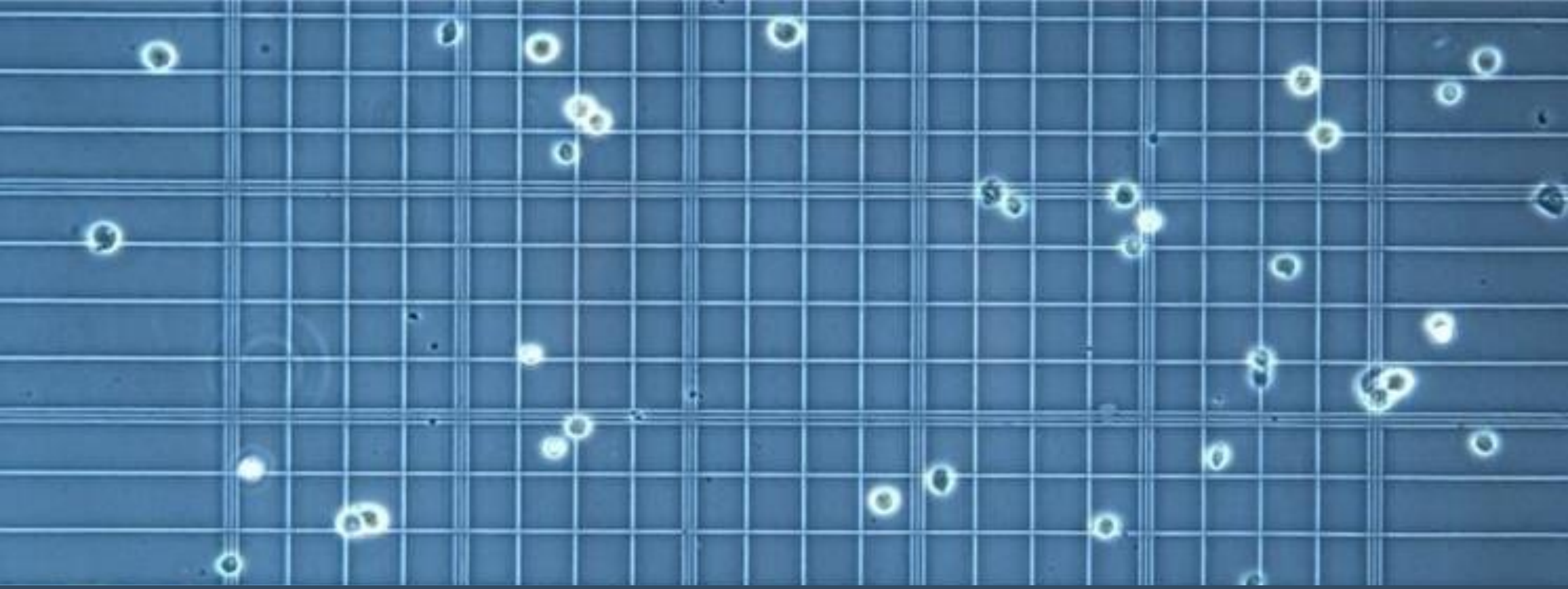

IMAGE ANALYSIS FOR AUTOMATED CELL COUNTING

Ana Filipa Fernandes | Brenda Belissimo| Bruna Santos | Miguel Cardoso

Group 2

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CELL COUNTING

Cell counting is performed **manually** using a **hemocytometer**

- Reliability highly relies on the operator's concentration and experience

AUTOMATED TECHNIQUES BASED ON IMAGE ANALYSIS AND COMPUTER VISION PROVIDE DATA THAT IS MORE RELIABLE AND CONSISTENT

Essential tool to improve the accuracy of the process

Abstract

Main Purposes

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MAIN GOALS

Automate the delineation of the region of interest (ROI) in cell culture images

TASK 1

1. Pre-processing techniques are applied
2. ROI is detected using a custom segmentation function
3. Compare the detected ROI with the corresponding ground truth ROI
4. Study the average results for the metrics

→ **Jaccard Index**
Average Euclidean Distance

The ROI delineation data includes the original image, paired with the manual delimitation (ground truth-GT) in the form of a binary mask

Abstract

Main Purposes

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MAIN GOALS

Automate the delineation of the region of interest (ROI) in cell culture images

Development of a method for segmenting and counting cells within the ROI previously delineated

TASK 2

1. Segment the cells inside the ROI and count them
2. Compare the detected cells with the provided position of each of the counted cells (GT)
3. Study the average results for the metrics

→ **Recall**
Precision
F1-measure

The cell segmentation data includes, for each image, the same data provided for ROI delineation (image + ROI), and, as GT, the position of each of the counted cells

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CODE EXPLANATION

Its first part is related to the image directories, then it goes into a loop for each image and at the end it updates the global metrics and updates the best result. **In each loop:**

1. It gets the image and the respective ROI
2. Converts the image to double, turns it to gray and equalizes the histograma to enhance contrast
3. Performs the segmentation
4. Calculates the Euclidean distance and the Jaccard index metrics
5. Displays the image name

