A Pictorial Review and an Algorithm for the Determination of Sickle Cell Anemia

Hariharan.S, Parvathy.B.H, Aruna.N.S

Abstract—Sickle cell anemia (SCA) is a heritable blood disorder which is caused by lack of red blood cells in the blood. In sickle cell anemia, red blood cell shape is changed to sickle shape or half-moon shape, which blocks the flow of blood in small blood vessels in the body. In this disease the characteristics of red blood cell will change and they become sticky and bind together. In some cases it elongates and becomes elliptical in shape. In this paper a brief pictorial review of sickle cell anemia is presented to attract the attention among researchers to work with a common goal for the elimination of this disease from this world. We have collected few SCA affected blood images and an effort is made for the analysis of these images. An algorithm is proposed to detect the presence of SCA.

Index Terms— Computer processing of Red blood corpuscles, Image processing of blood cells, Cell image analysis, Sickle cell anemia.

I. INTRODUCTION

Analyses of biomedical images are very important and very much essential for the diagnosis of diseases, treatment planning and other clinical investigations. Biomedical images can be broadly classified into two categories namely, microscopic images and macroscopic images. Analysis of the images of the first category is called microscopic image analysis whereas the analysis of the images of later type is called macroscopic image analysis. In microscopic image analysis, microscopically small objects are being considered. Cell image analysis comes in this category. Macroscopic image analysis is gaining importance day by day due to their non-invasive nature, patient comfort, painless nature, fast accurate and easy procedure etc. The output images obtained from modern imaging modalities such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasonography (USG) etc. are sufficient for the physicians to do their diagnosis. In some cases such as genetically transmitted diseases, these methods are not sufficient and we have to go for other options. Another approach for solving the above problem is to use the blood smear images and there analysis. Microscopic image analysis mainly falls under this category. Depending on the nature of the disease we have to concentrate on RBC, WBC or platelets or other components of human blood. Literature survey clearly shows several papers based on the above facts.

Diseases such as anemia, sickle cell anemia, beta-thalassemia etc. mainly concentrates on the analysis of red blood cells [1,2,3,4,5], whereas diseases such as leukaemia, leucocytosis, paediatric blood cell disease etc. mainly depends on the analysis of white blood cells[6,7,8,9,10].

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II. PICTORIAL REVIEW

In this pictorial review first of all we can visualize a colour image of a normal RBC and sickle shaped RBC. A normal RBC is spherical disc shape or biconcave in nature. Sickle cell anemia affected RBC is like half-moon shape or Sickle shape as shown in Fig 1.

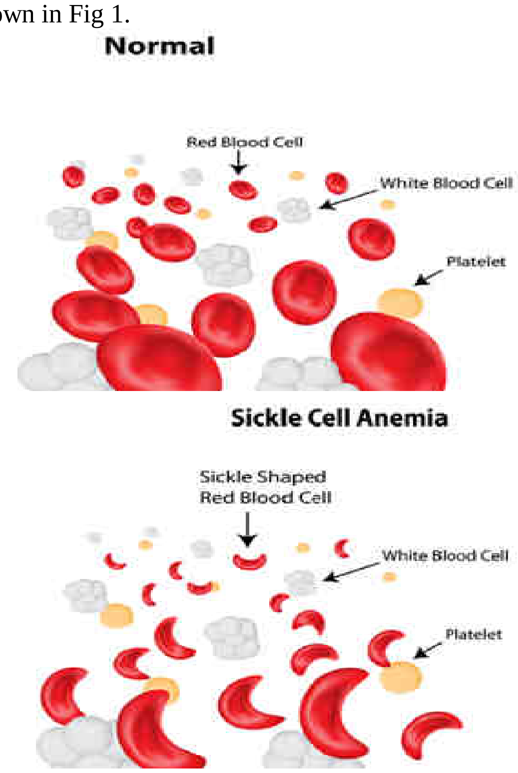

Fig 1 Comparison of normal RBC and sickle cell anemia blood cell images

Human blood mainly consists of two parts. One is the liquid part called plasma and the other one is the formed elements. The formed elements mainly consist of RBC, WBC, and platelets. These are shown in Fig1 in which the above figure shows the normal blood cell image and the other figure shows the sickle cell disease affected cells. Normal RBC got a semi concave disc shape as shown in Fig.2.

