Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 46 No. 12
December 2025

Identification and Enhancement of Diabetic Retinopathy Images Using Filtration Techniques

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Abstract - Diabetic Retinopathy is an eye disease that is vision threatening and caused due to high blood sugars due to diabetes. This disease is further classified in various stages and a person may be blind forever if not detected at an early stage. An early detection of this disease is required but due to the high number of patients and very high cost involved in various tests done by ophthalmologists only very few patients report timely. There is a need of an automated method which may be used for early detection of diabetic retinopathy for accurate and precise diagnosis of the disease. In this paper, an approach for comparing the various filtration techniques has been proposed so as to better detect any type of fundus in the eye. The performance is tested with fundus images from different severity levels of Diabetic retinopathy. The efficacy of proposed work has been quantitatively measured by entropy and standard deviation. The resultant images will provide enhanced images for doctors to analyze and may help in detection of diabetic retinopathy more accurately at early stages.

Keyword: Gaussian filter, Median filter, Wiener filter, Average filter, Retinopathy, Filtering, Fundus, Diabetic retinopathy.

1. INTRODUCTION

Diabetic retinopathy (DR) is an ocular disease which can be caused by continuous high blood sugar levels and high blood pressure which results in blood leaks in the veins of eyes which ultimately leads to blindness if not diagnosed on time. In 2010, of an estimated 285 million people worldwide with diabetes, over one-third have signs of DR, and a third of these are afflicted with vision-threatening diabetic retinopathy (VTDR), defined as severe non-proliferative DR or proliferative DR (PDR) or the presence of diabetic macular edema (DME) [1]. Correctly grading retinopathy in all diabetic patients is a difficult and time-consuming job so to save time and getting more accurate results an automated technique is required.

The identification and enhancement of diabetic retinopathy through filtration techniques play a crucial role in early diagnosis and effective management.

According to various international protocols the severity of DR can be measured on different scales as No DR, mild DR, moderate DR, severe DR, and very severe DR. The grading usually depends on the number and severity of lesions present in the eye. Fig.1, shows the comparison of a healthy eye with an eye image having different types of abnormalities due to retinopathy. That image shows issues like hemorrhages, abnormal growth of blood vessels, aneurysm, Cotton wool Spots and Hard exudates which usually appear with different stages of retinopathy.

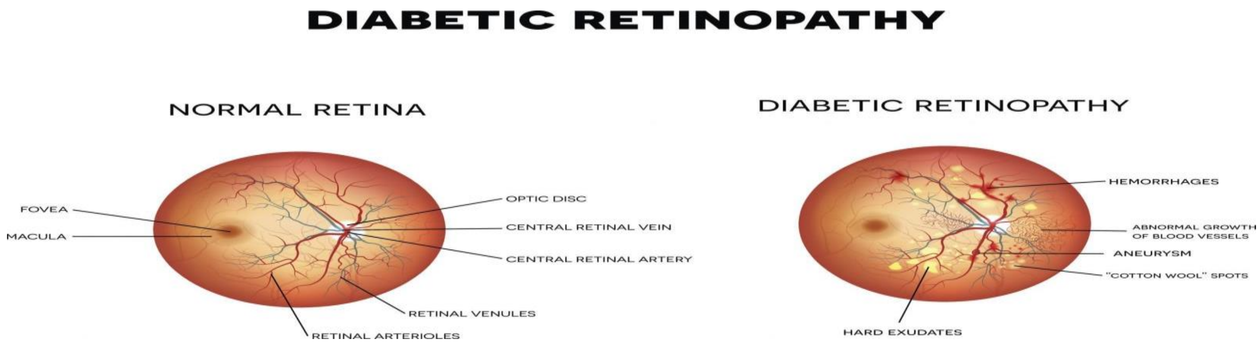


Fig. 1.) Image illustrating normal retina v/s Diabetic retinopathy [2]

Filtration can be used as one of the crucial methods for fundus scanning and lesion detection because it can identify an area in the eye that is affected with DR and thus helps in easy identification of DR. This paper has been organized in following sections: In the first section introduction is presented and followed by proposed methodology in second section. The third section focuses on quality measuring parameters. Further, the result and discussion summarized the key findings and provides recommendations out of various filtration techniques which one gives the most promising results.

This research aims to employ advanced image processing filters to enhance image quality, facilitating accurate detection of retinal abnormalities associated with diabetes. By leveraging these filtration techniques, we strive to improve diagnostic precision, ultimately contributing to early intervention and enhanced health care outcomes for individuals with diabetic retinopathy.

2. PROPOSED METHODOLOGY

Diabetes retinopathy (DR) stands as a poignant manifestation of the intricate relationship between diabetes and ocular health. As a progressive complication arising from prolonged exposure to high blood sugar levels, DR exacts a toll on the delicate network of blood vessels within the retina. The retina , responsible for converting the light into neural signals for vision, becomes a battleground where diabetes inflicts damage, leading to a spectrum of retinal disorders.

The proposed methodology involves a multi step approach to identify and enhance diabetic retinopathy images using filtration techniques. Firstly we'll preprocess the images to remove noise and artifacts , ensuring a clean input for subsequent analysis. Next we plan to employ various filtering algorithms such as Guassian filter, Median filter to enhance image features relevant to diabetic retinopathy.

In this paper 50 fundus images from a dataset of 276 images were obtained from different severity levels. The images were clicked through a good fundus camera to obtain high quality images and remove any kind of discrepancy from the image. Following steps were performed over the image to obtain the results:

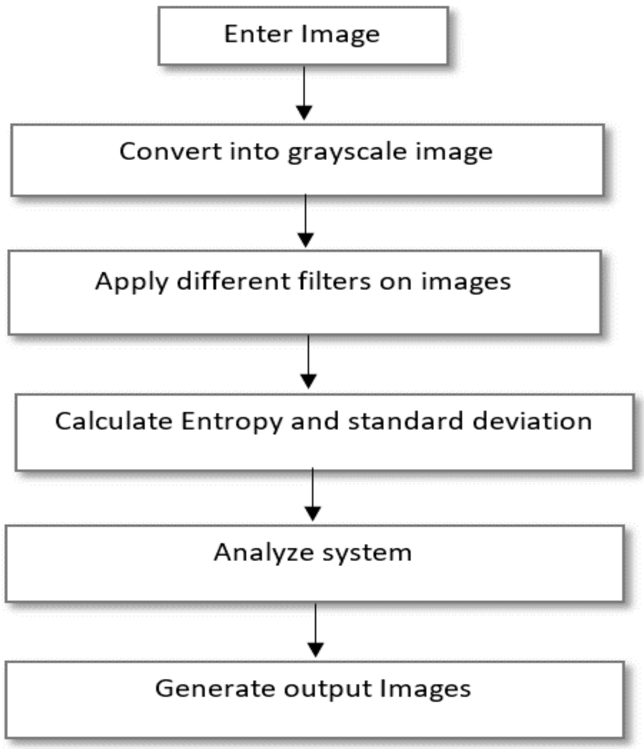


Fig 2. Flow chart for Proposed Methodology Description[14]

The aim of this technique is to build a computer technique for filtration of eye fundus images. The overview of the proposed method is shown in the inflow chart in Fig.2.