Functions

- Segmentation method
- Function that calculates the Euclidean distances
- Function that displays the best result
- Function that displays the average results

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METRICS RESULTS FOR THE TEST DATASET

Table 1. Average resutls obtained for test dataset

Best Jaccard Index	Best Mean Euclidean Distance	Best Max Euclidean Distance
0.98	6.74	7.07

Table 2. Best resutls obtained for test dataset

Average Jaccard Index	Average Mean Euclidean Distance	Average Max Euclidean Distance
0.98	9.08	10.76

These **consistent and favorable results** across all metrics highlight the **effectiveness of the segmentation algorithm** performed, reinforcing its reliability and suitability for automated ROI segmentation

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CODE EXPLANATION

Overall code

- Setup directories
- Initialize variables
- Loop through each image in the director
- Calculate average of the metrics
- Display result

In each loop:

1. Load the appropriate data from the GT matrices
2. Process the image and segmenting
3. Detect the cells
4. Calculate metrics - TP, FP, FN, Jaccard index, precision, recall and F1
5. Update the global metrics
6. Update the best result - if it is better than the previous one

Task 2 – Cell Segmentation and Counting

Project Development

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IMAGE PROCESSING

1. **Conversion to Grayscale**

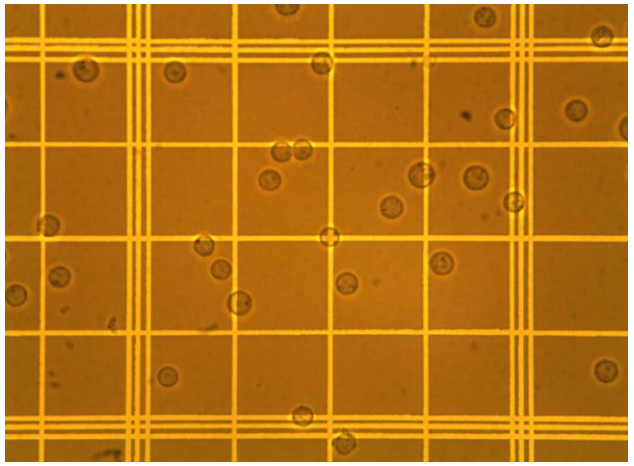
- focuses analysis on pixel intensity levels, which are most relevant for cell segmentation

