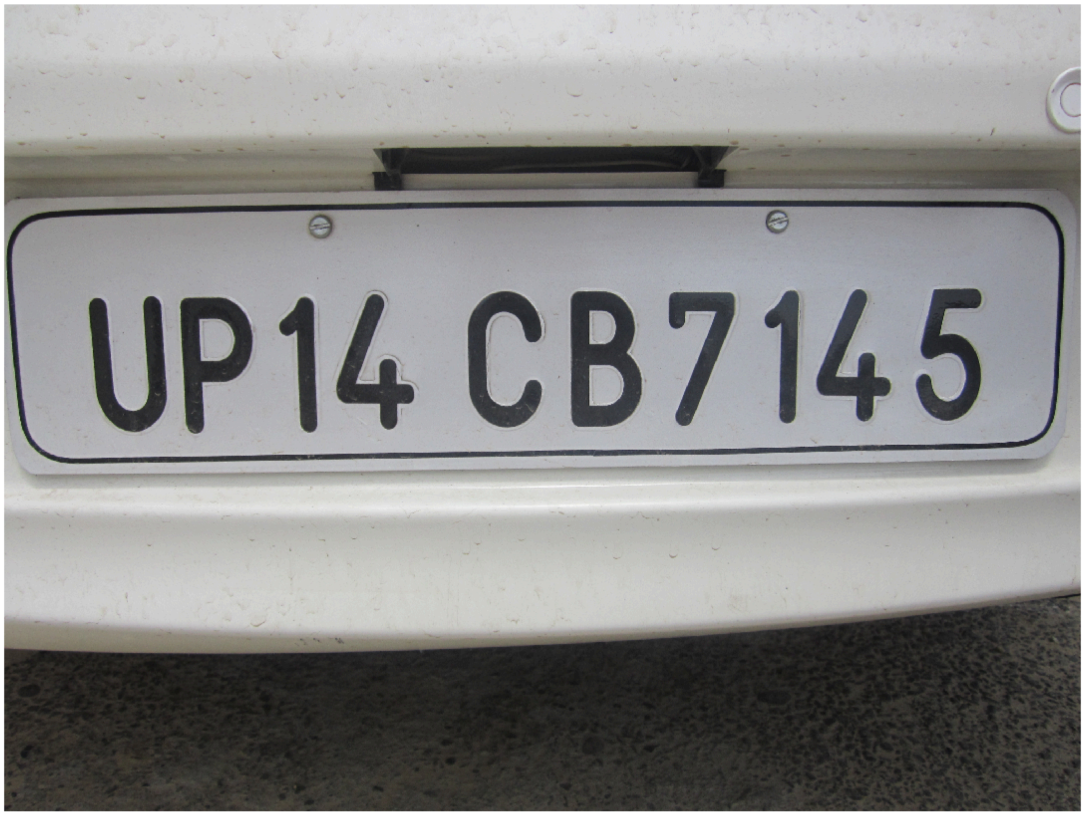
Signal and System CA2

Part 1.

1) Read and load the picture in a 3d-matrix.

```
[file, path] = uigetfile({'*.jpg;*.bmp;*.png;*.tif'}, 'Select the image to process.');
source = [path, file];
picture = imread(source);
figure;
imshow(picture);
```



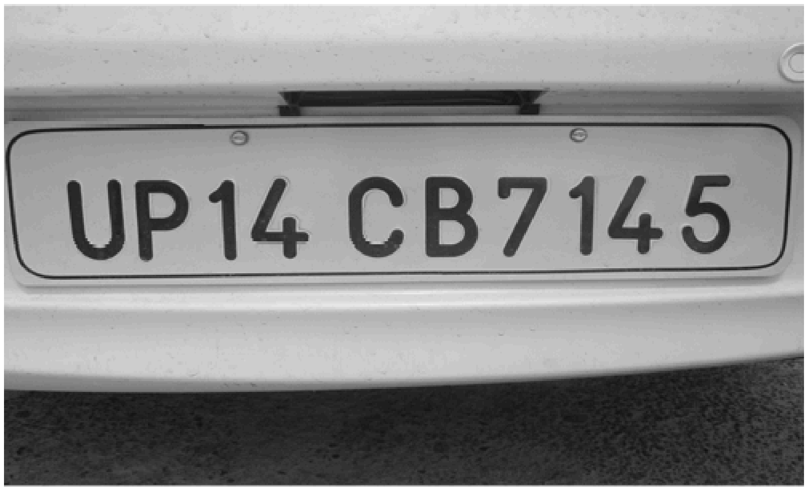
2) Resize the picture for better recognation and process.

```
picture = imresize(picture,[300 500]);
figure;
imshow(picture);
```

3) Convert the picture to gray scale using `myGreyFunc.`

- We are using the below formula for gray channel:
- $Gray_{channel} = 0.299 \times Red_{channel} + 0.578 \times Green_{channel} + 0.114 \times Blue_{channel}$