- **Input image:** A collection of images was obtained out of which 50 random images were picked from different severity levels of diabetic retinopathy starting from No diabetic retinopathy to very severe diabetic retinopathy so as to analyze different types of images in the proposed methodology. The image was read from the imageread() function.
- **Converting Colored image to Grayscale Image:** "Grayscale conversion is also a vital part of image processing. Colored images make signal processing heavy as they have three dimensional properties (RGB information). This makes grayscale conversion necessary. Therefore, grayscale images do not carry any color information as all the color information is converted" [6]
- **Applying different filters on images:** An image can be enhanced or modified using the filtering process. For instance, you can filter an image to highlight particular elements while removing others. Filtering is used to accomplish image processing tasks like edge enhancement, sharpening, and smoothing.

  The value of every given pixel in the output image is decided by applying some algorithm to the values of the pixels in the vicinity of the corresponding input pixel. This is known as a neighborhood operation or filtering. A group of pixels that are identified by their proximity to a given pixel are said to be in that pixel's neighborhood.

  For image processing, image filtering is considered to be an important step, as it helps in removing noise and generating a good output image. In this study, various filters were applied over the image:

1) **Gaussian Filter:** A 2-D convolution operator is used in this filter. Images used to be blurry. It also eliminates noises and details. Mean filter and the gaussian filter are comparable. The primary distinction is that the Gaussian filter employs a kernel. The kernel has a gaussian hump form. The center of the Gaussian kernel is given a substantially higher weight than its edges. [17]

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \text{ ……….. [8]}$$

2) **Median Filter**: "Median filter is a non-linear filter. It replaces each pixel values by the median values of its neighbor pixels." [7]. "Median filter proves to preserves the edges and lines of an image in the best possible way thereby removing the outliers. It can be stated as:

   y[m,n] = median{x[i,j], (i,j) € w } ………. [9]

   Where w is neighborhood focussed on location [m,n] in an image [18]

3) **Wiener Filter:** The Wiener filter is the MSE-optimal stationary linear filter for images degraded by additive noise and blurring. Wiener filters are effective at removing blur from an image caused by linear motion.[19] A continuous evaluation of an actual image that can be expressed in the Fourier domain is as follows:

$$W(f1,f2) = \frac{H*(f1,f2)S_{xx}(f1,f2)}{(|H(f1,f2)|)^2 S_{xx}(f1,f2)+S_{nn}(f1,f2)} \text{ ……………[10]}$$

4) **Average Filter**: Average filter is one of the techniques which is used to reduce noise of the images. This is a local averaging operation and it is one of the simplest linear filters. The value of each pixel is replaced by the average of all the values in the local neighborhood.[11]

3. Quality Measuring Parameters

i) Entropy

Entropy is used to quantify the amount of information that an image contains. It is also used to judge the quality of an image. Entropy is an important parameter in image processing as it can be used to assess the performance of image enhancement techniques. Entropy helps to identify the best techniques to be used for image enhancement and evaluation. Entropy also helps to detect the presence of noise in an image. Entropy is used to compare the image before and after image enhancement, as it reflects the amount of information in the image. Entropy also helps to calculate the similarity between two images. Images with low entropy values appear to be blacker as compared to images with high entropy values

Entropy is calculated by:

$$E = -\sum_{i=0}^{L-1} p_i . p_i \quad [3]$$

Where L is the total of gray levels, p = $\{p_0, p_1, \dots\dots p_{L-1}\}$ is the probability distribution of each level.[15]

P_i = Probability of randomly selecting an example in class I;

Entropy always lies between 0 and 1, however depending on the number of classes in the dataset, it can be greater than 1. [13],[16]

ii) Standard deviation

"Standard deviation is used to quantify the amount of variation or dispersion of a set of data values. It is used to measure the statistical dispersion of the contrast in the image and also evaluate how widely spread the gray values in an image. It denotes the deviation degree of the estimation and the average of the random variable. An image with high contrast would have a high standard deviation. Larger the standard deviation, better the result". [4], [12]

$$S = \left(\frac{1}{n} \sum_{i=1}^{n} (x_i - \underline{x})^2 \right)^{\frac{1}{2}}$$

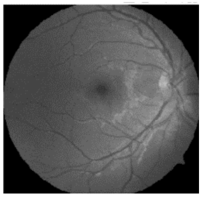
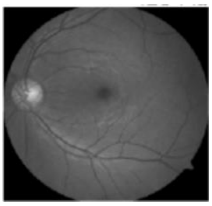
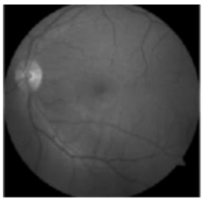
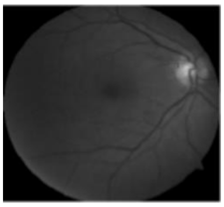
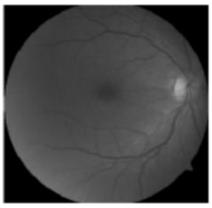
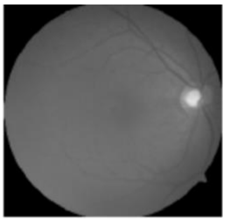
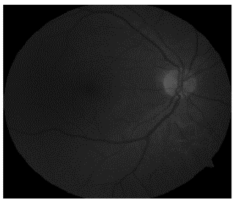
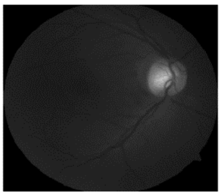
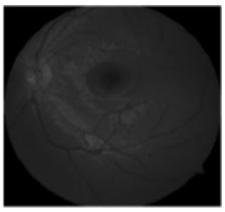
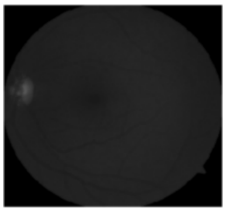
Where

