



Análise de Métodos de Adaptive Thresholding

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Introdução

- Adaptive Thresholding.
 - Global Threshold.
 - O que é Adaptive Threshold???
 - Motivo.
 - Métodos.

Original Image



Global Thresholding



Adaptive Thresholding



Global Threshold

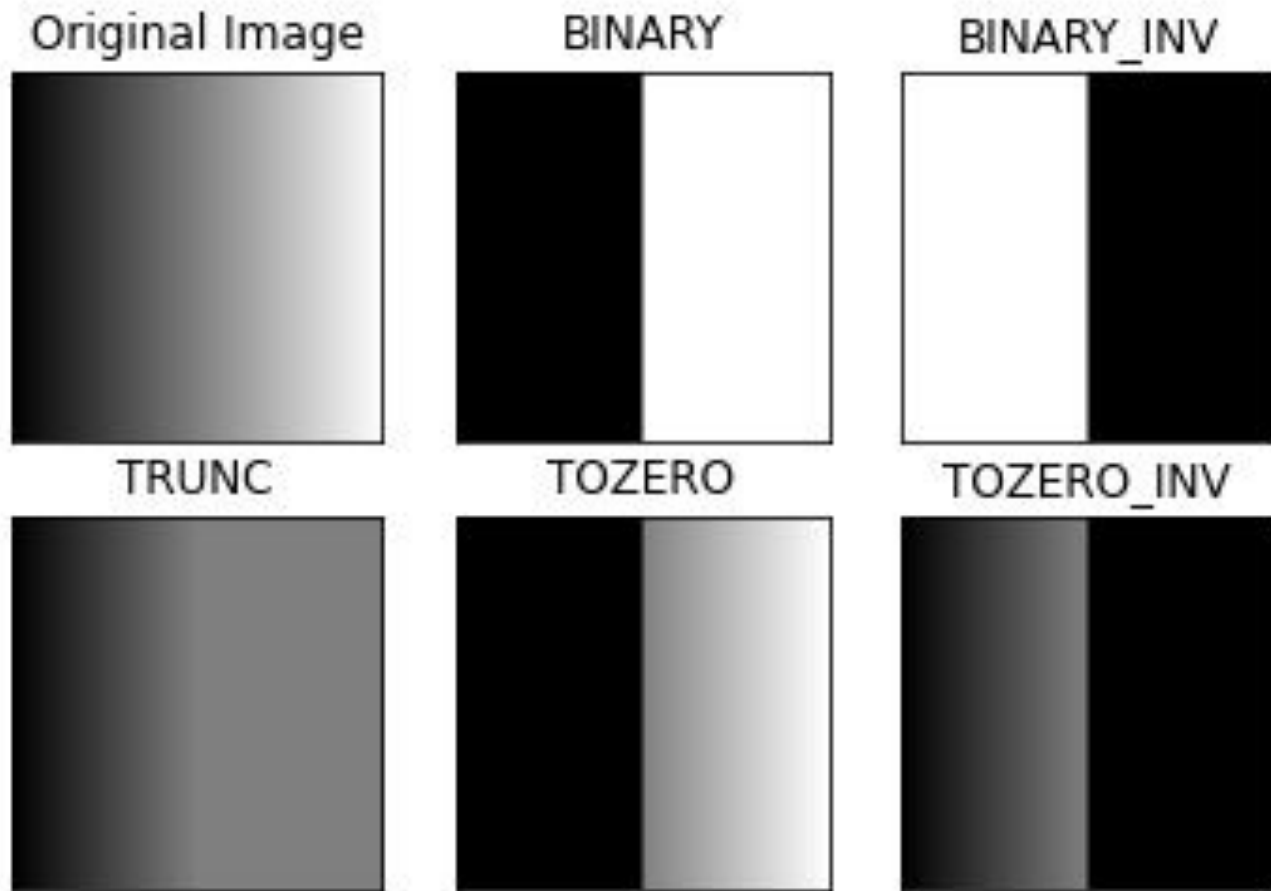


Original Image



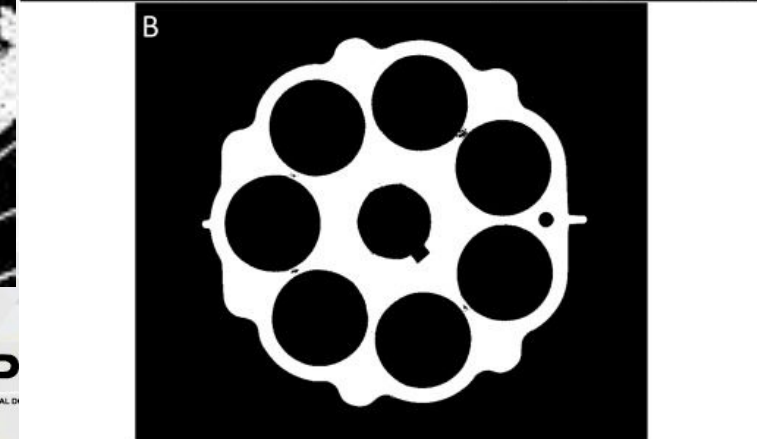
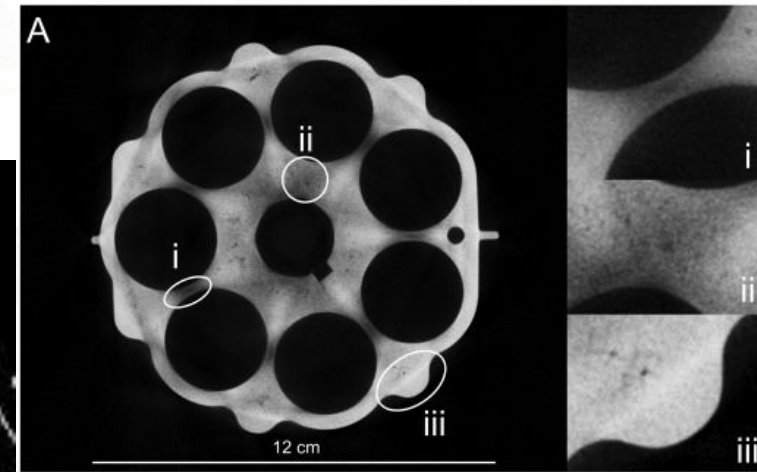
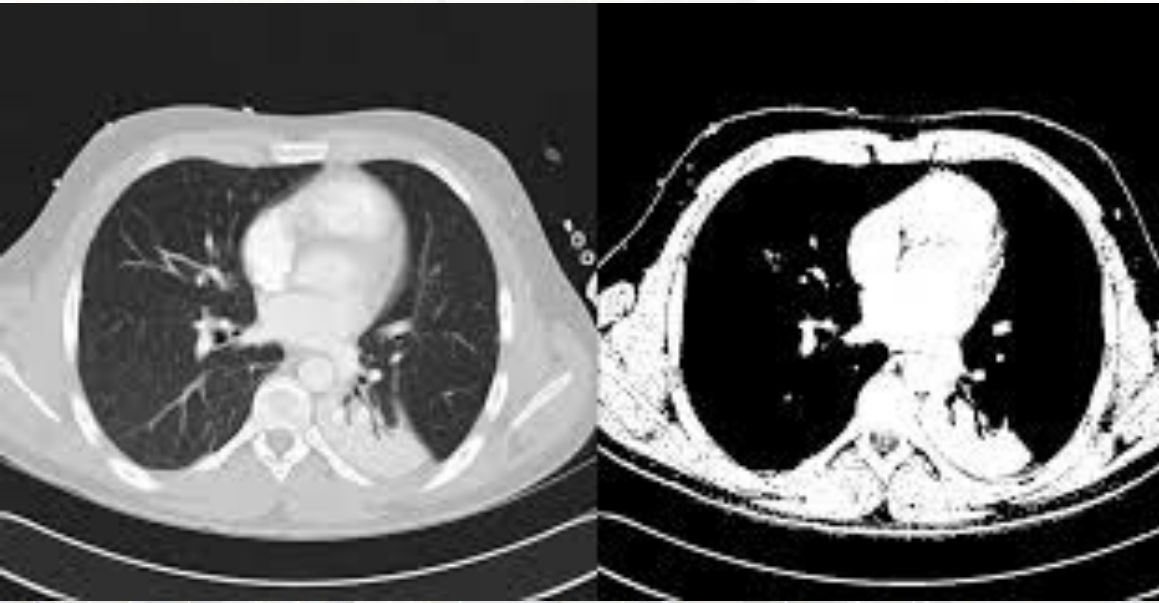
Thresholded and segmented Image

Adaptative Threshold



Aplicações

- Detecção de Objetos em Cenários Complexos.
- Processamento de Documentos e OCR.
- Análise Médica e Biomédica.
- Visão Computacional e Robótica



Método Matlab (adaptthresh)

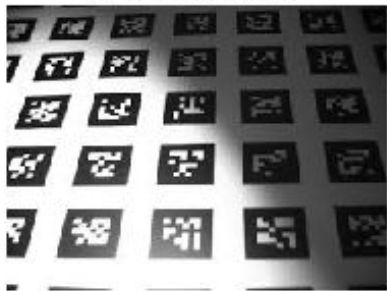
```
function img_output = matlab_adaptive_threshold(input_image, threshold_sensitivity, statistic_mode, num_iter)
    total_time = 0;
    for i = 1:num_iter
        tic;
        img_output = adaptthresh(input_image, threshold_sensitivity, 'Statistic', statistic_mode);
        img_output = imbinarize(input_image, img_output);
        total_time = total_time + toc;
    end
    avg_time = total_time / num_iter;
    fprintf('Tempo médio de execução (%s): %.6f s\n', statistic_mode, avg_time);
    fprintf('Tempo médio de execução (%s): %.6f ms\n', statistic_mode, avg_time*1000);
end
```

0.0 - 1.0

- mean
- median
- gaussian

Método Matlab (adaptthresh)