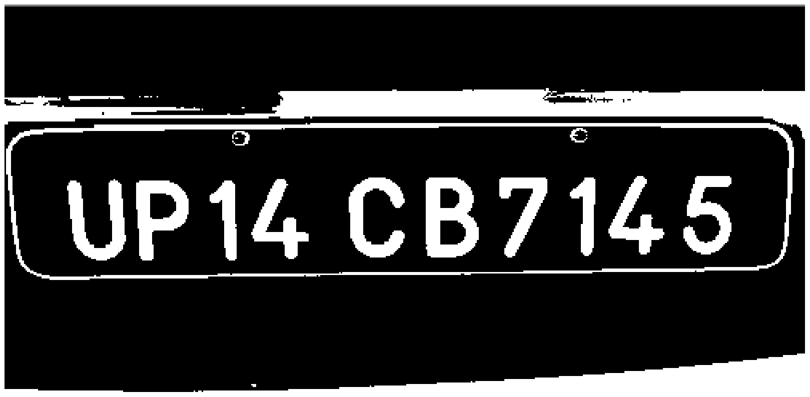
```
picture = myGrayFunc(picture);
figure;
imshow(picture);
```



4) Convert the gray picture to a binary picture using `myBinaryFunc.`

- The threshold is a number between 0 and 1. The number we assigned to threshold is close to the average of thresholds the `graythresh` function calculated for some samples.

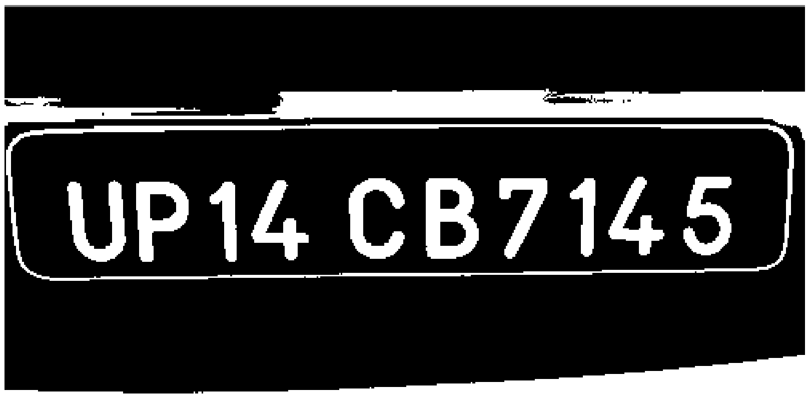
```
threshold = 0.4555;
picture = ~myBinaryFunc(picture, threshold);
figure;
imshow(picture);
```



5) Now we should remove the noisy componants in the picture using `myRemoveComFunc`.

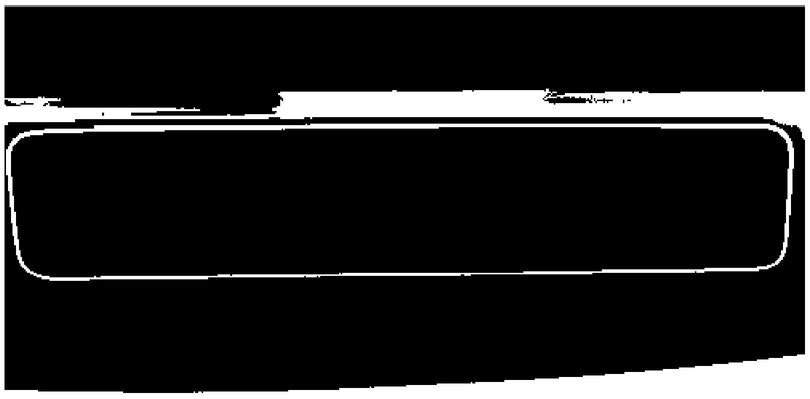
- `myRemoveComFunc` works by looping over every pixel in the binary image. If a pixel is part of an object and has not been visited yet (using `visited` variable), it initializes a queue with this pixel and starts a BFS. The BFS checks each pixel in the connected component visited and adds it to an auxiliary binary image (`component`). Once all pixels in a component have been visited, if the size of this component is greater than or equal to `n`, which is the limit for noise, it is added to the output image. All other components which sizes are less than `P` are considered as noise and are ignored from the output.

```
minPixelComp = 380;
picture = myRemoveComFunc(picture, minPixelComp);
figure;
imshow(picture);
```



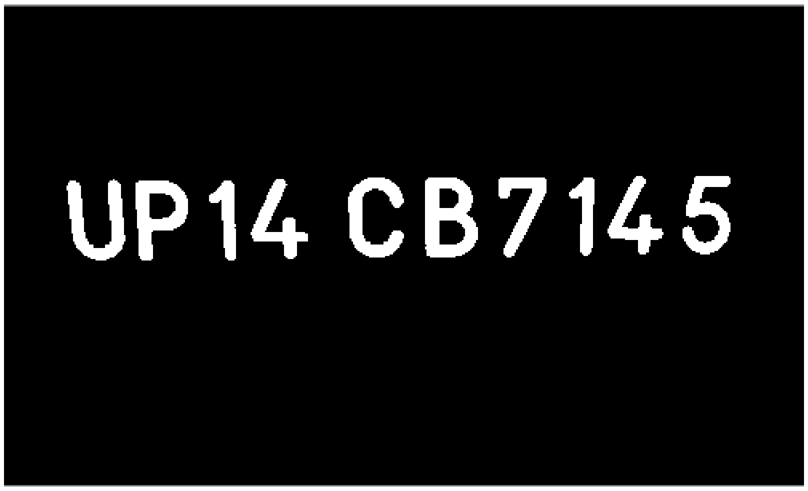
- After removing noises, we also should remove the plate's frame and other big componants which are not usefull for the segmenting of plate characters. We name set of these parts as `background` and in order to remove it, we first make a picture with only big objects (for example bigger than 2500 px).

```
minPixelBackground = 2500;
background = myRemoveComFunc(picture, minPixelBackground);
figure;
imshow(background);
```



- Then with subtracting the background from the original picutre, only the needed characters and numebrs remain.

