied to compute the distance from every pixel to the neighborhood nonzero valued pixel. Distance transform can be computed by using,

D=bwdist(f) (1)

To make suitable for performing watershed transform, it has to be converted to gray scale image by using different DT operation.

Gradient method:

It uses gradient magnitude to preprocess a gray scale image. The gradient magnitude has high pixel along the edges and low pixel at all the points of the image. The topological gradient provides a global analysis of the image and the unwanted contours in the image which was raised due to noise would be reduced by using this approach. The topological distance between point P and Q is computed by using,

$$T_f(p,q) = inf \int \gamma \left|\left|\nabla f\left(\gamma(s)\right)\right|\right| ds \quad (2)$$

It partition the AAA ultrasound image into two steps.

(a)Detection of main edges of the image

(b)Compute the watershed of the gradient detected.

Marker extraction method:

A marker is a connected component belonging to an entire image. The two markers used are Internal and external markers. Internal markers is highly associated with the object and external markers associated with the background. It is facile and robust method for performing segmentation. The boundaries in the image is expressed as ridges. After performing segmentation, the regions are arranged in the form of ridges thus they separate each object from its neighbor.

4.2 Genetic Based Feature Extraction:

The genetic algorithm is also applied for the process of feature extraction. While performing feature extraction, the features are taken randomly as population and then the features which have been chosen is treated as parents, randomly from the input space. This generates the children for next generation to get the finite solution by using the fitness function, mutation and crossover.

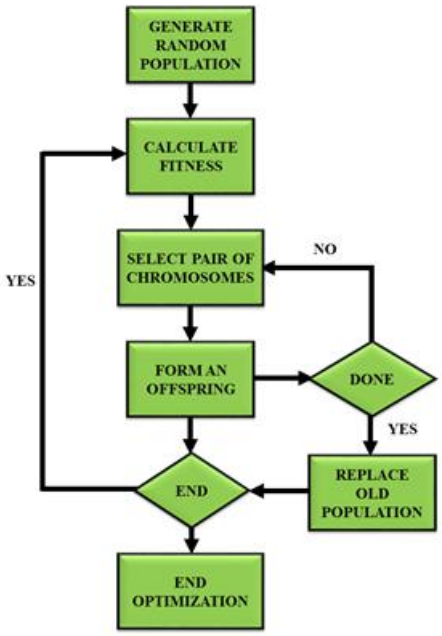

Fig 3: Genetic algorithm

Fitness is computed by using,

$$Fitness = C_{oA}\left(\frac{100}{oA}\right) + C_{fs} \times \frac{N_s}{N} \quad (3)$$

Where OA represents Overall Classification

C_{oA} denotes weight

C_{fs} represents the weight of selected features

N_s denotes total feature count.

This fitness function return the calculated value of fitness. It helps to determine the order in which individual strings are copied for the process of reproduction. It is computed by the sum of the intensities of the boundaries in an image.

Mutation:

It cannot find the correct solution to the problem without performing mutation operator. Encoding and crossover are the two parameters used here. When performing encoding operation, mutation exchanges two genes. Switching of bit takes place in binary encoding. It changes from 0 to 1 and 1 to 0.

Crossover:

In crossover, two genes combine to form a new chromosome. The resulted chromosome have better characteristic. By using crossover operator, the inheritance property is implemented. Crossover can be of special category like one point, two point and uniform.

In feature extraction, texture measures plays a main role. Two different texture measures are extracted, the first one is obtaining texture measures from different sources of data. Second it measures the mutual dependence of neighborhood pixel. The correlated datasets are chosen by using mean and variance

$$Mean = \frac{1}{w}\sum_{k=0}^{n} i.f_i \quad (4)$$

$$\frac{1}{w}\sum_{k=0}^{n}(i - mean)^2.f_i \quad (5)$$

By using mean, variance and correlation, texture measures are extracted.

