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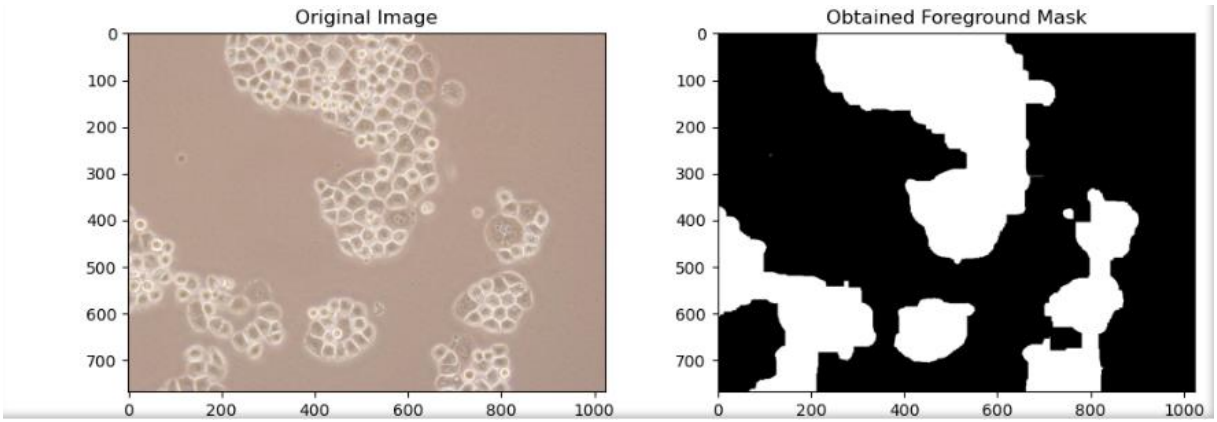
HW1

Image Preprocess

The input to the image_process(im) function is an image (im). This function transforms the image into a grayscale and blurred version. The operations of grayscale conversion and blurring were employed to reduce noise in the image and enhance details. These operations were carried out using the cv2.GaussianBlur and enhance_contrast functions. The contrast intensity in enhance_contrast was adjusted using a disk, specifically selecting a disk size of 3 for optimal results. A pixel area of 3x3 was chosen for the blur effect, as smaller values tend to yield better outcomes. The value of 0 ensures that the standard deviation is automatically determined.

PART 1

In the ObtainGroundMask function, the processed image was utilized to generate a pixel mask based on the specified threshold value in the threshold function. The pixel values were segmented into 0 (black) and 1 (white). Using cv2.THRESH_BINARY_INV + cv2.THRESH_OTSU, we controlled the threshold value and type of the segmentation. The cv2.THRESH_BINARY_INV parameter facilitated the generation of an inverted mask following thresholding. The cv2.THRESH_OTSU parameter enabled automatic determination of the threshold value. By applying mask = 1 - mask, the resulting mask underwent inversion, effectively swapping black and white values. A structuring element named kernel was created with dimensions of 32x32, containing all ones. This selection of kernel size was made based on achieving optimal results. Subsequently, morphological closure was applied to the masked image using the specified kernel. Morphological closure operations serve to homogeneously fill small holes in the mask, as well as close and enlarge small objects.



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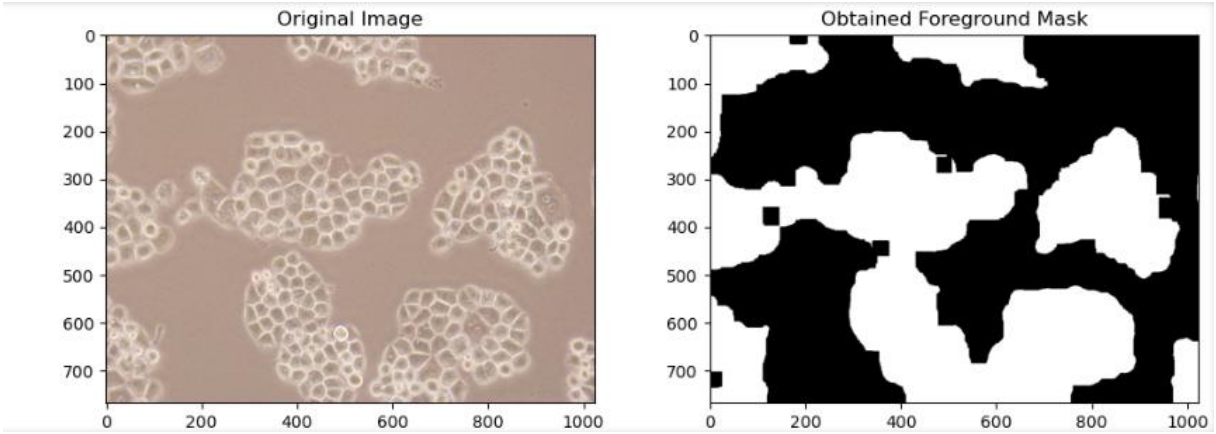

