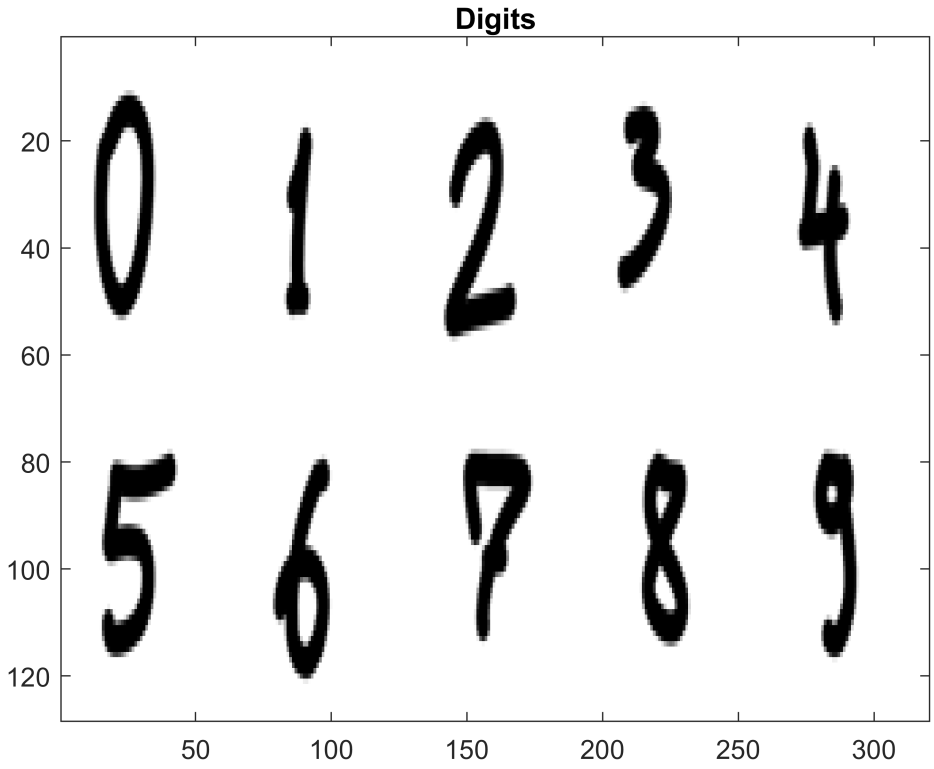
Character Recognition

```
clear all
clc
% There are 55 images of 0-9, A-Z, a-z handwritten images
files = imageDatastore(strcat('D:\Lakshay\M.Tech\Sem 1\EE608_Digital Image Processing\DIP Proje
nFiles = size(files)    % we require just 55 * (10 + 26) = 1980 files from this readed files
```

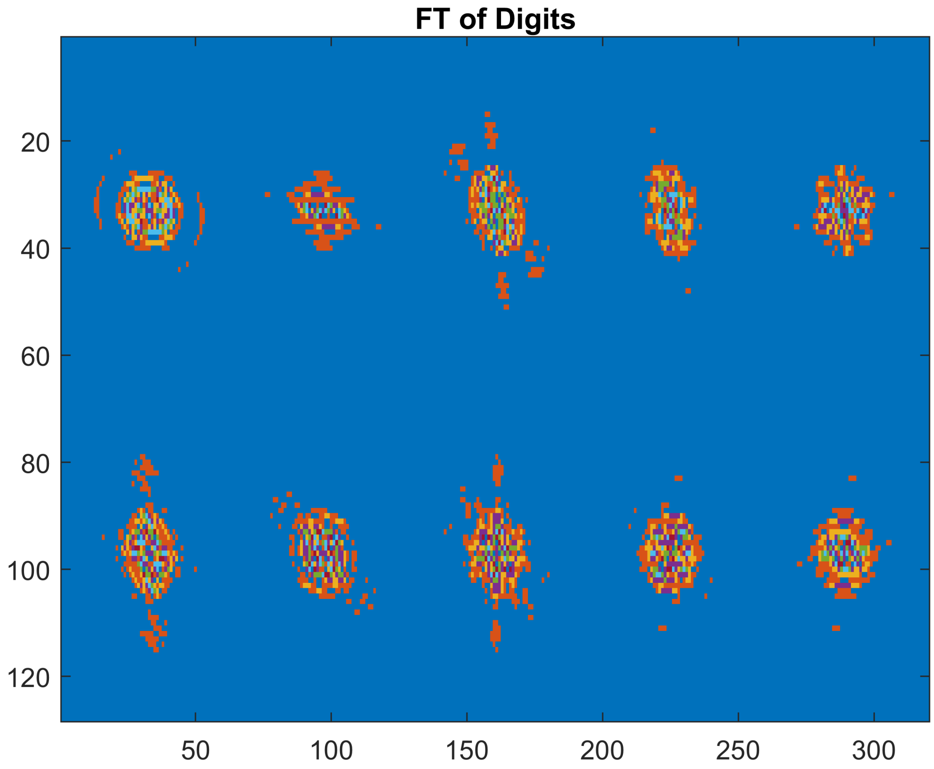
```
nFiles = 1×2
        3410           1
```

Digits

```
digits = zeros(64*64, 10);
for i = 1:10
    img = im2gray(imread(files{55*(i-1)+1}));
    imgSmall = imresize(img, [64 64]);  % Resizing the image to small size
    [row, col]= size(imgSmall);
    digits(:, i) = reshape(imgSmall, row*col , 1);
end

imgClusDigit = zeros(64*2, 64*5);  % 2*5 grid of images
FT_img_Digit = zeros(64*2, 64*5);
for i = 1:2
    for j = 1:5
        n = 5*(i-1) + j;    % 5 for the number of column
        imgClusDigit(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = reshape(digits(:, n), 64, 64);

        %% For Fourier Transform of Image
        ftimg = fft2(reshape(digits(:, n), 64, 64));
        ftimg_ = abs(ftimg)*255/max(max(abs(ftimg)));
%         figure; imshow(fftshift(ftimg_))
        FT_img_Digit(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = fftshift(ftimg_);
    end
end
figure; imagesc(imgClusDigit), colormap gray, title("Digits")
```

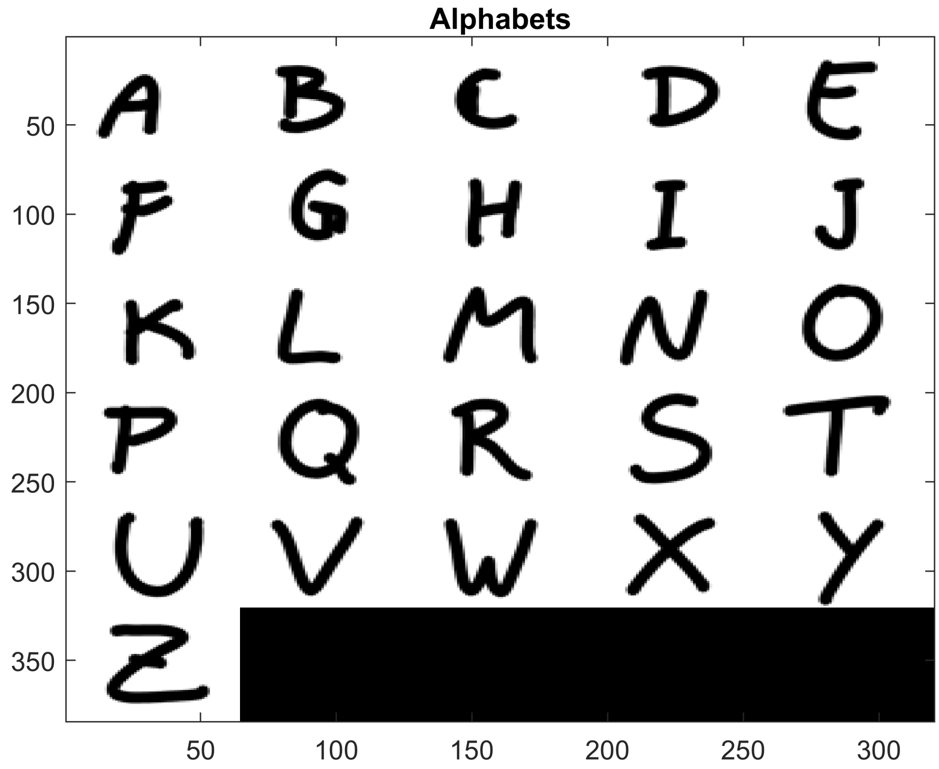


```
figure; imagesc(FT_img_Digit), colormap lines, title("FT of Digits")
```

