Relatório- Trabalho Prático 1- Processamento e Análise de Imagens

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Abstract. *Based on Exercise 6: Object Detection, from the list Relations between pixels and Tasks, the implemented code detects objects in a simple black and white image. Unlike the question, binarization was used to make counting the components in the image easier. The project ´s objective is to count these objects,using the Breadth-First Search (BFS) labeling technique. So that,later on, in the final practical work, an object counting system can be implemented in more complex images, such as the number of players in a soccer game.*

Resumo. *Baseando-se no Exercício 6: Detecção de Objetos, da lista Relações entre pixels e Tarefas, o código implementado detecta objetos em uma imagem simples em preto e branco. Diferentemente da questão, foi utilizado uma binarização para que a contagem dos componentes na imagem ficasse mais fácil. O objetivo do trabalho é contar esses objetos,utilizando a técnica de rotulagem por busca em largura (BFS - Breadth-First Search). Para que depois, no trabalho prático final, seja implementado um sistema de contagem de objetos em imagens mais complexas, como por exemplo a quantidade de jogadores em um jogo de futebol.*

1. Sobre o trabalho

Esse trabalho tem como objetivo a identificar e contar componentes conexos em imagens binárias, utilizando a técnica de rotulagem por busca em largura (BFS - Breadth-First Search). Para esse propósito, foi desenvolvido um programa em Python que realiza a binarizaçao da imagem e a aplicação do algoritmo de rotulagem.

A função binariza_imagem(caminho_imagem, limiar) converte uma imagem em escala de cinza pra uma matriz binária, onde os pixels com intensidade maior ou igual ao valor de limiar são representados como 1, e os outros como 0. Essa etapa é fundamental para transformar a imagem em um formato adequado para a análise de componentes, considerando apenas duas classes de pixels: ativos (1) e inativos (0). No desenvolvimento, foi utilizada a biblioteca Pillow para a leitura e conversão da imagem, e o parâmetro limiar permite ajustar a sensibilidade da binarização conforme o contraste da imagem original.

Depois de obeter a matriz binária, a rotulagem dos componentes conexos é feita por meio de uma matriz auxiliar chamada rótulos, inicializada com zeros. Essa matriz armazena os rótulos associados a cada componente identificado.

A função busca(x_inicial, y_inicial) é responsável pela execução da busca em largura a partir de um pixel ativo(1) que ainda não foi rotulado. A estrutura de fila (deque

da biblioteca collections) é utilizada para armazenar os pixels que serão visitados. A decisão pra usar BFS foi baseada na simplicidade da implementação e na forma com que o algoritmo propaga o rótulo de maneira ”em ondas” a partir de um ponto inicial, garantindo que todos os pixels conectados sejam visitados de maneira ordenada e eficiente.

A conectividade adotada foi a conectividade 4, considerando os vizinhos diretamente adjacentes nas direções norte, sul, leste e oeste. Essa escolha reduz a complexidade da verificação de vizinhança e é suficiente para muitos tipos de análise em imagens binárias.

O processo de rotulagem é iniciado com o contador = 1, que representa o primeiro rótulo válido. A cada novo componente encontrado, o contador é incrementado, garantindo que cada grupo de pixels conectados receba um rótulo único. O laço principal percorre toda a matriz binária, e ao encontrar um pixel ativo sem rótulo, a função de busca é chamada para rotular todos os pixels daquele componente.

Por fim, o programa exibe a matriz de rótulos gerada e a quantidade total de componentes encontrados (valor de contador - 1), o que permite uma análise visual e quantitativa do resultado.