Imagem original



Método Matlab mean

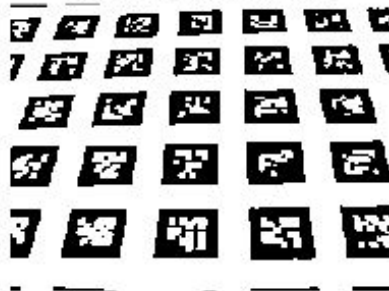
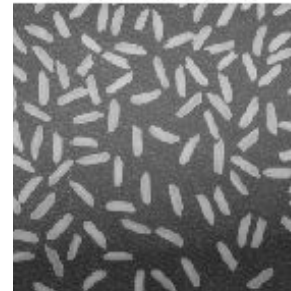


Imagem original



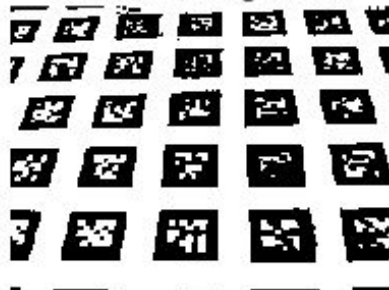
Método Matlab mean



Método Matlab median



Método Matlab gaussian



Método Matlab median

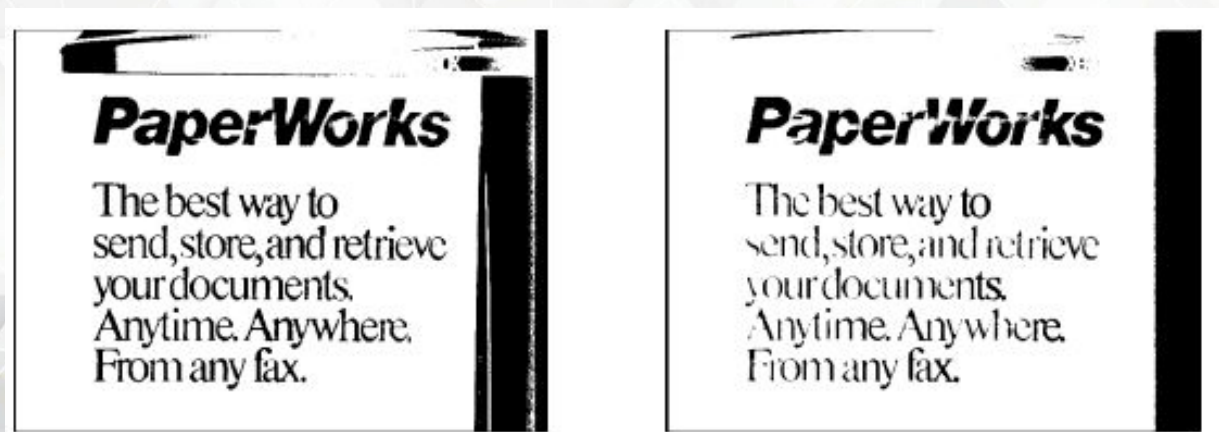


Método Matlab gaussian



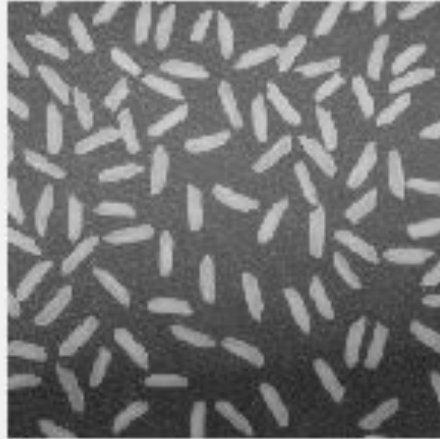
Método Wellner

- Funcionamento.
- Pontos positivos:
 - Rápido.
 - Percorre a imagem apenas uma vez.
- Pontos negativos:
 - Ordem da varredura altera o resultado.
 - Não ótimo para mudanças sutis na iluminação.