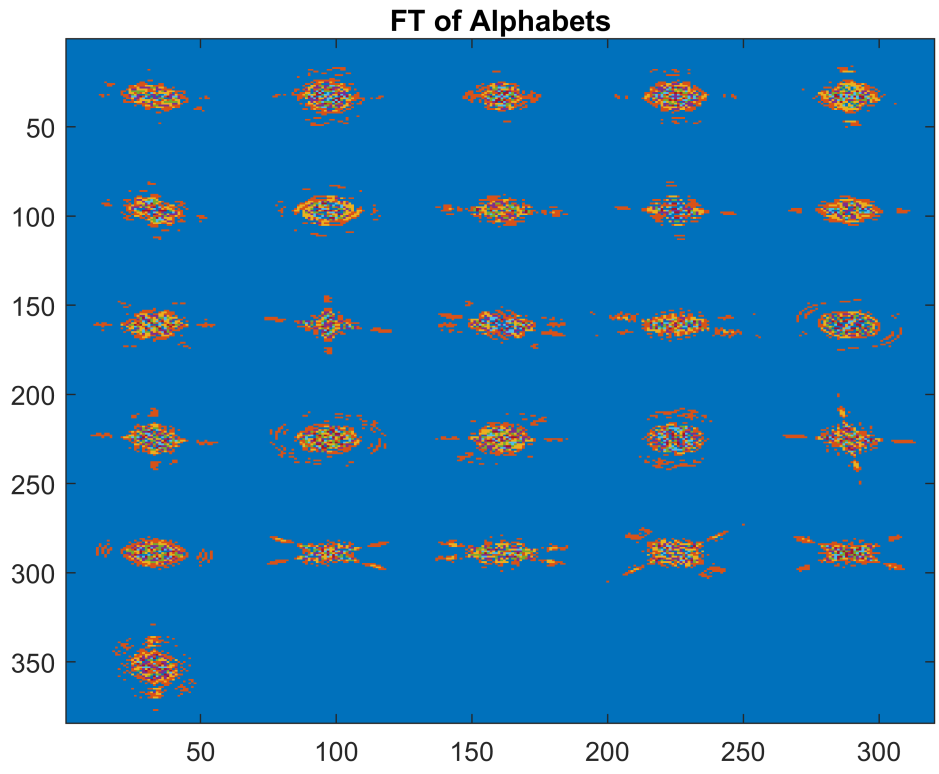


Alphabets

```
alphabets = zeros(64*64, 30);
for i = 11:36   % From 11 as 10 are for digits
    img = im2gray(imread(files{55*(i-1)+1}));
    imgSmall = imresize(img, [64 64]);  % Resizing the image to small size
    [row, col]= size(imgSmall);
    alphabets(:, i-10) = reshape(imgSmall, row*col , 1);
end

%% For output as the cluster images
imgClusAlp = zeros(64*6, 64*5);  % 6*5 grid of images
FT_img_Alphabets = zeros(64*6, 64*5);
for i = 1:6
    for j = 1:5
        n = 5*(i-1) + j;    % 5 for the number of column
        imgClusAlp(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = reshape(alphabets(:, n), 64, 64);

        %% For Fourier Transform of Image
        ftimg = fft2(reshape(alphabets(:, n), 64, 64));
        ftimg_ = abs(ftimg)*255/max(max(abs(ftimg)));
%          figure; imshow(fftshift(ftimg_))
        FT_img_Alphabets(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = fftshift(ftimg_);
    end
end
figure; imagesc(imgClusAlp), colormap gray, title("Alphabets")
```



```
figure; imagesc(FT_img_Alphabets), colormap lines, title("FT of Alphabets")
```



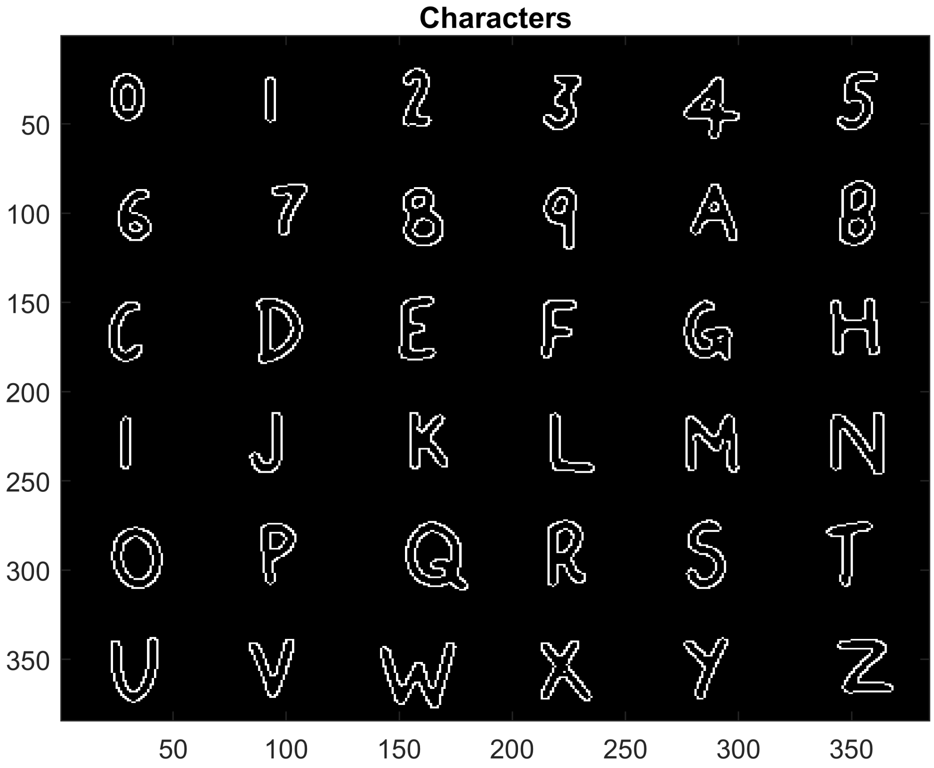
DataMatrix

```
%% It loads 4 matrix:
% 1. train_imgMat - Tran Images in column vector
% 2. train_img_FT_Mat - Tran Images Fourier Transform in column vector
% 3. test_imgMat,
% 4. test_img_FT_Mat

load imgEdgeMatrix.mat  % Canny Edge of Images
```

