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# Studies on Watershed Segmentation for Blood Cell Images Using Different Distance Transforms

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***Abstract:*** *In Biomedical images, image segmentation is a useful process. It partitions an image into its regions or objects. There are several complex images for which effective segmentation is one of the most difficult tasks in image processing. It is possible to use different useful algorithms for such purposes. It is well known that watershed segmentation is one of the most useful and important method for binary images. They have different transform techniques like Euclidean, City block, Chess board. In the present paper Quasi-euclidean transform technique is also used for few select samples of blood smear images. The results obtained in the above four methods are present in this paper.*

***Keywords:*** *Distance transform, Image, Segmentation, Watershed transform*

## I. Introduction

In manual process, counting of blood cells (RBC) requires more time and it is difficult to analyze more number of samples within the time. To overcome this problem, various image segmentation algorithms are proposed to achieve efficient and accurate results. Analysis of an image requires prior processing of image processing, including application of various techniques [1] on the image to improve quality, remove noise and unwanted pixels and to obtain more information of the image. Moreover, during capturing of Biomedical signal or image there may be chance for inclusion of noise [2] due to human artifacts leads to loss of quality. This requires prior processing of an image will give better analysis results, and is helpful for accurate diagnosis, this is important for better treatment of the disorders of the patient.

Most of the medical images are more complex with different intensity pixels; require segmentation of pixels and clustering regions of homogeneity base characteristics of pixels like grey level, texture, intensity and other characteristics [1]. In this paper images of blood sample slides are used and this type of images consists of overlapped and un-segmented cells. The author describes the salient features of watershed segmentation technique, considering as the best and efficient for complex images. For better segmentation of binary images, different distance transform techniques like Euclidean, City block, Chess board and Quasi Euclidean are applied, evaluated and compared the performance of watershed segmentation, are also included in this paper.

## II. Watershed Transform

Watershed method is a powerful mathematical morphological tool for the image segmentation [1]. It is more popular in the fields like biomedical and medical image processing, and computer vision [3]. In geography, watershed means the ridge that divides areas drained by different river systems. If image is viewed as geological landscape, the watershed lines determine boundaries which separate image regions. The watershed transform computes catchment basins and ridgelines, where catchment basins are corresponding to image regions and ridgelines relating to region boundaries [4].

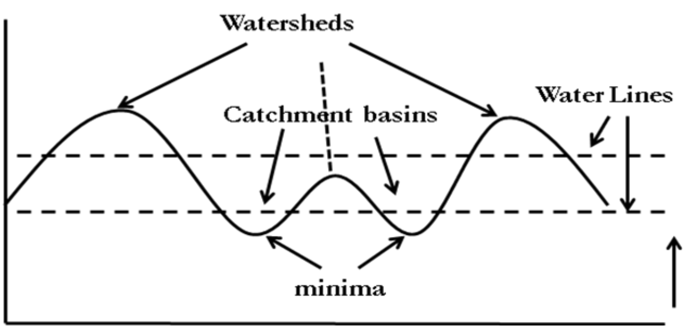


Fig.1. Watersheds and Catchment basins.

Watershed algorithms based on watershed transformation have mainly two classes. The flooding based watershed algorithms, a traditional approach and rainfalling based watershed algorithms as the second.

In traditional flooding based efficient algorithm, implementation of watershed based image segmentation approach is proposed by Luc Vincent and Pierre Soille [5], image is considered as a topographic surface as shown in the Fig.1 contains three points: (i) which indicate regional minimum, (ii) highest probability of water to fall into a single minimum region and (iii) probability of water to fall into more than one such a minimum region. For regional minimum, the groups of points satisfy second condition called watershed or catchment basin of that minimum and the groups of point satisfy third condition makes a crest line on topographic surface termed as a watershed line.

To understand this traditional concept clearly, a simple gray scale image and its topographic surface represents, the height of the topographic surface is proportional to gray level values of the given image. The maximum height of the topographic image is similar to the maximum gray level value of the image.

## III. Different Distance Transform Techniques

Watershed segmentation is a better technique for gray level images. The distance transform (DT) technique is required to be applied as a pre-process to watershed transform, when two black blobs are connected together [6] shows only one catchment basin in the topographic surface of binary image surface.

