# Analysis of Blood Smear Images of Sickle Cell Anaemia based on Wavelet Transform

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**Abstract:** ***Images obtained from medical imaging modalities contains high level component of noises. These noises have to be removed with the help of various noise reduction techniques in order to maintain the visual quality of the image before presenting for interpretation and disease diagnosis. Wavelet transforms are found to be an excellent tool for researchers. In the field of digital image processing, they have proved its capabilities not only in image compression and enhancement but also in image filtering applications. Wavelets are gaining popularity in biomedical image analysis applications due to its capability in image filtering without disturbing the signal characteristics. Researchers have studied and evaluated various types of filters and found that wavelet based filters perform well compared with other types of filters. In this paper wavelet based filters are used for the removal of noise from sickle cell anemia affected blood smear images.***

**Keywords:** Wavelet transform, image filtering, image denoising, wavelet based image analysis

## 1. Introduction

Wavelet transforms are found to be a very important and useful tool for researchers. Its application domain also increases gradually and now grown like a very big banyan tree raised in an open ground. The wave nature and transformation characteristics of this research tool forced scientist to use them in signal processing and image analysis applications for many years. Recently, they are proved to be one of the most powerful and commonly used research tools in medical image processing and imageology.

Wavelets are multi-resolution representation of signals and images. They can be used for decomposing the signal and image in multi-scale resolution. Various types of wavelets such as Pyramid, Haar, Daubechies, Coifelt, Meyer, Symlet etc, have been developed and implemented by many. Some of the latest trends in the field are the development of fast wavelet transform and soft thresholding etc. Wavelets are mathematical algorithms developed to convert a waveform in the time domain into a sequence of coefficients based on orthogonal basis of small finite waves called wavelets.

Fast wavelet transforms have been developed for reducing the complexity and memory requirements. Soft thresholding technique have been developed and implemented for more flexible image during analysis requirement. A comprehensive survey on wavelet based image analysis is published by Renjini and Jyothi [1]. Discrete wavelet transform is used for image processing application by Deepali Gupta and Siddhartha.C [2]. In a review work done by Vinita and Shrikant used different wavelet transform methods for image de-noising [3]. Gargandeep Kour and Sharad P Singh used wavelet transform for image decomposition [4]. KP Soman and KI Rama Chandran [5] used wavelet for various applications. Wavelet transforms has been used for feature extraction by Arya Panganibhan and Noel [6].

Extensive survey on image noising and denoising technique has been published by many [7-12]. For the quality improvement of medical images, various filters are studied and implemented. The studies summarised and have been presented in [13-17]. One of the basic image processing operations performed on image is filtering. Filtering is the process mainly used by signal and image processing community for removing the noise present in the signal or image. For removing noise from images the most commonly used filters are the linear filters and non-linear filters. Linear filters mainly consist of box blurr, Hann or index, Gaussian blurr etc. Examples of nonlinear filters are median filters, morphological filters, max-min filters etc. In the field of image processing we use smoothing techniques for improving the image quality and reduce the noise content. For this purpose we use either spatial filter or temporal filters. Spatial filters can be used for both static images and motion estimation where as temporal filters are useful for dynamic images.

## 2. Theory of Wavelet Filters

Wavelets are used for representing and analysing multi resolution images. It can be used for image compression and for removing noises. It always uses time frequency relationship hence it can be used for retrieving decomposed image through synthesis at any instant of time. These filters are also used for the analysis of images. The frequency at different levels can be performed for filtering. These filters represent high frequency component, hence smoothens the image. Different types of transforms available are Fourier transform, Hilbert transform, and Wavelet transform. Wavelet transform is superior to all transforms as it gives frequency representation of raw signal at any given interval of time. Less distortion to the spectral characteristics of the denoised image distinguishes wavelet transform from other transforms. Wavelet gives a better signal representation using multi resolution analysis with balanced resolution at any time and frequency.

Different types of wavelet filters proposed in this paper are:-

### 2.1 Haar Filter

The Haar filter is the simplest of all other wavelet filters. It is a certain sequence of rescaled square-shaped function which together forms a wavelet family or basis. The advantage of Haar filter is that it is fast, memory efficient and simple transform. The disadvantage of it is that, it is not continuous and therefore not differentiable. The Haar wavelet's mother wavelet function $\Phi(t)$ can be described as

$$\Phi(t)=\begin{cases}1 & 0\le t\le \frac{1}{2}\\ -1 & \frac{1}{2}\le t\le 1\\ 0 & otherwise\end{cases} \qquad (1)$$

Its scaling function $\Phi(t)$ can be $\emptyset(t) = \begin{cases}1 & 0\le t<1\\ 0 & otherwise\end{cases}$

The plot of wavelet family basis is shown in fig 1.

