Computer Vision HW7

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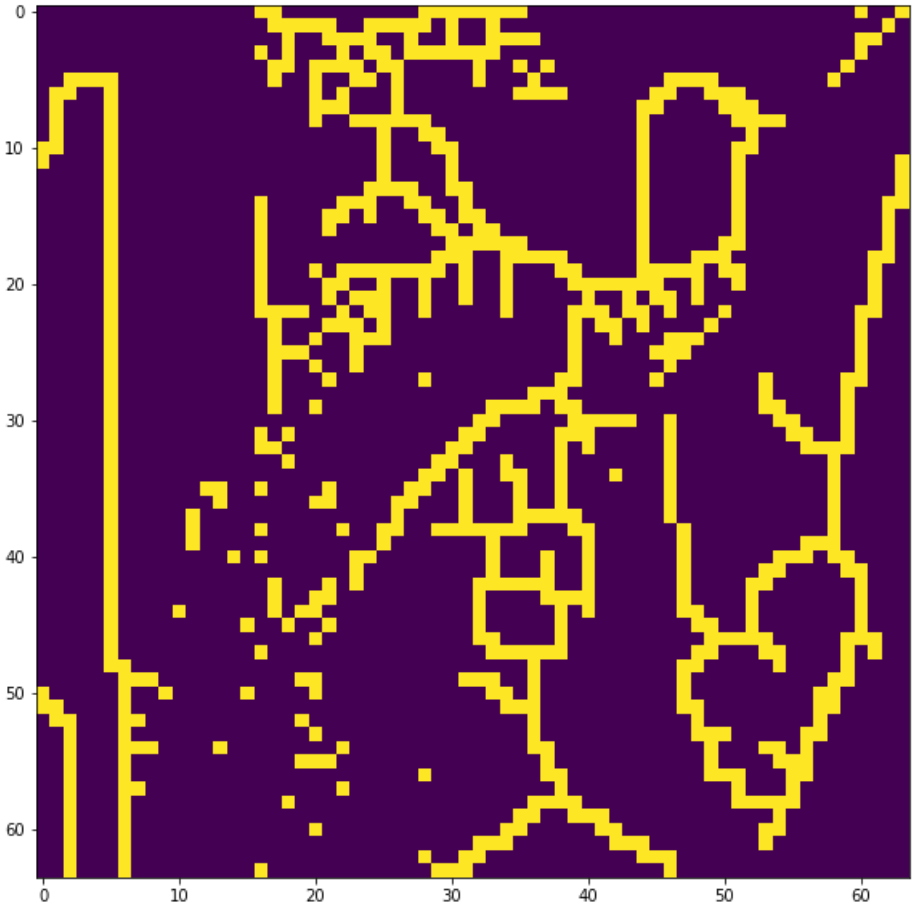
I use python 3.7 to implement all image processing requirements. Reading .bmp file by **PIL**, and then processing through **NumPy** array.

- ## 1. Results



- ## 2. Code fragment

```
def YokoiConnectivityNumberTransform(bin_img):
    def h(b, c, d, e):
        if b == c and (d != b or e != b):
            return 'q'
        if b == c and (d == b and e == b):
            return 'r'
        return 's'
```