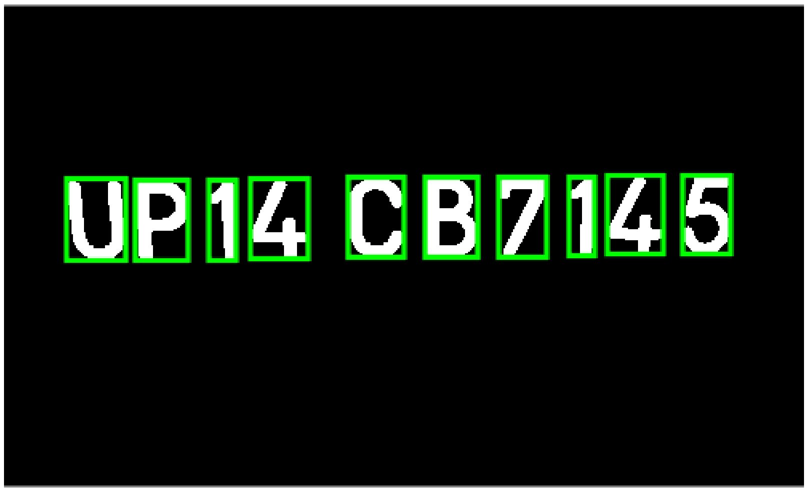
```
picture = picture - background;
figure;
imshow(picture);
```



6) In this part we need to label the components of the picture. `mySegmentationFunc` uses the exacty same BFS algorithm as the `myRemoveFunc` to detect the components. But instead of numbering them as only "1", it gives its elements in matrix a number(or a label).

- Then we draw rectangles to show the components better and be sure of its output.

```
[labeledComponents, numOfComps] = mySegmentationFunc(picture);
propied = regionprops(labeledComponents, 'BoundingBox');
figure;
imshow(picture);
hold on
for n = 1 : size(propied, 1)
    rectangle('Position', propied(n).BoundingBox,'EdgeColor','g','LineWidth',2)
end
hold off
```



7) Now we should make decision and check each character.

- First we should read the data set from files and save its contents. At last the given dataset is mapped to the name of it in 2D-matrix of `characters`.

```
DATASET_FOLDER = 'English Map Set';
contents = {dir(DATASET_FOLDER).name};
files = contents(3:end);
characters = cell(2, length(files));

for i = 1:length(files)
    c2m = cell2mat(files(i));
    characters(1, i) = {imread([DATASET_FOLDER, '\', c2m])};
    characters(2, i) = {c2m(1:find(c2m == '.') - 1)};
end
save("EnglishCharacters.mat", 'characters');
```

- Now we check each previously labeled component with the dataset and caluclate the 2D-corrolation between them using `corr2` to find the best match for the component. For better results, only if the maximum calculated corrolation is bigger than a limit, it is considered as an answer.

```
final_output=[];
t = [];
for n = 1 : numOfComps
    [r, c] = find(labeledComponents==n);
    Y = picture(min(r):max(r), min(c):max(c));
    Y = imresize(Y, [42,24]);

    ro = zeros(1,size(characters, 2));
    for k = 1 : size(characters, 2)
```

```
        ro(k) = corr2(characters{1,k},Y);
    end

    [MAXRO, pos] = max(ro);
    if MAXRO > .5
        out = cell2mat(characters(2, pos));
        final_output = [final_output out];
    end
end
```

8) In the end we print the output and also write it to file.

```
file = fopen('english_plate.txt', 'wt');
fprintf(file,'%s\n',final_output);
fclose(file);
final_output
```

```
final_output =
'UP14CB7145'
```

All implemented functions for this part:

```
function grayPicture = myGrayFunc(picture)
    redChannel = picture(:, :, 1);
    greenChannel = picture(:, :, 2);
    blueChannel = picture(:, :, 3);

    grayPicture = 0.299 * double(redChannel) + 0.578 * double(greenChannel) + 0.114 * double(bl
    grayPicture = uint8(grayPicture);
end

function binaryPicture = myBinaryFunc(picture, threshold)
    if size(picture, 3) == 3
        picture = myGrayFunc(picture);
    end

    binaryPicture = im2double(picture) > threshold;
end

function outputPicture = myRemoveComFunc(picture, n)
    [rows, cols] = size(picture);

    outputPicture = false(size(picture));
    visited = false(size(picture));

    neighbors = [-1 -1; -1 0; -1 1; 0 -1; 0 1; 1 -1; 1 0; 1 1];
    for i = 1:rows
        for j = 1:cols
            if picture(i, j) && ~visited(i, j)
                component = false(size(picture));
                queue = [i j];

                while ~isempty(queue)
```

