Find the Number of Labeled Components, Area, and Integrated Density in an Image

Domain: Earth Science

Created by: Preksha Shah

Concepts Used

1. Labeled Components: Labeled components refer to connected regions of similar intensity or pixel values in an image. These are identified using algorithms such as Connected Component Analysis (CCA).
2. Area: The area is the number of pixels in a labeled component.
3. Integrated Density: Integrated density is the sum of pixel intensities in the labeled region. It provides information about the "strength" or "weight" of the component.

```
# Required Libraries
import cv2
import numpy as np
from matplotlib import pyplot as plt
import pandas as pd
import os



def analyze_image_components(image_path):
    """
    Function to analyze the number of labeled components, their areas,
    and integrated densities in an image.

    Parameters:
    - image_path (str): Path to the input image.

    Outputs:
    - Displays visualizations for the original image, binary image, labeled components,
      and individual components.
    - Prints a table of statistics for each component.
    """
    # Check if the file exists
    if not os.path.exists(image_path):
        print(f"File not found: {image_path}")
        return

    # **Step 1: Load the Image**
    image = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)

    # Visualize the original image
    plt.figure(figsize=(8, 8))
    plt.imshow(image, cmap='gray')
    plt.title("Original Image")
    plt.axis("off")
    plt.show()

    # **Step 2: Thresholding**
    _, binary_image = cv2.threshold(image, 127, 255, cv2.THRESH_BINARY)

    # Visualize the binary image
    plt.figure(figsize=(8, 8))
    plt.imshow(binary_image, cmap='gray')
    plt.title("Binary Image")
    plt.axis("off")
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    plt.axis("off")
    plt.show()

    # **Step 3: Find Labeled Components**
    num_labels, labels, stats, centroids = cv2.connectedComponentsWithStats(binary_image)

    # Display the number of labeled components
    print(f"Number of Labeled Components (excluding background): {num_labels - 1}")

    # **Step 4: Analyze Components**
    component_data = []
    for i in range(1, num_labels):  # Start from 1 to exclude the background
        area = stats[i, cv2.CC_STAT_AREA]
        integrated_density = np.sum(image[labels == i])
        centroid = centroids[i]

        component_data.append({
            "Label": i,
            "Area": area,
            "Integrated Density": integrated_density,
            "Centroid": centroid
        })

        print(f"Component {i}: Area = {area}, Integrated Density = {integrated_density}, Centroid = {centroid}"

    # **Step 5: Visualize Labeled Components**
    colored_labels = np.zeros((*labels.shape, 3), dtype=np.uint8)
    for i in range(1, num_labels):
        mask = labels == i
        colored_labels[mask] = np.random.randint(0, 255, size=3)

    plt.figure(figsize=(10, 10))
    plt.imshow(cv2.cvtColor(colored_labels, cv2.COLOR_BGR2RGB))
    plt.title("Labeled Components")
    plt.axis("off")
    plt.show()

    # **Step 6: Insights and Statistics**
    df = pd.DataFrame(component_data)
    print("\nComponent Statistics:")
    print(df)

    # **Step 7: Visualize Individual Components**
    for i in range(1, num_labels):
        mask = labels == i
        highlighted_image = image.copy()
        highlighted_image[~mask] = 0  # Mask all other regions

        plt.figure(figsize=(6, 6))
        plt.imshow(highlighted_image, cmap='gray')
        plt.title(f"Component {i}")
        plt.axis("off")
        plt.show()

    return df


image_path_1 = "/content/Erosion.jpg"
image_path_2 = "/content/Metamorphic.jpg"
image_path_3 = "/content/espoircoraux.jpg"
image_path_4 = "/content/linnetreef.jpg"
image_path_5 = "/content/maxresdefault.jpg"
image_path_6 = "/content/olivine.jpg"
image_path_7 = "/content/olivine.jpg"

'''print("Analyzing Image 1:")
stats_image_1 = analyze_image_components(image_path_1)
```

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print("\nAnalyzing Image 2:")
stats_image_2 = analyze_image_components(image_path_2)

print("Analyzing Image 1:")
stats_image_3 = analyze_image_components(image_path_1)

print("\nAnalyzing Image 2:")
stats_image_4 = analyze_image_components(image_path_2)

