COMP9517 - Assignment 1
Image Thresholding Techniques Comparison Report
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Introduction

In the field of computer vision, image segmentation plays a crucial role in various applications. One common technique for image segmentation is intensity thresholding, where the goal is to separate relevant pixels (object) from the background. This report aims to compare and evaluate three thresholding techniques: Otsu thresholding, isodata thresholding, and triangle thresholding. The objective is to examine the differences in the results obtained by each technique and provide insights into when one technique may outperform the others.

Methodology

The implemented thresholding techniques utilize Python's OpenCV library for image processing operations and matplotlib for visualization. The algorithms are designed to take an input image, convert it to grayscale, compute the necessary parameters, and generate a binary segmented image based on the thresholding technique.

1. Otsu Thresholding: The Otsu thresholding technique aims to minimize intra-class variance or maximize inter-class variance of pixel values. It computes the optimal threshold by iterating through all possible threshold values and calculating the variance between the foreground and background pixels. The threshold that yields the maximum variance is chosen to segment the image.

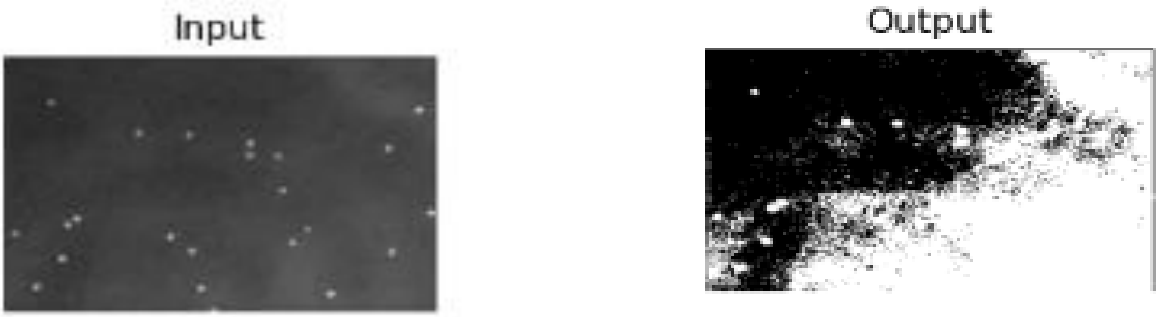
2. Isodata Thresholding: Isodata thresholding starts with an arbitrary threshold value and iteratively refines it until it converges. It calculates the mean intensity values of the resulting foreground and background pixels and updates the threshold as the mean of these means. This process continues until the threshold stabilizes.

3. Triangle Thresholding: Triangle thresholding determines the optimal threshold by analyzing the intensity histogram of the image. It constructs a straight line from the histogram peak to the extreme value (highest or lowest gray level) and identifies the gray level where the histogram deviates the most from this line. The threshold is then set based on this gray level.

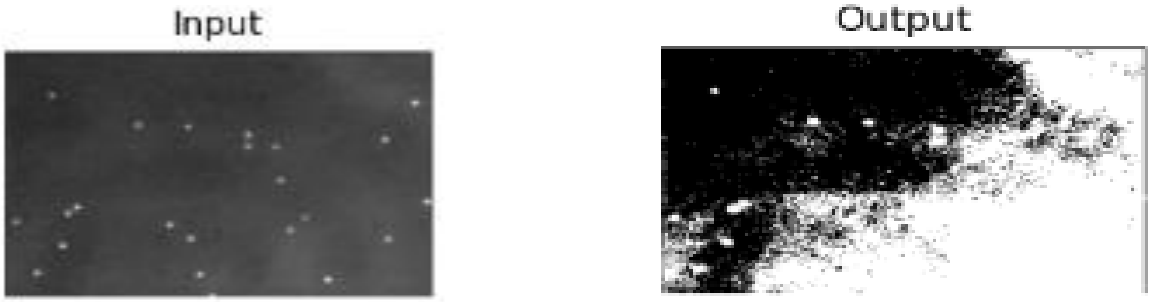
Analysis and Results

To evaluate the performance of the thresholding techniques, five sample images were used: Algae.png, CT.png, Nuclei.png, Rubik.png, and Satellite.png. The resulting binary segmented images obtained from each technique were compared visually and through the analysis of histograms.

