Task 3 - Number plate recognition

Pre-processing

```
figure;
```

Read images and turn them to grayscale

```
img_path = "images/final/task_3/";

image1 = imread(img_path + "example_number_plate.png");
subplot(2, 2, 1); imshow(image1); title("Original Image");

img1gray = rgb2gray(image1);
subplot(2, 2, 2); imshow(img1gray); title("1. Grayscale");
```

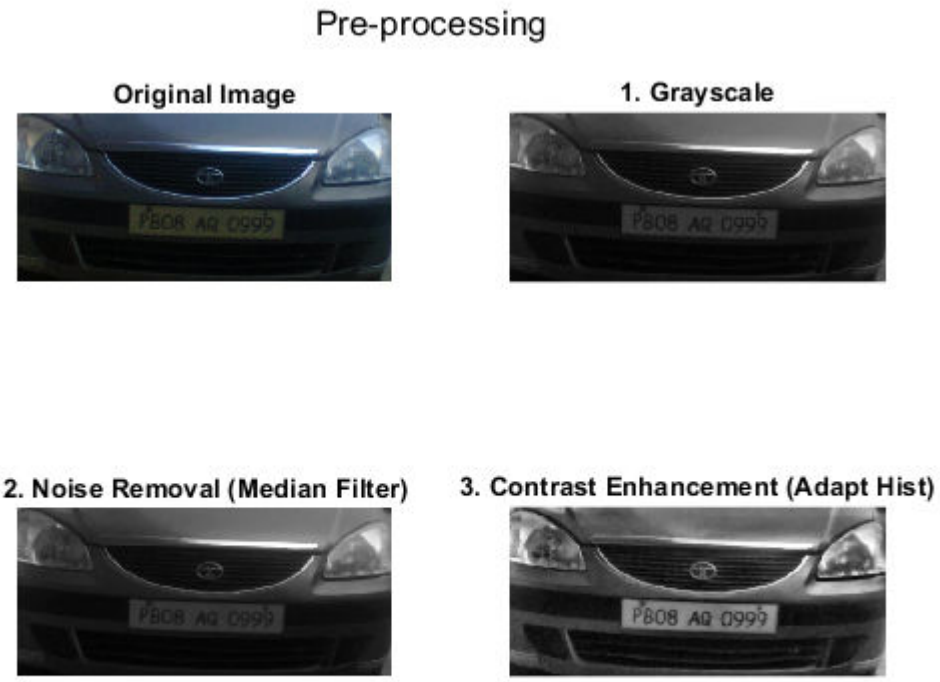
Noise removal

```
% Here I guess we could use imbilatfilt to filter it
% bilaterally like in the documentation.
img1med = medfilt2(img1gray);
subplot(2, 2, 3); imshow(img1med); title("2. Noise Removal (Median Filter)");
```

Contrast Enhancement with Adaptive Histogram Equalization

```
img1cont = adapthisteq(img1med);
subplot(2, 2, 4); imshow(img1cont); title("3. Contrast Enhancement (Adapt Hist)");

sgtitle("Pre-processing");
```



Morphological Opening and Image Subtraction Operations

```
figure;
```

Opening with structuring element of shape 'disk'

We open the image to remove any small objects from the foreground, while preserving the shape and size of larger objects.

```
se = strel('disk',15);
img1open = imopen(img1cont,se);
subplot(1, 3, 1); imshow(img1open); title("4. Disk Opening");
```

Subtraction from enhanced image

In order for the binarization to work better, we subtract the opened image from the contrast enhanced one.