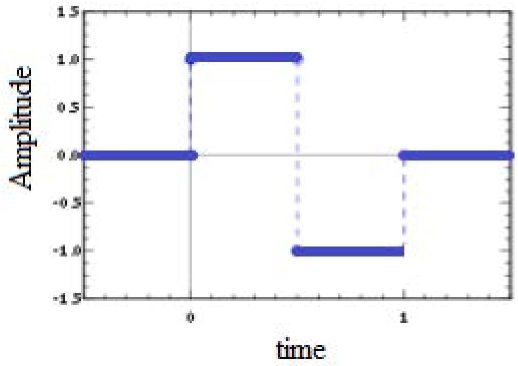



**Figure 1:** Haar Transform

### 2.2 Daubechies Filter

Daubechies wavelet transform used in this work is the most popular orthogonal wavelet in the family of wavelets. This wavelet is smoother than other wavelets due to its overlapping windows. This filter has the balanced frequency response but nonlinear phase response. It is easily adaptable to soft signals and images in terms of low frequency. This filter is characterised by a maximal number of vanishing moments for given support. The father wavelet is the scaling function which will generate a multi resolution analysis. this wavelet will have a higher number of vanishing moments. Daubenchies wavelets family is from db1-db10 are mostly used.

Different families of this filter are represented in fig 2.

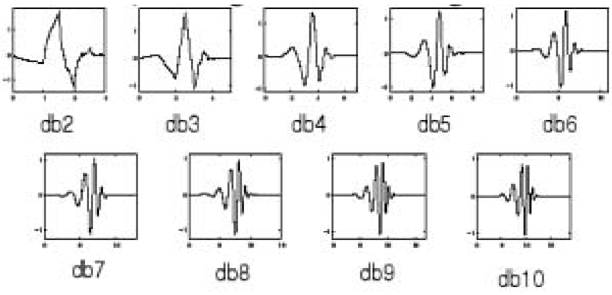



**Figure 2:** Daubechies filter families

### 2.3 Coiflet Filter

Coiflet Filter use normalized scaling function and wavelet function. The scaling function has vanishing moments. The wavelet function and scaling function is more symmetrical than that of Daubechies wavelets. Discrete and continuous wavelet transforms are possible with this filter.

### 2.4 Biorthogonal Filter

In order to gain more flexibility in the construction of wavelet bases, the orthogonality condition is changed allowing semiorthogonal, biorthogonal or non-orthogonal wavelet bases. Biorthogonal wavelets are families of compactly supported symmetric wavelets. The symmetry of the filter coefficients is often desirable since it results in linear phase of the transfer function. In the biorthogonal case, rather than having one scaling and wavelet function, there are two scaling functions that may generate different multi resolution analysis and accordingly two different wavelet functions.

## 3. Results and Discussions

Wavelets are mathematical tools which can be split up into different frequency components. Using wavelets, data can be set into different frequency components and it is possible to study them separately, with a resolution matched to different scales. The advantage of wavelet transform over Fourier transform is that it can be used in places where time and frequency information is needed at the same time. There are different types of wavelet filters such as Haar, Daubechies, Coiflet, orthogonal and non-orthogonal etc. These wavelets can be used for decomposition and denoising applications. Researchers have exploited the power and utility of wavelet transforms for many years. The use of wavelet filters removes noise while preserving the characteristics of image regardless of its frequency content. Wavelets are gaining popularity day by day in the area of biomedical image processing due to its sparsity and multi-resolution properties.

Selection of wavelet plays an important part in achieving an effective coding performance because there is no filter that performs the best for all the images. Nowadays,

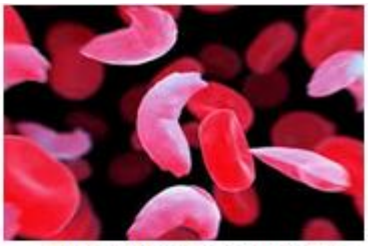
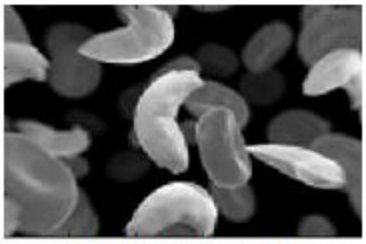
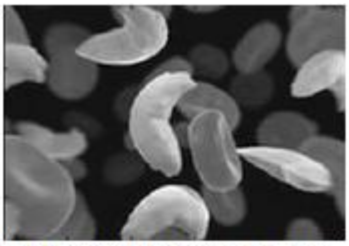
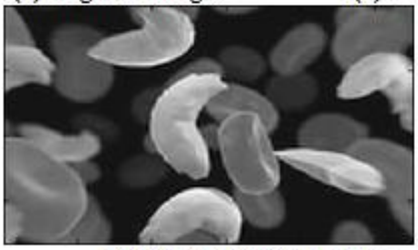
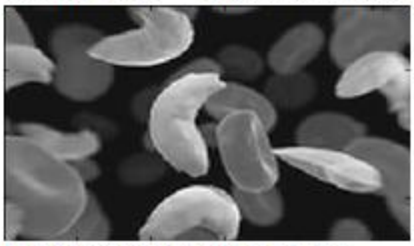




