GENERALCONFEDERATION OF LABOR OF VIETNAM

TON DUC THANG UNIVERSITY FACULTY OF INFORMATION TECHNOLOGY

DIGITAL IMAGE PROCESSING

REPORT ASSIGNMENT

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Class: **18H50205**

Course: **22**

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With limited time and experience, this report can not avoid mistakes. We are looking forward to receiving advice and comments from teachers so that we can improve our awareness, better serve the practical work later.

Thank you!

EVALUATION OF INSTRUCTING LECTURER

Confirmation of the instructor

Ho Chi Minh, ... , 2022

(Sign and write your full name)

The assessment of the teacher marked

Ho Chi Minh, ... , 2022

(Sign and write your full name)

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I. Implement

Step 1: Preprocessing

```
6
7   def pre_process_image(img, skip_dilate=False):
8       """Uses a blurring function, adaptive thresholding and dilation to expose the main features of an
9       proc = cv2.GaussianBlur(img.copy(), (9, 9), 0)
0       proc = cv2.adaptiveThreshold(proc, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C, cv2.THRESH_BINARY, 11, 2)
1       proc = cv2.bitwise_not(proc, proc)
2       if not skip_dilate:
3           kernel = np.array([[0., 1., 0.], [1., 1., 1.], [0., 1., 0.]],np.uint8)
4           proc = cv2.dilate(proc, kernel)
5       return proc
6
```

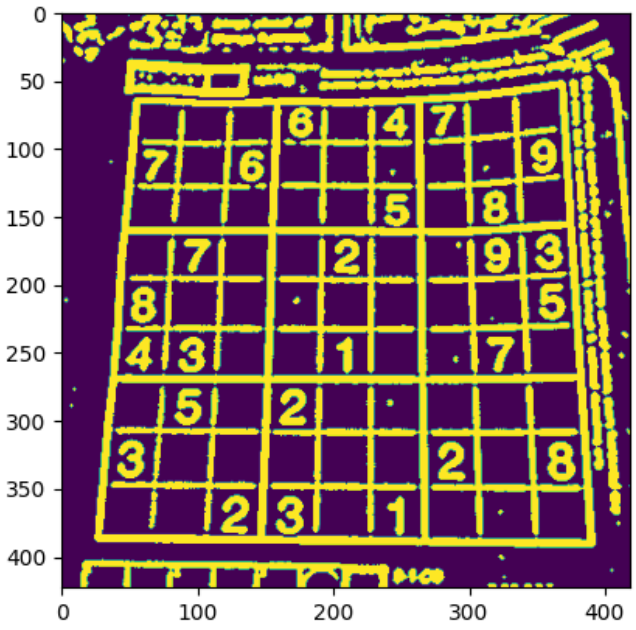
Blur the image a little. This smooths out the noise a bit and makes extracting the grid lines easier.

With the noise smoothed out, we can now threshold the image. The image can have varying illumination levels, so a good choice for a thresholding algorithm would be an adaptive threshold. It calculates a threshold level several small windows in the image. This threshold level is calculated using the mean level in the window. So it keeps things illumination independent.

It calculates a mean over a 5x5 window and subtracts 2 from the mean. This is the threshold level for every pixel.

Since we're interested in the borders, and they are black, we invert the image *outerBox*. Then, the borders of the puzzles are white (along with other noise).

This thresholding operation can disconnect certain connected parts (like lines). So dilating the image once will fill up any small "cracks" that might have crept in.



Step 2: Find the biggest connected pixel structure in the image.

```python
def find_largest_feature(inp_img, scan_tl=None, scan_br=None):
    """
    Uses the fact the `floodFill` function returns a bounding box of the area it filled to find the biggest
    connected pixel structure in the image. Fills this structure in white, reducing the rest to black.
    """
    img = inp_img.copy()
    height, width = img.shape[:2]
    max_area = 0
    seed_point = (None, None)
    if scan_tl is None:
        scan_tl = [0, 0]
    if scan_br is None:
        scan_br = [width, height]
    for x in range(scan_tl[0], scan_br[0]):
        for y in range(scan_tl[1], scan_br[1]):
            if img.item(y, x) == 255 and x < width and y < height:
                area = cv2.floodFill(img, None, (x, y), 64)
                if area[0] > max_area:
                    max_area = area[0]
                    seed_point = (x, y)
    for x in range(width):
        for y in range(height):
            if img.item(y, x) == 255 and x < width and y < height:
                cv2.floodFill(img, None, (x, y), 64)

    mask = np.zeros((height + 2, width + 2), np.uint8)
    if all([p is not None for p in seed_point]):
        cv2.floodFill(img, mask, seed_point, 255)
    top, bottom, left, right = height, 0, width, 0
    for x in range(width):
        for y in range(height):
            if img.item(y, x) == 64:
                cv2.floodFill(img, mask, (x, y), 0)
            if img.item(y, x) == 255:
                top = y if y < top else top
                bottom = y if y > bottom else bottom
                left = x if x < left else left
                right = x if x > right else right
    bbox = [[left, top], [right, bottom]]
    return img, np.array(bbox, dtype='float32'), seed_point
```