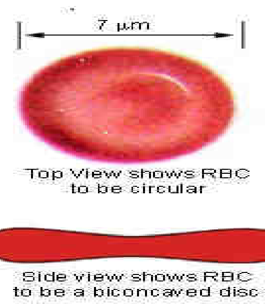

Fig 2.Plan and end view of a normal blood cell.

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In Fig. 2, a normal RBC is shown which has got a semi concave disc shape. It shows RBC's plan and end view. In a sickle cell anemia affected RBC, the shape is sickled or half-moon shape as shown in fig 2.a, 2.b, & 2.c.

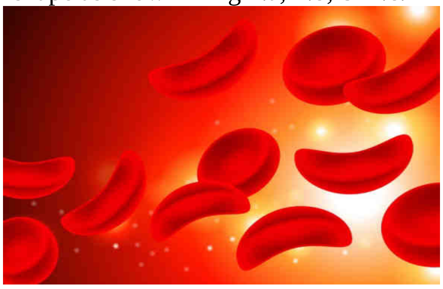

Fig 2.a. Normal and sickled RBC in blood smear

Fig 2.b. One normal and one sickled RBC

In Fig.2. a., we can see both RBC and sickle cell affected RBC. In Fig.2.b & 2.c shows one normal RBC and one SCA affected RBC in different view.

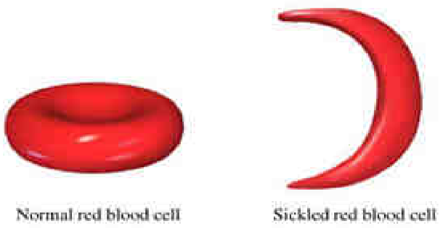

Fig 2.c. One normal and one SCA affected RBC.

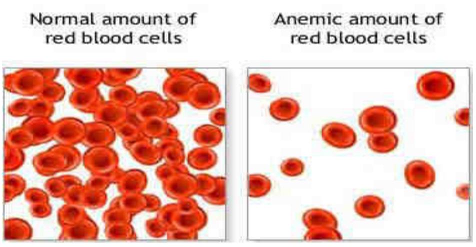

Fig 3 Normal and anemic amount of RBCs

In fig 3, a normal blood cell and anemic image is shown. Here we can see many RBC's in a unit area. In the case of SCA affected blood cell image sample, we can see a reduction in number of RBC's in the unit area. This is because the life span of RBCs will reduce from 120days to 20 days when it is affected with Sickle cell anemia.

III. METHODOLOGY

A. Segmentation

The classical image thresholding operation commonly used in image analysis is very simple and easy to perform. Hence it is not repeated in this paper. Instead we propose an adaptive thresholding method.

Image can be represented as P(i) = {R1,R2,….Rn} and $R_p \cap R_q = \Phi$; $P \neq Q$ where P(i) is the image and R1, R2….Rp…Rq…Rn represents n number of objects in the image. A partial likelihood function associated with each segment in the image is defined as $ln(\Theta_n)$.

$$ln(\Theta_n) = -\int \log Pn(g/\ \Theta_n)N_n \qquad (1)$$

Threshold value of each segment is initially selected from the peak values of the histogram. The threshold values act as the seed points. Threshold values are varied based on the partial likelihood function $ln\ (\Theta_n)$. Θ_n holds the value of mean and standard deviation of n^{th} segment. The gray value intensity which gives minimum partial likelihood function is selected as new threshold. N_n corresponds to the total number of pixels in n^{th} segment.