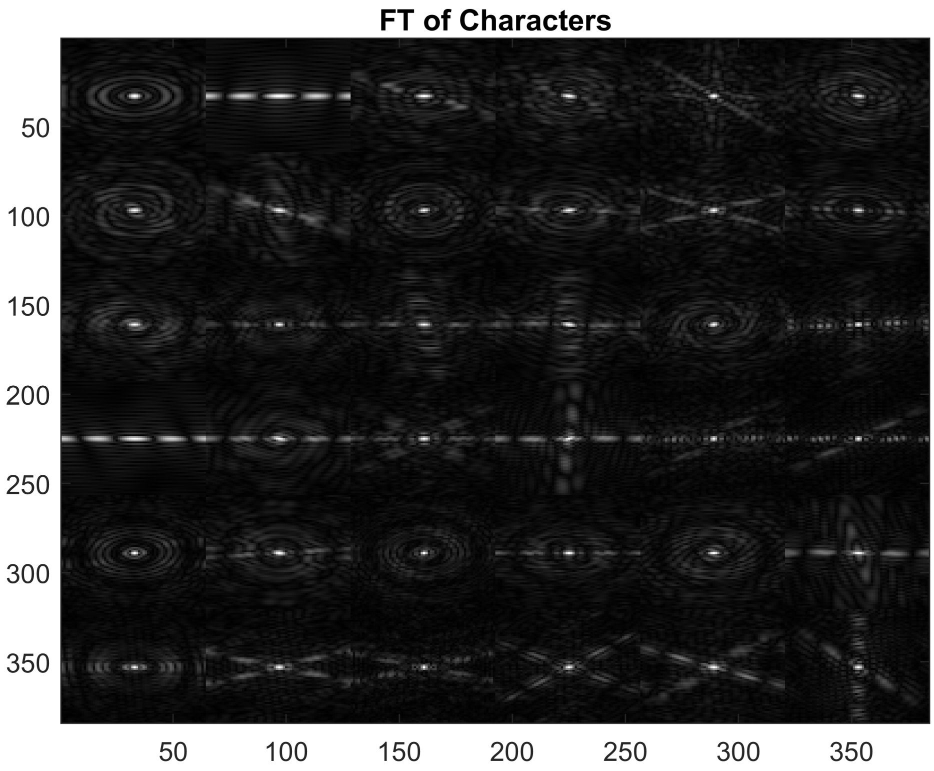
Reading DataMatrix

```
% Reading each char from datamatrix
digAplha = zeros(64*64, 36);
digAplha_FT = zeros(64*64, 36);
for i = 1:36
    % As train set have 40 image of each character
    digAplha(:,i) = train_imgMat(:, 40*i);
    digAplha_FT(:,i) = train_img_FT_Mat(:, 40*i);
end

% Now ploting the readed image in the grid form

digAplhaClus = zeros(64*6, 64*6);  % 6*6 grid of images of 0-9 & A-Z
digAplha_FT_Clus = zeros(64*6, 64*6);
```

```
for i = 1:6
    for j = 1:6
        n = 6*(i-1) + j;    % 6 for the number of column
        digAplhaClus(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = reshape(digAplha(:, n), 64, 64);
        digAplha_FT_Clus(1+(i-1)*64:i*64, 1+(j-1)*64:j*64) = reshape(digAplha_FT(:, n), 64, 64
    end
end
figure; imagesc(digAplhaClus), colormap gray, title("Characters")
```



```
figure; imagesc(digAplha_FT_Clus), colormap gray, title("FT of Characters")
```



```
% % For individual reading the character form dataMatrix
% for i = 1:36
%     Img = reshape(train_imgMat(:, 40*i), row , col);    % As train set have 40 image of each
% %     ftimg = fftshift(fft2(Img));
% %     figure; montage({Img, abs(ftimg)})
%     imgFt = reshape(train_img_FT_Mat(:, 40*i), row , col);
%     figure; montage({Img, imgFt})
% end
```

```
% charDict for keys 1-36  while values being 0-9 & A-Z
digit = 48:57;  % As ASCII code of zero is 48
alphabets = 'A':'Z';
keySet = 1:36;     % As there are 36 character in dataset
valueSet = ones(1, 36);
for i = 1:10
    valueSet(i) = digit(i);
end
for i = 11:36
    valueSet(i) = alphabets(i-10);
end

% Creating dictionary of characters
charDict = containers.Map(keySet,valueSet)
```

```
charDict = 
  Map with properties:

        Count: 36
      KeyType: double
    ValueType: double
```

```
% char(charDict(35))    % Will print the character representation
```

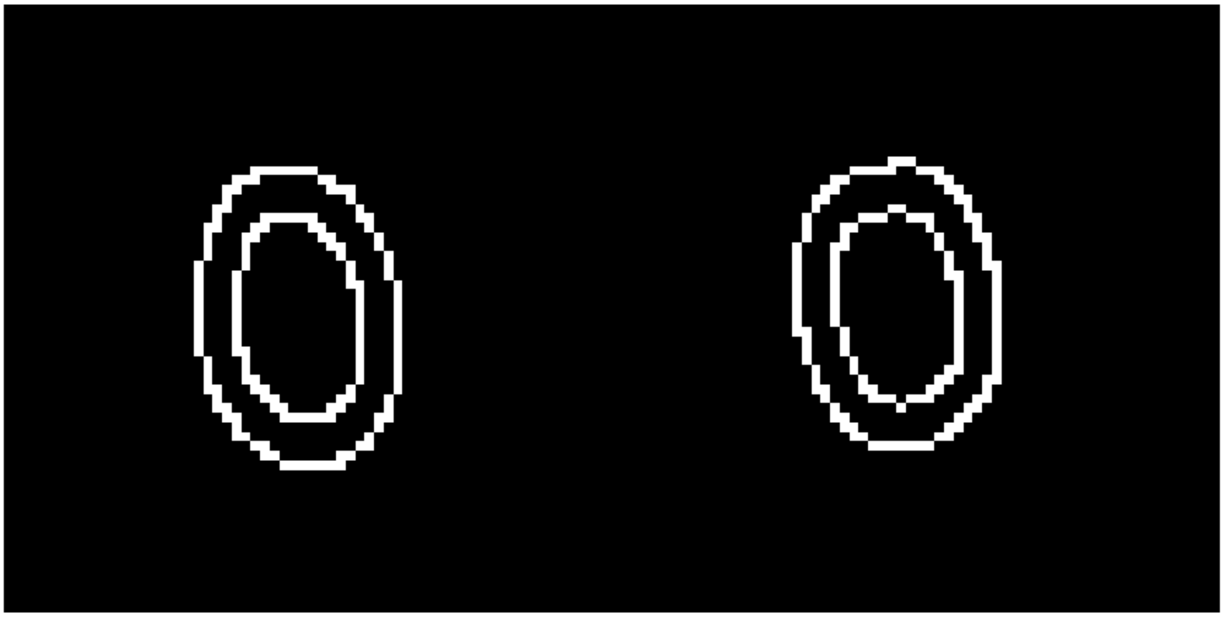
Evaluating Model

```
% Predicting just on the basis of MSE of test image FT
% and the train image FT dataset
predTrue = 0;
szTestMat = size(test_img_FT_Mat);
ntestCol = szTestMat(2);

tImg_tobeDisp = 1:15:ntestCol   % As 15 test image available for each charcater
```

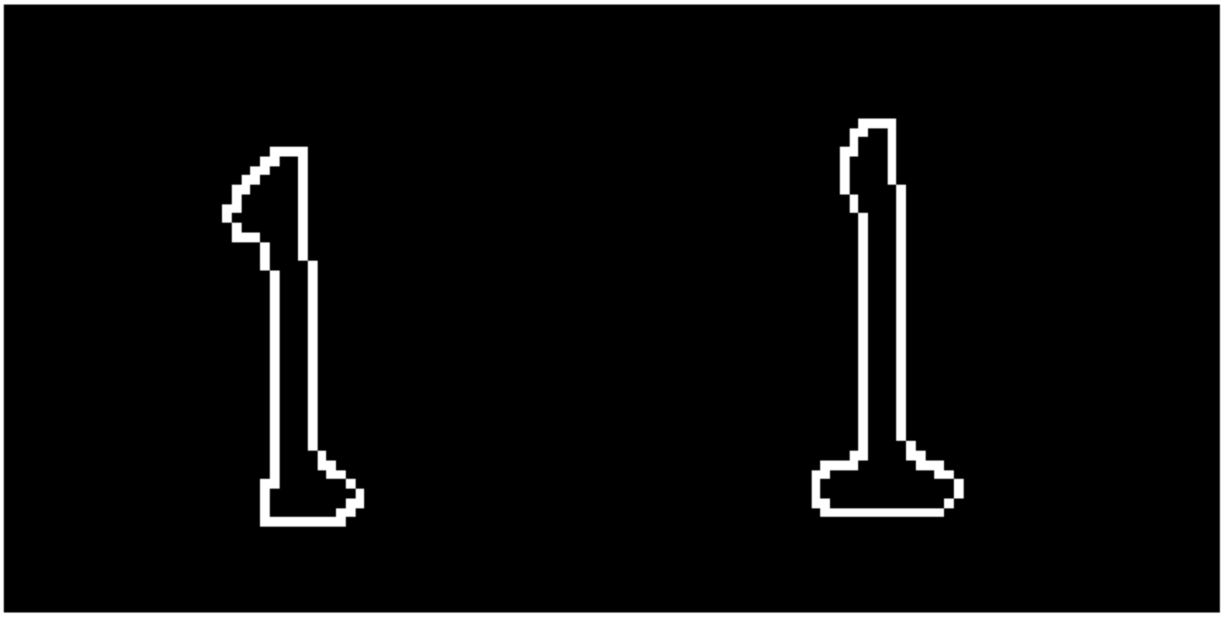
```
tImg_tobeDisp = 1×36
     1    16    31    46    61    76    91   106   121   136   151   166   181 ···
```

```
dispCnt = 1;
for i = 1:ntestCol
    testImg = test_img_FT_Mat(:, i);
    err = (train_img_FT_Mat - testImg).^2;  % Eucledian Distance
    err = sum(err, 1);  % Sum along colums
    % idx correspond to match found with column of train_img_FT_Mat
    [minErr ,idx] = min(err,[],'all', 'linear');

    k1 = int8(idx/40) + 1;   % As 40 train image available for each charcater
    k2 = int8(i/15) + 1;   % As 15 test image available for each charcater
    if k1 == 37
        k1 = 36;
    end
    if k2 == 37
        k2 = 36;
    end
    if k1 == k2
        predTrue = predTrue + 1;
    end

    %% Displaying some results
    if all(i == tImg_tobeDisp(dispCnt) && dispCnt <= 35)
        input = reshape(test_imgMat(:, i), 64, 64);
        predictImg = reshape(train_imgMat(:, idx), 64, 64);
        figure; montage({input, predictImg}), title("Result " + dispCnt + "   Given Test Image

%          input_FT = reshape(test_img_FT_Mat(:, i), 64, 64);
%          predictImg_FT = reshape(train_img_FT_Mat(:, idx), 64, 64);
%          figure; montage({input_FT, predictImg_FT}), colormap gray, title("There Fourier Trans
        dispCnt = dispCnt + 1;
    end
end
```