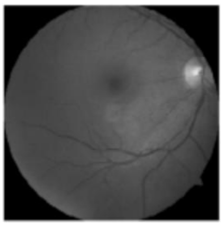
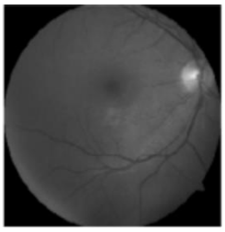
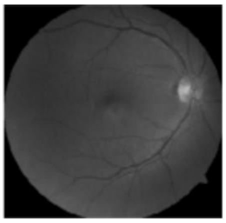
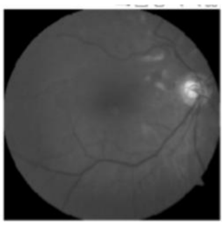
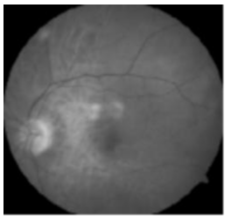
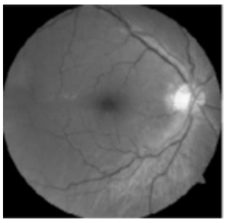
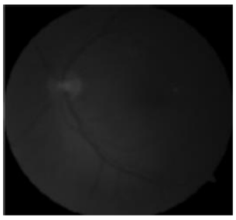
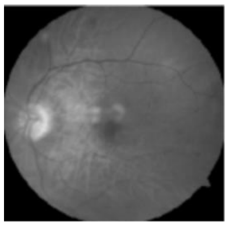
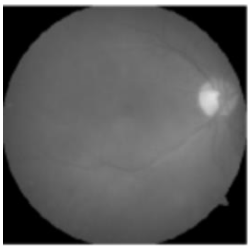
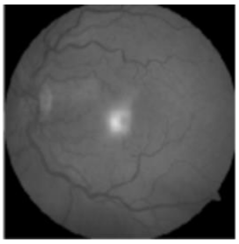
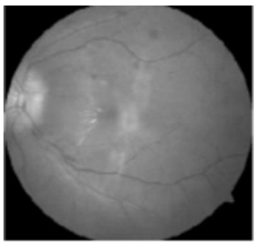
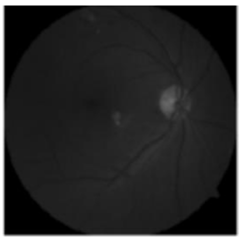
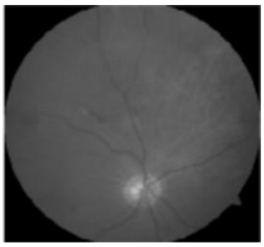
$$\underline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

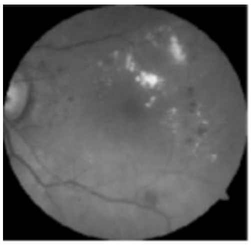
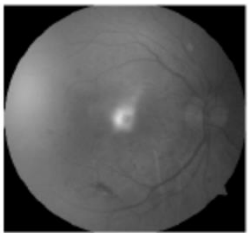
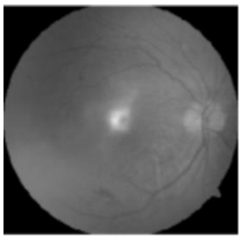
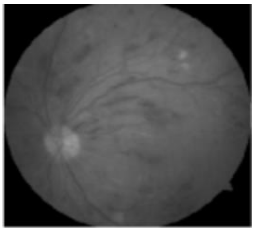
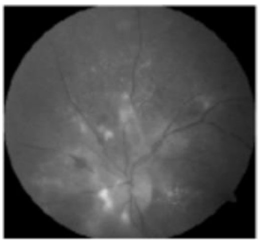
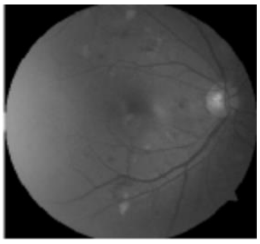
And n is the number of elements in the sample. The two forms of the equation differ only in n-1 versus n in the divisor.

The following images have been used to perform different type of filtrations:

Table 1: Image dataset used with different level of severity

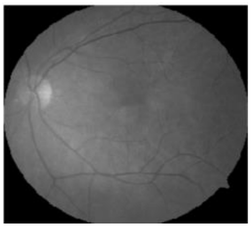
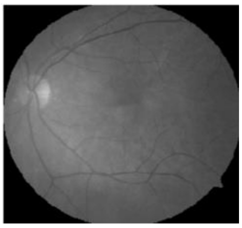
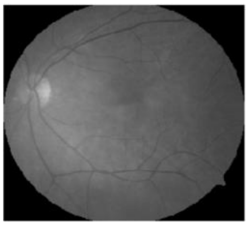
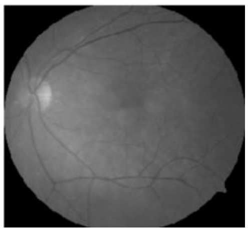
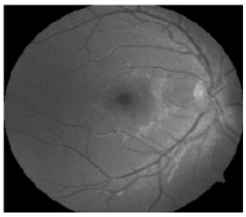
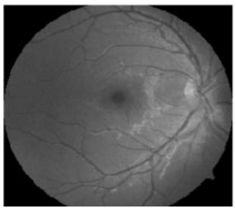
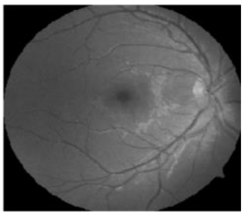
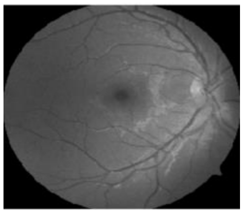
NO DR			
Gray-scale Image			
			
			
			