Segmentation is the process of partitioning an image into various components or regions. The classical segmentation process involves either thresholding, region growing, splitting and merging etc. Several modifications of the above mentioned methods are available in the literature [11, 12]. In this work we employ a simple adaptive thresholding method which is based on Shannons entropy. For the detection of sickle cell anemia affected, red blood cell segmentation technique has been used. This is followed by selection of region of interest (ROI).

B. Selecting the Region of Interest

Finding the region of interest (i.e. finding RBC) is another important task. Now a day, this is usually done manually. Human blood consists of RBC, WBC, platelets etc. It is not difficult to find a small area with RBC in high power fields of Scanning Electron Microscope (SEM). The ratio of RBC to WBC in normal blood ranges from 1000:1 or 2000:1 in adult male human beings. RBC count in adult male human beings is 4.6 to 6.2 million per mm^3 and in females 4.2 to 5.4 million per mm^3.

Sickle cell anemia can be detected by the analysis of blood smear images. If half-moon shaped RBC are seen, it shows the presence of Sickle cell anemia. Platelets are very small in size and are of the order of 2to 4 µm in diameter which are half the size of an RBC. They appear like light purple granules when stained. They can easily discarded from blood smear diagram during back ground lighting.

IV. Proposed System for Determination of SCA

The proposed system consists of step by step procedure as shown in the figure below. In this an overview of the proposed model is described. Image processing operations performed are enhancement and segmentation. The first step involves pre-processing the complete images to overcome any back-ground non uniformity due to irregular illumination. Edge detector provides image edges very clearly. The input images are then filtered with a median filter to remove noise.

This process will also eliminate the presence of noise in the input image and provide a smooth image for further processing. Pre-processing usually involves edge detection, filtering, contrast stretching, un-sharp masking etc. Edge is a very important aspect in image analysis. In this work, edge

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enhancement is performed using Sobel operators and Canny edge detector. Sobel operator is preferred over other edge detection operators due to their image smoothening characteristics. The next edge detection operator is the Canny edge detector which provides image edges very clearly. The input images are then filtered with a median filter to remove noise.