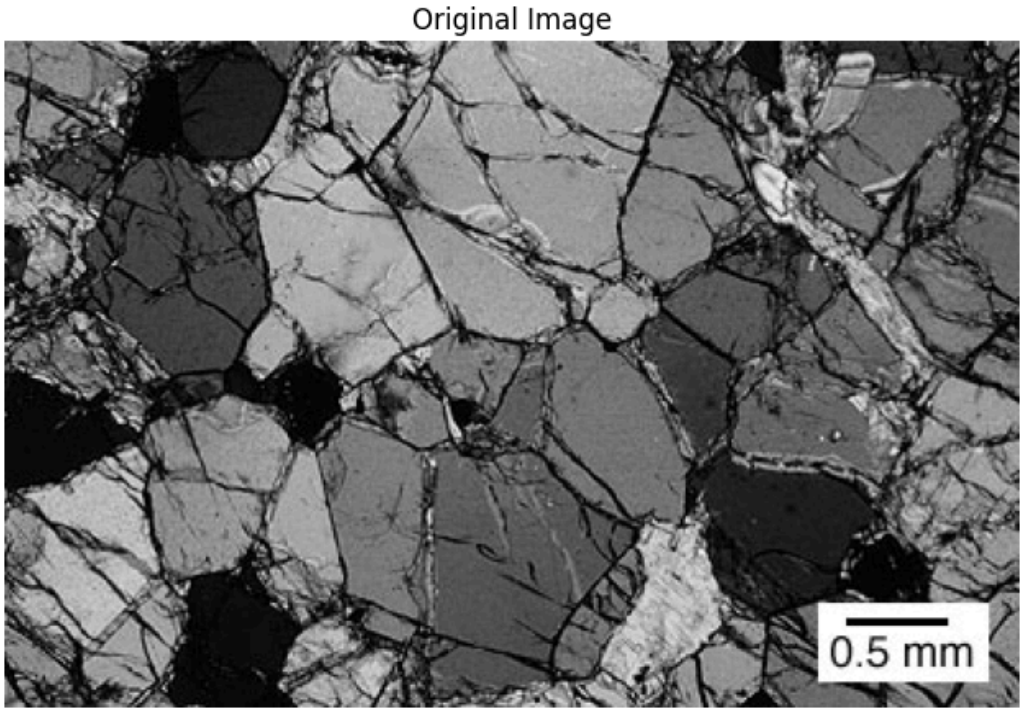
print("Analyzing Image 1:")
stats_image_5 = analyze_image_components(image_path_1)

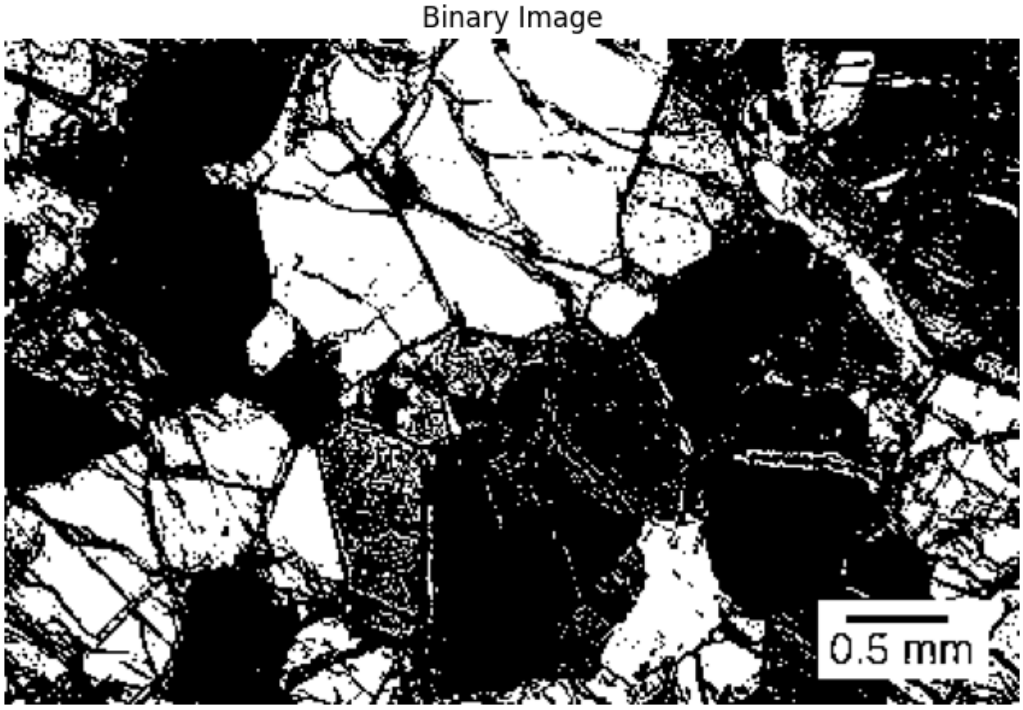
print("\nAnalyzing Image 2:")
stats_image_6 = analyze_image_components(image_path_2)'''
```