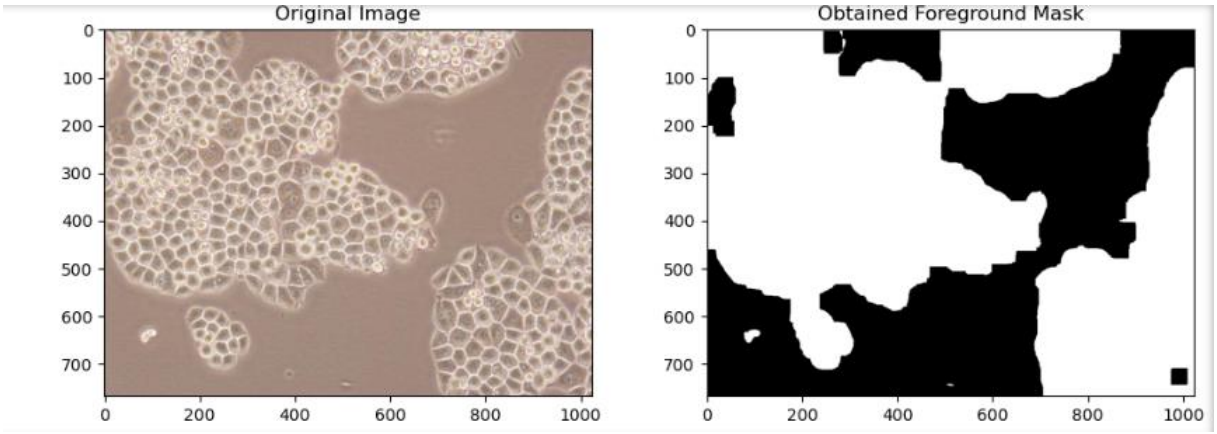

Image No	Precision	Recall	F-score
1	0.91	0.99	0.95
2	0.94	0.98	0.96
3	0.97	0.98	0.98

PART 2

In the "FindCellLocations" function, the cell centers were determined by processing the images through several steps. Initially, we applied grayscale and blurring to the images using the "image_process" function. Subsequently, a thresholding operation was performed where pixel values were set to 0 or 255. A kernel size of 3x3 was utilized for this operation. The resulting mask was then inverted to swap black and white values.

Next, the "distanceTransform" function was employed to compute distances from the center of objects in the mask, using the L2 norm. The distances were subsequently normalized. To identify cell centers, pixel peaks were identified using the "peak_local_max" function, with a specified minimum distance parameter of 10, which yielded improved outcomes. Finally, based on these computations,