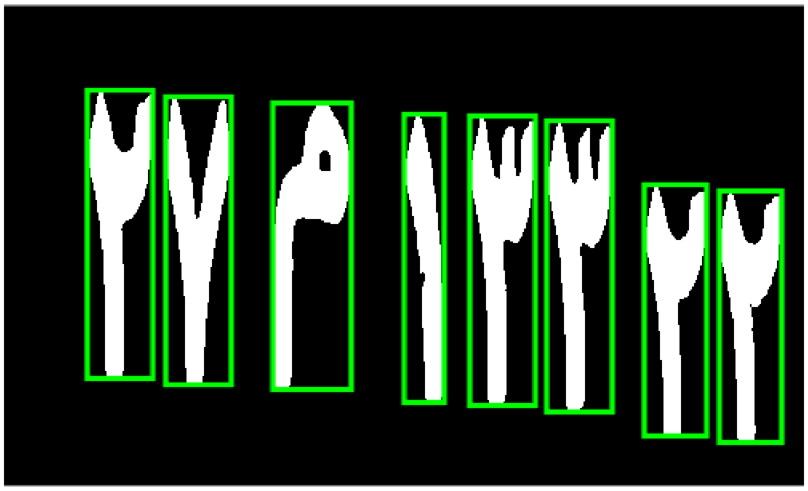
```
                    pixel = queue(1, :);
                    queue(1, :) = [];

                    if ~visited(pixel(1), pixel(2))
                        visited(pixel(1), pixel(2)) = true;
                        component(pixel(1), pixel(2)) = true;

                        for k = 1:size(neighbors, 1)
                            neighbor = pixel + neighbors(k, :);
                            if neighbor(1) >= 1 && neighbor(1) <= rows && neighbor(2) >= 1 &&..
                                    neighbor(2) <= cols && picture(neighbor(1), neighbor(2)) &&
                                    ~visited(neighbor(1), neighbor(2))
                                queue(end + 1, :) = neighbor;
                            end
                        end
                    end
                end
                if nnz(component(:)) >= n
                    outputPicture = outputPicture | component;
                end
            end
        end
    end
end


function [labeledComponents, numOfObjects] = mySegmentationFunc(picture)
    [rows, cols] = size(picture);
    visited = false(size(picture));
    labeledComponents = zeros(size(picture));
    numOfObjects = 0;

    neighbors = [-1 -1; -1 0; -1 1; 0 -1; 0 1; 1 -1; 1 0; 1 1];
    for j = 1:cols
        for i = 1:rows
            if picture(i, j) && ~visited(i, j)
                numOfObjects = numOfObjects + 1;
                queue = [i j];

                while ~isempty(queue)
                    pixel = queue(1, :);
                    queue(1, :) = [];
                    if ~visited(pixel(1), pixel(2))
                        visited(pixel(1), pixel(2)) = true;
                        labeledComponents(pixel(1), pixel(2)) = numOfObjects;

                        for k = 1:size(neighbors, 1)
                            neighbor = pixel + neighbors(k, :);
                            if neighbor(1) >= 1 && neighbor(1) <= rows && neighbor(2) >= 1 && .
                                    neighbor(2) <= cols && picture(neighbor(1), neighbor(2)) &&
                                    ~visited(neighbor(1), neighbor(2))
                                queue(end + 1, :) = neighbor;
                            end
                        end
                    end
                end
            end
        end
    end
end
```

Signal and System CA2

Part 2.

- In this part we are using matlab built-in functions and persian dataset. As we can see, its result have a error and it matched the 5th character which is '3' as a '2'. This error is coming from built-in `corr2` function and there is nothing we can do.

```
[file, path] = uigetfile({'*.jpg;*.bmp;*.png;*.tif'}, 'Select the image to process.');
source = [path, file];
picture = imread(source);
picture = imresize(picture,[300 500]);
picture = myGrayFunc(picture);
threshold = graythresh(picture);
picture = ~myBinaryFunc(picture, threshold);
minPixelComp = 450;
picture = bwareaopen(picture, minPixelComp);
minPixelBackground = 3800;
background = bwareaopen(picture, minPixelBackground);

picture = picture - background;
[labeledComponents, numOfComps] = bwlabel(picture);
propied = regionprops(labeledComponents,'BoundingBox');
figure;
imshow(picture);
hold on
for n=1:size(propied, 1)
    rectangle('Position',propied(n).BoundingBox, 'EdgeColor','g','LineWidth',2)
end
hold off
```



```
DATASET_FOLDER = 'Persian Map Set';
```