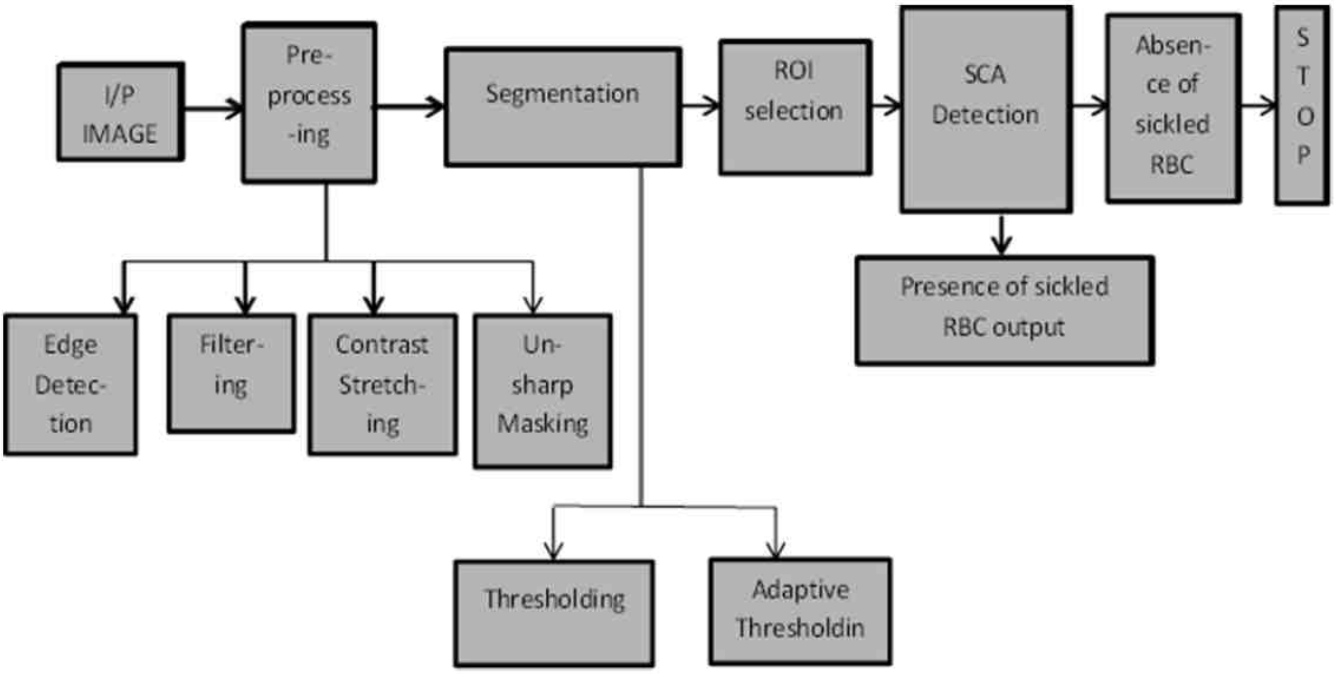

Fig.4. Block schematic of SCA detection system.

V. RESULTS AND DISCUSSION

Human visual system always concentrates on the edges where the variation in intensity is a maximum. An edge is a very important feature as far as image processing is concerned. Hence edge detection is an unavoidable operation in pattern recognition and image analysis. Edge detection is performed in the present work with the help of Canny edge detector and Sobel operator which is shown in Fig 6 and 7 are two blood smear images used as input to the system of the original image shown in fig 5. Another image shown in fig 8 has its corresponding output images obtained in Fig 9 and 10. Fig 5 is the image of a sickle cell. The edges are highlighted very well in this picture. However noise is found to be highlighted more in this picture. Fig 9 is the output image of fig 8 obtained after applying the Sobel edge detector. Here also we can see that the edge detection is performed very well and the noise is removed much more efficiently. This image output is much smoother because Sobel operator not only highlights the edges but also has got an image smoothing characteristics. Ultimately we get a smoothed image as shown in Fig 7 for fig 5. In Fig 8, colour image of a sickle cell disease affected RBC is shown. It has been grey scaled and Canny edge detector is applied and the output is shown in Fig.9. In this case edge detection is performed well and the output image obtained is shown in Fig 9. In fig 10, Sobel operator is applied on the grey scaled image and the output is shown in Fig.10.

Image Segmentation is a process of partitioning an image into its various constituents. It is a high level image processing technique usually employed in image analysis applications. It can be done in various ways such as region growing, splitting and merging, thresholding etc. In the present work for the purpose of segmentation, adaptive thresholding has been employed. Several variations of these methods have been developed and applied in various fields by the image processing researchers throughout the world.