2. Testes e Resultados

```
matriz = [
    [0,0,1,1,0,0,0,1,0,0],
    [0,0,1,1,0,0,0,1,0,0],
    [0,0,0,0,0,1,1,0,0,0],
    [1,1,0,0,0,1,1,0,0,0],
    [1,1,0,0,0,0,0,0,1,1],
    [0,0,0,0,0,0,0,0,1,1],
    [0,1,0,0,1,0,0,0,0,0],
    [0,1,0,0,1,0,0,1,1,0],
    [0,0,0,0,0,0,0,1,1,0],
    [1,1,0,0,0,0,0,0,0,0],
]
```

Figure 1. Matriz escrita à mão

O primeiro teste executado foi feito apenas com uma matriz binária ”aleatória” escrita à mão.A matriz da figura 1. Essa matriz possui, como é possível contar apenas observando-a, 9 componentes conexos. O teste foi feito para validar a rotulagem e busca em largura. Os resultados foram corretos: Matriz de rótulos: [0 0 1 1 0 0 0 2 0 0] [0 0 1 1 0 0 0 2 0 0] [0 0 0 0 0 3 3 0 0 0] [4 4 0 0 0 3 3 0 0 0] [4 4 0 0 0 0 0 0 5 5] [0 0 0 0 0 0 0 0 5 5] [0 6 0 0 7 0 0 0 0 0] [0 6 0 0 7 0 0 8 8 0] [0 0 0 0 0 0 0 8 8 0] [9 9 0 0 0 0 0 0 0 0]

Componentes encontrados: 9

O segundo teste foi feito com a imagem da Figura 2. Essa figura em preto e branco foi criada através do Chat GPT 4.0 com o intuito de ser uma figura com poucos pixels e componentes bem definidos. É possível perceber a olho nu, a presença de 6 componentes

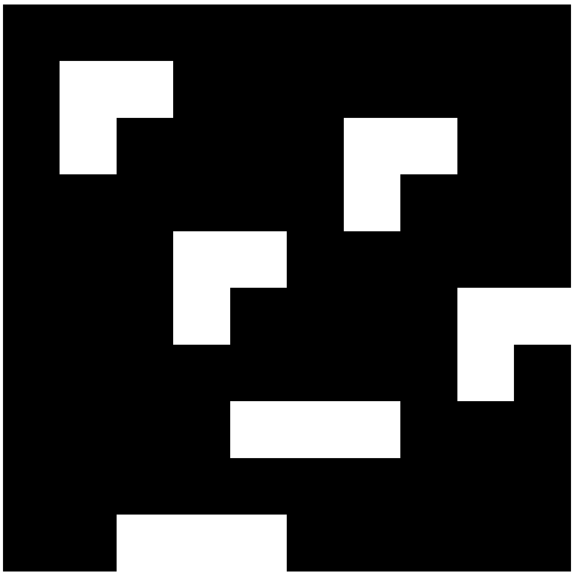

Figure 2. Imagem em preto e branco gerada com Inteligência Artificial(Chat GPT 4.0)

