Homework 4

Mathematical Morphology - Binary Morphology
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Programming language: Python 3.7.3

Library used for this homework:

✦ Numpy

✦ OpenCv: to read and write the image file

Image info: lena.bmp [512(width),512(height),1(Grayscale)]

Code explanation:

First, read in lena.bmp as grayscale image and turn it into a binary image.

```python
def binarize():
    for r in range(rows):
        for c in range(columns):
            if lena[r,c] < 128:
                lena[r,c] = 0
            else:
                lena[r,c] = 255
```

(a)Document about dilation: https://en.wikipedia.org/wiki/Dilation_(morphology)

Go through each pixel with two "for" loop. If the pixel is black (0), skip it. Next step is to go through a 5*5 kernel. Check if the corresponding pixels on the origin image and copied image are both black. If they are black, change pixel on the copied image to the same one on the kernel.

```python
#Go through a 5*5 kernel
for numRow in range(-2,3):
    if (r+numRow) >= 0 and (r+numRow) < rows: #Check row isn't below 0 or larger than 51
        for numCol in range(-2,3):
            if (c+numCol) >= 0 and (c+numCol) < columns: #Check column isn't below 0 or
                if lena[r+numRow, c+numCol] == 0 and lenaCopy[r+numRow, c+numCol] == 0:
                    lenaCopy[r+numRow, c+numCol] = kernel[2+numRow, 2+numCol]
```

(b)Document about erosion: https://en.wikipedia.org/wiki/Erosion_(morphology)

The beginning part is same as dilation. Go through each pixel with two "for" loop and skip the black pixel. Examine the 5-5-5 part of the kernel first. Use a Boolean variable "flagSame" to record the current state of erosion. If a mismatch is found, the flag will be captured as False, and the target pixel will be recorded as black.

```python
flagSame = True
#Go through a 3*5 kernel. First and last row of the kernel will be examine
for numRow in range(-1,2):
    if flagSame == False:
        break
    if (r+numRow) >= 0 and (r+numRow) < rows: #Check row isn't below 0 or l
        for numCol in range(-2,3):
            if (c+numCol) >= 0 and (c+numCol) < columns: #Check column isn'
                if lena[r+numRow, c+numCol] != kernel[2+numRow, 2+numCol]:
                    flagSame = False
                    break
```

The remaining 3-3 part of the kernel will be examined with the similar process.

(c) Document about opening: https://en.wikipedia.org/wiki/Opening_(morphology)
Call erosion function, and call dilation function using the erosion result.

$$A \circ B = (A \ominus B) \oplus B,$$

(d) Document about closing: https://en.wikipedia.org/wiki/Closing_(morphology)
Call dilation function, and call erosion dilation function using the dilation result.

$$A \bullet B = (A \oplus B) \ominus B,$$

(e)Document: https://en.wikipedia.org/wiki/Hit-or-miss_transform
The main formula for calculating hit-and-miss: $A \odot B = (A \ominus C) \cap (A^c \ominus D)$
Call the erosion function with the 5*5 kernel and original Lena image, and call the erosion function with the disjoint kernel and complement Lena image. Find the intersection of this two sets.

```python
for r in range(rows):
    for c in range(columns):
        if lena[r,c] == 255 and lena[r,c] == lenaCopyCopy[r,c]:
            lenaCopy[r,c] = 255
        else:
            lenaCopy[r,c] = 0
```

Result:
(a) Dilation

(b) Erosion

(c)

(d)

(e)