Comparison of Superpixel and Correlation Based Segmentation for Improved WBC Segmentation in Microscopic Images

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Keywords: Segmentation, Novel Superpixel Algorithm, Correlation Based Segmentation, White Blood Cells, Microscopicimage, Accuracy, Medical.

Abstract: The objective of this investigation is to refine the precision of segmentation for white blood cells (WBCs) by employing an innovative Superpixel algorithm. Additionally, the efficacy of this innovative approach will be evaluated by comparing it to the correlation-based segmentation technique. Methods and Materials: The specimens were examined using the new Superpixel Algorithm as group 1, encompassing N=10 samples, while adopting the Correlation-based method as group 2 segmentation, also comprising N=10 samples. A preliminary test power of 80%, alongside alpha and beta values of 0.05 and 0.2, respectively, were assumed, along with a 95% confidence interval. The analysis was conducted using the MATLAB software. Results: The novel Superpixel Algorithm demonstrated an accuracy of 87% in segmenting white blood cells, whereas the Correlation-based segmentation achieved 74% accuracy. A statistically significant p-value of 0.001 ($p < 0.05$, two-tailed), determined through SPSS statistical analysis, indicates a substantial disparity in the segmentation data. This difference affirms the absence of errors in the acquired data. Conclusion: The Superpixel method surpasses the correlation-based segmentation approach in terms of enhancing the accuracy of white blood cell segmentation.

1 INTRODUCTION

Accurate segmentation of white blood cells (WBCs) within microscopic images holds paramount importance in the domain of medical image analysis. This significance arises from the fact that the accuracy of the segmentation outcomes directly impacts the overall precision of subsequent analyses and diagnostic interpretations. Segmentation algorithms play a pivotal role in this procedure by delineating the target entities from the background (Alharbi et al. 2022). Various methodologies for WBC segmentation in microscopic images have been explored, including thresholding, edge detection, and region-based techniques. Among these approaches, two of the most extensively utilized methods encompass the innovative superpixel algorithm and the correlation-based segmentation (Khan and Mir 2022). The novel superpixel algorithm partitions the image into small, homogenous regions and aggregates them into larger segments, whereas the correlation-based segmentation employs the intensity correlations among pixels to effectuate image segmentation. Nonetheless, owing to the diverse dissimilarities in shape, size, edges, and positions of WBC cells, data collection can prove intricate in medical devices. Furthermore, the lighting conditions during image capture influence the extent of contrast between the background and cell boundaries (AS et al. 2013). The analysis of WBCs involves both cell segmentation and feature extraction. During the white blood cell segmentation process, leukocytes are extracted from blood smear images. This extraction endeavors to unveil distinctive attributes that facilitate their differentiation from other categories of blood cells (Mask R-CNN 2022).

A comprehensive compilation of research materials encompasses 80 papers on GitHub, 40 papers on Google Scholar, and 30 papers within the MathWorks articles repository. These publications have surfaced within the last five years and pertain to the specific research domain at hand. The compositional analysis of white blood cells imparts valuable medical insights into the patients' condition (Vickram, A. S et al 2020). The findings derived from the estimation provide crucial understanding of the patient's health status, thereby streamlining the diagnostic process. As a result, the accuracy of the algorithmic differential white blood cell count assumes a pivotal role in this context. The

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methodology frequently entails prevalent techniques like image segmentation, feature extraction, and classification to accomplish its objectives. Previous studies indicate that this leads to diminished accuracy, subsequently raising the accuracy level. To address this limitation, a comparison is made between the novel superpixel algorithm for WBC segmentation and the correlation-based segmentation (Lagerberg and Korte 2020) (Ramkumar, G. et al. 2021).

The microscopic examination of medical blood smears, encompassing the quantification of diverse types of white blood cells (WBCs), constitutes a widely employed blood test in the realm of medical hematology. Consequently, the enhancement of precision for white blood cell images within the microscopic view during the segmentation process emerges as a crucial objective. This enhancement is pursued through the integration of the innovative superpixel algorithm with correlation-based segmentation methodologies (Faried Effendy. 2022) (Nanmaran et al 2022). As observed, some of the drawbacks associated with existing techniques, such as Correlation-based segmentation, involve susceptibility to noise and artifacts in the image, potentially leading to false positives or false negatives. This approach necessitates a reference image or template, which may not be available or suitable for WBCs within microscopic images. Additionally, Correlation-based segmentation might struggle to capture the intricate shapes and structures of WBCs, resulting in inaccurate segmentation outcomes. The process is computationally demanding and may necessitate substantial time and resources for the analysis of extensive images or datasets.