Here's the technique I use. First, I use the floodfill command. This command returns a bounding rectangle of the pixels it filled. We've assumed the biggest thing in the picture to be the puzzle. So the biggest blob should have be the puzzle. Since it is the biggest, it will have the biggest bounding box as well. So we find the biggest bounding box, and save the location where we did the flood fill.

Step 3: Crop and warps a rectangular

```
def distance_between(p1, p2):
    """Returns the scalar distance between two points"""
    a = p2[0] - p1[0]
    b = p2[1] - p1[1]
    return np.sqrt((a ** 2) + (b ** 2))
```

```
58
59  def crop_and_warp(img, crop_rect):
60      """Crops and warps a rectangular section from an image into a square of similar size."""
61      top_left, top_right, bottom_right, bottom_left = crop_rect[0], crop_rect[1], crop_rect[2], crop_rect[3]
62      src = np.array([top_left, top_right, bottom_right, bottom_left], dtype='float32')
63      side = max([
64          distance_between(bottom_right, top_right),
65          distance_between(top_left, bottom_left),
66          distance_between(bottom_right, bottom_left),
67          distance_between(top_left, top_right)
68      ])
69      dst = np.array([[0, 0], [side - 1, 0], [side - 1, side - 1], [0, side - 1]], dtype='float32')
70      m = cv2.getPerspectiveTransform(src, dst)
71      return cv2.warpPerspective(img, m, (int(side), int(side)))
72
```

Simple code. We calculate the length of each edge. Whenever we find a longer edge, we store its length squared. And finally when we have the longest edge, we do a square root to get its exact length.

Next, we create source and destination points. The top left point in the source is equivalent to the point (0,0) in the corrected image. And so on.

Then we create a new image and do the undistortion

Step 4: Get digits

The idea is extract the largest component in the square. First step I extract each cells from the image by slicing the Sudoku grid

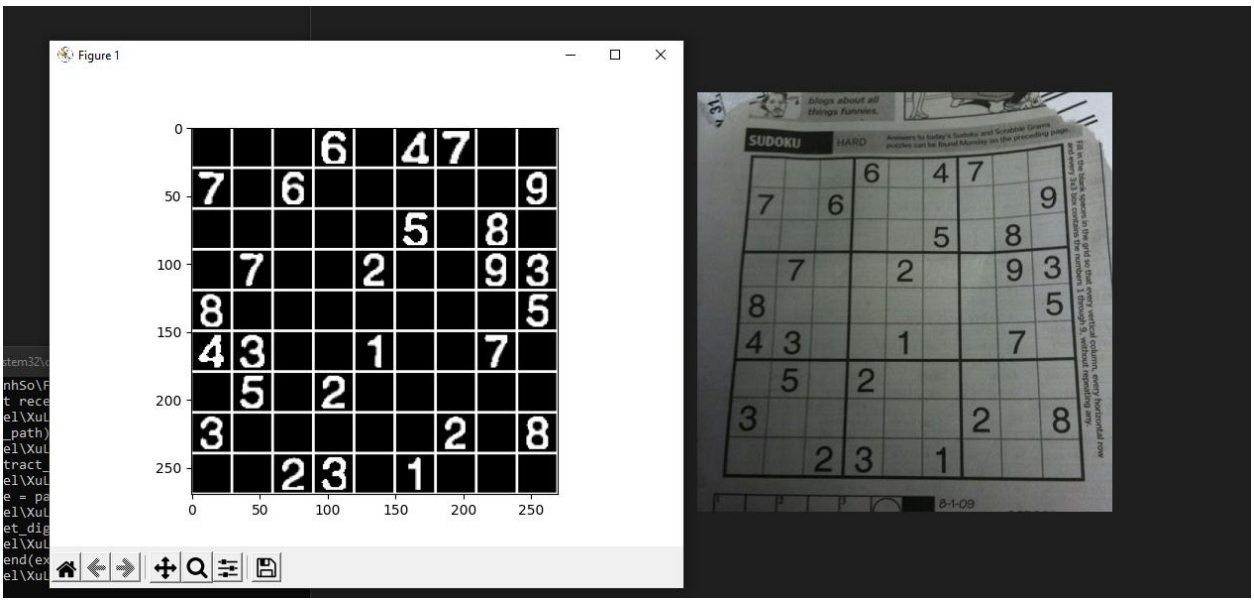
```
def infer_grid(img):
    """Infers 81 cell grid from a square image."""
    squares = []
    side = img.shape[:1]
    side = side[0] / 9
    for j in range(9):
        for i in range(9):
            p1 = (i * side, j * side)
            p2 = ((i + 1) * side, (j + 1) * side)
            squares.append((p1, p2))
    return squares
```