Método Wellner

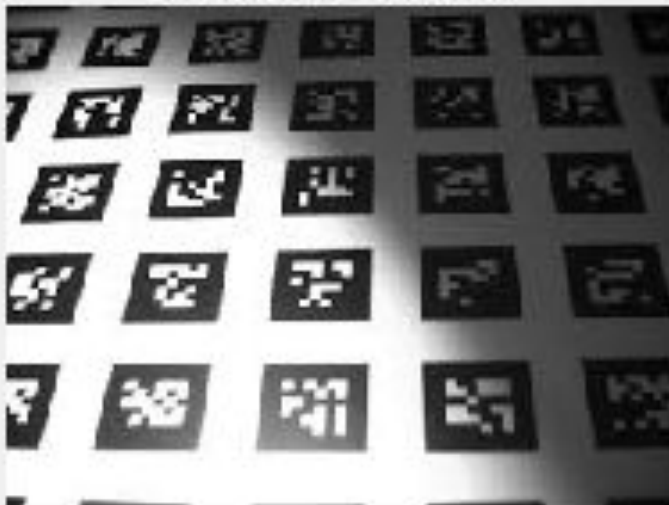
Imagem original



Método Wellner



Imagem original



Método Wellner



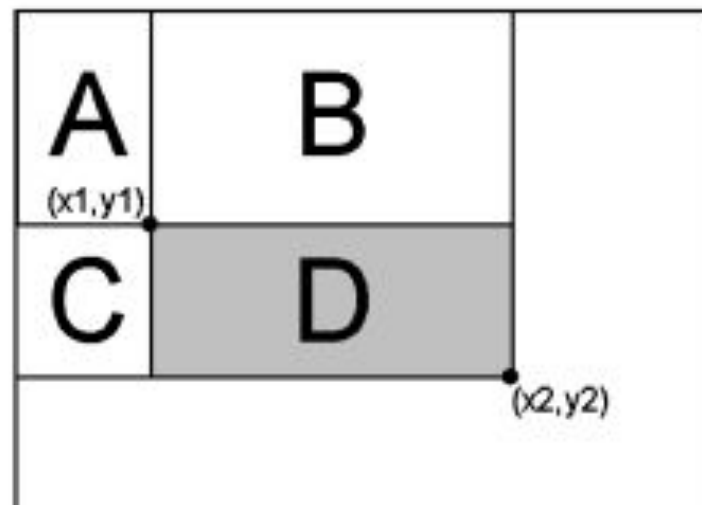
Método Wellner com Imagens Integrais

- Diferenciação do método Wellner.
- Pontos positivos:
 - Melhor sensibilidade a variação de contraste.
 - Independente da ordem de varredura.
 - Rápido.
- Pontos negativos:
 - Mais complexo do que o método Wellner.
 - Varre a imagem duas vezes.

Imagens Integrais

4	1	2	2
0	4	1	3
3	1	0	4
2	1	3	2

4	5	7	9
4	9	12	17
7	13	16	25
9	16	22	33



```
for i = 1:cols
    sum_col = 0;
    for j = 1:rows
        sum_col = sum_col + input_image(j, i);
        if i == 1
            intImg(j, i) = sum_col;
        else
            intImg(j, i) = intImg(j, i - 1) + sum_col;
        end
    end
end
```

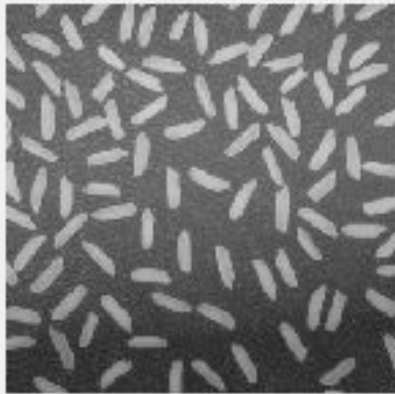
```
for i = 1:cols
    for j = 1:rows
        % Definir coordenadas da janela
        x1 = max(i - half_s, 1);
        x2 = min(i + half_s, cols);
        y1 = max(j - half_s, 1);
        y2 = min(j + half_s, rows);

        % Número de pixels na janela
        count = (x2 - x1 + 1) * (y2 - y1 + 1);

        % Calcular a soma na janela usando imagem integral
        sum_window = intImg(y2, x2);
        if x1 > 1
            sum_window = sum_window - intImg(y2, x1 - 1);
        end
        if y1 > 1
            sum_window = sum_window - intImg(y1 - 1, x2);
        end
    end
end
```


Método Wellner com Imagens Integrais

Imagem original



Método integral image



Imagem original



Método integral image

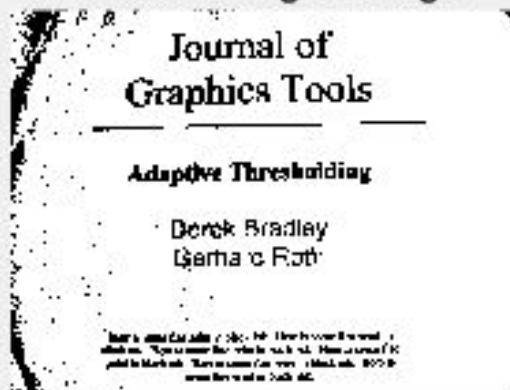
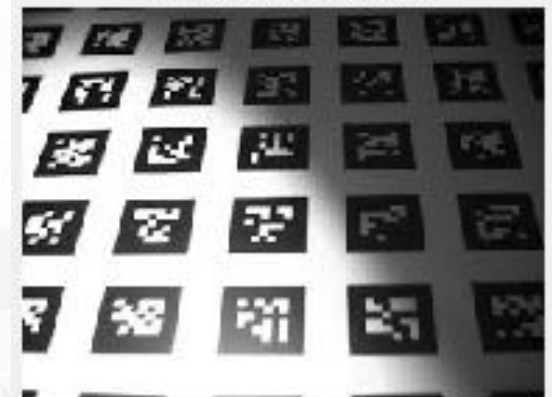
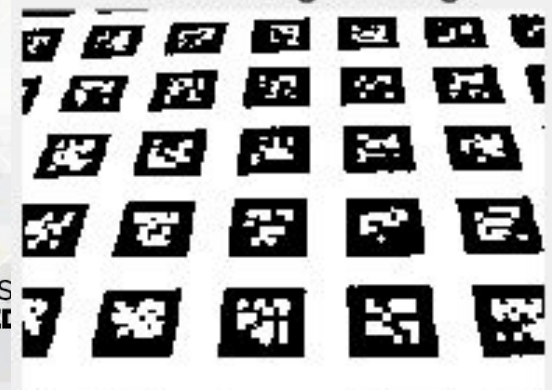