In genetic algorithm, the number of initial feature is equal to the length of the binary sequence. A feature which is to be discarded is represented as 0 and the value 1 denotes the selected feature in the binary string. Genetic based method generates solution to the problem by means of evolution.
The generated solution is used for performing optimization. By designing an effective fitness function, it maintains the purpose of high accuracy of classification. The main purpose of this proposed work is to obtain highly accurate datasets.

4.3 Optimization Technique:

It finds the parameter that provides the maximum value of a target function. The optimization technique helps for performing easier classification. In this proposed work, particle swarm optimization is applied. The main advantage of using this algorithm is, it maintains multiple potential solutions at a time. It is derived from the field of evolutionary computation.

4.4 Particle Swarm Optimization:

It is applied to solve optimization problem. Each and every particle which is selected have fitness value. It starts with the group of random particle and by updating generation it searches for optima. In each and every iteration, each solution is evaluated to determine its fitness by using objective function. Each solution is represented by a particle in the fitness landscape (search space). Through search space it finds the maximum value which is returned by objective function. PSO does not have operators like crossover and mutation. By using internal velocity, particle update themselves. It has its own memory which is important to the algorithm.

4.5 PSO algorithm:

Initialize the parameter
Select the population randomly
For each particle,
Initialize position vector and velocity vector.
Do
{
Update each particle's velocity;
Find a permutation by using updated particle's velocity;
Evaluate and find the best one;
Apply local search;
} while (! stop criterion)

Each particle velocity is computed by using,

$$v_i(t+1) = wv_i(t) + c_1r_1[x_i(t) - x_i(t)] + c_2r_2[g(t) - x_i(t)] \quad (6)$$

Where i represent the index of the particle.
W denotes the coefficient. It is usually set between 0.8 to1.2. The smaller value speed up the convergence and the higher value helps in exploring the search space.
C_1, C_2 denotes the acceleration coefficient $0 \leq c_1, c_2 \leq 2$.
r_1, r_2 represent the random values $(0 \leq r_1, r_2 \leq 1)$.

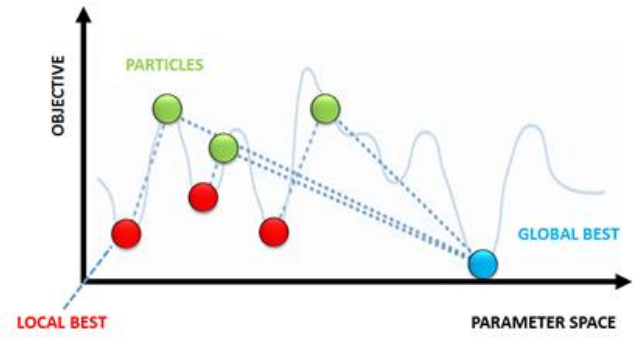

Fig 4: Particle swarm optimization

This algorithm helps the particle to move to the best region, the swarm has found so far.

4.6 Deep Neural Network Classifier:

It's a neural network with several layer of nodes between input and output. For classification and recognition, deep neural network classifier is used, it is not a simple layer of computation. It span across two or more layers. The three layers involved are

(1) Input layer

(2) Hidden layer and
(3) Output layer.

If f(x) is nonlinear, a network with 1 hidden layer can perform any classification problem. A set of weight exist that can produce the targets from the input. While analogizing with SVM, neural network use nonlinear F(x) so they draw complex boundaries but it keeps the data unchanged. Neural network architecture should be capable of learning the true underlying features therefore it generalize very well. It performs a remarkable job when the problem becomes more complicated. In order to perform classification, there is a need to train a set of data. It helps in accurate prediction of AAA image.