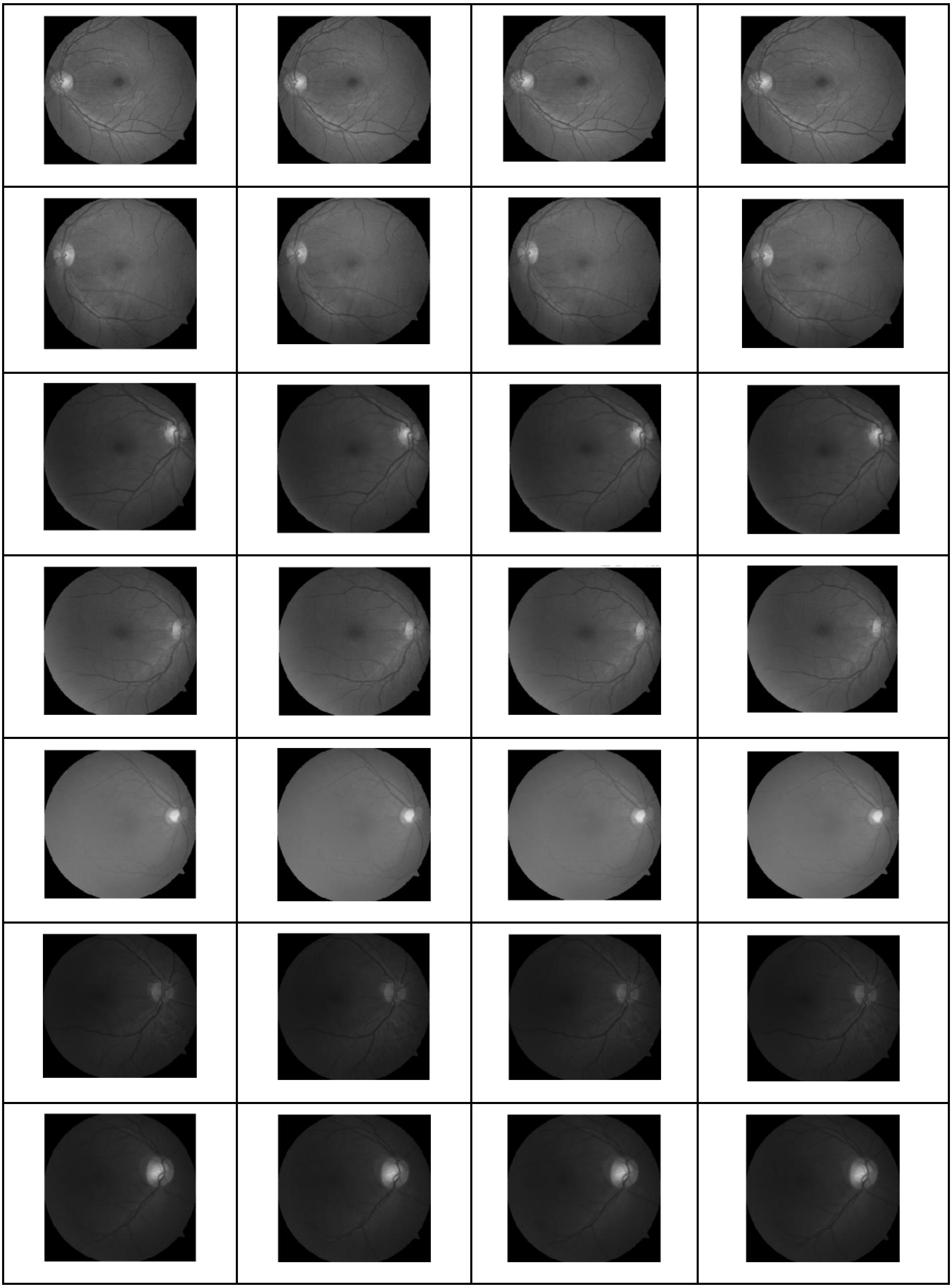
MILD DR		
		
Moderate DPR		
		
		
Severe DPR		
		
		

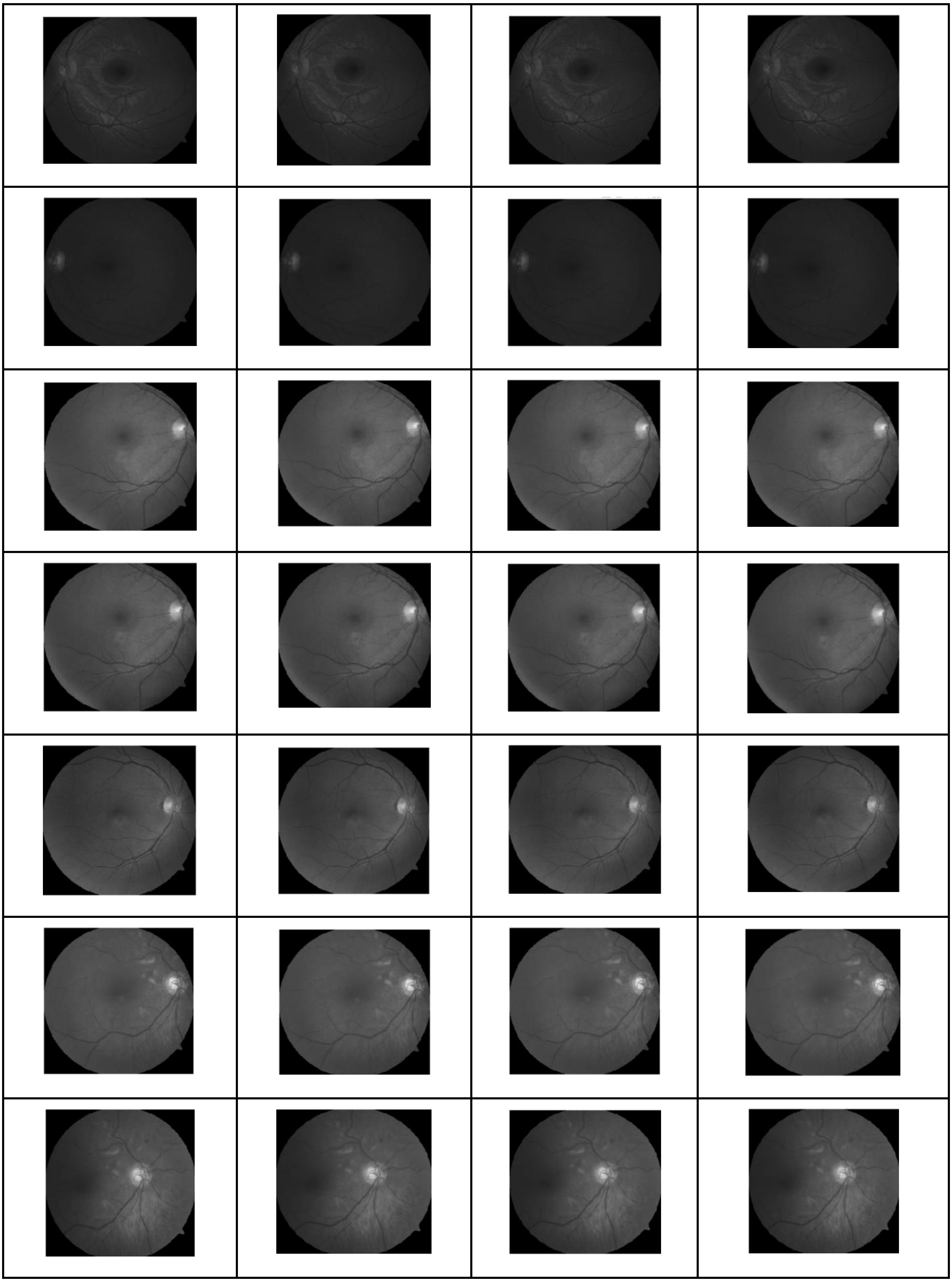
Very Severe DPR		
		
		