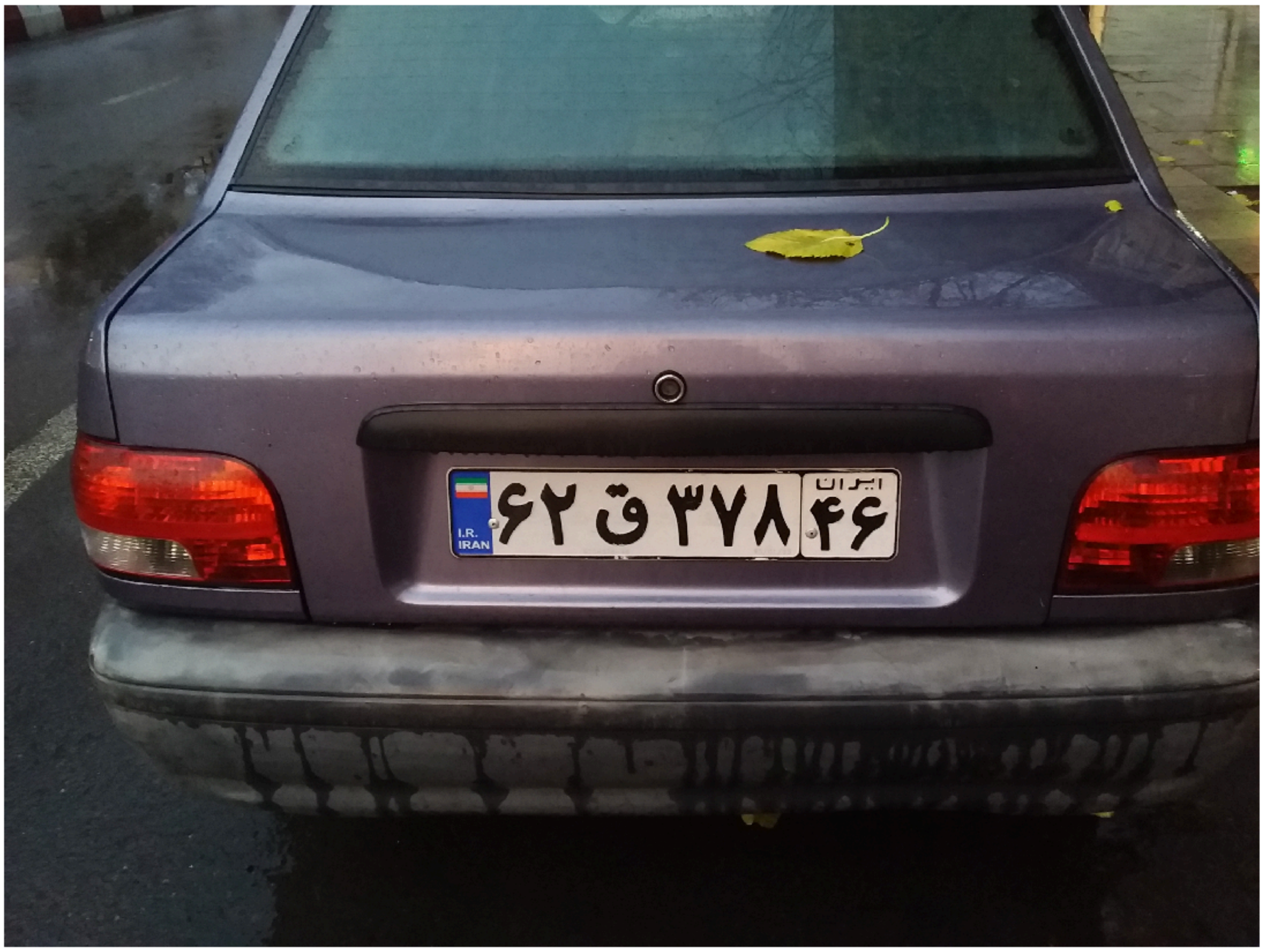
```
contents = {dir(DATASET_FOLDER).name};
files = contents(3:end);

characters = cell(2, length(files));

for i = 1:length(files)
    c2m = cell2mat(files(i));
    characters(1, i) = {imread([DATASET_FOLDER, '\', c2m])};
    characters(2, i) = {c2m(1:find(c2m == '.') - 1)};
end
save("PersianCharacters.mat", 'characters');
final_output=[];
t = [];
for n = 1 : numOfComps
    [r, c] = find(labeledComponents==n);
    Y = picture(min(r):max(r), min(c):max(c));
    Y = imresize(Y, [100,80]);

    ro = zeros(1,size(characters, 2));
    for k = 1 : size(characters, 2)
        ro(k) = corr2(characters{1,k},Y);
    end

    [MAXRO, pos] = max(ro);
    if MAXRO > .5
        out = cell2mat(characters(2, pos));
        final_output = [final_output out];
    end
end

file = fopen('persian_plate.txt', 'wt');
fprintf(file,'%s\n',final_output);
fclose(file);
final_output
```

```
final_output =
'27mm12322'
```

Signal and System CA2

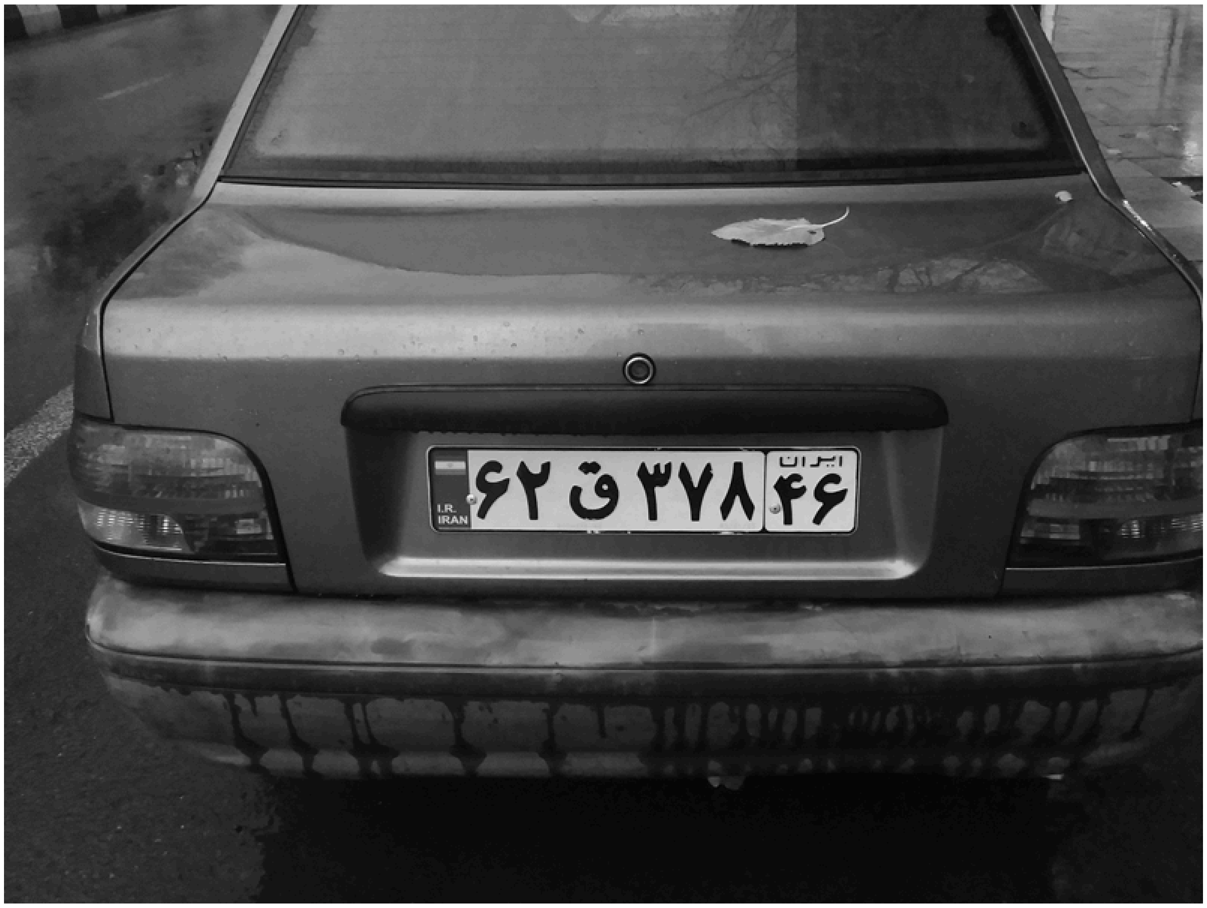
Part 3.

```
[file, path] = uigetfile('*.jpg;*.png;*.jpeg;*.bmp');
picture = imread([path, file]);
imshow(picture);
```