Imagem original



Método integral image

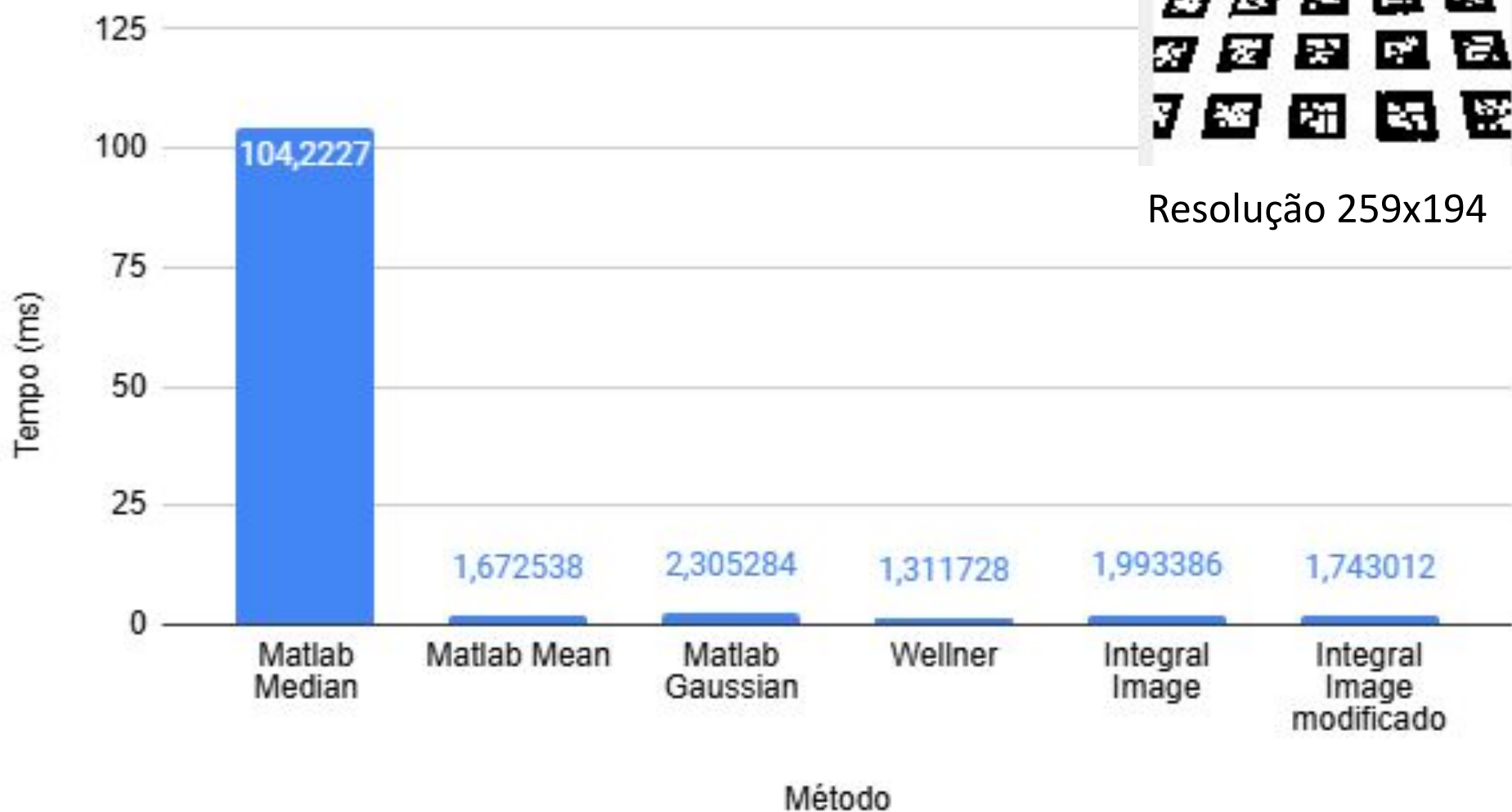


Comparativo de velocidade

- Média de 50 execuções
- Tic Toc.

```
function img_output = matlab_adaptive_threshold(input_image, threshold_sensitivity, statistic_mode, num_iter)
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        tic;
        img_output = adaptthresh(input_image, threshold_sensitivity, 'Statistic', statistic_mode);
        img_output = imbinarize(input_image, img_output);
        total_time = total_time + toc;
    end
    avg_time = total_time / num_iter;
    fprintf('Tempo médio de execução (%s): %.6f s\n', statistic_mode, avg_time);
    fprintf('Tempo médio de execução (%s): %.6f ms\n', statistic_mode, avg_time*1000);
end
```