The objective of this study is to surmount the limitations associated with correlation-based segmentation by implementing the super pixel algorithm. The integration of the super pixel algorithm renders the segmentation process more resilient to noise and image artifacts, thereby augmenting segmentation accuracy and conferring greater adaptability compared to correlation-based segmentation. This adaptability stems from the ability to tailor super pixel algorithms to match various image types and objects. For instance, distinct super pixel algorithms can be employed based on the size and shape of the segmented WBCs (Junaid Mir, 2022). From a broader perspective, the application of a super pixel algorithm exhibits the potential to refine the precision of white blood cell (WBC) segmentation in microscopic images, surpassing the capabilities of the correlation-based segmentation technique.

2 MATERIALS AND METHODS

This study was conducted within the Digital Image Processing Laboratory, located in the Department of Electronics and Communication Engineering at Saveetha School of Engineering, which is a part of SIMATS (Saveetha Institute of Medical and Technical Sciences), situated in Tamil Nadu, India. The central focus of this investigation was to enhance the precision of white blood cell segmentation within microscopic images. This improvement was accomplished through the incorporation of an innovative super pixel algorithm, and its performance was assessed in comparison to correlation-based segmentation. The determination of the sample size was based on findings from a prior study (Nithyaa et al. 2021). The current analysis was executed using the clinical.com platform, maintaining a statistical power of 80% with a confidence interval set at 0.86% and a threshold set at 86%. Each group consisted of a sample size of 10, resulting in an overall sample size of 20. Furthermore, all images were uniformly resized to a standard dimension of 512x512.

Super pixel Algorithm

Steps to super pixel algorithm :

- Input image
- SLIC segmentation
- DBSCAN clustering.
- Combining the diminutive and noisy super pixels.
- Segmentation followed by amalgamation of sizable and noisy super pixels.

For the purpose of obtaining merged regions, the initial clusters are combined by considering factors such as colour similarity and spatial adjacency.

Noisy super pixels with mixed colours are segmented and subsequently integrated within each of the merged regions.

Segmented image

The algorithmic steps and calculations are performed according to the equation provided below (Equation 1). The calculation of the number of pixels in the input image (N) is derived from the input image, and the number of super pixels employed for segmenting the input image (K). The segmentation output is obtained by dividing N by K.

$$S = \sqrt{N/K} \quad (1)$$

N/K gives Approximate size of each super pixel.

Correlation based segmentation

Steps to correlation-based segmentation

1. Both sequences should be loaded.
2. Codification of images.
3. The correlation procedure.

4. Determine the peak location and intensity
5. peak>threshold? If yes go to step 6, if no follow step 7.
6. The item is in the scene
7. The item is not the scene
8. What was the last object? If yes go to follow step 9, if no go back to step 3
9. Evaluation.

Table 1: The process of collecting data for the Superpixel Algorithm.

Iterations	Accuracy (%)
1	84.67
2	84.21
3	85.14
4	85.95
5	86.32
6	86.84
7	88.54
8	89.36
9	89.34
10	90.24

The correlation coefficient (ρ) acts as an indicator of both the strength and direction of the linear correlation existing between two variables, designated as x and y. The covariance (cov(x,y)) between x and y measures the degree to which these variables display concurrent fluctuations. Equation 2 is expressed as the mean value of the products of the deviations of x and y from their individual means.

$$\rho x,y = cov/(x,y)/\sigma x\ \sigma y \quad (2)$$

Where, (cov) means covariance between x & y σx, σy are variance of x & y

Data Collection: A dataset of microscopic images featuring white blood cells (WBCs) was assembled from publicly accessible sources such as medical image repositories. The selection of images aimed to encompass a diverse spectrum of WBC types and imaging conditions.

Image Pre-processing: The amassed medical microscope images underwent pre-processing procedures designed to eliminate noise, artifacts, and background details. Techniques like image denoising and image thresholding were employed for this purpose.