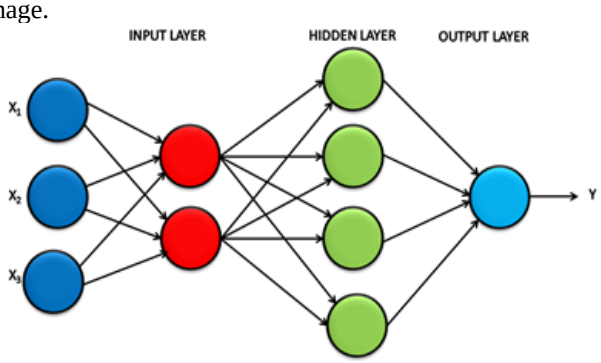

Fig 5: Layers of Deep Neural network

(1)The training data and the corresponding labels are given to the model

(2)The entire dataset will be passed to the model and it is iterated for 3 times and in each iteration it contains 256 steps.

(3)Finally it generates the output.

Accuracy: The evaluate method of the classifier need to receive the test input for evaluation. It will output an object containing the accuracy obtained with current implementation it's about 96.5%.

Accuracy is a metric to find out how correctly the classifier classifies the data objects.

Accuracy= (TP+TN)/ Total (7)

Total= TP+TN+FP+FN

V. RESULTS AND DISCUSSION

An adaptive median channel is utilized for surface assessment which suggest that whether there are particular repeat content exist in the image specifically course in a constrained region around the point of examination. From the filter, the yield MRI AAA picture is separated.

Watershed-based picture division is the least troublesome segmentation strategy utilized to select the lower level of pixels. The establishment and the dissent are the two essentialities. The dim level possesses most of the content in the image. In this segmentation strategy, dull level is tremendously zenith. By observing the particular picture, the witness can judge on the whole tonal dispersing from the outset. As the data contained in the framework is a portrayal of pixel motion as a segment of tonal variety, image is broken down into peak or valley.

A hereditary calculation is presented to enhance the image segmentation and investigates the course of action space by a methodology that are uneven as every pixel is gathered. Genetic calculation is the reasonably improved system. It is valuable in image optimization and segmentation. It is an impressive broad plan space. This clarifies the expanding reputation of GAs application in image processing field. Our proposed work is executed in Matlab.

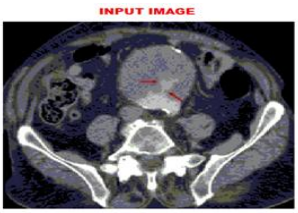

Fig. 6 Input image for the proposed analysis

The figure 6 represents the AAA image that has both blur and radiation noises which are then removed by adaptive median filter.

Fig 7. Noise reduced image using adaptive median filter

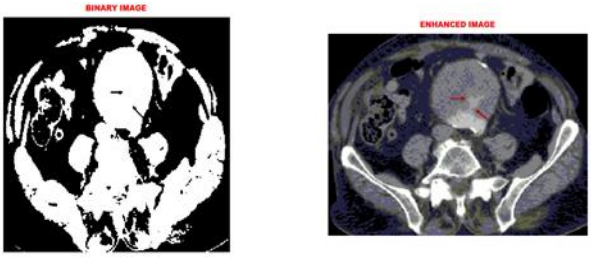

Fig 8. Binary pattern output image

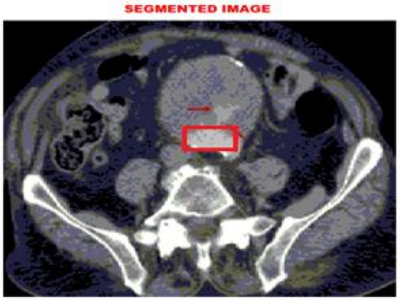

Fig 9. Segmented result from the input image

Preprocessing of data normalizes pictures. The division and ordering of medicinal MRI AAA pictures gives a chance to acknowledge zone and thickness observing by utilizing the locale removed progressively condition. This examination investigates the plausibility of tumor acknowledgment utilizing pixel (seed) point highlights for recognizing the influenced districts in the cell. The aftereffects of AAA division and the acknowledgment of human and AI calculations are compared and evaluated to prove our execution superior to the other highlight based division and identification.