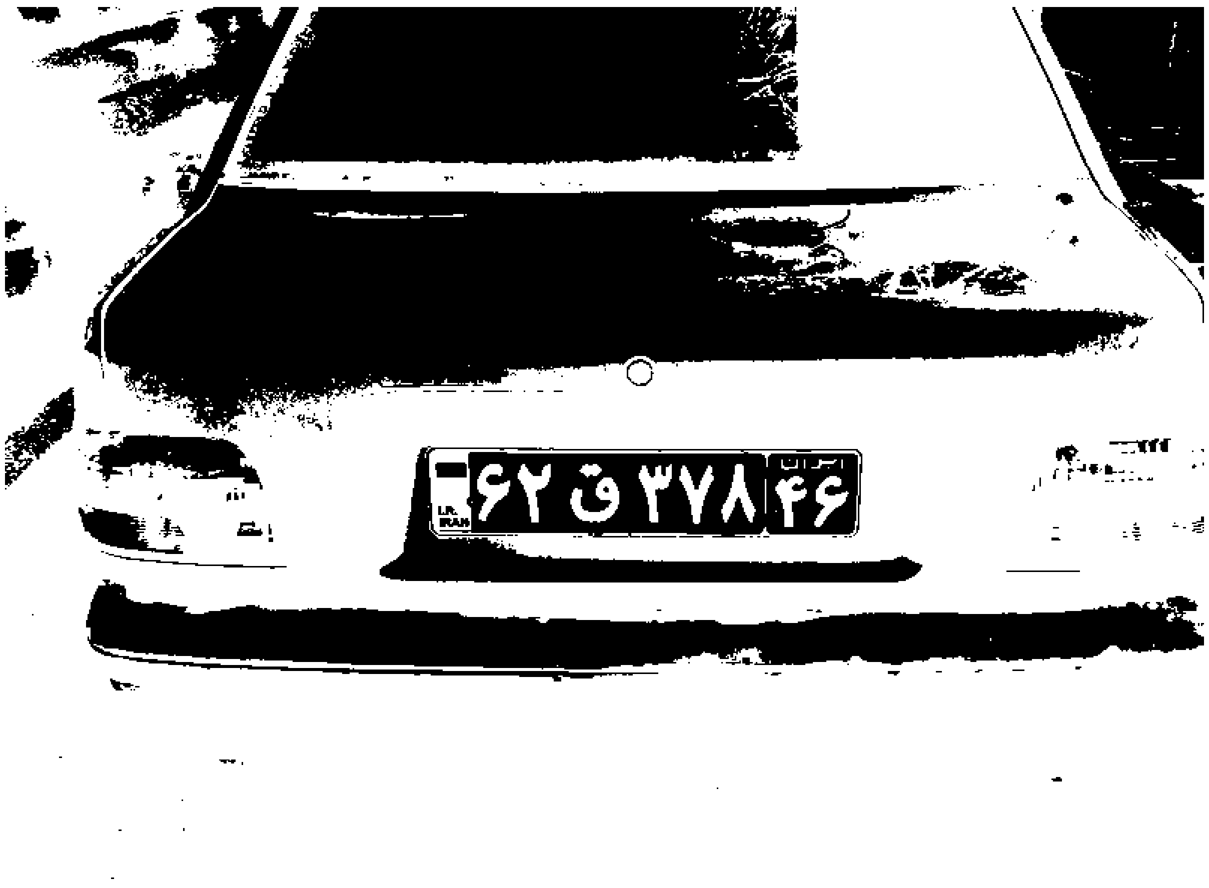
- Resize the picture and make it gray for better processing.

```
picWidth = 600;
picLength = 800;
picture = imresize(picture, [picWidth, picLength]);
picture = rgb2gray(picture);
imshow(picture);
```