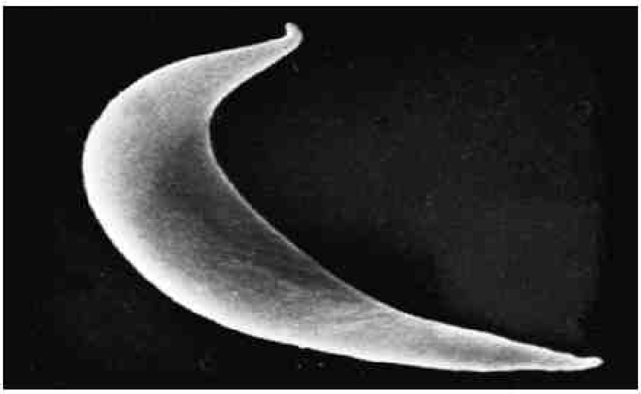

Fig.5 Sickle shaped RBC

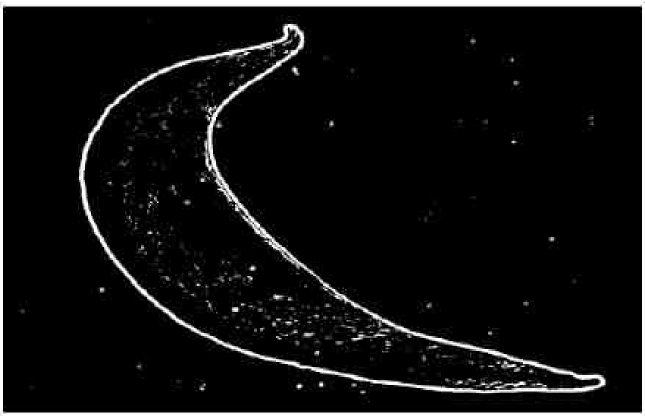

Fig 6 Edge detected with Canny operator of Sickled RBC

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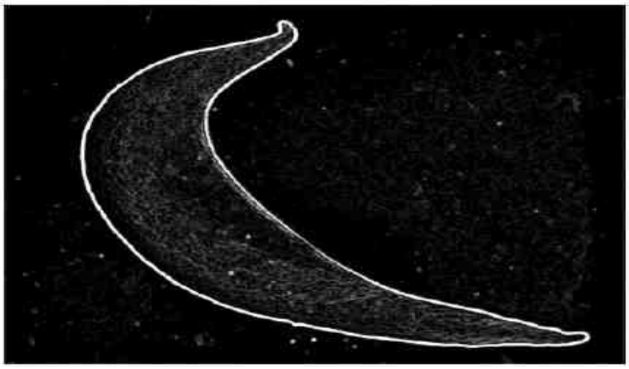