5.1 Performance parameters comparison

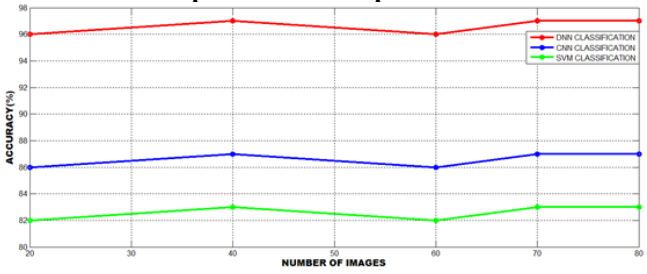

Fig 10: Accuracy

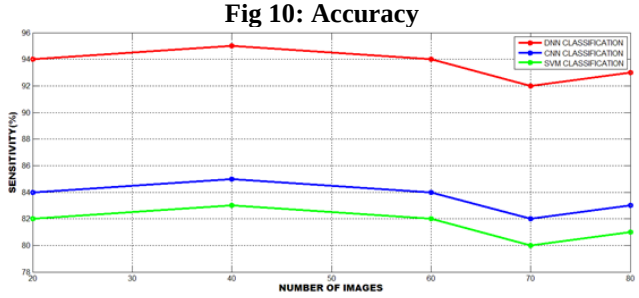

Fig 11: Sensitivity

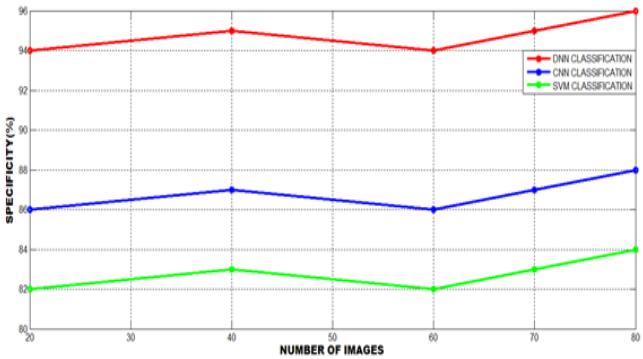

Fig 12: Specificity

Table 1 and 2. Accuracy, precision, F-Score and computational time comparison table.

IMAGE NO.	ACCURACY		PRECISION	
	WITHOUT OPTIMIZATION	WITH OPTIMIZATION	WITHOUT OPTIMIZATION	WITH OPTIMIZATION
IMAGE 1	90.3	93.2	89.5	94.2
IMAGE 2	89.2	94.1	88.6	92.8
IMAGE 3	88.4	95.8	89.8	94.7
IMAGE 4	91.6	96.6	91.3	93.3
IMAGE 5	91.4	96.3	92.2	95.5

The above table gives the deviation in ordering of MRI AAA images with single level segmentation and conducting with the similar pictures with our proposed watershed segmentation.

IMAGE NO.	F- SCORE		COMPUTATION TIME(ns)	
	WITHOUT OPTIMIZATION	WITH OPTIMIZATION	WITHOUT OPTIMIZATION	WITH OPTIMIZATION
IMAGE 1	91.3	95.5	0.823	0.832
IMAGE 2	88.4	96.9	0.843	0.821
IMAGE 3	87.5	94.6	0.885	0.835
IMAGE 4	89.2	96.8	0.829	0.823
IMAGE 5	91.3	96.2	0.856	0.814

The streamlining to decrease the hunt dimensionality would marginally expand the calculation extend however the execution of the proposed framework is well-improved with respect to order exactness, accuracy and f-score esteem. Time parameter is undermined with division and arrangement exactness.

VI. CONCLUSION:

This proposed methodology focuses more on the accurate size and position of the AAA image. A cohort of 25 dataset were taken for analysis. The input image is preprocessed by adaptive median filter to remove salt and pepper noises. Then watershed algorithm is applied to segment the AAA image. By implementing several approaches, analysis were performed. In DNN classifier, once the data gets trained prediction are pretty fast and it is reliable in many task which involve many features. By analogizing with the trained data, it generates an output. By this proposed methodology, size and location is found out with high infallible information. The accuracy achieved by this methodology is 91.4 %.

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