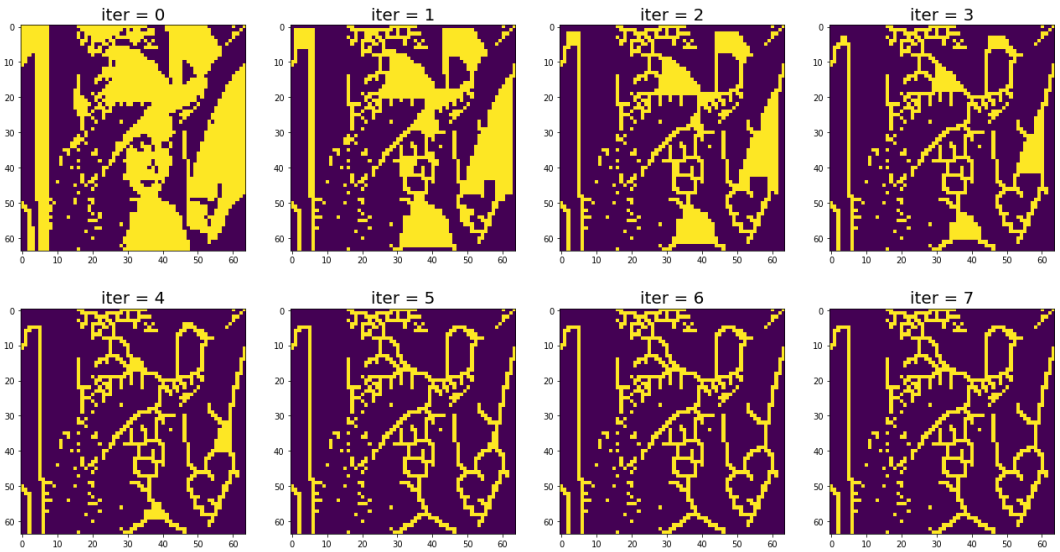
```
    def YokoiConnectivityNumber(bin_img, i, j):
        if i == 0:
            if j == 0:
                # top-left
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, bin_img[i + 1, j], bin_img[i + 1, j + 1]
            elif j == bin_img.shape[1] - 1:
                # top-right
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = bin_img[i + 1, j - 1], bin_img[i + 1, j], 0
            else:
                # top-row
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = bin_img[i, j -
                                     1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = bin_img[i + 1, j -
                                     1], bin_img[i + 1, j], bin_img[i + 1, j +
1]
        elif i == bin_img.shape[0] - 1:
            if j == 0:
                # bottom-left
                x7, x2, x6 = 0, bin_img[i - 1, j], bin_img[i - 1, j + 1]
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, 0, 0
            elif j == bin_img.shape[1] - 1:
                # bottom-right
                x7, x2, x6 = bin_img[i - 1, j - 1], bin_img[i - 1, j], 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = 0, 0, 0
            else:
                # bottom-row
                x7, x2, x6 = bin_img[i - 1, j -
                                     1], bin_img[i - 1, j], bin_img[i - 1, j +
1]
                x3, x0, x1 = bin_img[i, j -
                                     1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, 0, 0
        else:
            if j == 0:
                x7, x2, x6 = 0, bin_img[i - 1, j], bin_img[i - 1, j + 1]
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, bin_img[i + 1, j], bin_img[i + 1, j + 1]
            elif j == bin_img.shape[1] - 1:
                x7, x2, x6 = bin_img[i - 1, j - 1], bin_img[i - 1, j], 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = bin_img[i + 1, j - 1], bin_img[i + 1, j], 0
            else:
                x7, x2, x6 = bin_img[i - 1, j -
                                     1], bin_img[i - 1, j], bin_img[i - 1, j +
1]
                x3, x0, x1 = bin_img[i, j -
                                     1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = bin_img[i + 1, j -
```

```
                                    1], bin_img[i + 1, j], bin_img[i + 1, j +
1]

        a1 = h(x0, x1, x6, x2)
        a2 = h(x0, x2, x7, x3)
        a3 = h(x0, x3, x8, x4)
        a4 = h(x0, x4, x5, x1)

        if a1 == 'r' and a2 == 'r' and a3 == 'r' and a4 == 'r':
            return 5
        else:
            return sum(np.array([a1, a2, a3, a4]) == 'q')

    output = np.zeros(bin_img.shape)

    # compute and output Yokoi Connectivity Number ...
    for i in range(bin_img.shape[0]):
        for j in range(bin_img.shape[1]):
            if bin_img[i, j] > 0:
                output[i, j] = YokoiConnectivityNumber(bin_img, i, j)

    return output


def MarkPairRelationship(bin_img, yokoi_img):
    # for marking pair relationship
    def PairRelationship(yokoi_img, i, j):
        if yokoi_img[i, j] != 1:
            return 2
        x1, x2, x3, x4 = 0, 0, 0, 0
        x1 = 1 if j + 1 < yokoi_img.shape[0] and yokoi_img[i, j+1] == 1 else 0
        x2 = 1 if i - 1 >= 0 and yokoi_img[i-1, j] == 1 else 0
        x3 = 1 if j - 1 >= 0 and yokoi_img[i, j-1] == 1 else 0
        x4 = 1 if i + 1 < yokoi_img.shape[1] and yokoi_img[i+1, j] == 1 else 0
        return 1 if x1 + x2 + x3 + x4 >= 1 else 2

    output = np.zeros(yokoi_img.shape)
    # background pixel: 0
    # p: 1
    # q: 2
    for i in range(yokoi_img.shape[0]):
        for j in range(yokoi_img.shape[1]):
            if bin_img[i, j] > 0:
                output[i, j] = PairRelationship(yokoi_img, i, j)
    return output


def ConnectedShrinkOperator(bin_img, img_pair):
    def h_cs(b, c, d, e):
        if b == c and (d != b or e != b):
            return 1
        else:
            return 0

    def f_cs(a1, a2, a3, a4, x0):
```

```
        if sum(np.array([a1, a2, a3, a4]) == 1) == 1:
            return 0
        else:
            return x0

    def ConnectedShrink(bin_img, i, j):
        if i == 0:
            if j == 0:
                # top-left
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, bin_img[i + 1, j], bin_img[i + 1, j + 1]
            elif j == bin_img.shape[1] - 1:
                # top-right
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = bin_img[i + 1, j - 1], bin_img[i + 1, j], 0
            else:
                # top-row
                x7, x2, x6 = 0, 0, 0
                x3, x0, x1 = bin_img[i, j -
                                     1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = bin_img[i + 1, j -
                                     1], bin_img[i + 1, j], bin_img[i + 1, j +
1]
        elif i == bin_img.shape[0] - 1:
            if j == 0:
                # bottom-left
                x7, x2, x6 = 0, bin_img[i - 1, j], bin_img[i - 1, j + 1]
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, 0, 0
            elif j == bin_img.shape[1] - 1:
                # bottom-right
                x7, x2, x6 = bin_img[i - 1, j - 1], bin_img[i - 1, j], 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = 0, 0, 0
            else:
                # bottom-row
                x7, x2, x6 = bin_img[i - 1, j -
                                     1], bin_img[i - 1, j], bin_img[i - 1, j +
1]
                x3, x0, x1 = bin_img[i, j -
                                     1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, 0, 0
        else:
            if j == 0:
                x7, x2, x6 = 0, bin_img[i - 1, j], bin_img[i - 1, j + 1]
                x3, x0, x1 = 0, bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = 0, bin_img[i + 1, j], bin_img[i + 1, j + 1]
            elif j == bin_img.shape[1] - 1:
                x7, x2, x6 = bin_img[i - 1, j - 1], bin_img[i - 1, j], 0
                x3, x0, x1 = bin_img[i, j - 1], bin_img[i, j], 0
                x8, x4, x5 = bin_img[i + 1, j - 1], bin_img[i + 1, j], 0
            else:
                x7, x2, x6 = bin_img[i - 1, j -
```

```
                                    1], bin_img[i - 1, j], bin_img[i - 1, j +
1]
                x3, x0, x1 = bin_img[i, j -
                                    1], bin_img[i, j], bin_img[i, j + 1]
                x8, x4, x5 = bin_img[i + 1, j -
                                    1], bin_img[i + 1, j], bin_img[i + 1, j +
1]

        a1 = h_cs(x0, x1, x6, x2)
        a2 = h_cs(x0, x2, x7, x3)
        a3 = h_cs(x0, x3, x8, x4)
        a4 = h_cs(x0, x4, x5, x1)
        return f_cs(a1, a2, a3, a4, x0)

    bin_img = bin_img.copy()
    for i in range(bin_img.shape[0]):
        for j in range(bin_img.shape[1]):
            if bin_img[i, j] > 0 and img_pair[i, j] != 2:
                bin_img[i, j] = ConnectedShrink(bin_img, i, j)
    return bin_img
```

- ## 3. Brief Description



All the assigned operators ' implementation details follow the course's lecture slides. Each transformation used 4-connected, and their h function has been shown in the code fragment part.

Firstly, the preprocessing processes, downsampling image from 512x512 to 64x64, and the binarization at the threshold 128 were conducted. Then, the image would be processed by the three-step operations iteratively.