Fig.7 Edge detected with Sobel operator of Sickled RBC

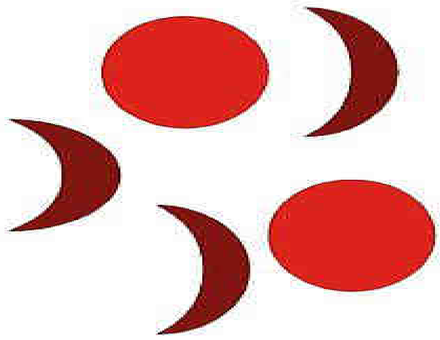

Fig 8 Colour image of RBC and Sickled RBC

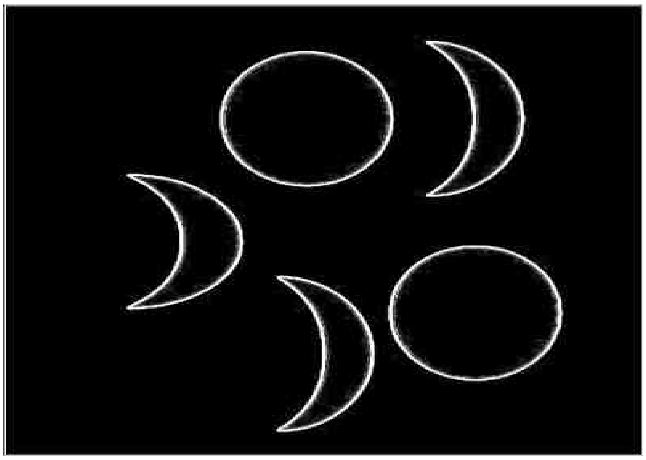

Fig.9 Edge detected with Canny operator of Fig 8

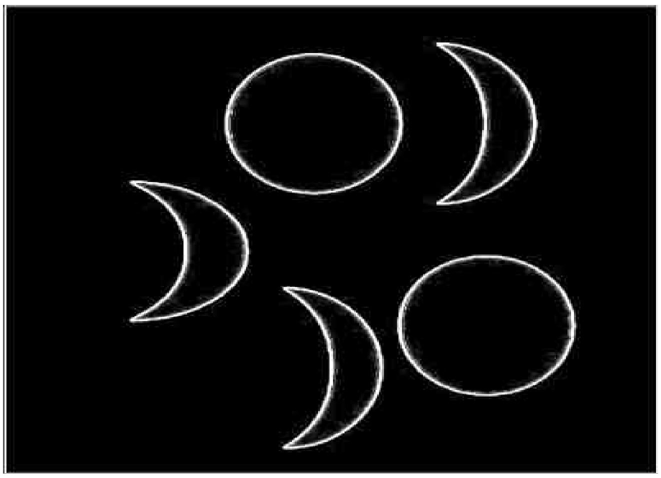

Fig.10 Edge detected with Sobel operator of Fig 8

In Fig 11, 12, 13 and 14, we have 4 SCD affected blood smear images are shown. They include the original images used for the conducting the experiments. Thresholding is done on the above figures images and the resulting output images are shown in Fig 15, 16, 17 and 18 respectively. Also grey scaling of the input images are performed and the output are shown in Fig 19, 21, 23 and 25. This is again subjected to the adaptive thresholding operation and the results are shown in Fig 20, 22, 24 and 26 respectively.

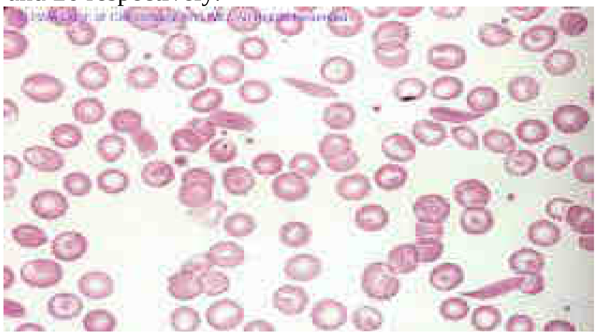

Fig. 11 Original SCA affected image(Sample1)

Fig. 12 Original SCA affected image (Sample 2)

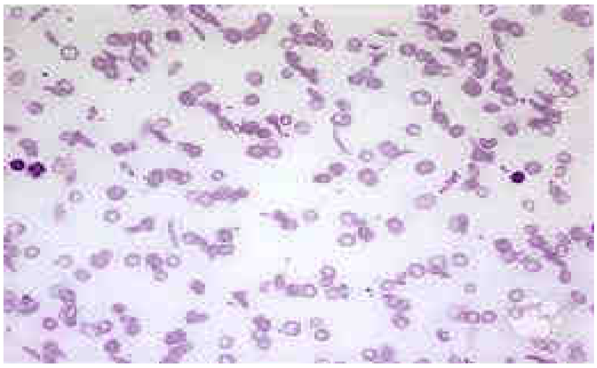

Fig.13 Original SCA affected image (Sample 3)

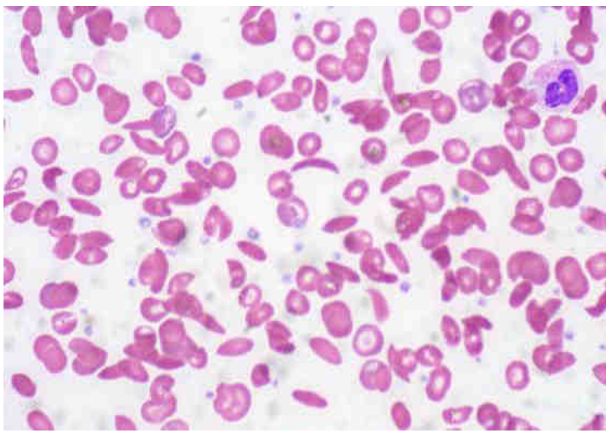

Fig.14 Original SCA affected image (Sample 4)

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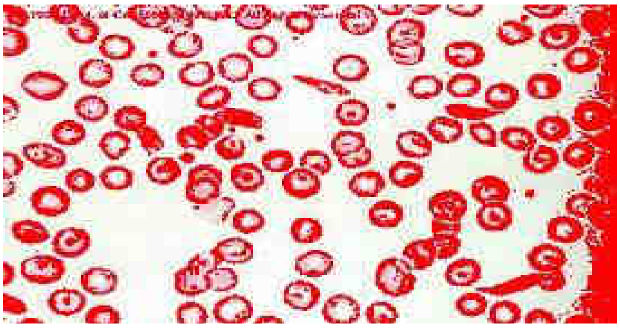