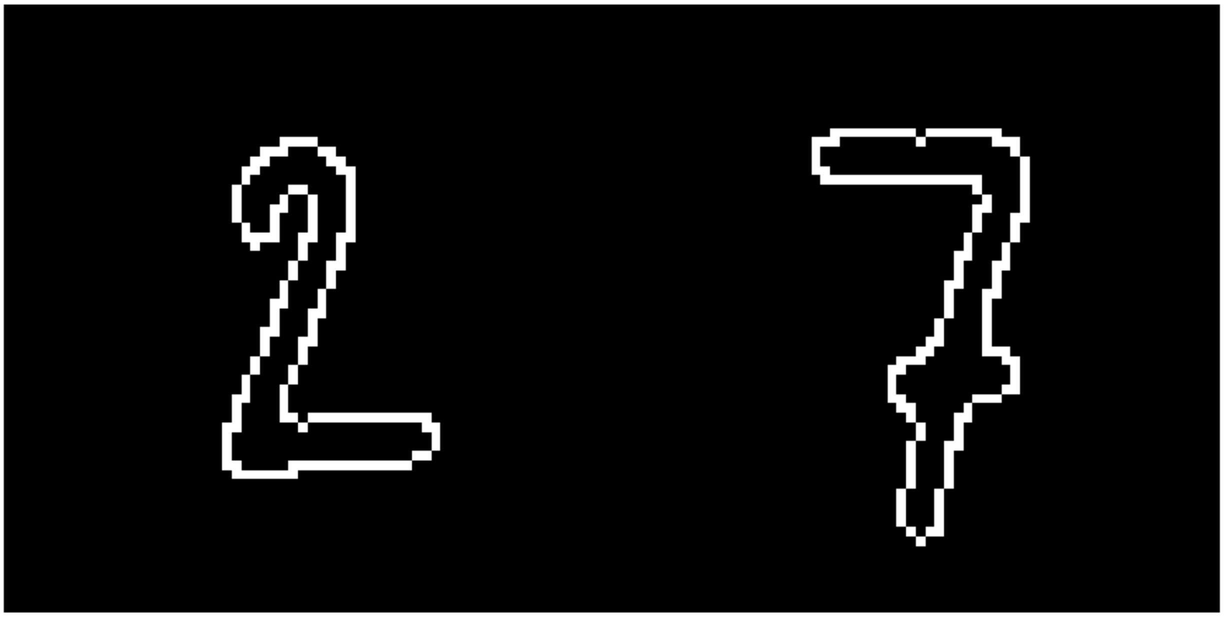
Result 1   Given Test Image is 0   Predict Image is O



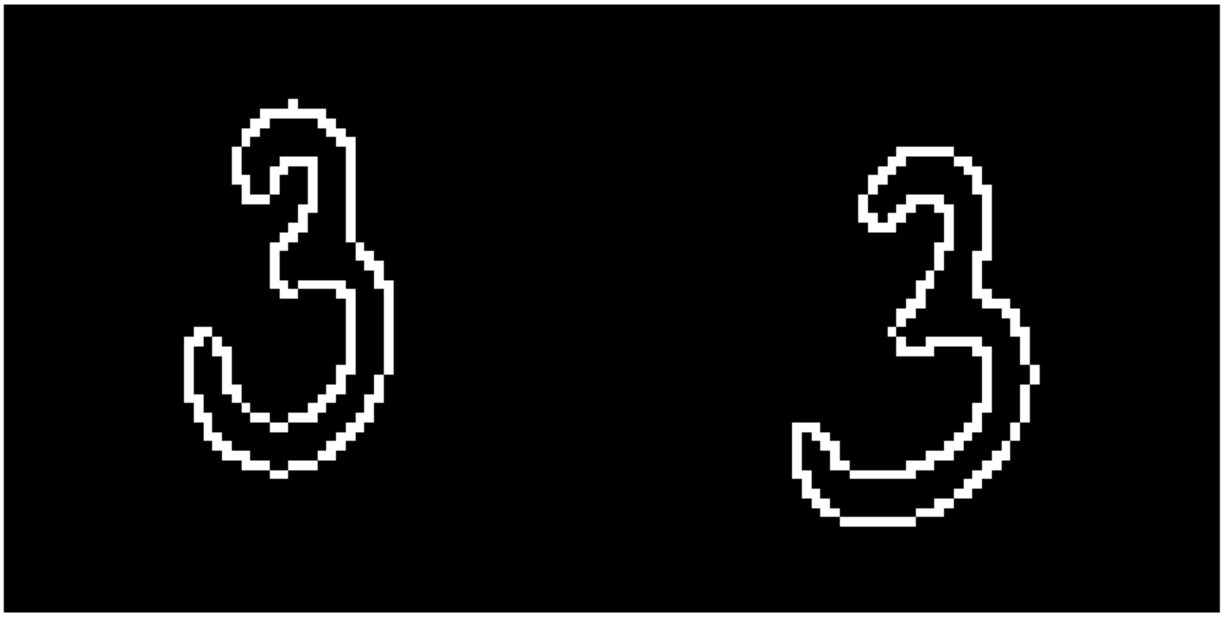
Result 2   Given Test Image is 1   Predict Image is 2