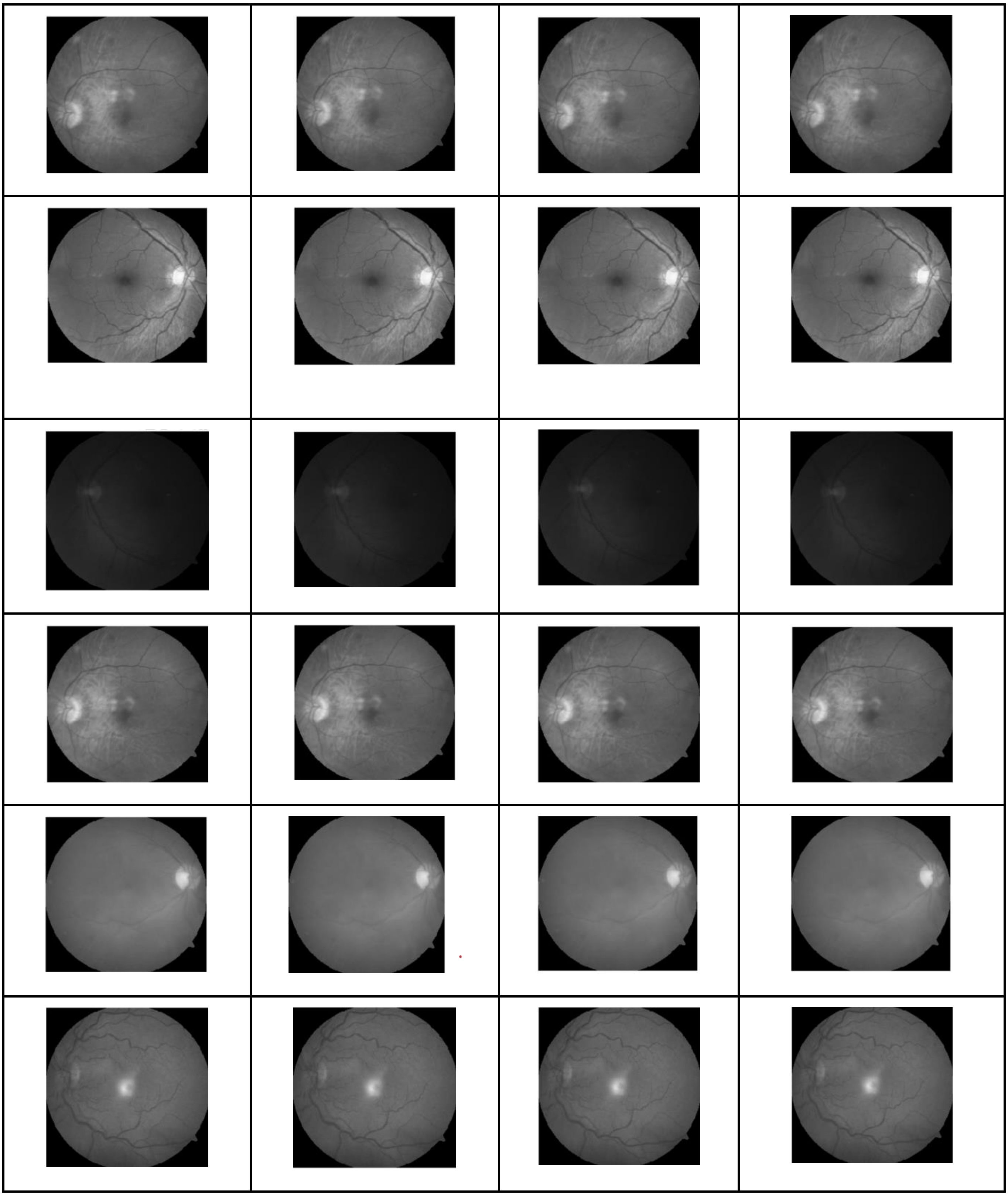
Different types of filtration techniques like gaussian , median, wiener and average filter were applied on the obtained dataset of images. The following table was obtained after applying different filtration techniques on the given dataset. :