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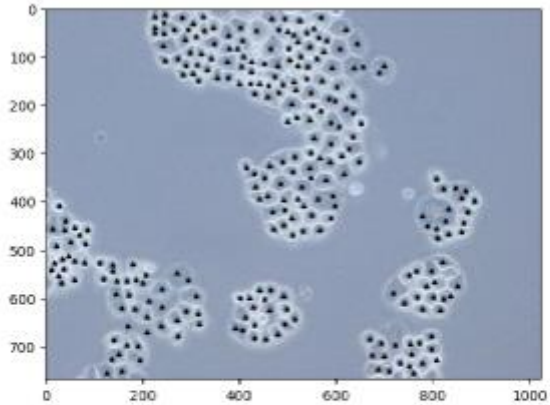
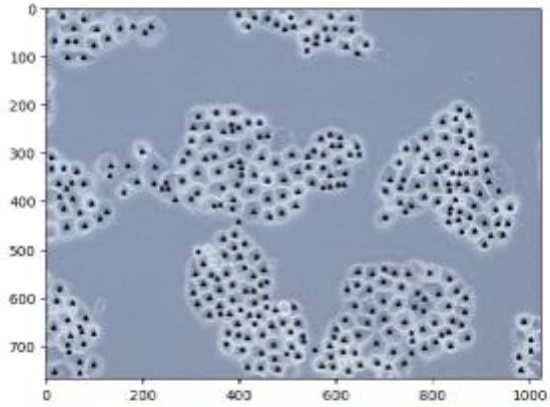
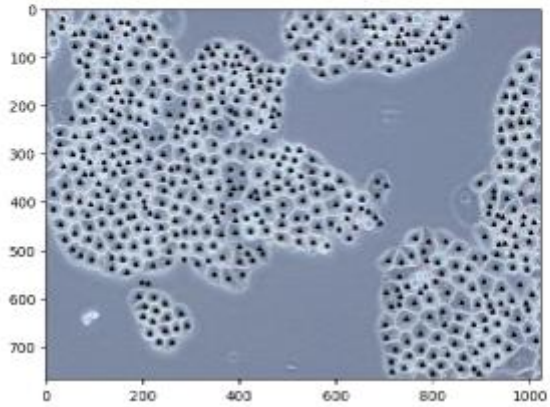
pixel peaks and cell centers were determined from the output of the previous steps.







The "evaluation2" function was developed to compute metrics for the generated results. This function takes as inputs the gold cell images and the detected cell center positions obtained from the "findCellLocations" function. Within this function, we determine our True Positive (TP), False Positive (FP), and False Negative (FN) values by comparing each position individually. Each checked location is added to a "checked" list to ensure comprehensive examination of each position. Additionally, we extract all non-zero cells as unique cells and use these to calculate our true values.

Image No	Precision	Recall	F-score
1	0.83	0.91	0.87
2	0.82	0.92	0.87
3	0.8	0.89	0.85

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PART 3

The FindCellBoundaries function is designed to perform region growing segmentation on a given image to identify and label individual cells. It begins with initial seed points identified in Part 2 and grows regions based on a color similarity threshold. The primary parameter in this algorithm is the color similarity threshold, set to a value of 30. This threshold was selected empirically to balance between under-segmentation and over-segmentation of the cells. A value too high would merge distinct cells, while too low would split single cells into multiple segments.

Pseudocode:

```
FindCellBoundaries(image, foreground_map, cell_locations):
    Initialize labels as zeros with shape of foreground_map and type int
    Set label_count to 1
    For Each loc in cell_locations:
        If labels at loc is 0:
            Initialize queue with loc
            Set labels at loc to label_count
            While queue is not empty:
                Set x, y to queue.pop(0)
                For Each neighbor dx, dy in [-1, 0, 1]:
                    Calculate new positions nx, ny
                    If nx, ny within image bounds and labels at nx, ny is 0 and foreground_map at nx, ny is 1:
                        If color difference between image at nx, ny and image at x, y is less than 30:
                            Append (nx, ny) to queue
                            Set labels at nx, ny to label_count
```

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Increment label_count

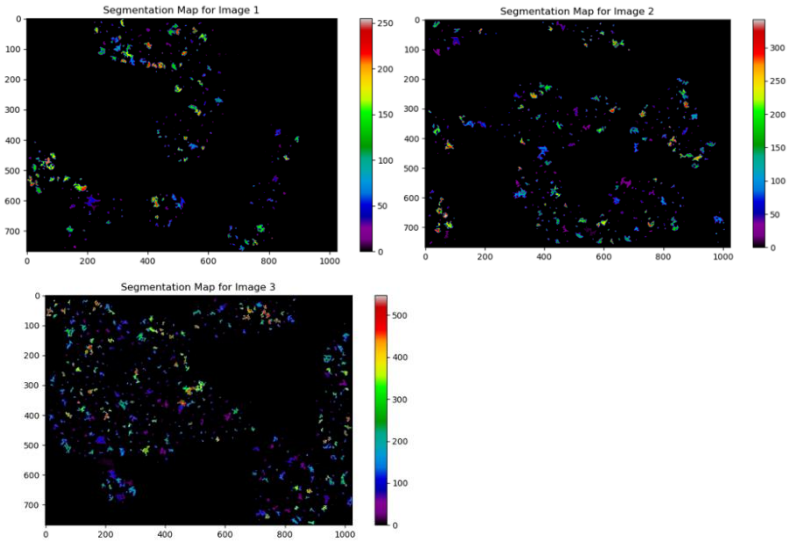

Image	Dice Score	IoU Score
Image 1	0.0048	0.0024
Image 2	0.0027	0.0014
Image 3	0.0021	0.001