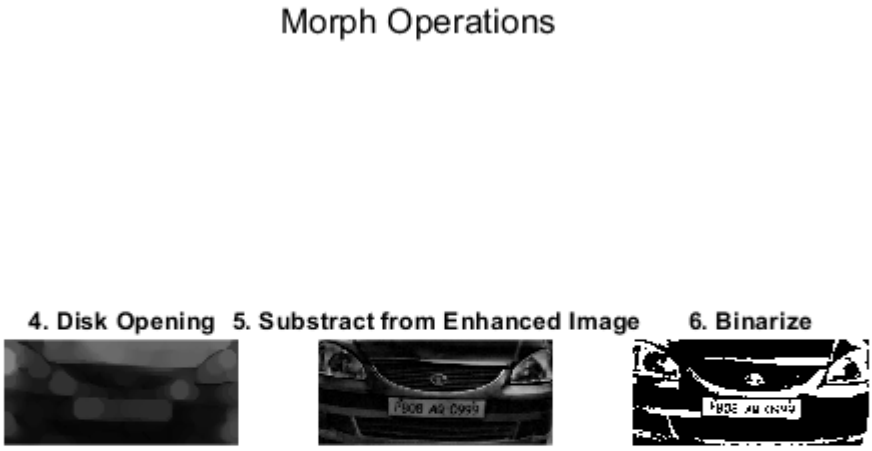
```
img1sub = imsubtract(img1cont, img1open);
subplot(1, 3, 2); imshow(img1sub); title("5. Substract from Enhanced Image");
```

Image binarization

```
% Find grayscale threshold and binarize
bins = 19;
[counts,x] = imhist(img1sub, bins);
g_thresh = otsuthresh(counts); %graythresh(img1sub)
```

```
img1bin = imbinarize(img1sub, g_thresh);

%imshowpair(img1bin, img1bin_filled);
subplot(1, 3, 3); imshow(img1bin); title("6. Binarize");
sgtitle("Morph Operations");
```



Creating Mask

```
figure;
```

Detect edges with the Sobel operator

```
img1edge = edge(img1bin);
subplot(2, 3, 1); imshow(img1edge); title("7. Sobel Edge Detection");
```

Candidate plate area detection with morphological operators

Dilation

We dilate the image to widen the edges from the Sobel operator.

```
se2 = strel('square', 2);
img1dil = imdilate(img1edge, se2);
subplot(2, 3, 2); imshow(img1dil); title("8. Square Dilation");
```

Filling holes

Fill any holes in order to show plate location.

```
img1fill = imfill(img1dil, 'holes');
subplot(2, 3, 3); imshow(img1fill); title("9. Fill Holes");
```

Opening

Again, we open to get rid of smaller objects, gradually.

```
se3 = strel('square',22);
img1open = imopen(img1fill, se3);
subplot(2, 3, 4); imshow(img1open); title("10. Square Opening");
```

Remove smaller objects

```
img1clean = bwareaopen(img1open, 800);
subplot(2, 3, 5); imshow(img1clean); title("11. Removed small objects");
```