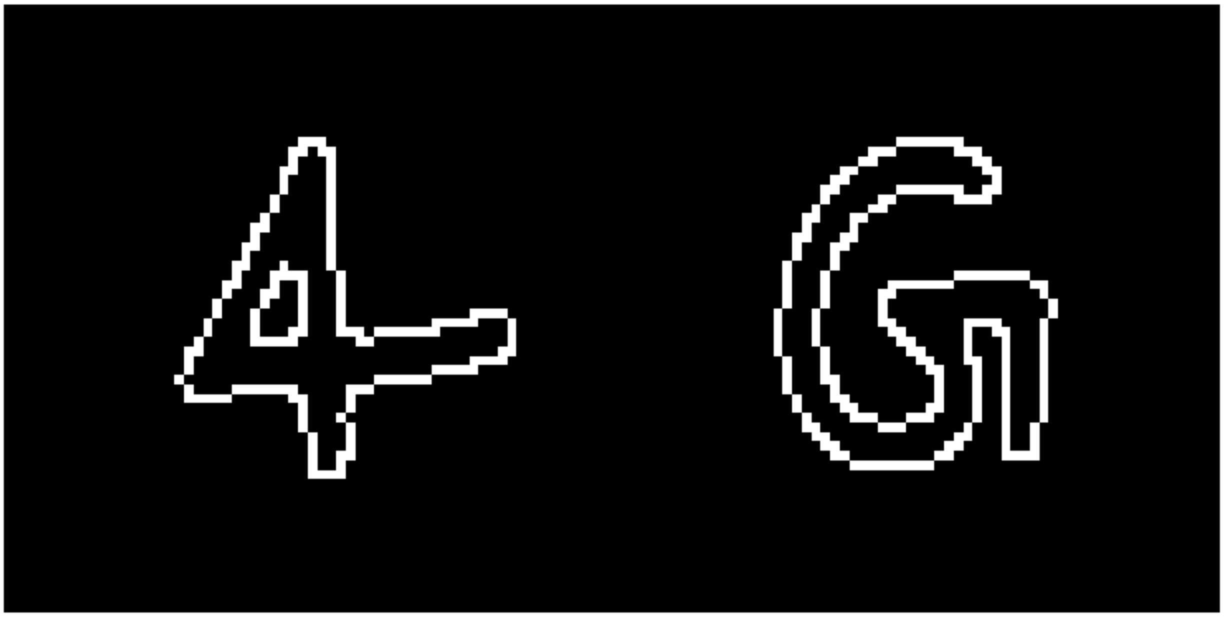
Result 3   Given Test Image is 2   Predict Image is 7



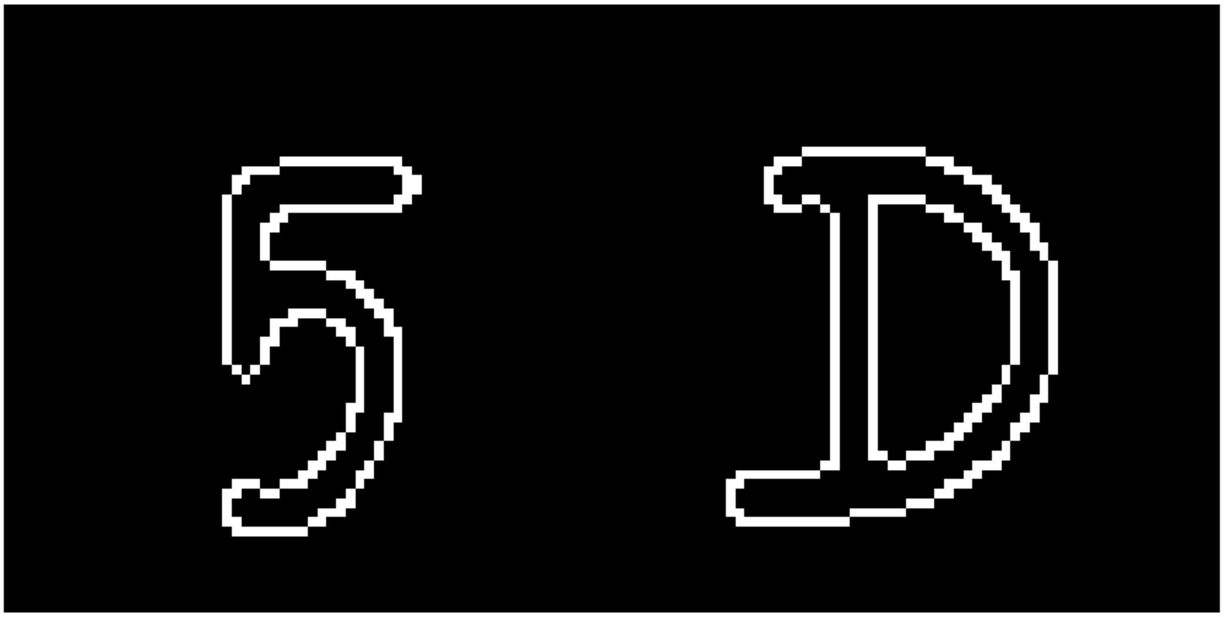
Result 4   Given Test Image is 3   Predict Image is 4



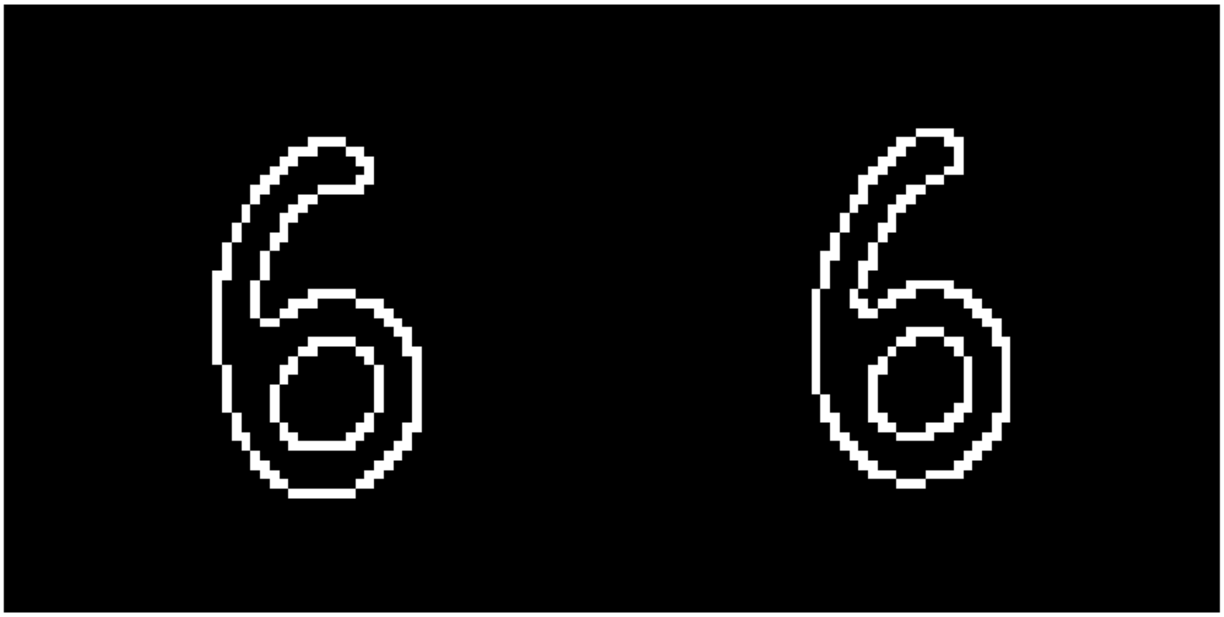
Result 5   Given Test Image is 4   Predict Image is G



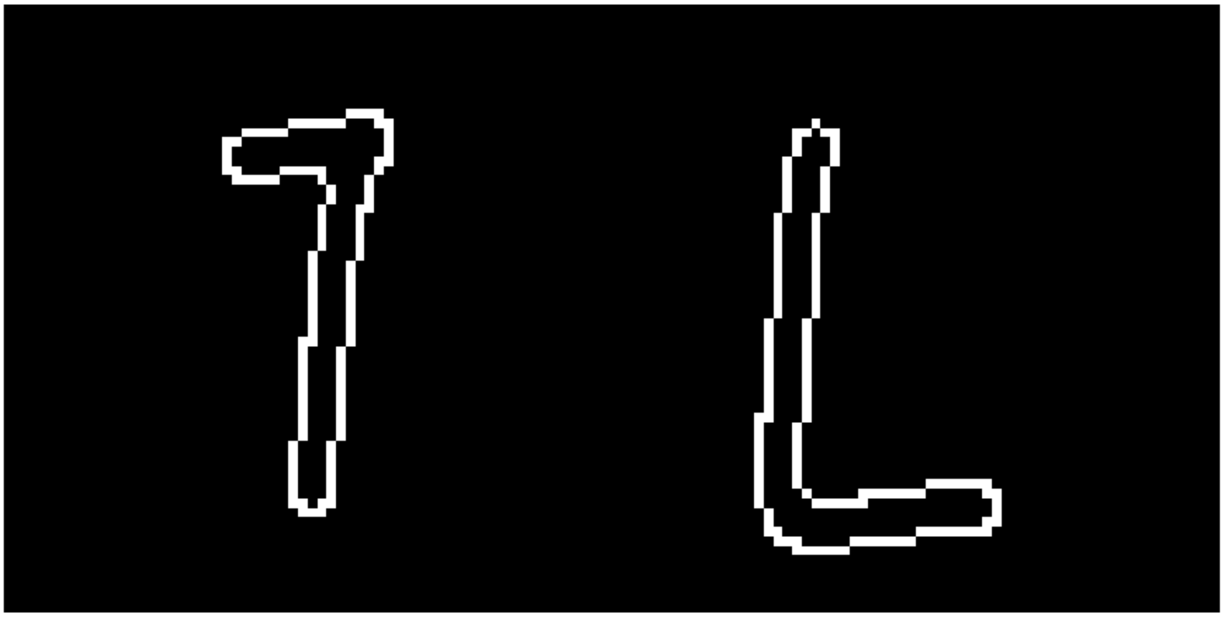
Result 6   Given Test Image is 5   Predict Image is D