Segmentation Algorithms: The MATLAB environment was employed to implement both the Superpixel algorithm and the correlation-based segmentation algorithm. The Superpixel algorithm was utilized to generate Superpixels, which in turn were applied for segmenting WBCs (R. Aarthi, 2019). On the other hand, the correlation-based segmentation algorithm adopted a correlation-centric approach for the WBC segmentation process.

Evaluation Metrics: The appraisal of the effectiveness of the two algorithms encompassed the utilization of diverse metrics, encompassing accuracy, sensitivity, and specificity. These metrics were computed for each image within the dataset and were averaged across the entire dataset, furnishing a comprehensive comparative assessment of the two algorithms.

3 STATISTICAL ANALYSIS

Statistical analysis of the collected data for the segmentation of white blood cells was carried out using SPSS version 21 (Kelly Small, 2022). Within the SPSS software, the Independent Sample t-test and group statistics were calculated. In this context, sensitivity, specificity, and noise were considered as independent variables, whereas accuracy was treated as the dependent variable.

Table 2: A comparison between the Superpixel algorithm and correlation-based segmentation.

		Levene's test for equality of variances		T-test for equality of means						
		F	Sig	t	df	sig(two tailed)	Mean differences	Standard. error difference	95% confidence interval of the difference	
									lower	upper
Accuracy	Equal variances assumed	1.108	0.307	10.88	18	0.001	12.726	1.168	10.27	15.18
Accuracy	Equal variances not assumed			10.88	16.3	0.001	12.726	1.168	10.25	15.19

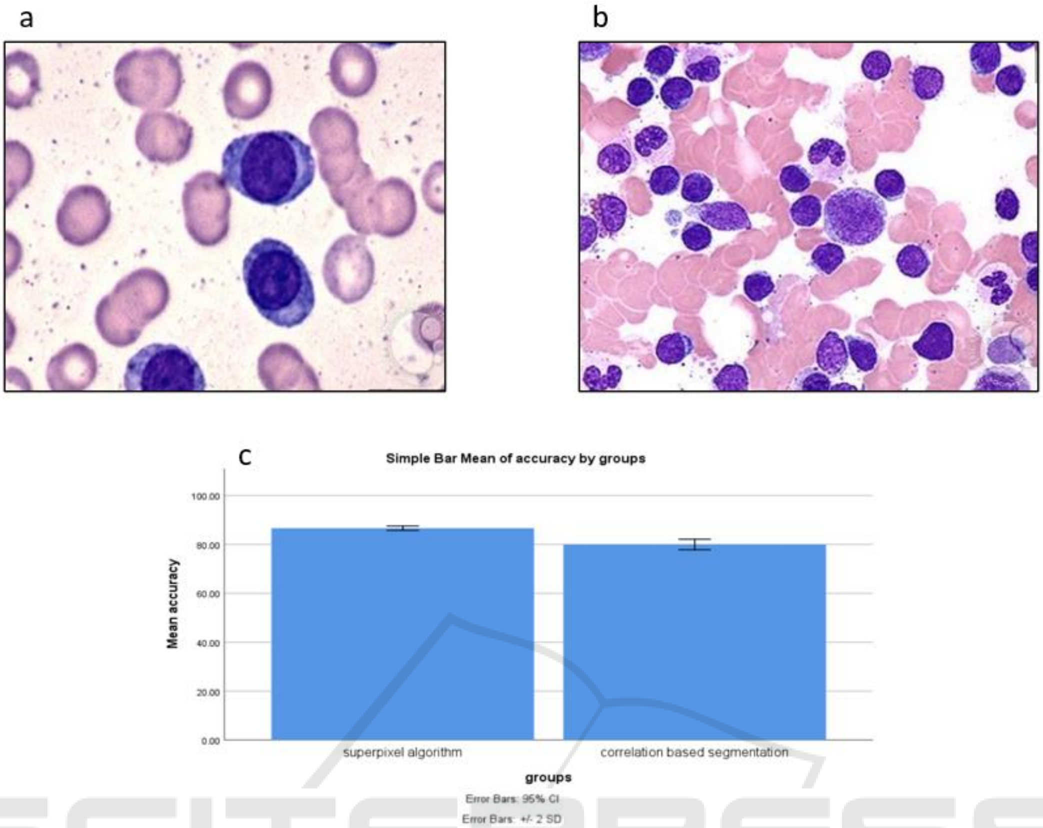

Figure 1: (a)&(b) White blood cells extracted from microscopic images (c) Mean accuracy Superpixel algorithm and the Correlation-based segmentation algorithm.