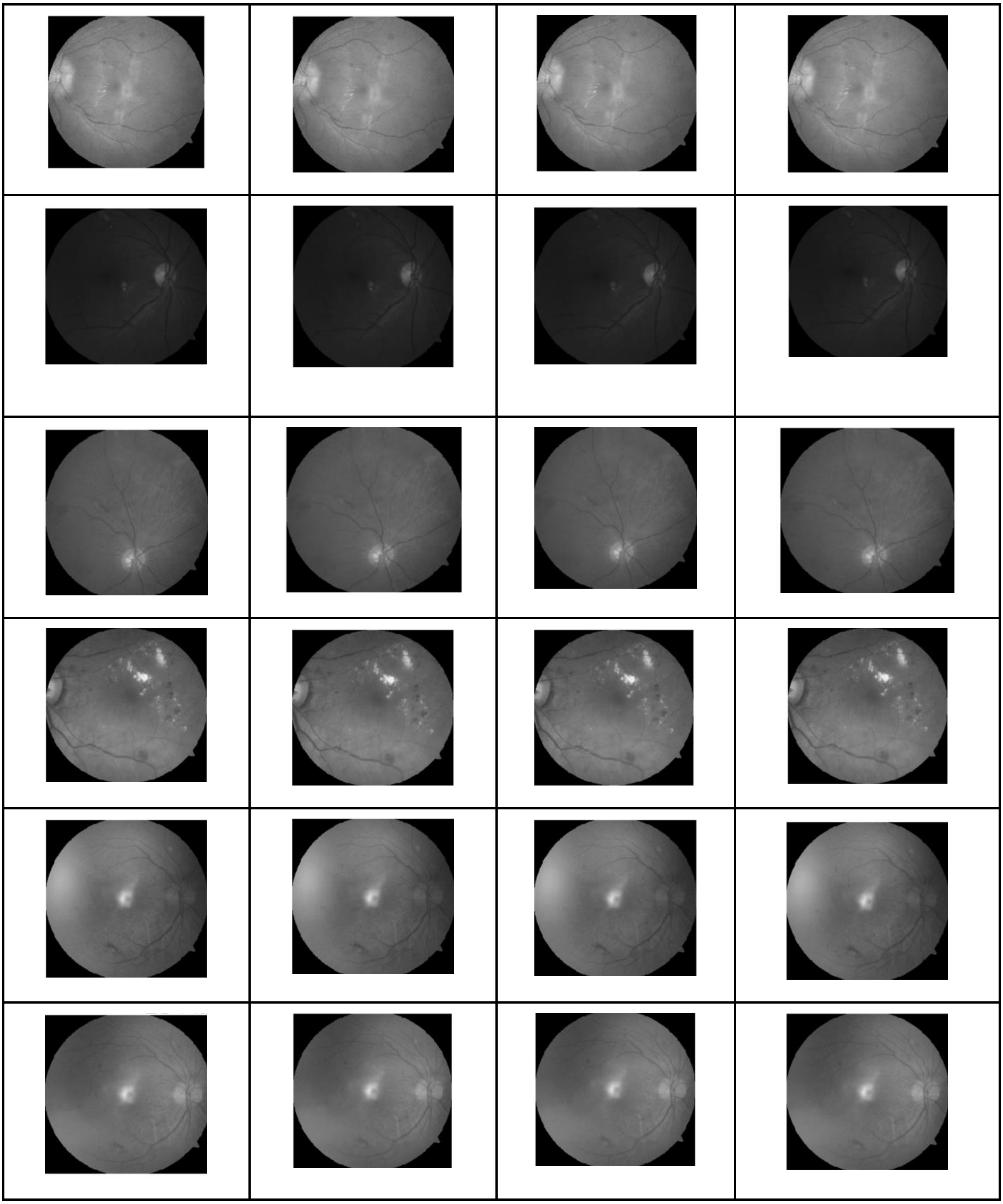
Table 2: Different image dataset after applying different filters.

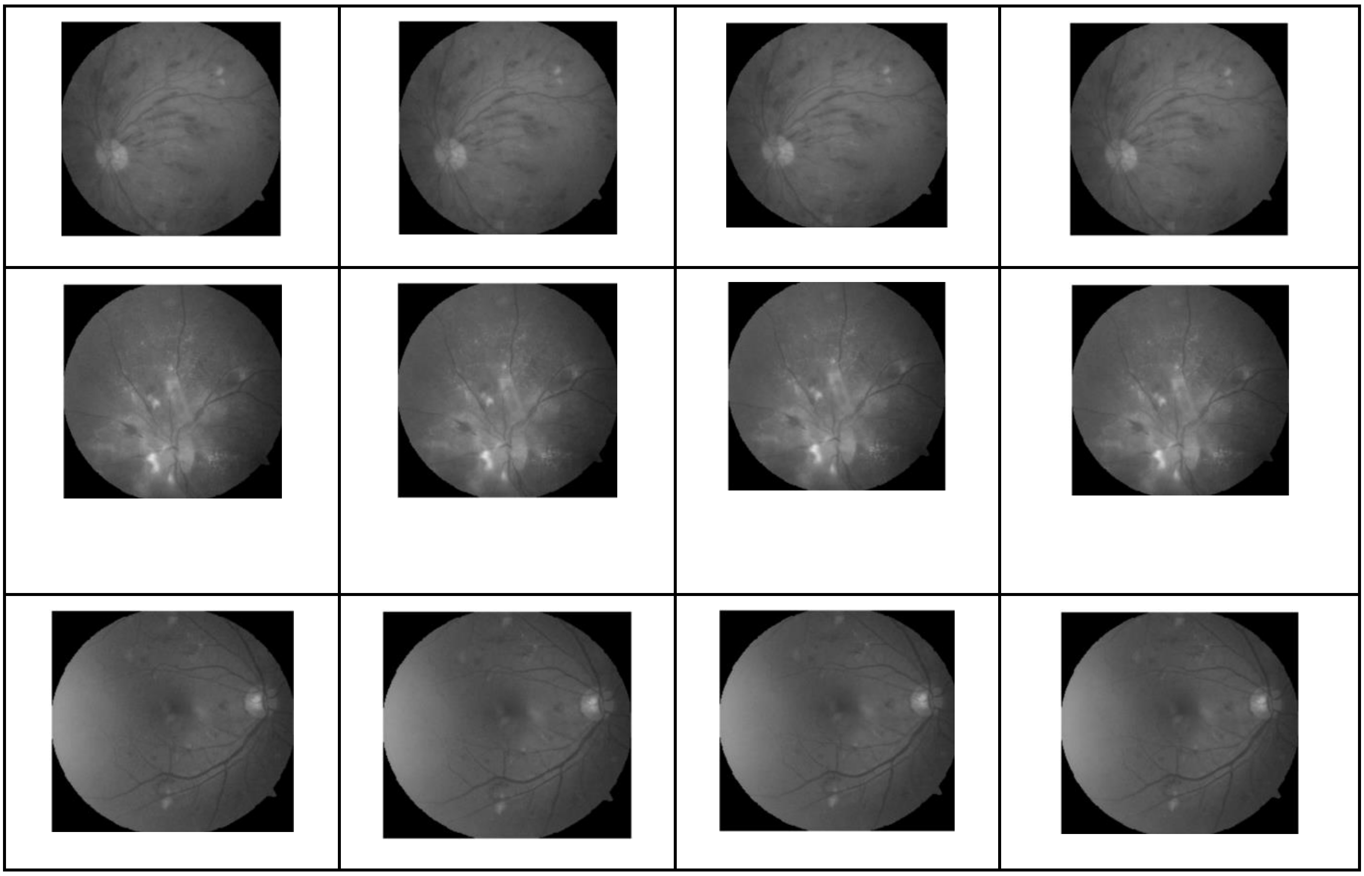
Gaussian	**Median**	**Wiener**	**Average**
			
			