PART 4

In this process, grayscale conversion and subsequent blurring were applied to the images. Following this preprocessing step, image contrast was enhanced using the createCLAHE method to improve image quality, specifically enhancing vessel visibility. To achieve optimal results, a smaller clipLimit and tileGridSize were selected within the clahe function.

Next, adaptiveThreshold was used to generate vessel masks, a method particularly suited for images with sensitivity to brightness variations. The chosen parameters, including a block size of 17 and a constant (C) value of 11, were carefully selected to optimize precision.

As part of an iterative refinement process, kernel operations and morphological transformations were applied to further refine the vessel masks. This systematic approach significantly contributes to enhancing the accuracy and quality of vessel segmentation within the images.

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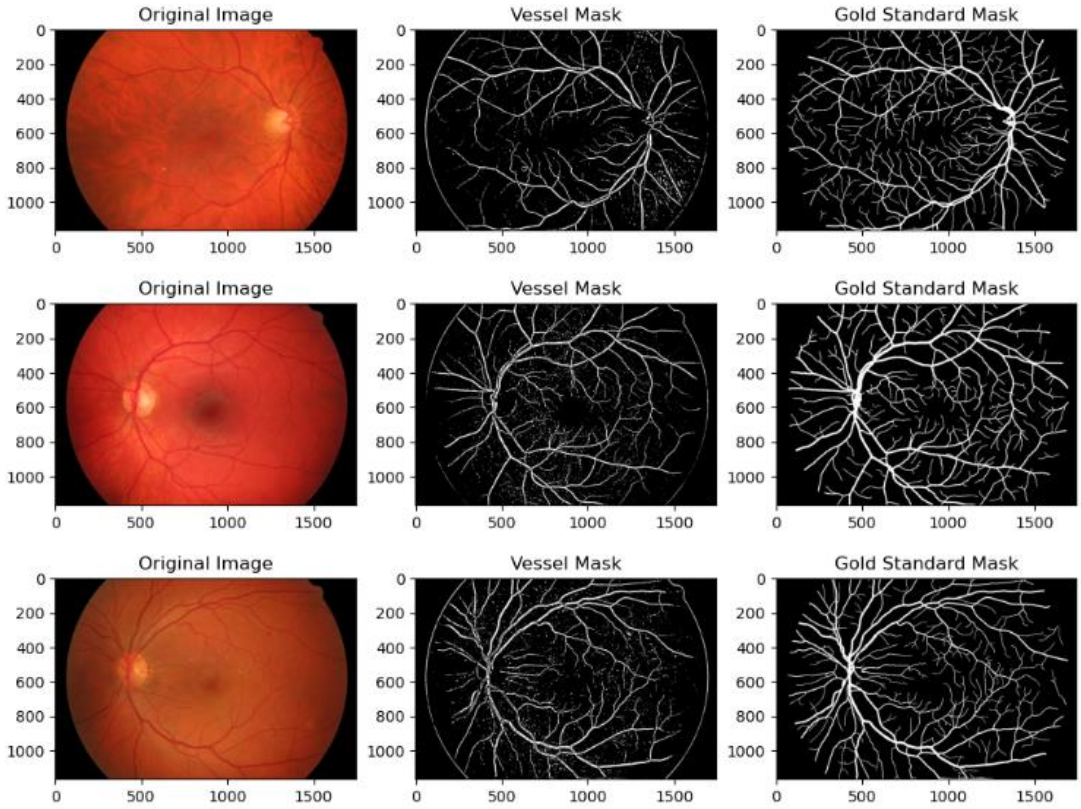

Image No	Precision	Recall	F-score
1	0.8	0.35	0.49
2	0.81	0.35	0.49
3	0.71	0.37	0.48