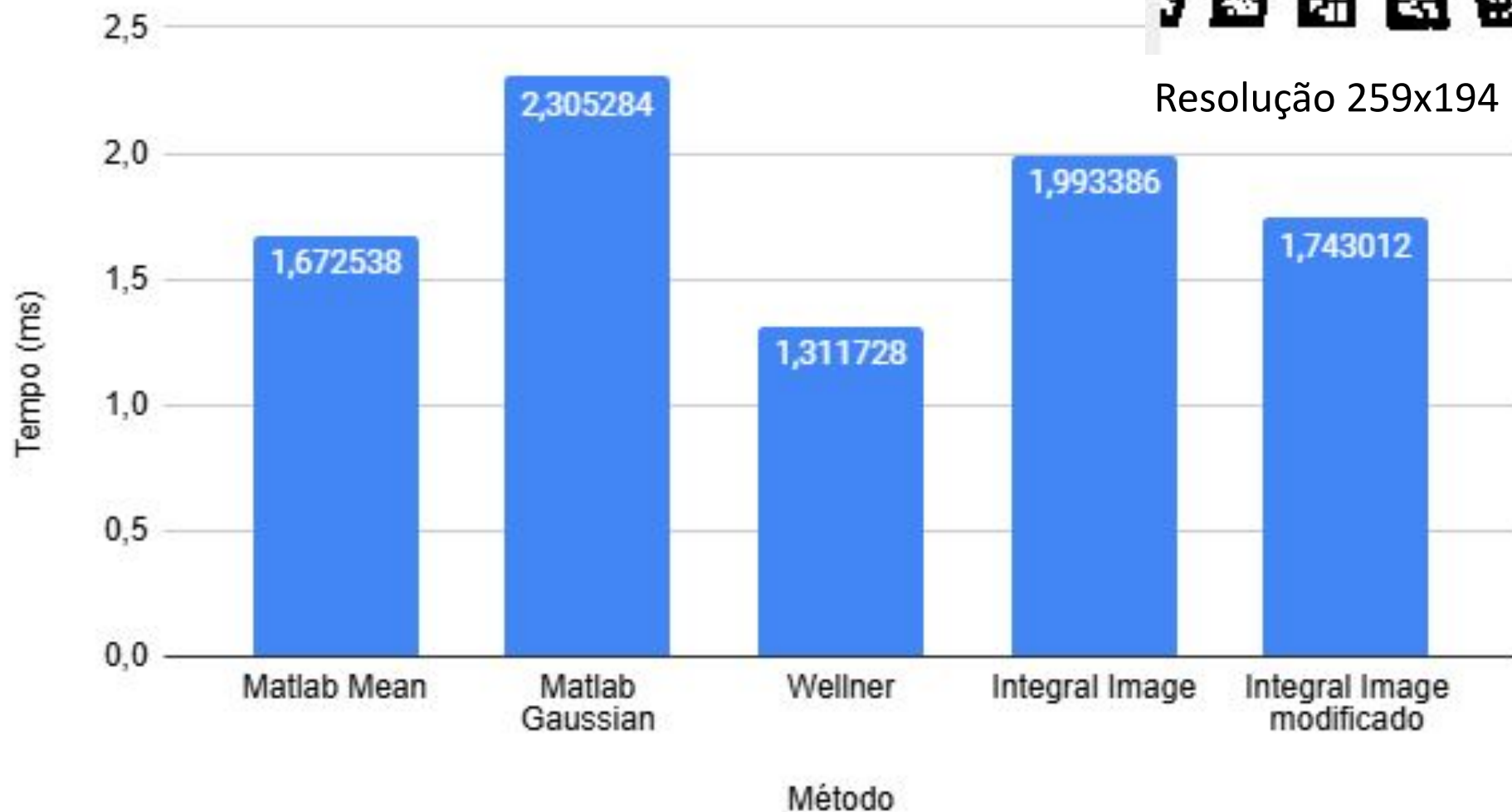
Adaptive Threshold QR codes



Adaptive Threshold QR codes



Resolução 259x194