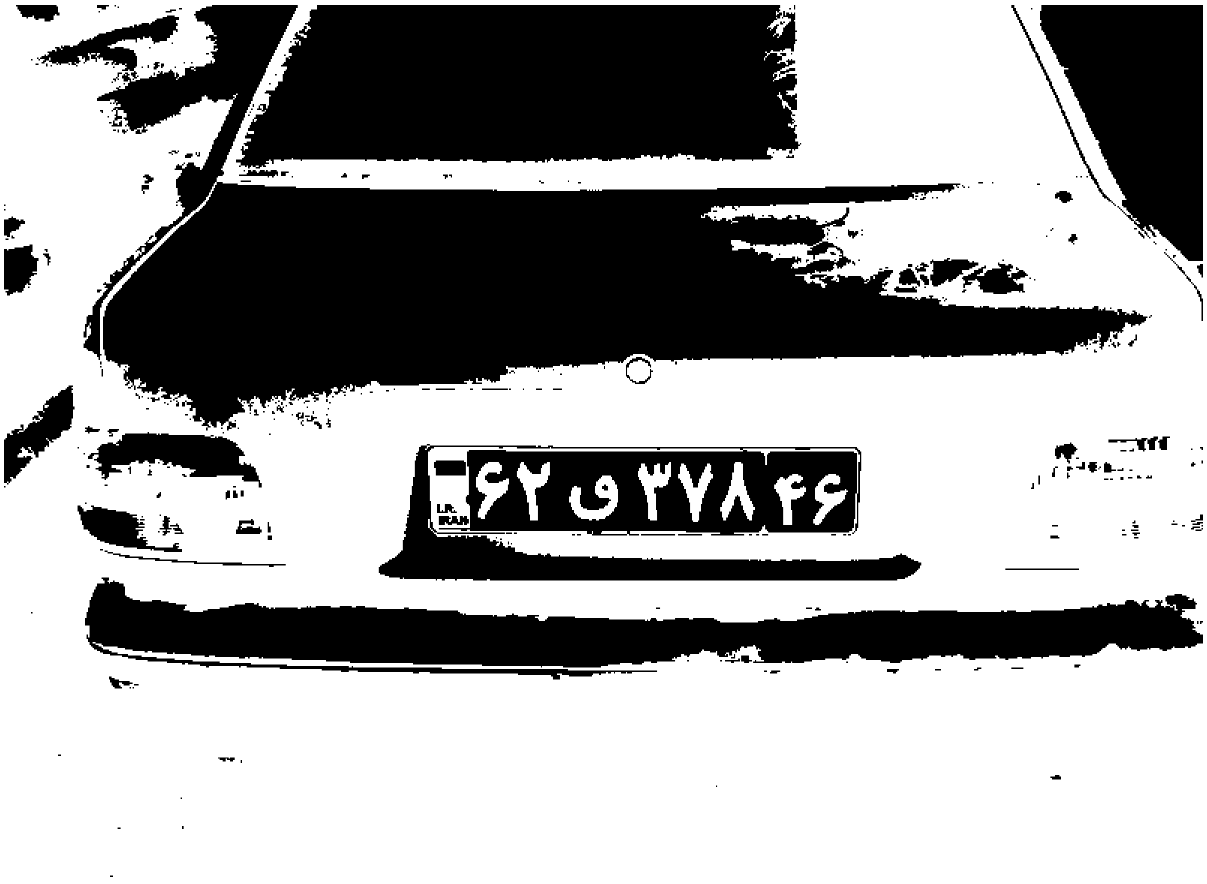
- Then binarize this picture using `graythresh` for threshold.

```
threshold = graythresh(picture);
picture = ~imbinarize(picture, threshold);
imshow(picture);
```



- Then we remove noises and background using the same technics in first part.

```
picture = myRemoveComFunc(picture, 280);
imshow(picture);
```



```
background = myRemoveComFunc(picture, 1250);
imshow(background);
```

```
picture = picture - background;
imshow(picture);
```

- Now we have to detect the characters in the big picture. Since the original picture has many details, it is common that the picture we have in this part still contains some components that are not plate's characters. To overcome this problem, we first find the row with the most horizental edges in the picture. A horizental edge is where the next pixel (meaning the pixel that is not right side) is not same as the pixel we are at this time.

- For the detecting edges part, we iterate through rows and for each row we iterate through all columns and check for any edges in the pixels.

- Also for the found row to be considered as the answer, not every row with most changes count, but the rows that are in a limited position (which we estimated using some samples) are considered as answer. The reason for doing this is to reduce possible errors and to defend this values for estimation, we can say that in all pictures that are provided as samples which are veriaty of cars, it is obvoius that the plates are approximatly in the middle of the picture and also are not at the lowest position.(Roughly 45% to 80% of the width of the picture.) But of course this method can also produce errors for some samples.

```
MIN_ESTIMATED_ROW = picWidth / 2 - 100;
MAX_ESTIMATED_ROW = picWidth - 220;
```

```
MIN_ESTIMATED_COL = 150;
MAX_ESTIMATED_COL = picLength - 150;
[bottomRowFrame, topRowFrame] = deal(MAX_ESTIMATED_ROW, MIN_ESTIMATED_ROW);
[rightColFrame, leftColFrame] = deal(MAX_ESTIMATED_COL, MIN_ESTIMATED_COL);

limitedRowsEdges = zeros(1, MAX_ESTIMATED_ROW - MIN_ESTIMATED_ROW);

for i = MIN_ESTIMATED_ROW : MAX_ESTIMATED_ROW
    tmpMax = 0;
    for j = 1 : picLength - 1
        if picture(i, j) ~= picture(i, j + 1)
            tmpMax = tmpMax + 1;
        end
    end

    if i > MIN_ESTIMATED_ROW && i < MAX_ESTIMATED_ROW
        limitedRowsEdges(i - MIN_ESTIMATED_ROW) = tmpMax;
    end
end
[maxRowsEdges, rowWithMostEdges] = max(limitedRowsEdges);
rowWithMostEdges = rowWithMostEdges + MIN_ESTIMATED_ROW;
```

