Binarize

Dilation

Erosion

Opening

Closing

Hit and miss

(a) Dilation

```python
def dilation(img,kernel):
    im = np.array(img)
    temp = np.zeros((512,512))

    for i in range(width):
        for j in range(height):
            if im[i][j] == 255:
                for point in kernel:
                    x, y = point
                    if (x+i) >= 0 and (x+i) < width and (y+j) >= 0 and (y+j) < height:
                        temp[i+x][j+y] = 255
    result = Image.fromarray(np.uint8(temp))
    # result.show()
    return result
```

題目規定對白色（255）做 kernel 為 octagonal 的 dilation
讀入照片後轉為 ndarray，接著按照順序讀入每個 pixel
如果為白色，將 kernel 帶入進行 dilation

(b) Erosion

```
def erosion(img, kernel):
    im = np.array(img)
    temp = np.zeros((512,512))

    for i in range(width):
        for j in range(height):
            temp[i][j] = 255
            for point in kernel:
                x, y = point
                if (x+i) < 0 or (x+i) >= width or (y+j) < 0 or (y+j) >= height or im[i+x][j+y] != 255:
                    temp[i][j] = 0
                    break
    result = Image.fromarray(np.uint8(temp))
    # result.show()
    return result
```

讀入照片後轉為 ndarray，接著按照順序讀入每個 pixel
先將每個 pixel 填入白色
接著將 kernel 帶入，若超出邊界或不為白色
則將該 pixel 改為黑色

(c) Opening & Closing

```
def opening(img, kernel):
    return dilation(erosion(img, kernel), kernel)

def closing(img, kernel):
    return erosion(dilation(img, kernel), kernel)
```

According to the course slides,

The definition of opening is $B \circ K = (B \ominus K) \oplus K$

The definition of closing is $B \bullet K = (B \oplus K) \ominus K$

(d) Hit and miss

```
def hit_miss(img):
    im = np.array(img)
    A = np.array(erosion(im, J))
    B = np.array(erosion(255-im, K))
    temp = np.zeros((512,512))

    for i in range(width):
        for j in range(height):
            if B[i][j] == 255 and A[i][j] == 255:
                temp[i][j] = 255
    result = Image.fromarray(np.uint8(temp))
    result.show()
    return result
```

The definition of hit-and-miss is $A \otimes (J, K) = (A \ominus J) \cap (A^c \ominus K)$

首先 image 對 J kernel 做 erosion
接著 image 的補集（255-im）對 K kernel 做 erosion
找兩者的交集