na imagem. Os resultados também apresentaram acerto: Matriz de rótulos: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0] [0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]
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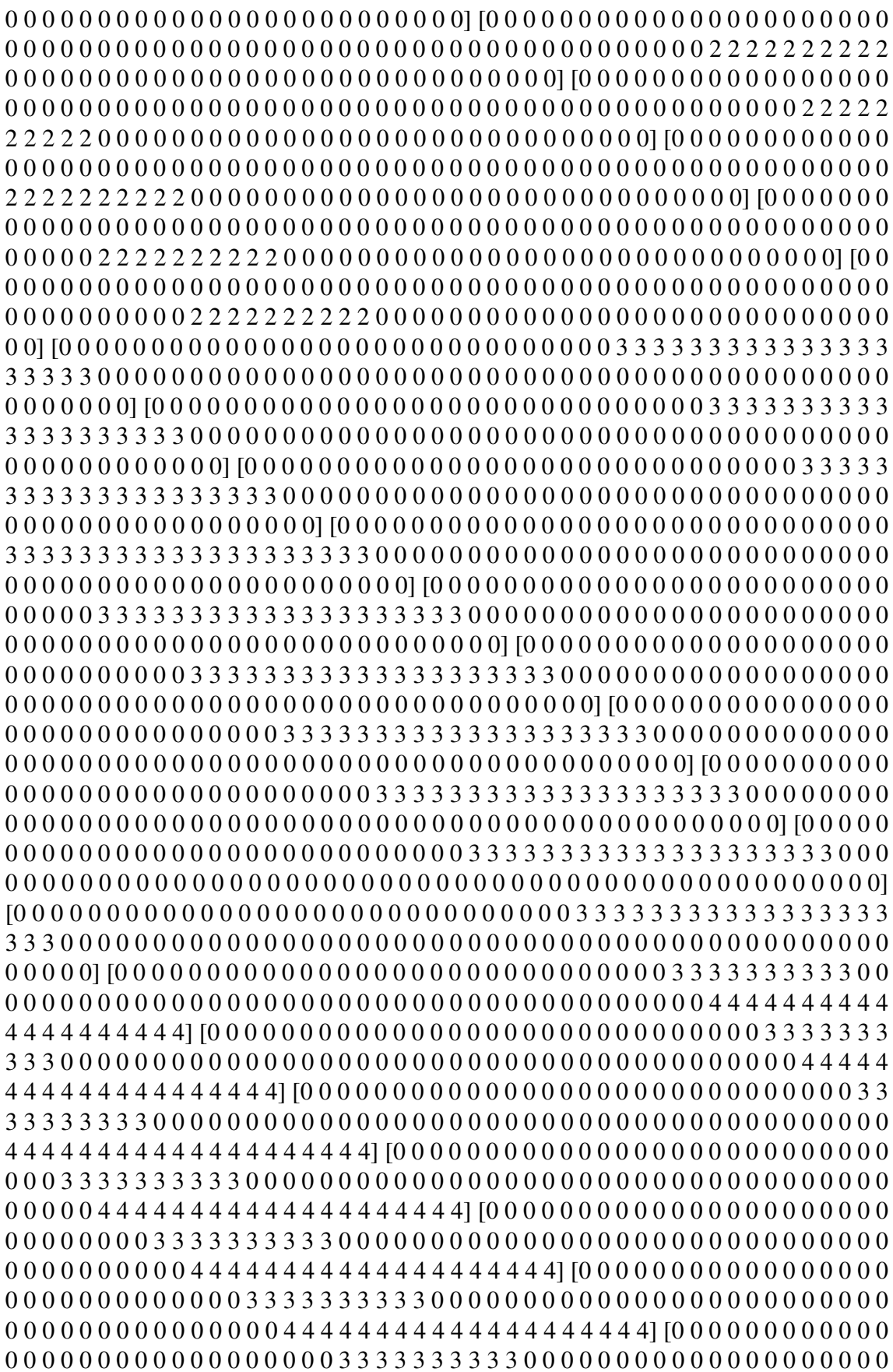

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O terceiro teste foi feito com a imagem da figura 3. A figura novamente em preto e branco, também foi gerada pelo Chat GPT 4.0, ela tem mais pixels, mas ainda componentes bem divididos e vistos a olho nu. Os resultados também foram corretos: Componentes encontrados : 5. Infelizmente a matriz de rótulos ficou grande demais para ser colcoada aqui.

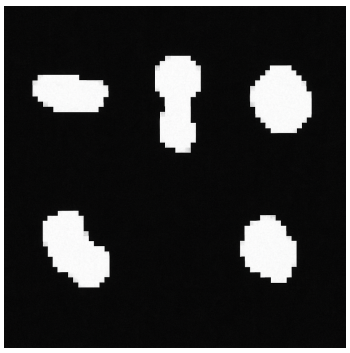

Figure 3. Imagem em preto em branco com mais pixels 2.

3. Conclusão

O trabalho funciona muito bem com o seu propósito de encontrar componentes em imagens binárias, porém precisa e será aprimorado para que possa ser utilizado de maneira útil no Trabalho Prático final da disciplina. Os próximos passos incluem mudanças simples, como implementar a vizinhança de 8 e compará-la com a de 4 até uma implementação de algoritmos mais complexos e um pré-processamento mais robusto para que possa ser possível a contagem de objetos em imagens reais e mais complexas.

4. Referências

https://medium.com/@tharindad7/image-binarization-in-a-nutshell-b40b63c0228e

[Silvela and Portillo 2001]

References

Silvela, J. and Portillo, J. (2001). Breadth-first search and its application to image processing problems. *IEEE Transactions on Image Processing*, 10(8):1194–1199.