1. Otsu Thresholding: The Otsu thresholding technique calculates the optimal threshold that minimizes the intra-class variance. In some cases, this technique may work well when the foreground and background pixel intensities are clearly separated. However, for the Algae.png image, where the object of interest has high-intensity white pixels, both Otsu and isodata thresholding techniques may struggle to differentiate between the foreground and background due to the lack of distinct intensity peaks.

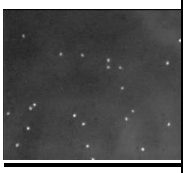
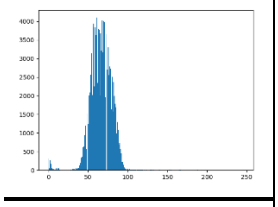
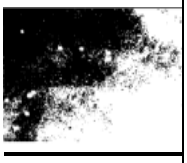
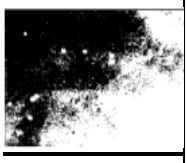
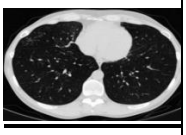
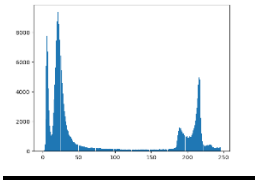
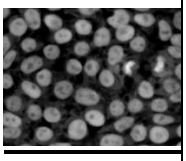
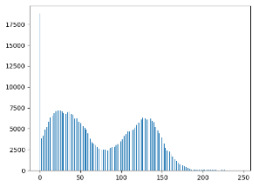
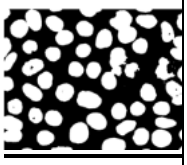
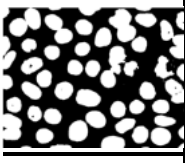
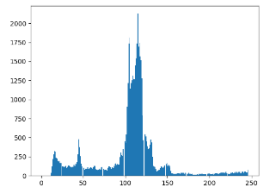
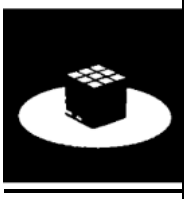
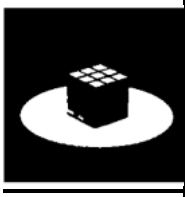
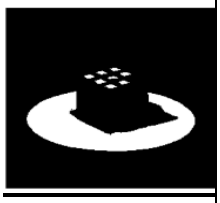
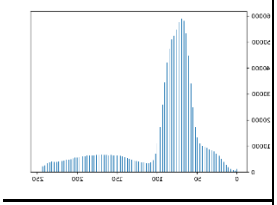


2. Isodata Thresholding: The isodata thresholding technique iteratively computes the mean intensities of the two resulting classes to find the optimal threshold. It starts with an initial threshold value and adjusts it until convergence. Isodata thresholding can handle images with varying intensities, but it may require more iterations to converge. In the case of Algae.png, the isodata thresholding technique, like Otsu thresholding, may not be able to accurately segment the object due to the lack of distinct intensity peaks.



3. Triangle Thresholding: The triangle thresholding technique computes the optimal threshold based on the intensity histogram of the image. It calculates a straight line from the peak of the histogram to the extreme value and determines the gray level with the greatest deviation from this line. This technique can handle flipped histograms and is less sensitive to outliers. For the Algae.png image, where the object has distinct pixels, the triangle thresholding technique may perform better compared to Otsu and isodata thresholding, as it focuses on the deviation from the line rather than the overall distribution.

Comparison Chart

Image	Input Image	Histogram	Otsu Thresholding	Isodata Thresholding	Triangle Thresholding
Algae.png					
CT.png					
Nuclei.png					
Rubik.png					
Satellite.png					

Conclusion

In conclusion, the implemented thresholding techniques, namely Otsu thresholding, isodata thresholding, and triangle thresholding, provided different results depending on the characteristics of the input images. Otsu thresholding excelled in cases where images had distinct bimodal intensity distributions and well-separated foreground and background pixels. Isodata thresholding performed better for images with slightly overlapping intensity distributions and less distinct peaks. Triangle thresholding demonstrated effectiveness when images had skewed intensity distributions towards high or low gray levels.

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