4. Result And Discussion

In this various kinds of filtering like Gaussian filter, median filter, wiener filter, average filter is applied on the dataset to remove noise and see the performance on around 50 images to see the result. Entropy and Standard deviation has been used as a parameter to evaluate the quality of original image with the filtered image. From the result shown in table 3 it is clearly indicated that there is a significant change in the standard deviation and entropy values. For No Diabetic retinopathy few images were collected, for which the value of standard deviation was 42.5703, 42.0115, 38.3365, 36.5228, 25.3841, 33.2681, 42.5886, 31.668, 15.63, 20.413, 17.5645, 14.2656 and entropy was 5.7912, 5.8331, 5.5456, 5.7192, 5.7192, 5.1782, 5.4262, 5.1777, 5.5013, 5.5013, 4.6221, 4.5373, 4.7171, and 3.7005 respectively. When gaussian filter were applied on no DPR images the value of standard deviation came as 42.5395, 41.9657,38.2731, 36.4758, 25.3636, 33.2222, 42.5613,31.6413, 15.6218, 20.4058, 17.5547, 14.2556 and the entropy value for gaussian filter were 5.798, 5.8372, 5.546, 5.7208, 5.1803, 5.4269, 5.1868, 5.5085, 4.6269, 4.5414, 4.7237, 3.7031 respectively. Now median filter were applied on no DPR images the value of standard deviation came as 42.5482, 41.9539, 38.2519, 36.4567, 25.361, 33.2197, 42.5829, 31.6428, 15.6171, 20.4037, 17.5506, 14.2536 and the entropy value for median filter were 5.7814, 5.8114, 5.5182, 5.6948, 5.162, 5.4032, 5.1634, 5.4922, 4.606, 4.5178, 4.705, 3.6617 respectively. After applying wiener filter on no DPR images the value of standard deviation came as 42.542, 41.9504, 38.2422, 36.4525, 25.359, 33.2142, 42.5775, 31.6394, 15.6168, 20.4031, 17.5489, 14.253 and the entropy value for wiener filter were 5.7884, 5.8211, 5.5282, 5.7056, 5.1682, 5.4109, 5.1709, 5.4997, 4.6109, 4.5225, 4.7101, 3.6667 respectively. After average filter were applied on no DPR images the value of standard deviation came as 0.1667, 0.1643, 0.1498, 0.1428, 0.0993, 0.13, 0.1668, 0.1239, 0.0612, 0.0799, 0.0687, 0.0558 and the entropy value for average filter were 5.8029, 5.8356, 5.5406, 5.7161, 5.1785, 5.4205, 5.1861, 5.5113, 4.6268, 4.5382, 4.7259, 3.6826 respectively.

For Mild Diabetic retinopathy few images were collected, for which the value of standard deviation was 34.86510, 33.09060, 29.53540 and entropy was 5.4062, 5.4221, and 5.3041 respectively. The Gaussian filters were applied on mild DPR images the value of standard deviation came as 34.8317, 33.0603, 29.5009 and the entropy values for gaussian filters were 5.4135, 5.7445, and 5.3068 respectively. When median filters were applied on mild DPR images the value of standard deviation came as 34.8343, 33.062, 29.4961 and the entropy value for median filter was 5.3908, 5.4051, and 5.2842 respectively. Now wiener filters were applied on mild DPR images the value of standard deviation came as 34.829, 33.0566, 29.492 and the entropy value for wiener filter was 5.4002, 5.4142, and 5.292 respectively. After applying average filter on mild DPR images the value of standard deviation came as 0.1364, 0.1295, 0.1155 and the entropy value for the average filter were 5.4139, 5.4256, and 5.3026 respectively.

For moderate Diabetic retinopathy a few images were collected, for which the value of standard deviation was 33.7478, 33.20090, 43.45610, 47.43940, 14.24620, 44.42820 and entropy was 5.0595, 5.7492, 5.8047, 5.8493, 4.8001, and 5.7305 respectively. When Gaussian filters were applied on moderate DPR images the value of standard deviation came as 33.7241, 33.1823, 43.4371, 47.4108, 14.2382, 44.404 and the entropy values for gaussian filters were 5.0676, 5.7571, 5.8167, 5.8597, 4.8038, 5.7445 respectively. Now median filters were applied on moderate DPR images the value of standard deviation came as 33.7333, 33.1887, 43.4508, 47.4316, 14.2346, 44.4226 and the entropy value for median filter was 5.0454, 5.7388, 5.8012, 5.846, 4.7876, and 5.7261 respectively. After that wiener filters were applied on moderate DPR images the value of standard deviation came as 33.7288, 33.1862, 43.4444, 47.4241, 14.2353, 44.4162 and the entropy value for wiener filter was 5.0513, 5.7457, 5.8097, 5.8538, 4.7912, and 5.7358 respectively. Finally, when average filter were applied on moderate DPR images the value of standard deviation came as 0.1321, 0.13, 0.1702, 0.1858, 0.0558, 0.174 and the entropy value for the average filter were 5.0679, 5.7567, 5.826, 5.8666, 4.80065.7538 respectively.

For severe Diabetic retinopathy a few images were collected, for which the value of standard deviation was 43.85220, 39.22950, 52.18920, 14.88180, 35.86220 and entropy was 5.5536, 5.5082, 5.9976, 4.3847, and 5.2574 respectively. When gaussian filters were applied on severe DPR images the value of standard deviation came as 43.829, 39.1956, 52.1405, 14.8745, 35.8313 and the entropy values for gaussian filters were 5.5668, 5.5127, 6.0046, 4.3889, and 5.2621 respectively. After that median filters were applied on severe DPR images the value of standard deviation came as 43.8474, 39.1954, 52.1530, 14.8707, 35.8363 and the entropy value for median filter was 5.5471, 5.4887, 5.9860, 4.3682, and 5.2402 respectively. Now wiener filters were applied on severe DPR images the value of standard deviation came as 43.8402, 39.1887, 52.1351, 14.8709, 35.8302 and the entropy value for wiener filter was 5.5555, 5.4971, 5.9948, 4.3723, and 5.247 respectively. Finally when average filters were applied on severe DPR images the value of standard deviation came as 0.1718, 0.1535, 0.2042, 0.0582, 0.1403 and the entropy value for the average filter was 5.5729, 5.5114. 6.0084, 4.3873, 5.2611 respectively.

For very severe Diabetic retinopathy few images were collected, for which the value of standard deviation was 46.36130, 47.19230, 44.33790, 37.70480, 41.87820, 38.95340 and entropy was 5.7492, 6.1904, 5.6893, 5.6222, 6.1012, 5.861 respectively. When Gaussian filters were applied on severe DPR images the value of standard deviation came as 46.3443, 47.1457, 44.2948, 37.6659, 41.8428,38.9053 and the entropy values for gaussian filters were 5.7529, 6.1974, 5.696, 5.6254, 6.1046, 5.8646 respectively. After that median filters were applied on severe DPR images the value of standard deviation came as 46.3479, 47.1598, 44.3061, 37.6578, 41.8378, 38.9104 and the entropy value for median filter was 5.7463, 6.1792, 5.6744, 5.6035, 6.0865, and 5.8455 respectively. Now when wiener filters were applied on severe DPR images the value of standard deviation came as 46.345, 47.1497, 44.2979, 37.6538, 41.8300, 38.9041 and the entropy value for wiener filter was 5.749, 6.1881, 5.683, 5.6119, 6.0962, and 5.8534 respectively. After that when average filters were applied on severe DPR images the value of standard deviation came as 0.1816, 0.1847, 0.1735, 0.1475, 0.1639, 0.1523 and the entropy value for the average filter was 5.7563, 6.195, 5.6986, 5.6241, 6.10105.8603 respectively.