Different distance transform techniques are also used in this paper are Euclidean, city block, chess board and Quasi-Euclidean distance transform. The Euclidean distance is the straight-line distance between two pixels as shown in the Fig.2. The city block distance metric measures the path between the pixels based on a 4-connected neighbourhood. Pixels whose edges touch are 1 unit apart; pixels diagonally touching are 2 units apart as shown in the Fig.3. The chessboard distance metric measures [7] the path between the pixels based on an 8-connected neighbourhood. Pixels whose edges or corners touch are 1 unit apart as shown in the Fig.4. The Quasi-Euclidean metric measures the total Euclidean distance along a set of horizontal, vertical, and diagonal line segments as shown in the Fig.5.

The distance transforms of a binary image is the distance from every pixel of the object component which is black pixels to the nearest white pixel. In binary images there are only two gray levels 0 and 1 where 0 stand for black and 1 stands for white. The following are different ways to define the distance between two pixels $[i_1, j_1]$ and $[i_2, j_2]$ in a digital image.

Several commonly used distance transform functions [8] for image processing are:

**Euclidean**

$$d_{Euclidean}\left([i_1, j_1], [i_2, j_2]\right) = \sqrt{(i_1 - i_2)^2 + (j_1 - j_2)^2}$$

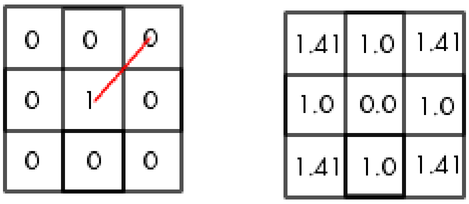


Image Distance transform

Fig.2. Euclidean distance transform

**Cityblock**

$$d_{Cityblock}\left([i_1, j_1], [i_2, j_2]\right) = |i_1 - i_2| + |j_1 - j_2|$$

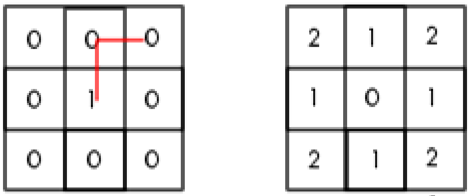


Image Distance transform

Fig.3. City block distance transform

**Chessboard**

$$d_{Chessboard}\left([i_1, j_1], [i_2, j_2]\right) = \max\left(|i_1 - i_2|, |j_1 - j_2|\right)$$

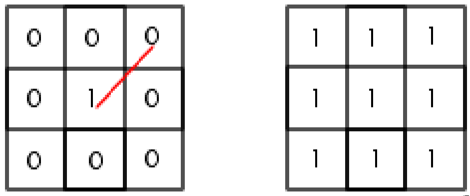


Image Distance transform

Fig.4. Chess board distance transform

**Quasi-euclidean:**

$$d_{Quasi\text{-}euclidean}([i_1, j_1], [i_2, j_2]) = \begin{cases} |i_1 - i_2| + (\sqrt{2} - 1)|j_1 - j_2|, & |i_1 - i_2| > |j_1 - j_2| \\ (\sqrt{2} - 1)|i_1 - i_2| + |j_1 - j_2|, & \text{otherwise} \end{cases}$$

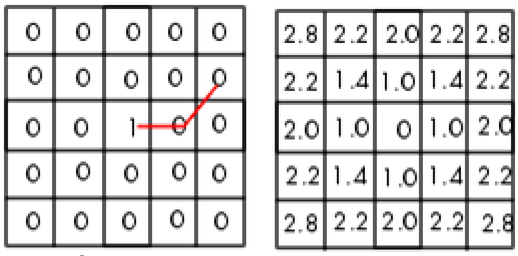


Image Distance transform

Fig.5. Quasi-Euclidean distance transform

## IV. Watershed Segmentation Comparisons For Different DTs

The watershed segmentation effects are compared with an example in this section, Fig.6 shows the gray scale and binary images and Fig.7 shows the watershed segmentation effect with different DTs for the binary image of a blood smear sample-1. The Chessboard and City block techniques, achieves the same effect among the four segmentation result can be seen apparently in the figures.