- For also columns, we use same estimation like the rows' process to make the processable area smaller.

```
limitedColsEdges = zeros(1, MAX_ESTIMATED_COL - MIN_ESTIMATED_COL);
for j = MIN_ESTIMATED_COL : MAX_ESTIMATED_COL
    tmpMax = 0;
    for i = 1 : picWidth - 1
        if picture(i, j) ~= picture(i + 1, j)
            tmpMax = tmpMax + 1;
        end
    end


    if j > MIN_ESTIMATED_COL && j < MAX_ESTIMATED_COL
        limitedColsEdges(i - MIN_ESTIMATED_COL) = tmpMax;
    end
end
[maxColsEdges, colWithMostEdges] = max(limitedColsEdges);
colWithMostEdges = colWithMostEdges + MIN_ESTIMATED_COL;
```

- Now the last step for finding the area of the plate to make it ready of character recognizing, is to create the frame around it using rows and columns with maximum edges.
- For both top and bottom axis of the frame, we set a frame with maximum 30 pixels distance from the row with maximum edges. And also all rows inside that frame which at most have 30 less edges than the maximum number of edges are included.

```
for i = MIN_ESTIMATED_ROW + 1 : rowWithMostEdges
    if maxRowsEdges - limitedRowsEdges(i - MIN_ESTIMATED_ROW) < 30 && rowWithMostEdges - i < 30
        topRowFrame = i;
        break;
    end
end

for i = size(limitedRowsEdges) :-1: rowWithMostEdges
    if maxRowsEdges - limitedRowsEdges(i) < 30 && i - rowWithMostEdges < 50
        bottomRowFrame = i;
        break;
    end
end
```

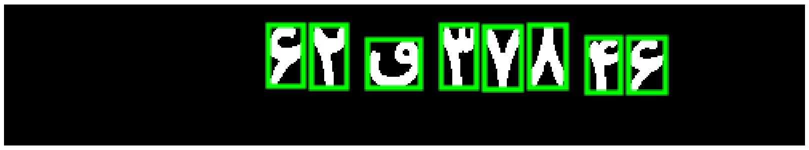
- We repeat the same process for columns with below numbers.
- ***Note that these numbers are just estimated using samples and surly are not accurate for every picture, but due to lack of time this esitmation is good for now.***

```
for j = MIN_ESTIMATED_COL + 1 : colWithMostEdges
    if maxColsEdges - limitedColsEdges(j - MIN_ESTIMATED_COL) < 40 && colWithMostEdges - j < 25
        leftColFrame = j;
        break;
    end
end

for j=size(limitedColsEdges) :-1: colWithMostEdges
    if maxColsEdges - limitedColsEdges(j) < 40 && j - colWithMostEdges < 250
        rightColFrame = j;
        break;
    end
end
```

- If the calculated height of plate is somehow small, we make a default height. This number is again estimated.

```
if bottomRowFrame - topRowFrame < 60
    bottomRowFrame = topRowFrame + 80;
end
% bottomRowFrame = (bottomRowFrame - topRowFrame < 60) ? topRowFrame + 80 : bottomRowFrame;
```

```
picture = picture(topRowFrame : bottomRowFrame, leftColFrame : rightColFrame);
imshow(picture);

[labeledComponents, numOfComps] = bwlabel(picture);
propied = regionprops(labeledComponents,'BoundingBox');
for n = 1 : size(propied, 1)
    rectangle('Position', propied(n).BoundingBox, 'EdgeColor', 'g', 'LineWidth',2)
end
```



- Now we only need to load the dataset and calculate corrolation for each character. This process is same as the previous parts.

```
DATASET_FOLDER = 'Persian Map Set';
contents = {dir(DATASET_FOLDER).name};
files = contents(3:end);

characters = cell(2, length(files));

for i = 1:length(files)
    c2m = cell2mat(files(i));
    characters(1, i) = {imread([DATASET_FOLDER, '\', c2m])};
    characters(2, i) = {c2m(1:find(c2m == '.') - 1)};
end
save("PersianCharacters.mat", 'characters');
final_output=[];
t = [];
for n = 1 : numOfComps
    [r, c] = find(labeledComponents == n);
    Y = picture(min(r):max(r), min(c):max(c));
    Y = imresize(Y, [100,80]);
    ro = zeros(1,size(characters, 2));
    for k = 1 : size(characters, 2)
        characters{1, k} = imresize(characters{1, k}, [100, 80]);
        ro(k) = corr2(characters{1,k},Y);
    end

    [MAXRO, pos] = max(ro);
    if MAXRO > .5
        out = cell2mat(characters(2, pos));
        final_output = [final_output out];
    end
end
file = fopen('persian_plate_from_car.txt', 'wt');
fprintf(file,'%s\n',final_output);
fclose(file);
final_output
```

```
final_output =
'۶۲ق۳۷۸۴۶'
```