Adaptive Threshold Rice



Resolução 256x256

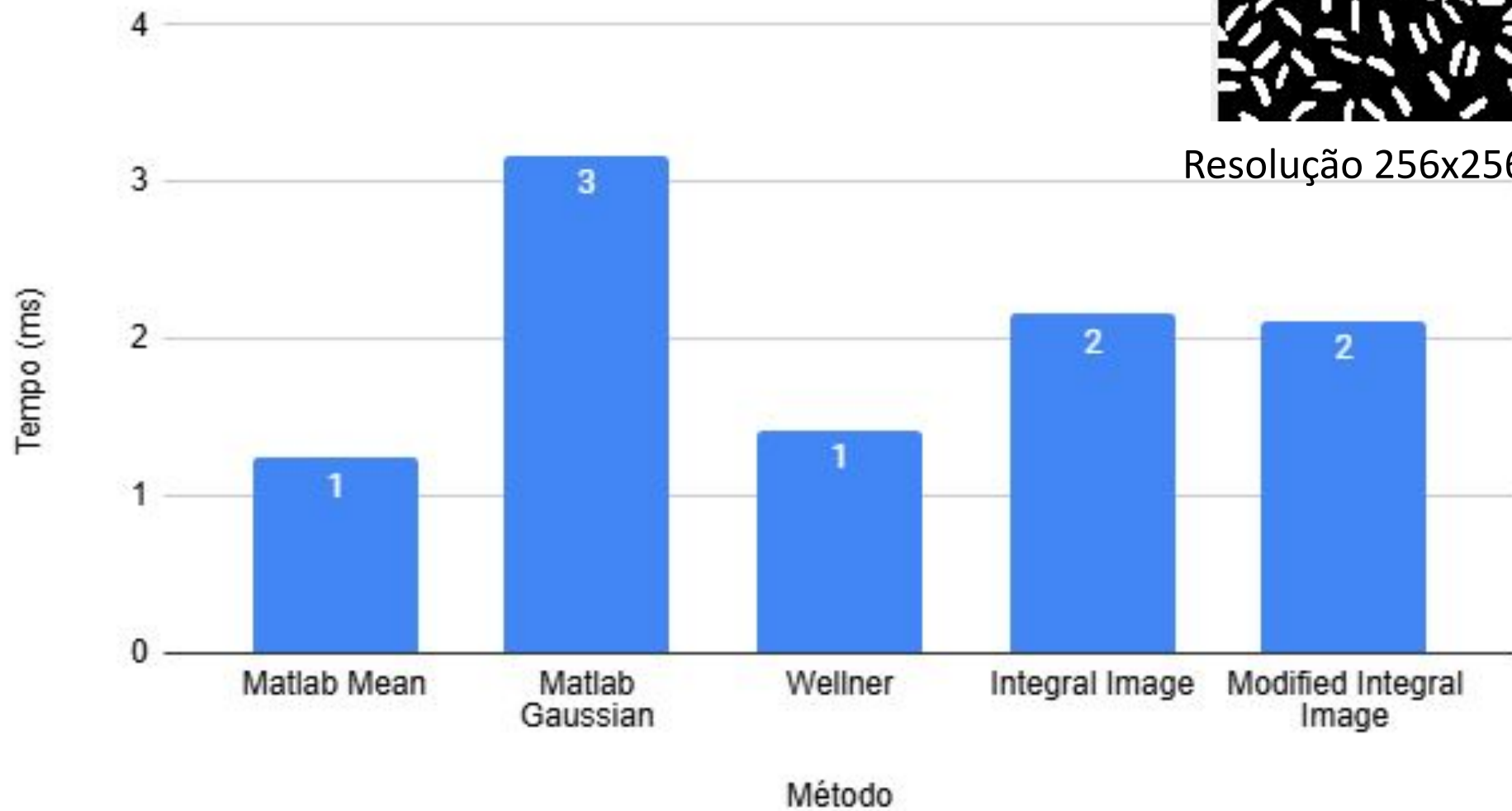
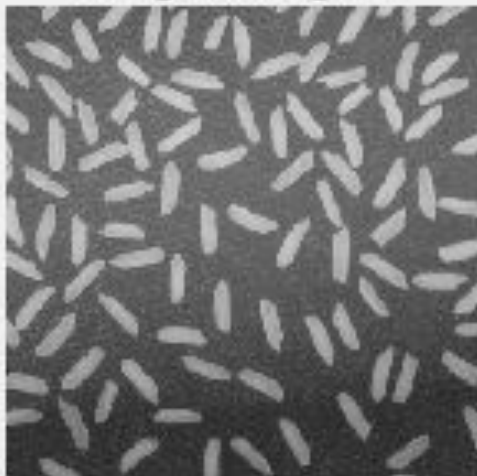