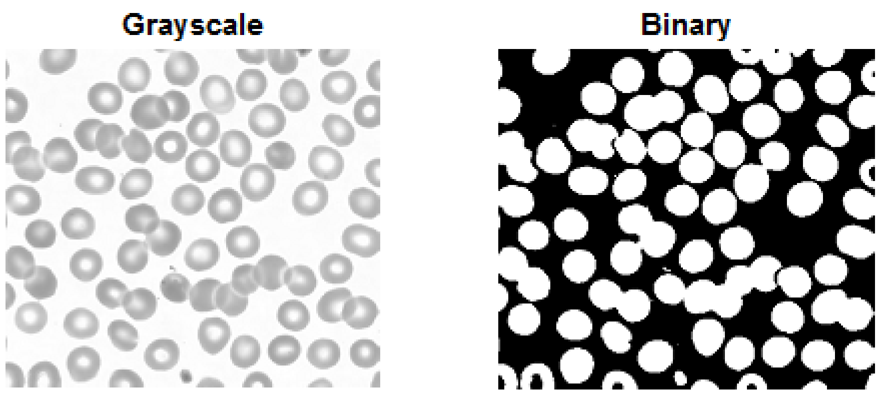


Fig 6. Original gray and binary image of the blood smear sample-1

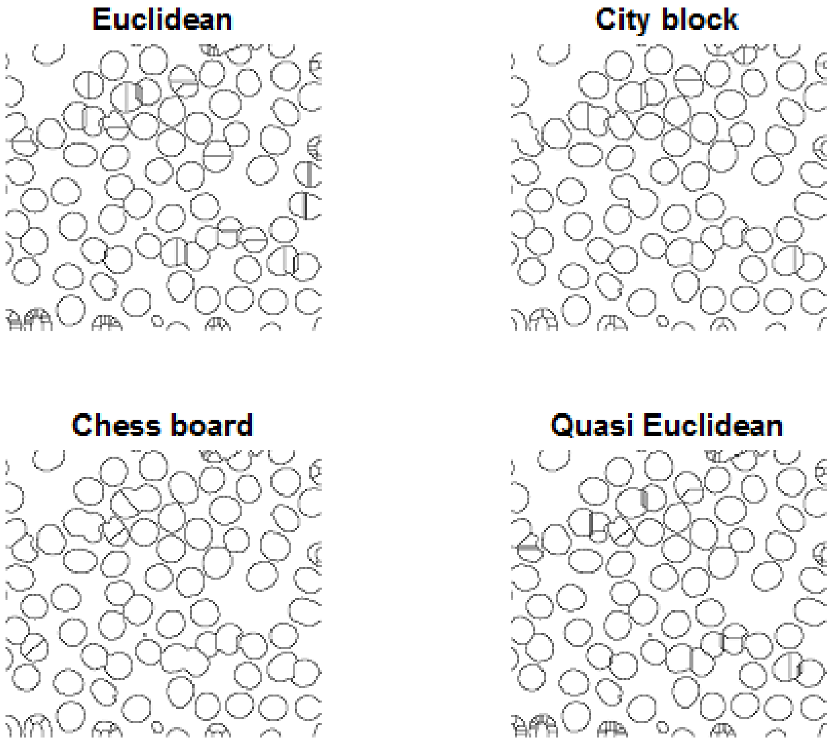


Fig 7. The watershed segmentation results for sample-1 with different DT's

## V. Results And Discussion

Different blood cell samples are analyzed using watershed segmentation with a preprocessing of distance transformation techniques applied for better and effective segmentation of clumped blood cells. Three more samples of binary images with different blood samples also provided for further proof of analysis using watershed segmentation effect with different DT functions. Fig.8 shows grayscale and binary images and Fig.9 shows the result after watershed segmentation of sample – 2. For sample – 3 grayscale and binary images are shown in Fig.10 and the resultant images are shown in Fig.11 and for sample – 4 the respective images are shown in the Fig.12-13.

Watershed segmentation using different distance transform techniques are developed to segment the cells into its individual components in the given blood smear images. Table 1 shows number of cells detected by different DT algorithms and its corresponding errors. Watershed segmentation on sample-1 image using Euclidean, City block, Quasi-euclidean and Chess board algorithms produces 81, 70, 74 and 70 cells in number respectively and its corresponding errors are 17, 1, 7 and 1 in percentage. It is observed that both City block and Chess board gives equal and low error and Euclidean and Quasi-euclidean shows over segmentation and high error. For further verification these techniques are applied on three more samples, sample-2 shows percentage of error as 9.5, 1.5, 3 and 1.5 respectively for Euclidean, City block, Quasi-euclidean and Chess board DT. Sample-3 shows percentage error as 6.9, 1.7, 3.4, -1.7 and sample - 4 shows -35.3, -23.5, -23.5 and -5.85 as percentage errors respectively for the four techniques.