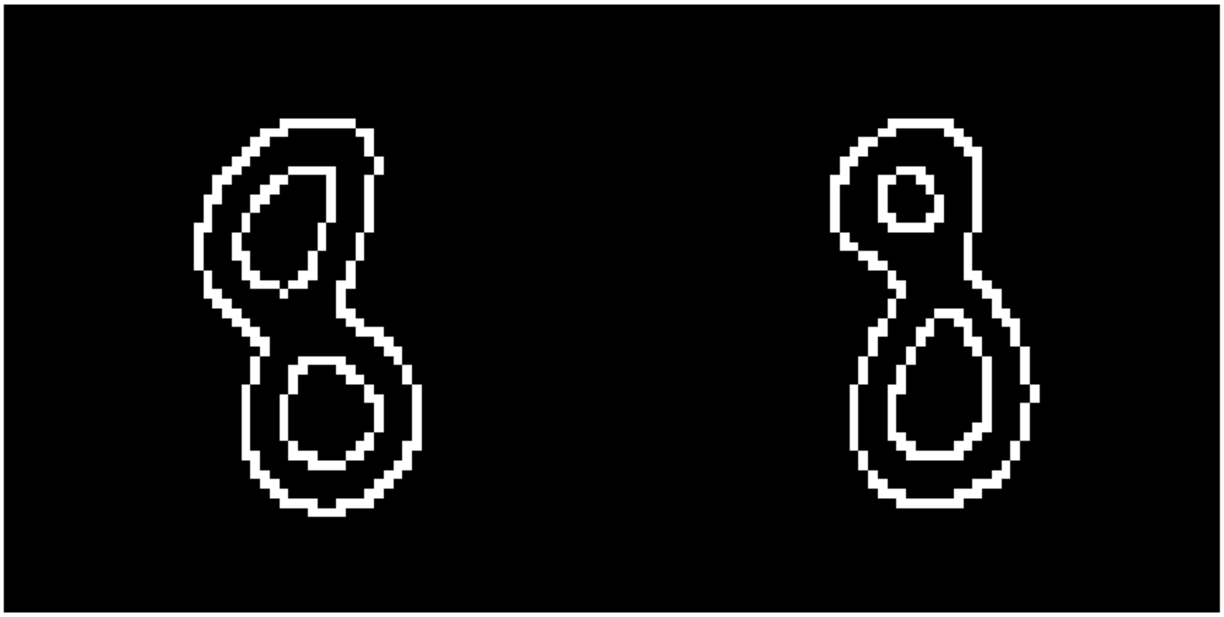
Result 7 Given Test Image is 6 Predict Image is 7



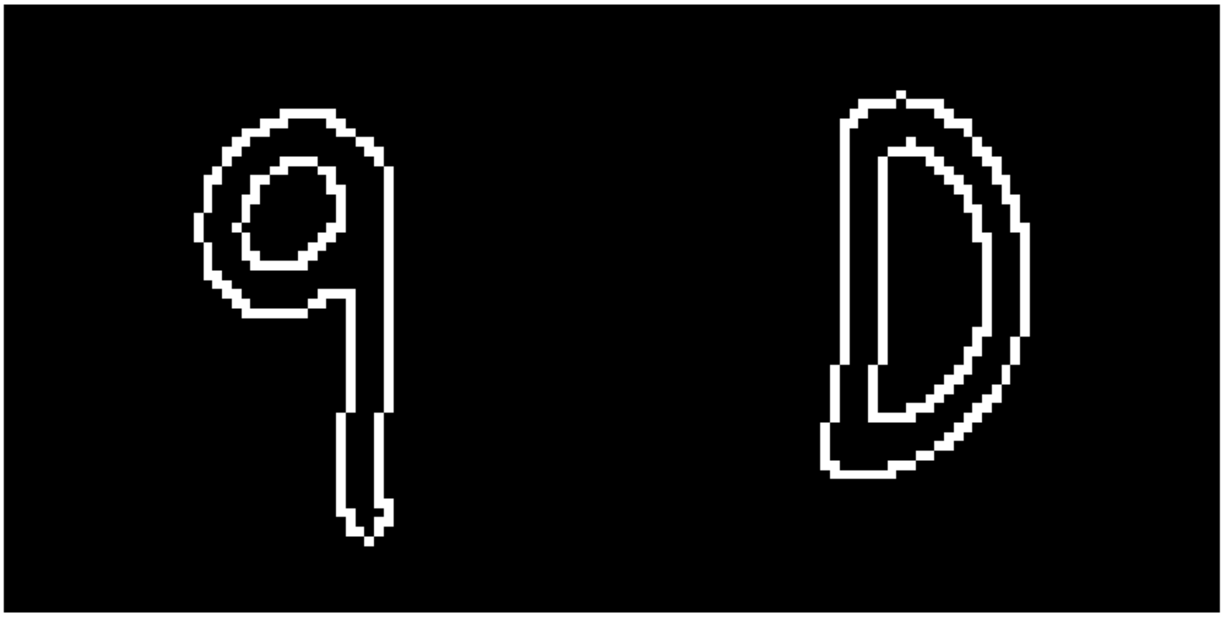
Result 8 Given Test Image is 7 Predict Image is L