Imagem original



Matlab mean



Matlab median



Matlab gaussian



Wellner



Integral image



Modified integral image



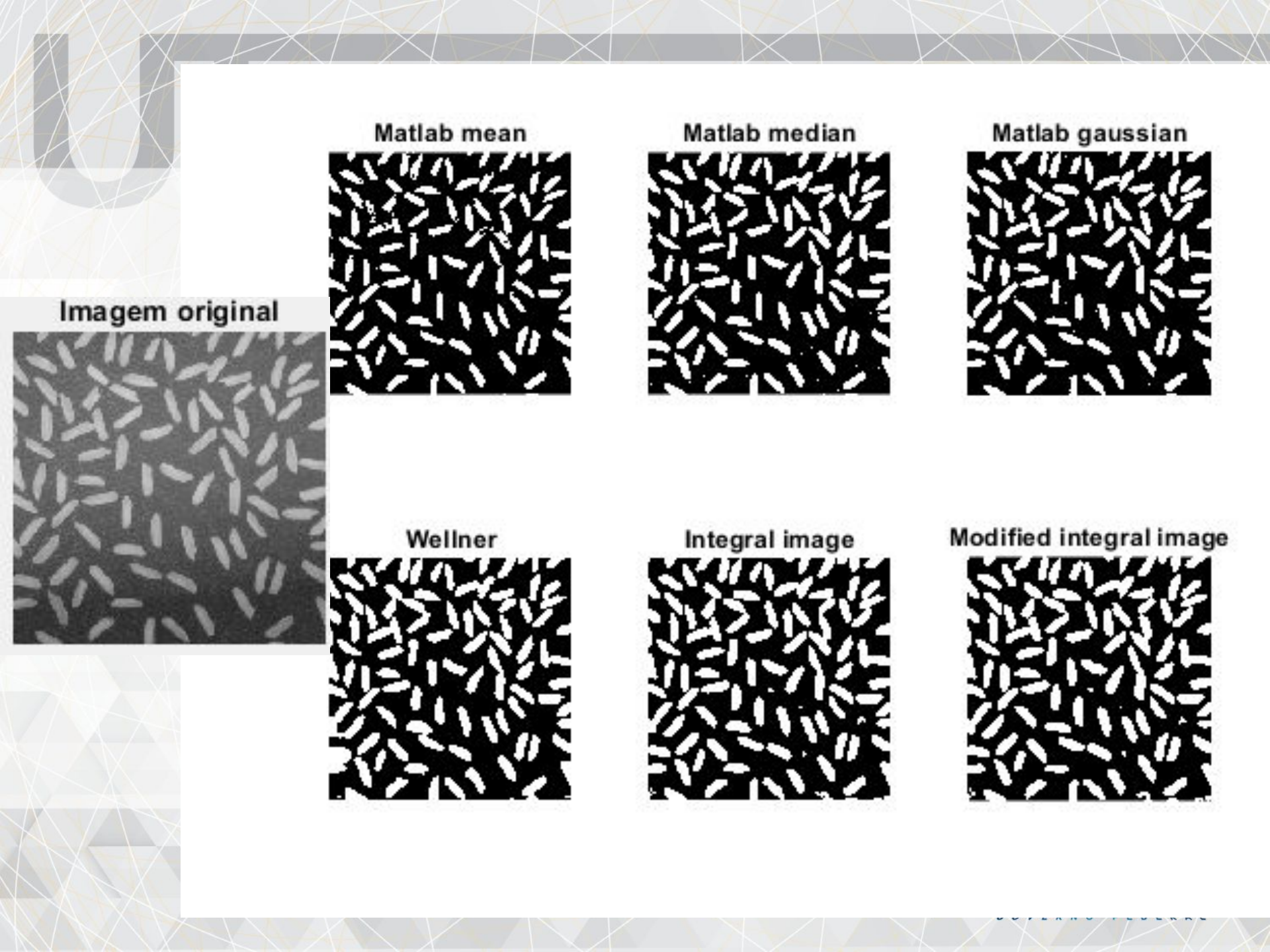
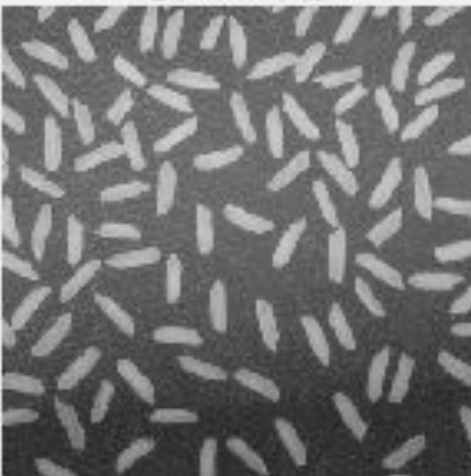


Imagem original



Matlab mean



Matlab median



Matlab gaussian



Wellner

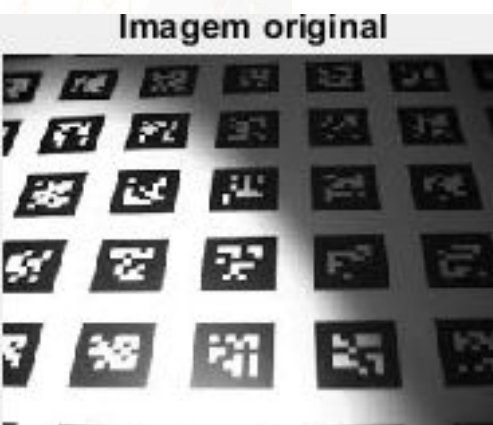


Integral image



Modified integral image





Método Matlab mean



Método Matlab median



Método Matlab gaussian



Método Wellner



Método integral image



Método modified integral image



Conclusão

- Foi possível avaliar:
 - Aplicações do Adaptive Threshold.
 - Diferentes métodos de aplicação.
 - Eficiência do método Wellner.
 - Qualidade de imagem do método com imagem integral
 - Eficiência e qualidade do método utilizado pelo Matlab

Código

https://github.com/chrisakira/Adaptive_Threshold

Referências

1. https://docs.opencv.org/4.x/d7/d4d/tutorial_py_thresholding.html
2. <https://www.mathworks.com/help/images/ref/adaptthresh.html>
3. <https://homepages.inf.ed.ac.uk/rbf/HIPR2/adpthrsh.htm>
4. <https://www.geeksforgeeks.org/python-thresholding-techniques-using-opencv-set-2-adaptive-thresholding/>
5. <https://www.sciencedirect.com/science/article/pii/S2214860421000646>
6. <https://www.sciencedirect.com/topics/computer-science/local-adaptive-thresholding>
7. <https://www.sciencedirect.com/science/article/pii/S2214860421000646>
8. <https://www.geeksforgeeks.org/thresholding-based-image-segmentation/>
9. <https://people.scs.carleton.ca/~roth/iit-publications-iti/docs/gerh-50002.pdf>