```
'print("Analyzing Image 1:")\nstats_image_1 = analyze_image_components(image_path_1)\n\nprint("\nAnalyzin
g Image 2:")\nstats_image_2 = analyze_image_components(image_path_2)\n\nprint("Analyzing Image 1:")\nstat
s_image_3 = analyze_image_components(image_path_1)\n\nprint("\nAnalyzing Image 2:")\nstats_image_4 = anal
yze_image_components(image_path_2)\n\nprint("Analyzing Image 1:")\nstats_image_5 = analyze_image_componen
```

```
print("\nAnalyzing Image 2:")
stats_image_6 = analyze_image_components(image_path_7)
```

Analyzing Image 2:



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Number of Labeled Components (excluding background): 1198
Component 1: Area = 87, Integrated Density = 12196, Centroid = [4.05747126 6.37931034]
Component 2: Area = 336, Integrated Density = 47458, Centroid = [22.67261905 10.00892857]
Component 3: Area = 4, Integrated Density = 581, Centroid = [33.   0.5]
Component 4: Area = 57, Integrated Density = 9275, Centroid = [45.78947368  2.8245614 ]
Component 5: Area = 2, Integrated Density = 320, Centroid = [56.   0.5]
Component 6: Area = 1, Integrated Density = 143, Centroid = [61.  1.]
Component 7: Area = 4, Integrated Density = 596, Centroid = [68.5  0.5]
Component 8: Area = 2, Integrated Density = 273, Centroid = [77.5  0.5]
Component 9: Area = 1, Integrated Density = 130, Centroid = [82.  0.]
Component 10: Area = 3, Integrated Density = 527, Centroid = [97.66666667  0.33333333]
Component 11: Area = 1, Integrated Density = 150, Centroid = [127.   0.]
Component 12: Area = 17, Integrated Density = 2828, Centroid = [134.70588235   1.23529412]
Component 13: Area = 6252, Integrated Density = 1021540, Centroid = [207.50047985  37.90786948]
Component 14: Area = 4, Integrated Density = 654, Centroid = [173.5   1. ]
Component 15: Area = 4, Integrated Density = 612, Centroid = [245.75   0.25]
Component 16: Area = 1, Integrated Density = 129, Centroid = [273.   1.]
Component 17: Area = 1, Integrated Density = 129, Centroid = [275.   0.]
Component 18: Area = 28, Integrated Density = 4605, Centroid = [283.60714286   3.17857143]
Component 19: Area = 210, Integrated Density = 33616, Centroid = [310.23809524  16.74761905]
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Component 20: Area = 2, Integrated Density = 383, Centroid = [385.   0.5]
Component 21: Area = 1, Integrated Density = 130, Centroid = [390.   1.]
Component 22: Area = 3, Integrated Density = 508, Centroid = [121.33333333   2.33333333]
Component 23: Area = 1, Integrated Density = 129, Centroid = [126.   2.]
Component 24: Area = 779, Integrated Density = 131655, Centroid = [140.17715019 23.18228498]
Component 25: Area = 1, Integrated Density = 143, Centroid = [141.   2.]
Component 26: Area = 1, Integrated Density = 156, Centroid = [143.   3.]
Component 27: Area = 1, Integrated Density = 128, Centroid = [267.   3.]
Component 28: Area = 3, Integrated Density = 478, Centroid = [271.66666667   3.33333333]
Component 29: Area = 2, Integrated Density = 268, Centroid = [275.5   2.]
Component 30: Area = 2, Integrated Density = 310, Centroid = [312.5   2.]
Component 31: Area = 12, Integrated Density = 1649, Centroid = [38.   7.16666667]
Component 32: Area = 2, Integrated Density = 410, Centroid = [62.5 4.]
Component 33: Area = 1, Integrated Density = 142, Centroid = [101.   4.]
Component 34: Area = 1, Integrated Density = 129, Centroid = [149.   4.]
Component 35: Area = 2, Integrated Density = 282, Centroid = [317.5   5.]
Component 36: Area = 150, Integrated Density = 25916, Centroid = [331.94666667 10.82666667]
Component 37: Area = 1, Integrated Density = 141, Centroid = [380.   5.]
Component 38: Area = 3, Integrated Density = 425, Centroid = [42.33333333 8.   ]
Component 39: Area = 1, Integrated Density = 146, Centroid = [48. 7.]
Component 40: Area = 1, Integrated Density = 129, Centroid = [113.   7.]
Component 41: Area = 29, Integrated Density = 4912, Centroid = [115.65517241 13.   ]