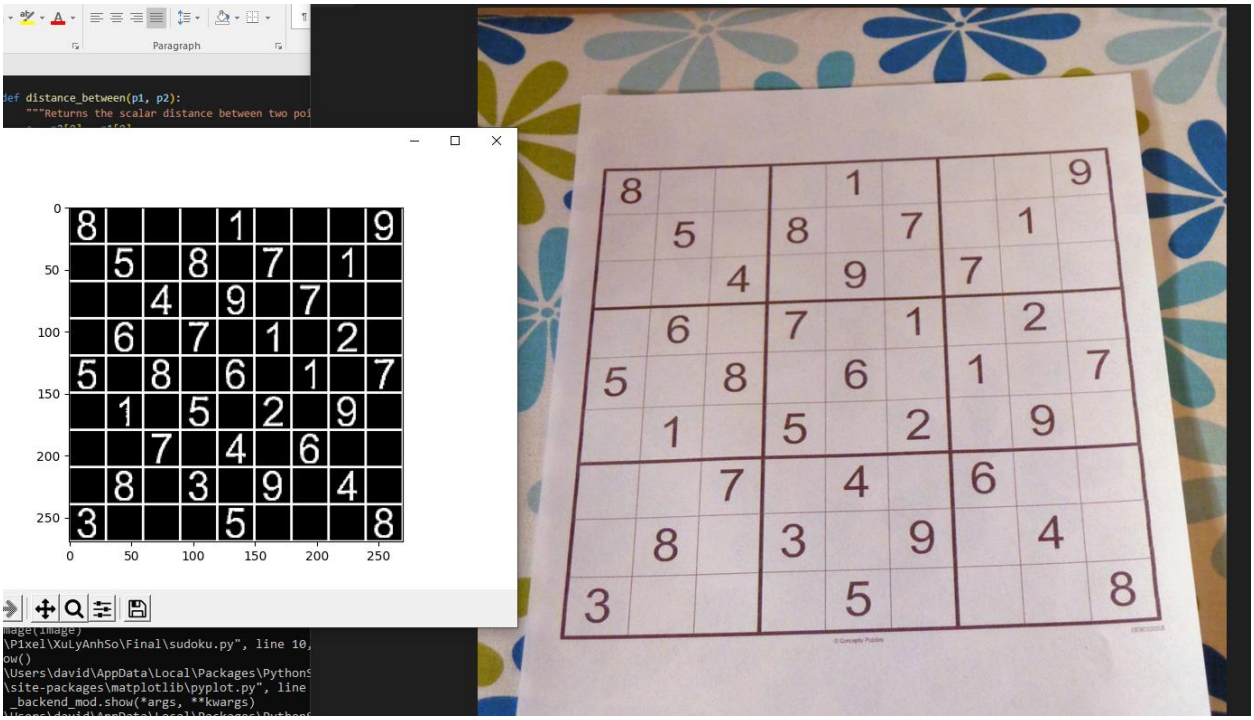
Next, I just need to extract the biggest component in each square and that is the number we need to get

```python
def extract_digit(img, rect, size):
    """Extracts a digit (if one exists) from a Sudoku square."""
    digit = cut_from_rect(img, rect)
    h, w = digit.shape[:2]
    margin = int(np.mean([h, w]) / 2.5)
    _, bbox, seed = find_largest_feature(digit, [margin, margin], [w - margin, h - margin])
    digit = cut_from_rect(digit, bbox)
    w = bbox[1][0] - bbox[0][0]
    h = bbox[1][1] - bbox[0][1]
    if w > 0 and h > 0 and (w * h) > 100 and len(digit) > 0:
        return scale_and_centre(digit, size, 4)
    else:
        return np.zeros((size, size), np.uint8)

def get_digits(img, squares, size):
    """Extracts digits from their cells and builds an array"""
    digits = []
    img = pre_process_image(img.copy(), skip_dilate=True)
#     cv2.imshow('img', img)
    for square in squares:
        digits.append(extract_digit(img, square, size))
    return digits
```

II. Demo




Paragraph
def distance_between(p1, p2):
"""Returns the scalar distance between two poi
0 50 100 150 200 250
\P1xel\XuLyAnhSo\Final\sudoku.py", line 10,
ow()
\Users\david\AppData\Local\Packages\Python
\site-packages\matplotlib\pyplot.py", line
_backend_mod.show(*args, **kwargs)