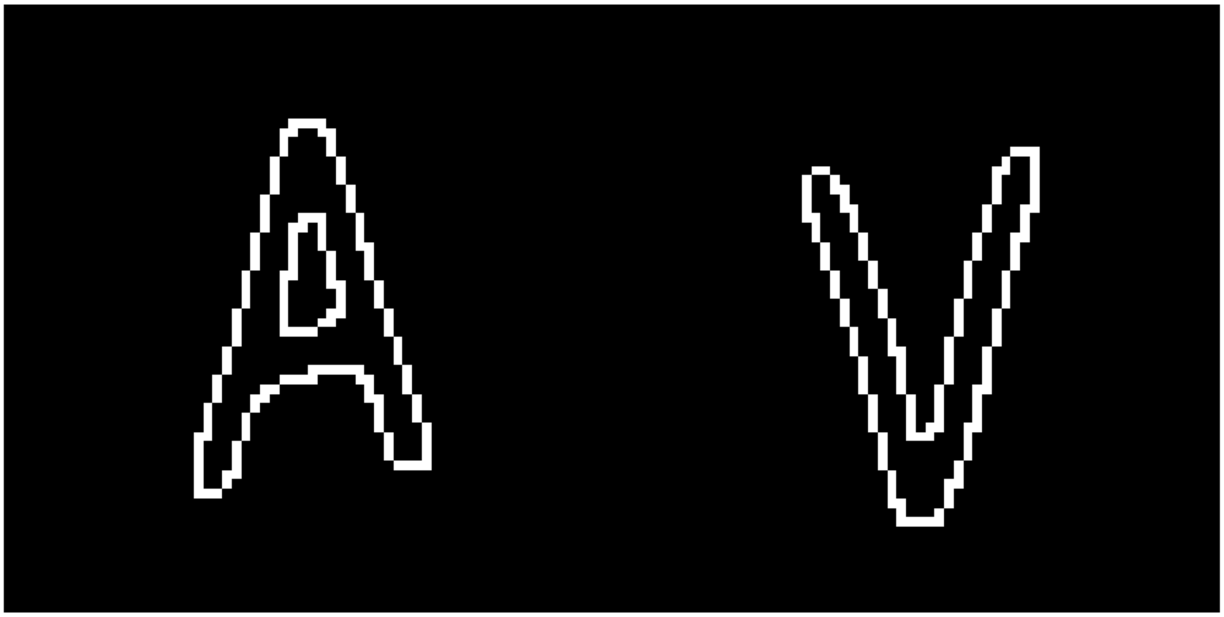


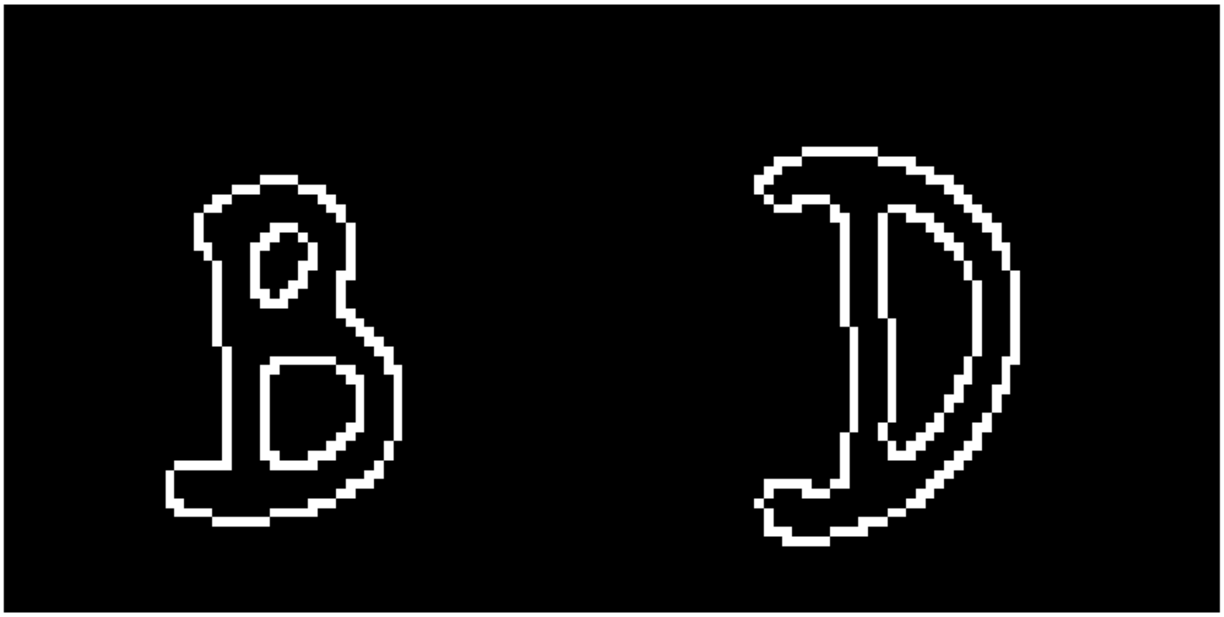
Result 9   Given Test Image is 8   Predict Image is 9