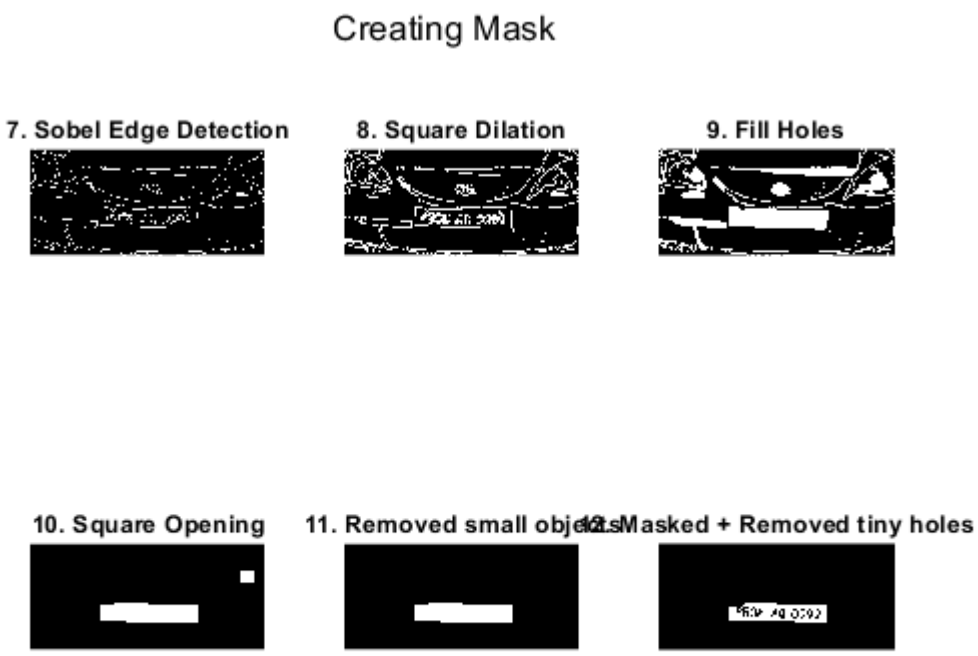
Apply Mask

We apply the mask that resulted from the previous operation onto the previously enhanced image.

```
img1bin(~img1clean) = 0;

% Remove tiny holes based on size (screws at the top of plate)
img1bin_filled = ~bwareaopen(~img1bin, 20);
subplot(2, 3, 6); imshow(img1bin_filled); title("12. Masked + Removed tiny holes");

sgtitle("Creating Mask");
```



OCR

With the help of OCR, we detect the characters on the license plate.

```
figure;
```

Should make it only check for

- Letters (Language) for the first 2 letters
- Numeric for the following 2 letters
- Letters for the middle 2 letters
- Numeric digits for the last 4 digits

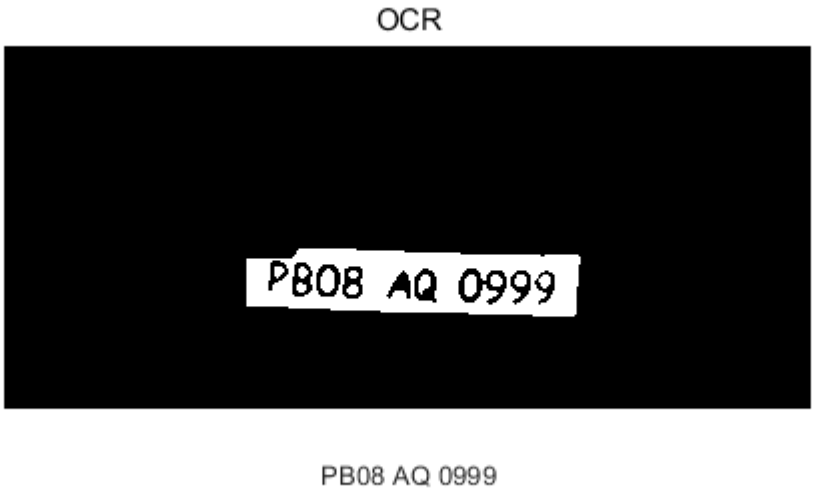
```
img_ocr = img1bin_filled;

plate_text = getLicensePlateByRegion_ocr(img_ocr, PlateTypes.Default);
```

```
Found letters:
ans = 3
  1:  PBOB
Found digits:
ans = 3
  1:  7808
```

```
imshow(img_ocr); xlabel(plate_text);

sgtitle("OCR");
```




```
fclose('all');
```

Questions

1. What is the purpose of each step in the workflow above?

- Steps have been explained throughout the script.

2. State the main decisions you needed to take. For example, which filter/technique did you choose and why?

- First off, we used Adaptive Histogram Equalization to enhance the contrast, as it seemingly gives better results than normal Histogram Equalization.
- The Sobel filter has been used for edge detection, which resulted in a satisfactory outcome.
- The series of dilation, filling, and then opening proved crucial in order to detect the location of the license plate in the picture.

3. How is the performance of morphological operators versus Hough transform for detecting the candidate plate area?

- Using morphological operators takes more steps to create mask than using a hough transform, and although Hough demands more memory to analyse and detect the image, there is no noticable performance delay. However, hough requires you to spend time analyzing and calculating the requirements needed to detect the lines that are of interest, while also needing some moprhological operators before-hand.

4. How accurate is this algorithm?

- The Hough algorithm used works by comparing each line with every other, and realizing the min and max difference vertical lines of a min length had between eachother, to recognize which 2 lines were more likely to belong to the plate. These assumptions were made based on a single image of a car of a certain distance, so the assumed scaling of the plate is heavily depended on the distance between the camera lens and the car plate. Therefore, the algorithm would behave differently when used on images with cars with varied distances to the camera than the assumed one.
- Overall, the algorithm works along a robust preprocessing section, where the segmentation is unfortunately limited by set requirements. Based on those requirements however the recognition works well.
- It should have been tested with images of the same requirements to test the recognition further, but it was hard to find that + the same region-based type of plate.