Module 6: Critical Thinking

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Critical Thinking 6

The goal of this assignment was to apply image segmentation using adaptive thresholding, which takes an image and separates it into labelled regions according to pixel intensity. This is an important step in a number of computer vision tasks, such as object detection and image analysis in which bringing the data down into meaningful regions or objects is important. Adaptive thresholding helps overcome the traditional thresholding level limitations by taking advantage of and adapting the threshold based on the local characteristics of the image. So in the majority of cases, adaptive thresholding can perform better due to illumination effects that create challenges for total image thresholding.

Adaptive Thresholding

Thresholding is a way to convert an image to binary (white / black) based on the pixel intensity level. In global thresholding, there is one threshold value for the entire image. This is a simple process, but it is not always effective in images where there is uneven lighting because a threshold value that works well in some regions of the image may not work well in others. Adaptive thresholding assigns one threshold value to each pixel and is based on the local neighborhood of each pixel. This way there is a thresholding calculation that is adapted to the local lighting conditions in the image. The adaptive thresholding algorithm adjusts to this by using the parameter “blockSize" which determines the size of the local region around each pixel from which the threshold value was calculated. Also, the constant “C" is subtracted from the calculated threshold and it is used to control the strictness of the segmentation. With regard to blockSize, in general, the larger the blockSize, the smoother the segmentation will be. The smaller the blockSize, the more local detail captured (OpenCV Documentation, 2025).

Code

Three images were selected for this assignment: an indoor scene, an outdoor scene, and a close-up of an individual object. These were selected to illustrate the performance of

adaptive thresholding under different lighting conditions and image complexities. The images were processed using Python and OpenCV, which includes implementations of both Gaussian adaptive thresholding and Mean adaptive thresholding (Buhl, N., 2023, September 12).

In Gaussian adaptive thresholding, the threshold for a pixel is calculated as the weighted mean of the values of its neighborhood where the weight is a Gaussian function. It is more sensitive to the local intensity gradient of the image and appropriate for images having smooth lighting changes.

On the other hand, Mean adaptive thresholding determines each pixel's threshold as the mean intensity of the pixels within its local neighborhood. It tends to be more uniform and less affected by extreme intensity variations.

The blockSize was 21, which is a nice size for capturing local intensity variation, and the constant C was 3. This constant provides a way to fine-tune the thresholding to get the segmentation just right so that it doesn't over- or under-segment.

Results

The difference when applying Gaussian and Mean adaptive thresholding techniques were similar but distinct. Although in the indoor scene, both methods could emphasize regions of fixed intensity, Gaussian thresholding produced a smoother result. The outdoor scene, which had more dramatic differences in illumination, was well-handled by both methods, but the Mean approach appeared to have greater intensity on edges.

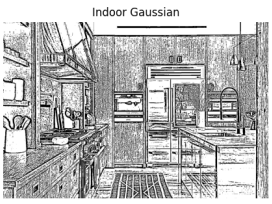
Close-up image was toughest. For this photo, both methods were short on holding minute detail owing to the relatively low object-to-background contrast. The Mean adaptive thresholding method was able to pick up only a small section of the background lighting while the Gaussian Method did not at all.

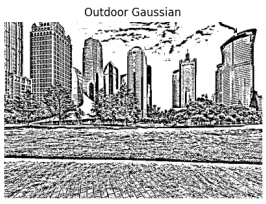
Overall, the Gaussian adaptive thresholding method fared better in images with more fluid transitions of lighting, such as the outdoor scene, while Mean adaptive thresholding was more consistent in outlining regions with subtle lighting differences.

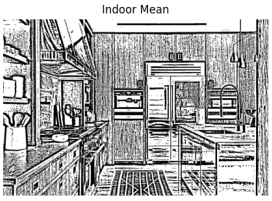
Conclusion

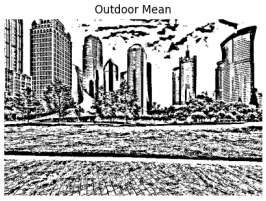
Mean and Gaussian adaptive thresholding approaches worked well for thresholding images with non-uniform lighting conditions, although with each having its strengths and weaknesses. Gaussian thresholding was particularly beneficial in images that have continuous, uniform lighting variations, while Mean thresholding was more appropriate for more uniform images with fewer extreme intensity variations.

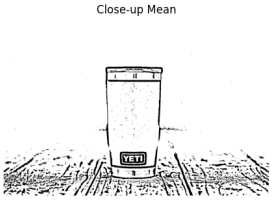
Successful Execution











References

Buhl, N., (2023, September 12) *Image Thresholding in Image Processing.* Encord. https://encord.com/blog/image-thresholding-image-processing

OpenCV Documentation, (2025) *Image Thresholding.* OpenCV. https://docs.opencv.org/4.x/d7/d4d/tutorial_py_thresholding.html