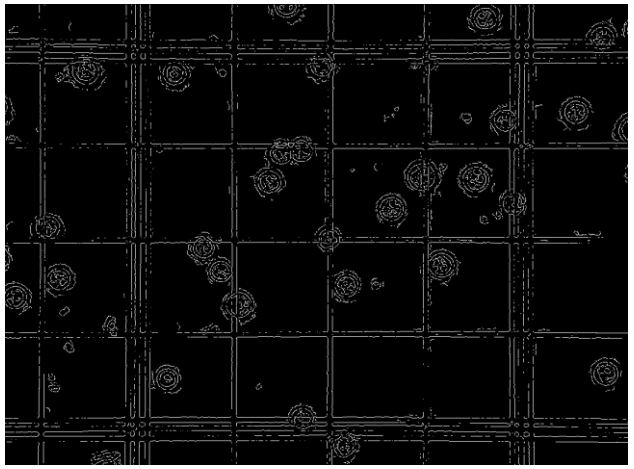
2. **Smoothing with Median Filter**

- reduces noise without blurring important cell edges

3. **Edge Detection with Canny**

- canny's algorithm is efficient in detecting edges in images with reduced noise





Task 2 – Cell Segmentation and Counting

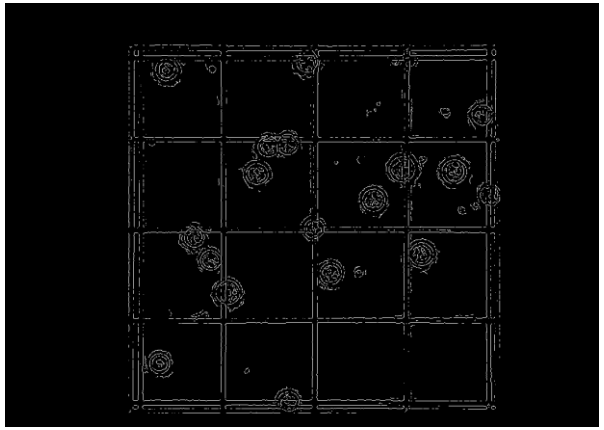
Code Development

SEGMENTATION

1. **Using Adaptive Threshold**

   - suitable for varying lighting conditions

   - segmenting dark cells on a bright background



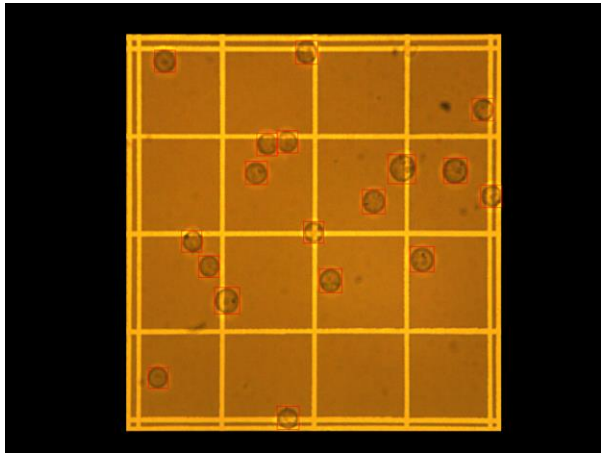
CELLS DETECTION

1. **Using Imfindcircles funtion**

   - detect circular shapes in the binary mask

2. **Using circlesToSquares funtion**

   - convert circular chapes to squares



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METRICS RESULTS FOR THE TEST DATASET

Table 3. Average resutls obtained for test dataset

Recall (R)	Precision (P)	F1-measure (F1)
0.84	**0.83**	**0.82**

The results for each of these metrics were **very favorable and very constant**, showing **good reliability in the algorithm**

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METRICS RESULTS FOR THE TEST DATASET

Accuracy could improve by counting cells not intersecting the bottom and right margins, and including those touching the top and left margins

The results for each of these metrics were **very favorable and very constant**, showing **good reliability in the algorithm**

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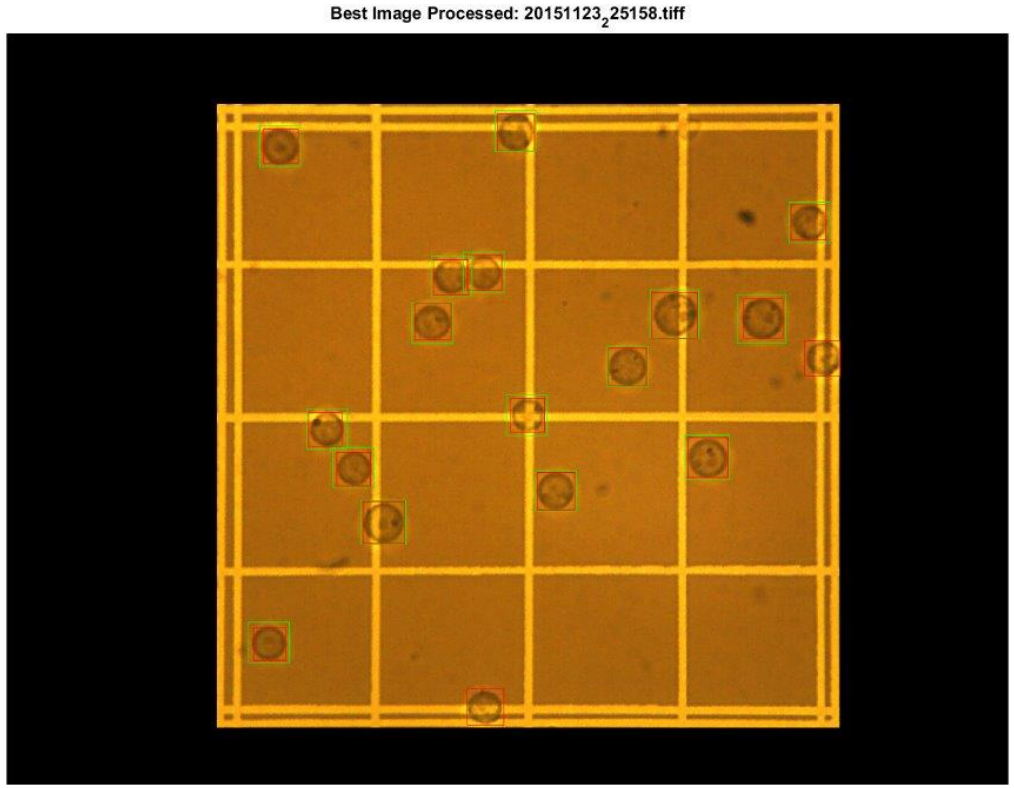
METRICS RESULTS FOR THE TEST DATASET

Table 3. Best resutls obtained for test dataset

Number of counted cells	18
True Positives (TP)	16
False Positives (FP)	2
False Negatives (FN)	0
Jaccard Index	0.81



Summary

Final Assumptions

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MAIN CONCLUSIONS

The method used in **Task 1** can **identify and segment the ROI**, which is very close to the ground truth

The algorithm for **Task 2** succeeded in **accurately quantifying and segmenting the cells**, with some minor issues with the metric calculations that require further enhancement

Despite some discrepancies that were encountered, the results affirm the **potential of the algorithm for cell counting accuracy and efficiency**

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For future work, new methods could be studied to reduce errors or increase the reliability of metrics

- Application of more reliable and higher quality **post-processing**
- Integration of image processing with a **machine learning model**
- Better code organization and use of collaborative development software


QUESTIONS AND ANSWERS