From the analysis, it has been observed that the entropy value of Gaussian filters has been significantly increased in all the cases keeping Standard deviation nearly constant which has proven that Gaussian filtering gives better results in comparison to other values.

Table 3: Entropy and Standard deviation for gray image Vs. different filters

NO DR										
Sno.	**Gray Image**		**Gaussian Filter**		**Median Filter**		**Wiener Filter**		**Average Filter**	
	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy
1	42.5703	5.7912	42.5395	5.798	42.5482	5.7814	42.542	5.7884	0.1667	5.8029
2.	42.0115	5.8331	41.9657	5.8372	41.9539	5.8114	41.9504	5.8211	0.1643	5.8356
3.	38.3365	5.5456	38.2731	5.546	38.2519	5.5182	38.2422	5.5282	0.1498	5.5406
4.	36.5228	5.7192	36.4758	5.7208	36.4567	5.6948	36.4525	5.7056	0.1428	5.7161
5.	25.3841	5.1782	25.3636	5.1803	25.361	5.162	25.359	5.1682	0.0993	5.1785
6.	33.2681	5.4262	33.2222	5.4269	33.2197	5.4032	33.2142	5.4109	0.13	5.4205
7.	42.5886	5.1777	42.5613	5.1868	42.5829	5.1634	42.5775	5.1709	0.1668	5.1861
8.	31.668	5.5013	31.6413	5.5085	31.6428	5.4922	31.6394	5.4997	0.1239	5.5113
9.	15.63	4.6221	15.6218	4.6269	15.6171	4.606	15.6168	4.6109	0.0612	4.6268
10.	20.413	4.5373	20.4058	4.5414	20.4037	4.5178	20.4031	4.5225	0.0799	4.5382
11.	17.5645	4.7171	17.5547	4.7237	17.5506	4.705	17.5489	4.7101	0.0687	4.7259
12.	14.2656	3.7005	14.2556	3.7031	14.2536	3.6617	14.253	3.6667	0.0558	3.6826
Mild DPR										
Sno.	**Gray Image**		**Gaussian Filter**		**Median Filter**		**Wiener Filter**		**Average Filter**	
	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy

1.	34.86510	5.4062	34.8317	5.4135	34.8343	5.3908	34.829	5.4002	0.1364	5.4139
2.	33.09060	5.4221	33.0603	5.7445	33.062	5.4051	33.0566	5.4142	0.1295	5.4256
3.	29.53540	5.3041	29.5009	5.3068	29.4961	5.2842	29.492	5.2923	0.1155	5.3026
Moderate DPR										
Sno.	**Gray Image**		**Gaussian Filter**		**Median Filter**		**Wiener Filter**		**Average Filter**	
	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy
1.	33.7478	5.0595	33.7241	5.0676	33.7333	5.0454	33.7288	5.0513	0.1321	5.0679
2.	33.20090	5.7492	33.1823	5.7571	33.1887	5.7388	33.1862	5.7457	0.13	5.7567
3.	43.45610	5.8047	43.4371	5.8167	43.4508	5.8012	43.4444	5.8097	0.1702	5.826
4.	47.43940	5.8493	47.4108	5.8597	47.4316	5.846	47.4241	5.8538	0.1858	5.8666
5.	14.24620	4.8001	14.2382	4.8038	14.2346	4.7876	14.2353	4.7912	0.0558	4.8006
6.	44.42820	5.7305	44.404	5.7445	44.4226	5.7261	44.4162	5.7358	0.174	5.7538
Severe DPR										
Sno.	**Gray Image**		**Gaussian Filter**		**Median Filter**		**Wiener Filter**		**Average Filter**	
	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy
1.	43.85220	5.5536	43.829	5.5668	43.8474	5.5471	43.8402	5.5555	0.1718	5.5729
2.	39.22950	5.5082	39.1956	5.5127	39.1954	5.4887	39.1887	5.4971	0.1535	5.5114

3.	52.18920	5.9976	52.1405	6.0046	52.1530	5.9860	52.1351	5.9948	0.2042	6.0084
4.	14.88180	4.3847	14.8745	4.3889	14.8707	4.3682	14.8709	4.3723	0.0582	4.3873
5.	35.86220	5.2574	35.8313	5.2621	35.8363	5.2402	35.8302	5.247	0.1403	5.2611
Very Severe DPR										
Sno.	**Gray Image**		**Gaussian Filter**		**Median Filter**		**Wiener Filter**		**Average Filter**	
	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy	St. Dev.	Entropy
1.	46.36130	5.7492	46.3443	5.7529	46.3479	5.7463	46.345	5.749	0.1816	5.7563
2.	47.19230	6.1904	47.1457	6.1974	47.1598	6.1792	47.1497	6.1881	0.1847	6.195
3.	44.33790	5.6893	44.2948	5.696	44.3061	5.6744	44.2979	5.683	0.1735	5.6986
4.	37.70480	5.6222	37.6659	5.6254	37.6578	5.6035	37.6538	5.6119	0.1475	5.6241
5.	41.87820	6.1012	41.8428	6.1046	41.8378	6.0865	41.8300	6.0962	0.1639	6.1010
6.	38.95340	5.861	38.9053	5.8646	38.9104	5.8455	38.9041	5.8534	0.1523	5.8603

5. Conclusion

Diabetic retinopathy detection in the early stages is key to treat, control and avoid severe complications. In this paper an automated method for filtering medical images using Image filtration is proposed. Various filters were used to eliminate the noise from the original input image of various types of eye fundus images of retina and Gaussian filter has worked in the best way as it was increasing in all the cases. This has been proven by comparing entropy of original image with the Entropy and standard deviation of different types of filters that the value is comparatively remarkable with Gaussian filter. Thus the images of retinopathy has been visibly enhanced and visible to doctors and in turn it may be beneficial to ophthalmologist to diagnose the diseases more accurately and precisely.

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