Component 42: Area = 7, Integrated Density = 1251, Centroid = [145.   7.57142857]
Component 43: Area = 1, Integrated Density = 185, Centroid = [150.   7.]
Component 44: Area = 1, Integrated Density = 178, Centroid = [169.   6.]
Component 45: Area = 3, Integrated Density = 544, Centroid = [271.   7.33333333]
Component 46: Area = 2, Integrated Density = 282, Centroid = [385.   7.5]
Component 47: Area = 1, Integrated Density = 167, Centroid = [396.   7.]
Component 48: Area = 12, Integrated Density = 1797, Centroid = [49.5 9.5]
Component 49: Area = 1, Integrated Density = 145, Centroid = [55. 8.]
Component 50: Area = 1, Integrated Density = 145, Centroid = [66. 8.]
Component 51: Area = 1, Integrated Density = 128, Centroid = [110.   8.]
Component 52: Area = 1, Integrated Density = 132, Centroid = [124.   8.]
Component 53: Area = 7, Integrated Density = 1164, Centroid = [155. 10.]
Component 54: Area = 2, Integrated Density = 283, Centroid = [320.5   9.5]
Component 55: Area = 1, Integrated Density = 135, Centroid = [113. 11.]
Component 56: Area = 3, Integrated Density = 415, Centroid = [385.33333333 10.66666667]
Component 57: Area = 3, Integrated Density = 402, Centroid = [395.   11.33333333]
Component 58: Area = 1, Integrated Density = 139, Centroid = [42. 13.]
Component 59: Area = 1, Integrated Density = 143, Centroid = [46. 12.]
Component 60: Area = 1, Integrated Density = 144, Centroid = [282. 12.]
Component 61: Area = 1, Integrated Density = 144, Centroid = [285. 13.]
Component 62: Area = 1, Integrated Density = 128, Centroid = [288. 12.]
Component 63: Area = 3, Integrated Density = 411, Centroid = [350. 13.]
Component 64: Area = 1, Integrated Density = 134, Centroid = [37. 15.]
Component 65: Area = 5, Integrated Density = 820, Centroid = [45. 16.]
Component 66: Area = 1, Integrated Density = 130, Centroid = [48. 14.]
Component 67: Area = 1, Integrated Density = 133, Centroid = [53. 14.]
Component 68: Area = 1, Integrated Density = 161, Centroid = [263. 15.]
Component 69: Area = 1, Integrated Density = 128, Centroid = [284. 15.]
Component 70: Area = 2, Integrated Density = 266, Centroid = [290.   15.5]
Component 71: Area = 5, Integrated Density = 779, Centroid = [344. 14.]
Component 72: Area = 25, Integrated Density = 4053, Centroid = [351.6   16.72]
Component 73: Area = 9, Integrated Density = 1372, Centroid = [360.33333333 16.22222222]
Component 74: Area = 3, Integrated Density = 415, Centroid = [369. 14.]
Component 75: Area = 1, Integrated Density = 135, Centroid = [397. 15.]
Component 76: Area = 102, Integrated Density = 15198, Centroid = [2.62745098 24.57843137]
Component 77: Area = 69, Integrated Density = 11746, Centroid = [42.57971014 23.97101449]
Component 78: Area = 3, Integrated Density = 408, Centroid = [50.33333333 17.   ]
Component 79: Area = 1, Integrated Density = 160, Centroid = [268. 16.]
Component 80: Area = 2, Integrated Density = 276, Centroid = [280.   16.5]
Component 81: Area = 2, Integrated Density = 262, Centroid = [342.5 17.]
Component 82: Area = 2, Integrated Density = 287, Centroid = [345.5 17.]
Component 83: Area = 4, Integrated Density = 600, Centroid = [368.   17.5]
Component 84: Area = 2, Integrated Density = 284, Centroid = [373.   16.5]
Component 85: Area = 2, Integrated Density = 272, Centroid = [380.5 17.]
Component 86: Area = 19, Integrated Density = 2993, Centroid = [35.63157895 22.10526316]
Component 87: Area = 69, Integrated Density = 11129, Centroid = [122.33333333 26.5942029]
Component 88: Area = 61, Integrated Density = 8278, Centroid = [261.40983607 29.3442623]
Component 89: Area = 2, Integrated Density = 288, Centroid = [266.5 19.5]
Component 90: Area = 3, Integrated Density = 404, Centroid = [275.33333333 19.   ]
Component 91: Area = 2, Integrated Density = 276, Centroid = [291.   18.5]
Component 92: Area = 209, Integrated Density = 32196, Centroid = [325.33492823 25.44497608]
Component 93: Area = 143, Integrated Density = 21106, Centroid = [14.36363636 30.23776224]