Fig. 15 Threshold image of Fig.11

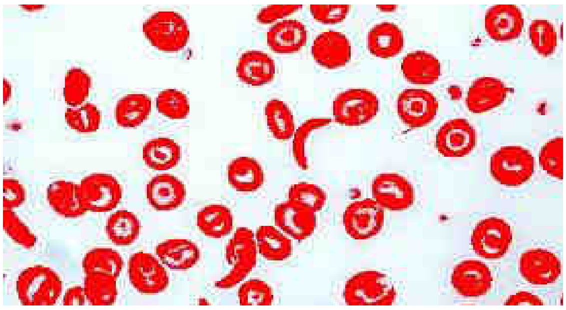

Fig.16 Threshold image of Fig.12

Fig.17 Threshold image of Fig.13

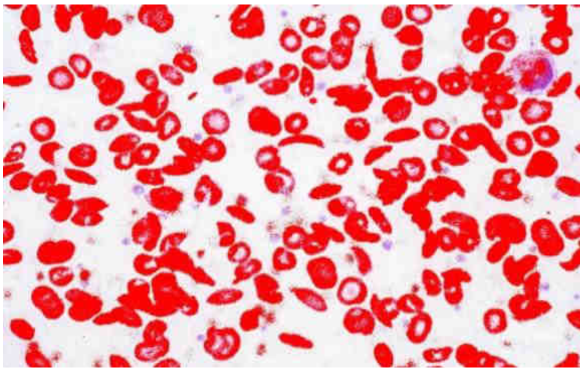

Fig.18 Threshold image of Fig.14

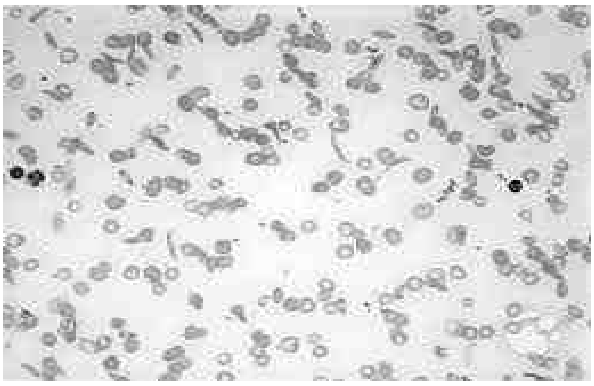

Fig. 19 Grey scale image of Fig.11

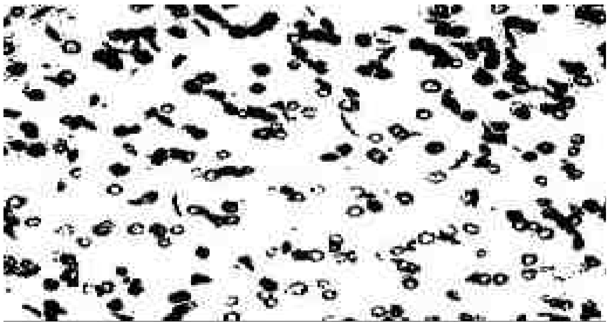

Fig.20 Threshold image of Fig.19

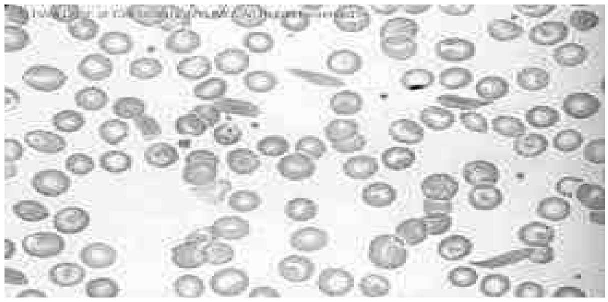

Fig.21 Grey scale image of Fig.12

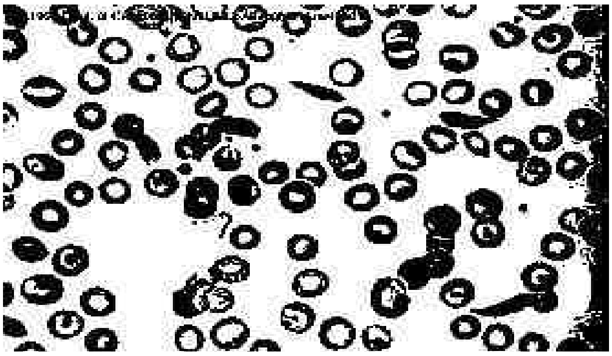

Fig. 22 Threshold image of Fig.21

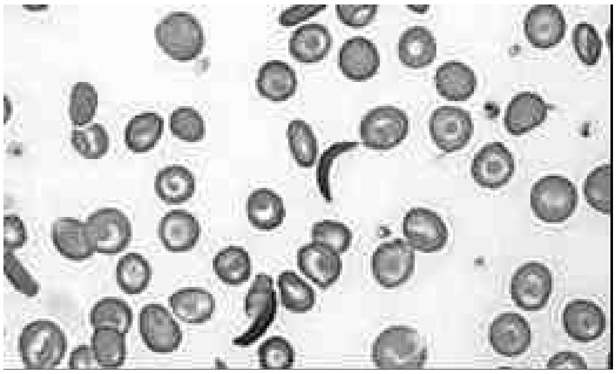

Fig. 23 Grey scale image of Fig.13

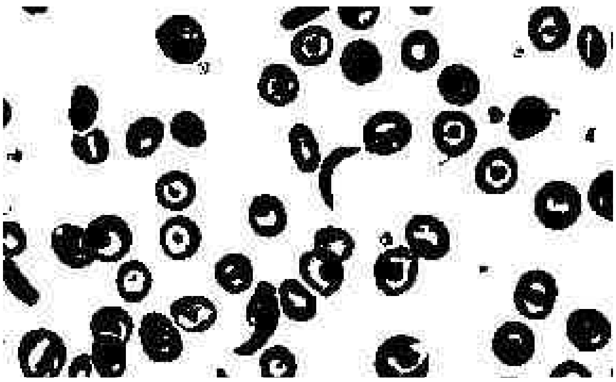

Fig. 24 Threshold image of Fig.23

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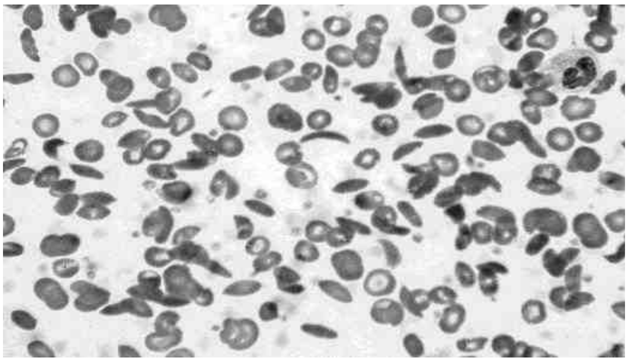

Fig 25 Grey scale image of Fig. 14

Fig 26 Threshold image of Fig.25

VII. CONCLUSION AND FUTURE SCOPE

Through this pictorial review, the authors would like to invite the attention among researchers to work with a common goal for the elimination of this disease. This disease is severely affected in many parts of the world. The works and study of sickle cell anemia are usually done manually but now computerized analysis of these images has got strong attention among researchers. In the present work a pictorial review is carried out and proposed a technique for the determination of sickle cell anemia. Various image processing techniques are implemented on these cellular images and the results are shown. The physicians, biomedical engineers and scientists are invited to take the new challenge and come to a common platform and work together for the irradiation of this dangerous disease from the world there by helping the mankind.

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