**Figure 3**(a) Original Image **3**(b) Haar Filtered image **3**(c) Daubechies Filtered image

**3**(d) Coiflet Filtered image **3**(e) Biorthogonal Filtered image

biorthogonal wavelet filters are used instead of orthogonal filters because orthogonal filters have a property of energy preservation whereas biorthogonal filters lacks it. In this paper, we have analysed the performance of various filters such as Haar, Daubechies, Coiflet and Biorthogonal filters. It is found that, for sickle cell anemia images Daubechies filters of orders 1 to 5 decomposition levels are most suitable. The results show that Daubechies $4^{th}$ order wavelet filter is most suitable and provided best results for sickle cell anemia blood smear images.

The images are acquired from different sources available. Original and synthetic images are used for differentiating the difference of using different filters mentioned in this paper. The processing of images is done with the help of MatlabR2014a.

Figure 3(a) is the synthetic image of sickle cell anemia. It is a 3 dimensional image used to show how the sickle cells appear in blood smear. Figure 3(b) is the output image of Haar filter. Figure 3(c) is the output image of Coiflet filter. Figure 3(d) is the output image of Daubechies filter and figure 3(e) is the output image of biorthogonal filter.

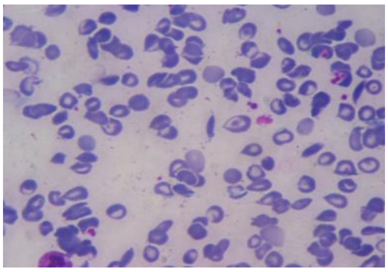
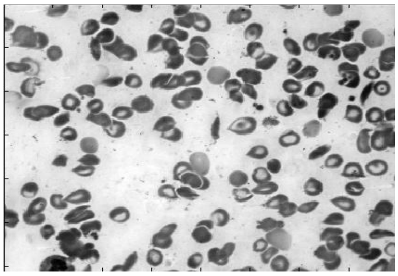
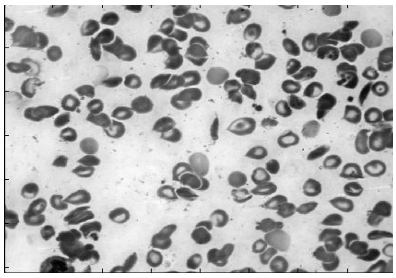




**Figure 4: (a)** Original Image **4(b)** Haar Filtered image **4(c)** Daubechies Filtered image

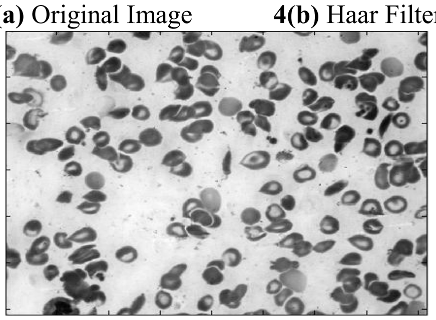
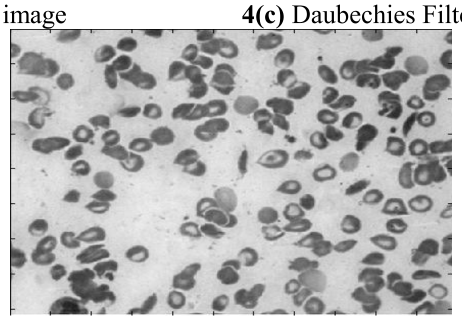



**Figure 4(d)** Coiflet Filtered image **4(e)** Biorthogonal Filtered image

Based on the performance of all the wavelet based filters used in this work, we have observed that Daubechies filter performed well and is well suited for images of sickle cell anemia. Daubenchies wavelets can be defined in the same way as the Haar wavelet transform by calculating the running averages and differences. Duabechies wavelets have balanced frequency response but nonlinear phase responses. It uses overlapping windows. Hence high frequency coefficient spectrum bound backs all high frequency variations. Because of this Daubechies wavelets are commonly used in image processing applications. Duabechies, Coiflet type of filters have special properties of more energy conservation, vanishing moments and regularity as compared to biorthogonal filters. Therefore, in this paper we have applied the above transforms of different orders to SCA images. We have compared these four transforms and found that Daubechies is the most suitable for sickle cell anemia blood images.

Table 1 is the performance evaluation of different filters used in this paper using Mean Square Error (MSE), Signal to noise ratio (SNR) and Peak Signal to noise ratio (PSNR).