4 RESULTS

Table 1 presents the compiled data for the Superpixel Algorithm, utilizing a sample size of 10 (N = 10), pertaining to the segmentation of white blood cells through microscopic images. The results highlight notable improvements in accuracy. Table 2 exhibits the collected data concerning the Correlation-Based Segmentation Algorithm, employing a sample size of 10 (N = 10), focusing on the segmentation of white blood cells within microscopic images. Remarkably, the findings suggest comparatively diminished accuracy.

Figure 1a: White blood cells extracted from microscopic images (datasets) were obtained from blood samples for analysis. These cells were employed as input for data collection via image extraction. The resultant data encompassed counts of both Red Blood Cells (RBCs) and White Blood Cells (WBCs), along with corresponding accuracy measurements.

Figure 1b: White blood cells extracted from microscopic images (datasets) were sourced from blood samples for examination. These cells served as input for data collection through image extraction, facilitating the determination of counts for both Red Blood Cells (RBCs) and White Blood Cells (WBCs), alongside accuracy measurements.

With an impressive overall accuracy of 87.06%, this approach underscores its effectiveness in successfully segmenting white blood cells within microscopic images. It has been observed that a comparison between the Superpixel and correlation-based segmentation yields a plotted mean accuracy. The highest accuracy is attained by the Superpixel algorithm for image segmentation at 87.06%

5 DISCUSSIONS

To enhance the precision of white blood cell (WBC) segmentation in microscopic images, two methodologies were employed. In a comparative assessment with correlation-based segmentation, the Superpixel technique exhibited superior performance in enhancing segmentation accuracy, yielding an average accuracy score of 88% (Sera Tort. 2020). In the SPSS statistical analysis, the resultant data showcased a significantly lower p-value of 0.001% ($p<0.05$), indicative of its statistical significance.

Employing the Superpixel method yielded a segmentation accuracy of 87.06% for white blood cells in images, whereas the utilization of the correlation-based segmentation approach resulted in an accuracy of 74%. These outcomes distinctly underscore the superior performance of the Superpixel algorithm (Shahzad et al. 2020). With the application of the superpixel technique, the accuracy was determined to be 87.06%, signifying a 13% enhancement. Comparatively, the accuracy obtained from a different algorithm (clustering) was measured at 85% (Deshpande et al. 2022). The segmentation process, implemented through the Superpixel algorithm, exhibited a heightened accuracy of 87%, consequently bolstering precision. Regarding this research, no contradictory findings were encountered (Al-Dulaimi et al. 2021).

A limitation of this study lies in the fact that correlation-based segmentation might necessitate a substantial volume of training data to achieve precise WBC segmentation. This requirement could potentially lead to a time-consuming and costly process. Furthermore, correlation-based segmentation could encounter challenges when dealing with intricate objects, including overlapping cells or cells exhibiting irregular shapes. In contrast, super pixel algorithms might demand less training data and prove to be more time-efficient. Thus, the super pixel algorithm exhibits superiority over correlation-based segmentation (Fatichah et al. 2022).

For future endeavours, the focus is on developing algorithms that can attain high-accuracy segmentation within a reduced timeframe. The goal is to produce algorithms capable of achieving optimal accuracy levels while streamlining the time required for the segmentation process.

6 CONCLUSION

Through an evaluation of performance metrics and a comparison of two algorithms, two different techniques for calculating the accuracy of WBC segmentation were scrutinized. The results revealed that the super pixel algorithm achieved a notably higher mean accuracy of 87% in comparison to the correlation-based segmentation, which yielded a mean accuracy of 74%. Consequently, the super pixel algorithm demonstrated enhanced efficacy in enhancing image accuracy. Additionally, the standard deviation for the super pixel algorithm was determined to be 2.16385, while the correlation-based segmentation exhibited a higher standard deviation of 2.99625.

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