**Table 1:** Number of cells (NOC) and errors produced by different DTs

| Image ID | NOC by Manual Count | NOC by Euclidean DT | NOC by Cityblock DT | NOC by Quasi Euclidean DT | NOC by Chessboard DT |
|---|---|---|---|---|---|
| Sample – 1 | 69 | 81<br>Error: +17% | 70<br>Error: +1% | 74<br>Error: +7% | 70<br>Error: +1% |
| Sample – 2 | 63 | 69<br>Error: +9.5% | 64<br>Error: +1.5% | 65<br>Error: +3% | 64<br>Error: +1.5% |
| Sample – 3 | 58 | 62<br>Error: +6.9% | 59<br>Error: +1.7% | 60<br>Error: +3.4% | 57<br>Error: -1.7% |
| Sample – 4 | 17 | 11<br>Error: -35.3% | 13<br>Error: -23.5% | 13<br>Error: -23.5% | 16<br>Error: -5.88% |

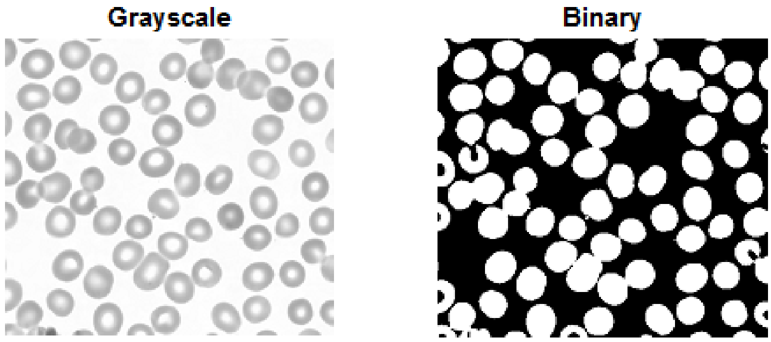


Fig 8.  Original gray and binary image of the blood smear sample-2

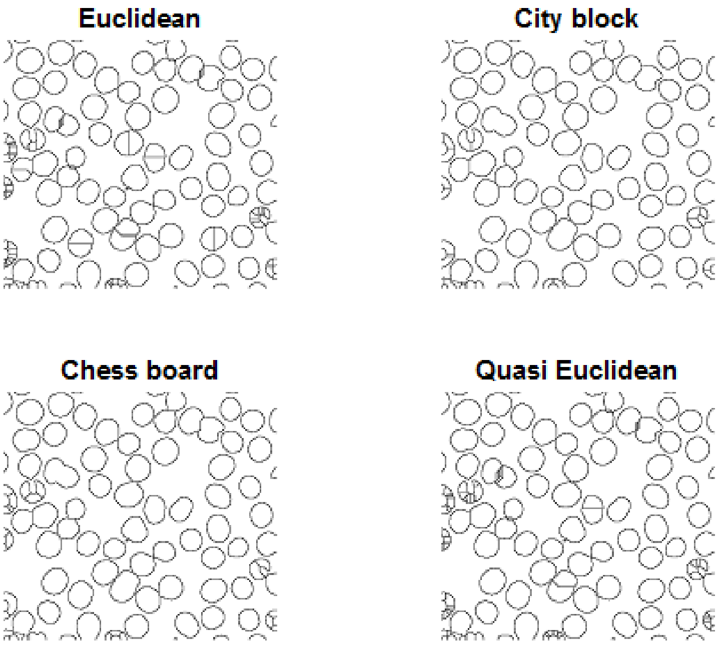


Fig 9. The watershed segmentation results for sample-2 with different DT's

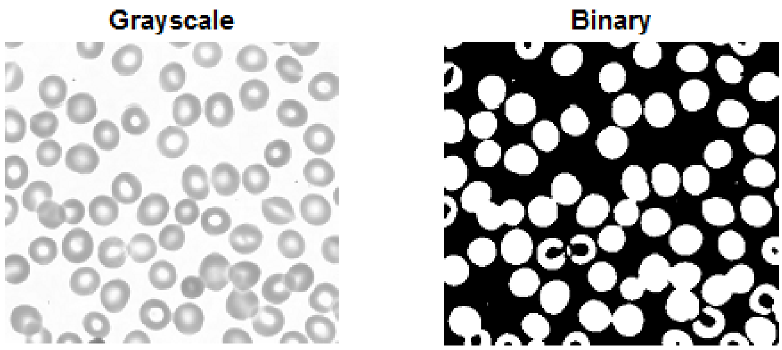


Fig 10.  Original gray and binary image of the blood smear sample-3

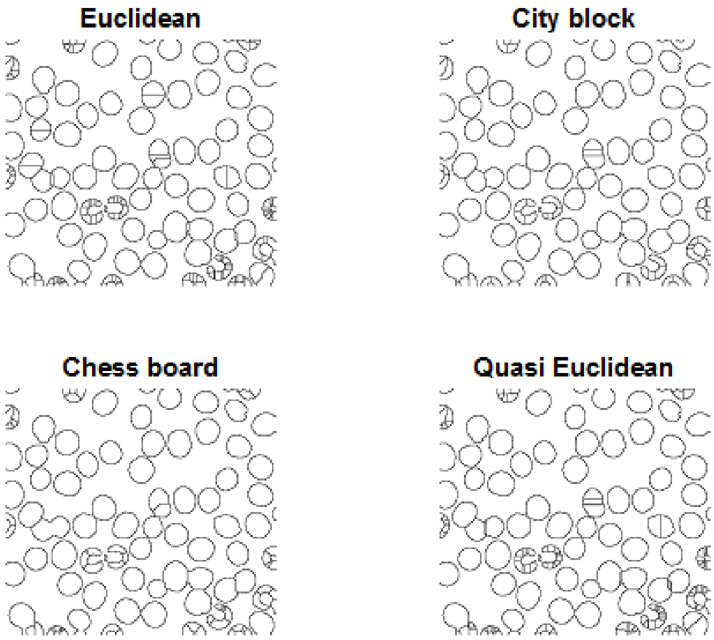


Fig 11. The watershed segmentation results for sample-3 with different DT's

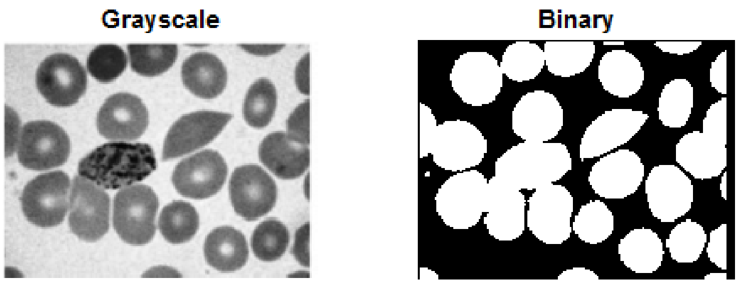


Fig 12. Original gray and binary image of the blood smear sample-4

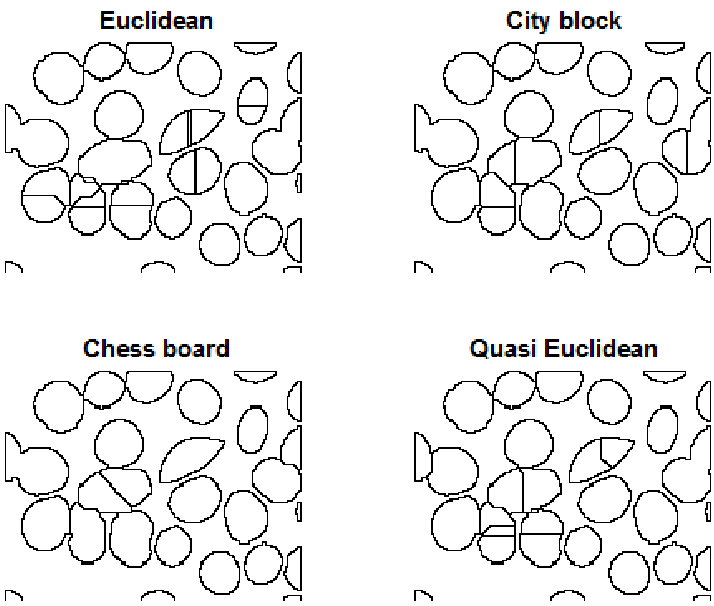


Fig 13. The watershed segmentation results for sample-4 with different DT's

## VI. Conclusion

Watershed with different DT algorithms is one of the vital methods for segmentation of cells in blood smear images. The Euclidean propagates to the neighbor pixels in the shape close to a round circle, and form a small island made of a few pixels between different components. When watershed is implemented, the small island will be treated as a separate minimum and forms the "salt and pepper" in the image [6]. City Block DT has a higher possibility of over segmentation for the components in the image, due to its propagation is to the neighborhood in the shape of diamond, and it has a very strong tendency to form multiple minima at the center area of the component where the pixels have different gray levels. When the watershed is implemented, due to the multiple minima at the center, one component will be segmented into different parts. The Quasi-Euclidean propagates through distance along a set of horizontal, vertical, and diagonal line segments. Chessboard DT has a better pruning effect due to its square shape propagation. It can effectively remove the jaggedness formed in the Euclidean DT and avoid the components over segmentation caused by City Block DT. It is observed that Chess board DT gives better detection and high performance than other methods such as Euclidean, City block and Quasi-euclidean DT. When image contains noise or irregularities Chess board DT produces over segmented results.

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