**Table 1:** Comparison of different filers using the noise ratio evaluation

| Sample Image | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Haar Filter | MSE | 171.75 | 62.44 | 88.68 | 87.85 | 96.58 | 100.25 | 75.69 | 156.36 | 121.1 | 68.35 |
| | SNR | 4.68 | 11.40 | 14.61 | 14.74 | 10.2 | 15.24 | 16.78 | 10.91 | 11.87 | 14.36 |
| | PSNR | 12.87 | 13.98 | 16.19 | 16.28 | 17.11 | 10.55 | 14.36 | 9.34 | 20.85 | 11.57 |
| Daubechi-es Filter | MSE | 162.43 | 65.55 | 207.27 | 97.53 | 150 | 90.47 | 109.58 | 210.86 | 140.6 | 81.11 |
| | SNR | 3.28 | 10.84 | 12.68 | 15.16 | 16.14 | 10.88 | 7.51 | 16.45 | 13.04 | 5.39 |
| | PSNR | 11.40 | 13.54 | 15.06 | 16.95 | 10.26 | 17.59 | 11.11 | 12.87 | 14.54 | 8.94 |
| Coiflet Filter | MSE | 165.28 | 65.08 | 211.03 | 110.85 | 150.75 | 68.23 | 170.78 | 210.36 | 111.9 | 200.0 |
| | SNR | 5.27 | 10.23 | 11.30 | 13.25 | 3.25 | 14.68 | 16.45 | 11.21 | 6.54 | 12.68 |
| | PSNR | 13.40 | 12.87 | 13.70 | 15.27 | 13.58 | 10.97 | 16.22 | 12.91 | 13.01 | 10.11 |
| Biorthogonal Filter | MSE | 166.15 | 47.38 | 213.40 | 111.35 | 200.16 | 91.35 | 245.51 | 198.45 | 170.3 | 233.8 |
| | SNR | 5.04 | 12.02 | 11.97 | 12.67 | 6.21 | 10.59 | 9.10 | 4.56 | 13.73 | 9.87 |
| | PSNR | 13.30 | 14.90 | 14.34 | 14.74 | 12.68 | 13.67 | 10.78 | 14.56 | 15.84 | 13.88 |

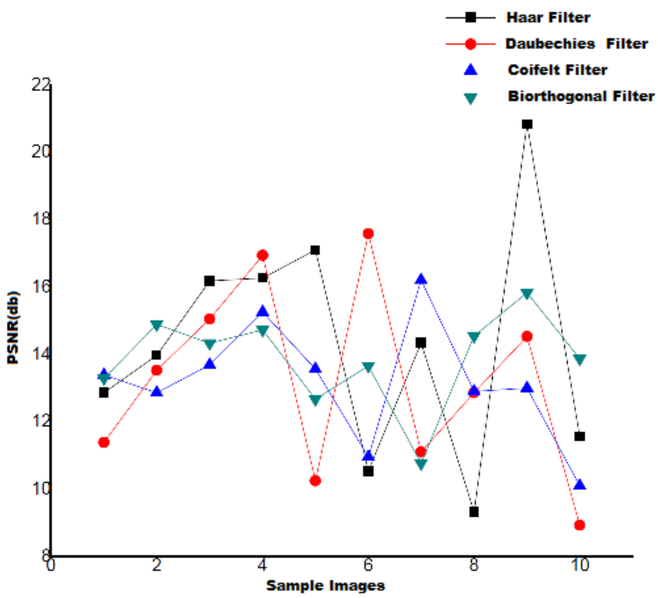



**Figure 5**: Plot of PSNR values against sample images

The plot of PSNR values of different filters versus the sample images is drawn in fig 5. This plot will be useful to identify the peak signal to noise ratio of different images.

## 4. Conclusions

Image denoising has been found to be an interesting research area for engineers. Medical professionals are also equally interested to get noiseless images for interpretation and disease diagnosis. The common interest of engineers and physicians can be fulfilled with the help of filters. However, normal filters can perform well in all images if the noise level is low. But when the noise is high they do not perform well. Wavelet transform based filters are found to be a suitable candidate and promising solution for eliminating high level noise in images. Wavelet based filters are best choice because of its characteristics such as sparsity, multi resolution and multi scale nature. Wavelet based filters provide computational advantages over other type of filters. Which type of wavelet filter is suitable for a specific application is still a question in front of the researchers today. In this paper various types of wavelet filters such as Haar, Debenchies Filter, Coiflets filter and biorthogonal filters have been studied and these filters are applied on sickle cell disease blood smear and the filtered images are obtained for further processing. In almost all the cases wavelet based filters out perform the conventional filters. In this paper, the performances of different types of wavelet filters are studied and results are obtained.

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