Result 10   Given Test Image is 9   Predict Image is E

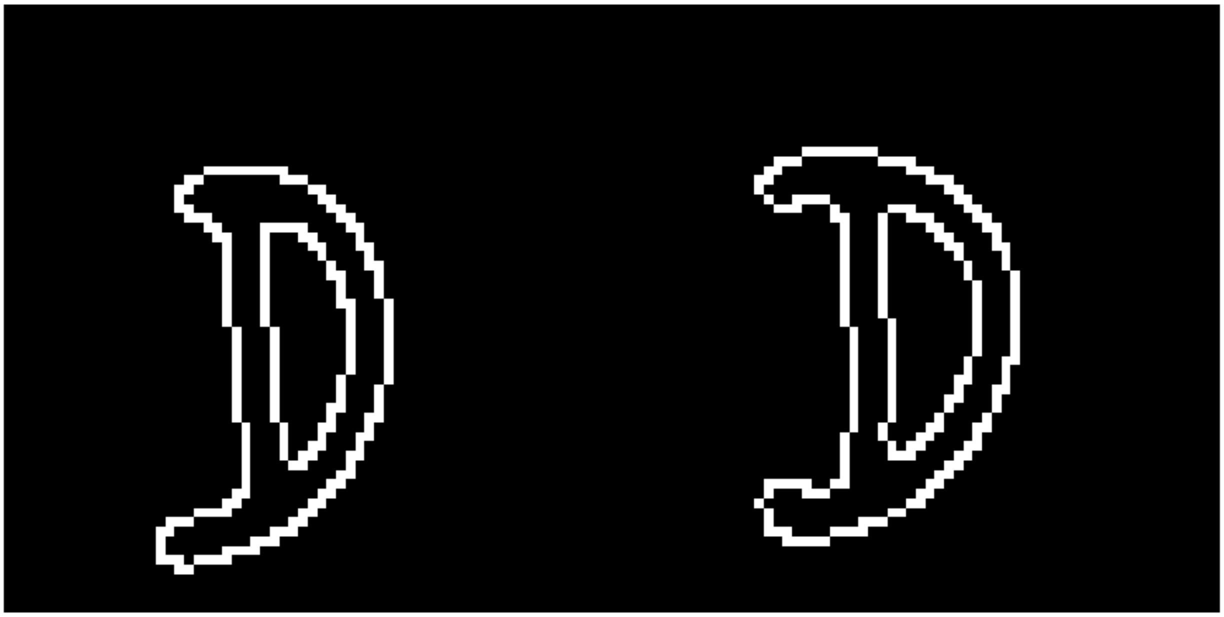


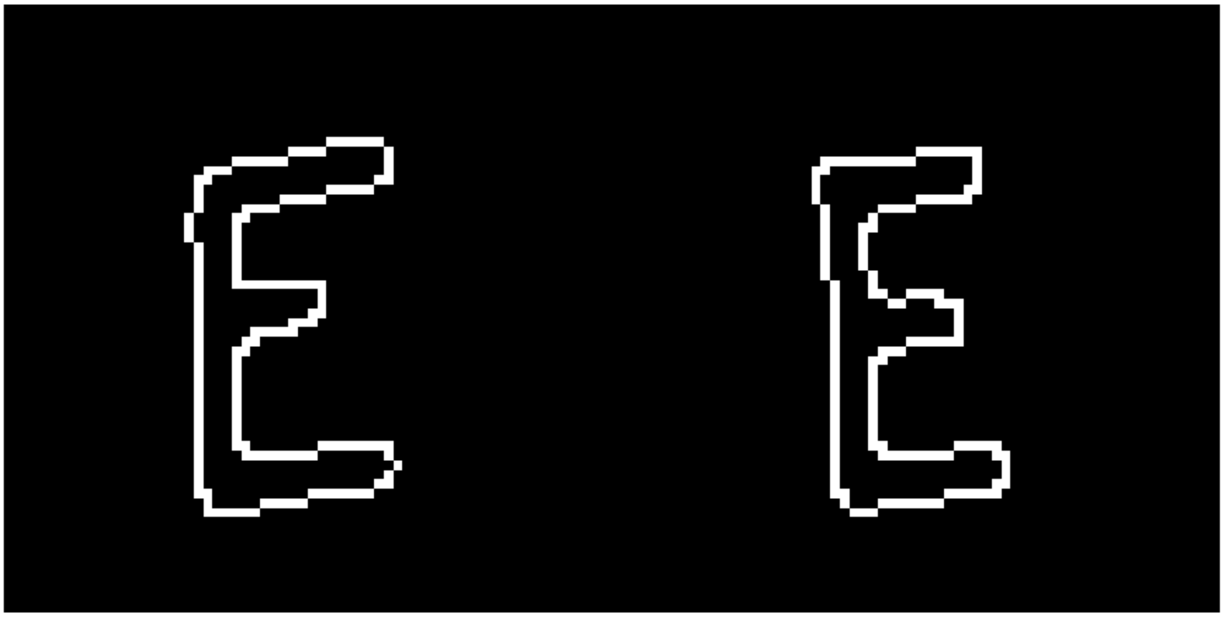

Result 11   Given Test Image is A   Predict Image is V


Result 12   Given Test Image is B   Predict Image is E

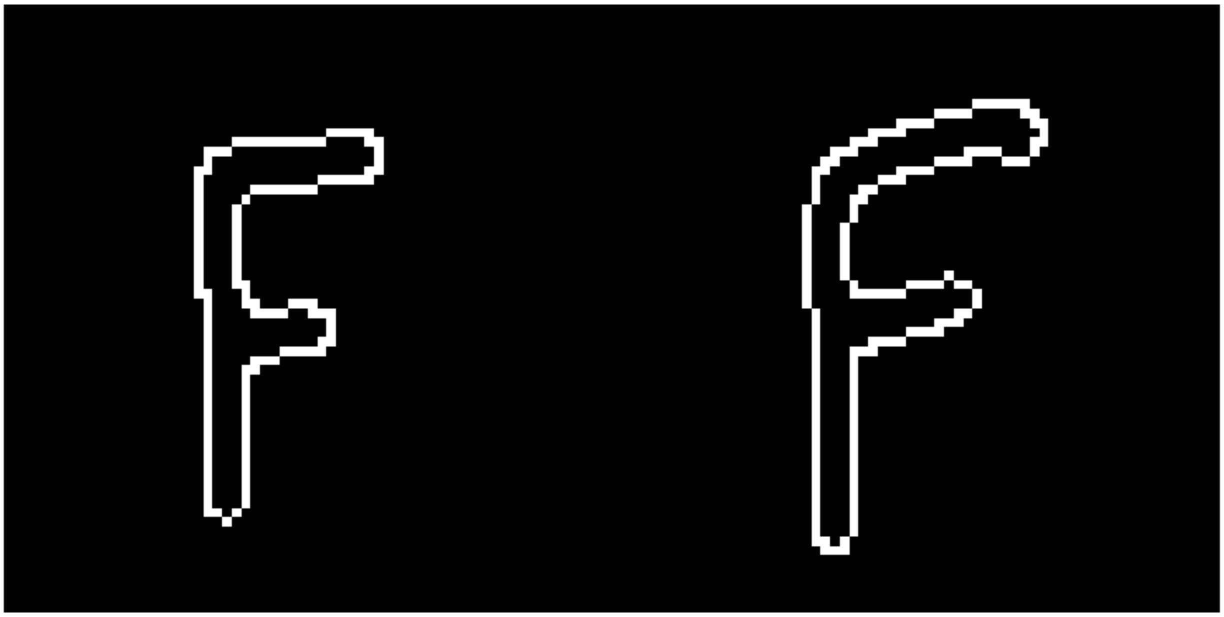
Result 13   Given Test Image is C   Predict Image is C

Result 14   Given Test Image is D   Predict Image is E





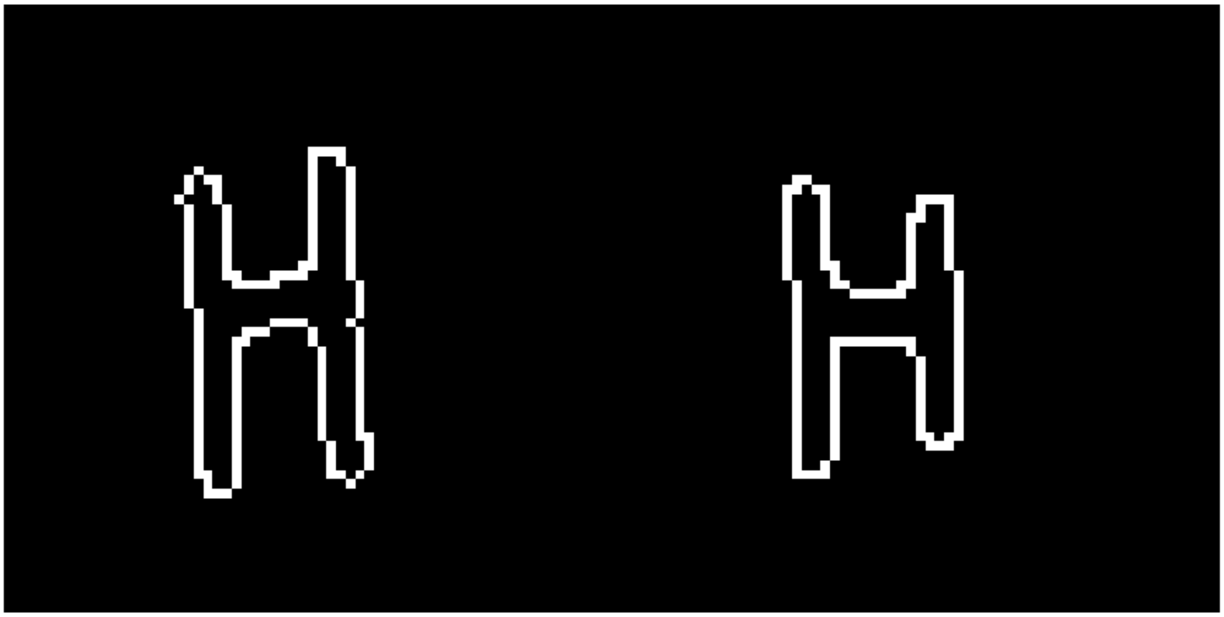
Result 15   Given Test Image is E   Predict Image is F



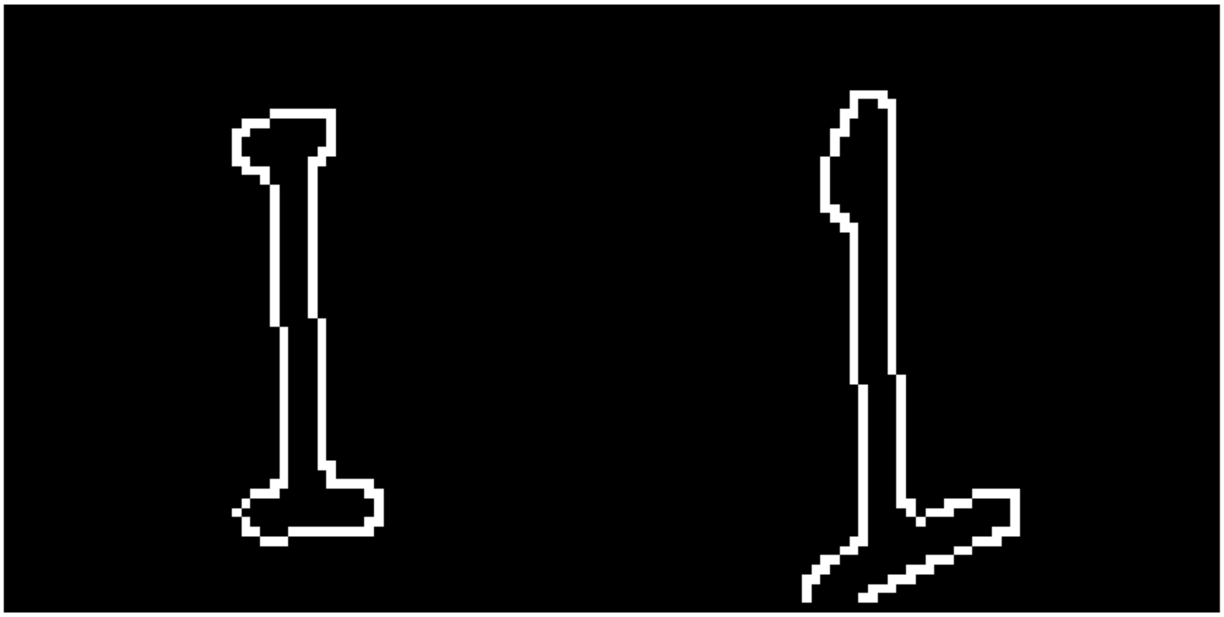
Result 16   Given Test Image is F   Predict Image is G

Result 17   Given Test Image is G   Predict Image is H

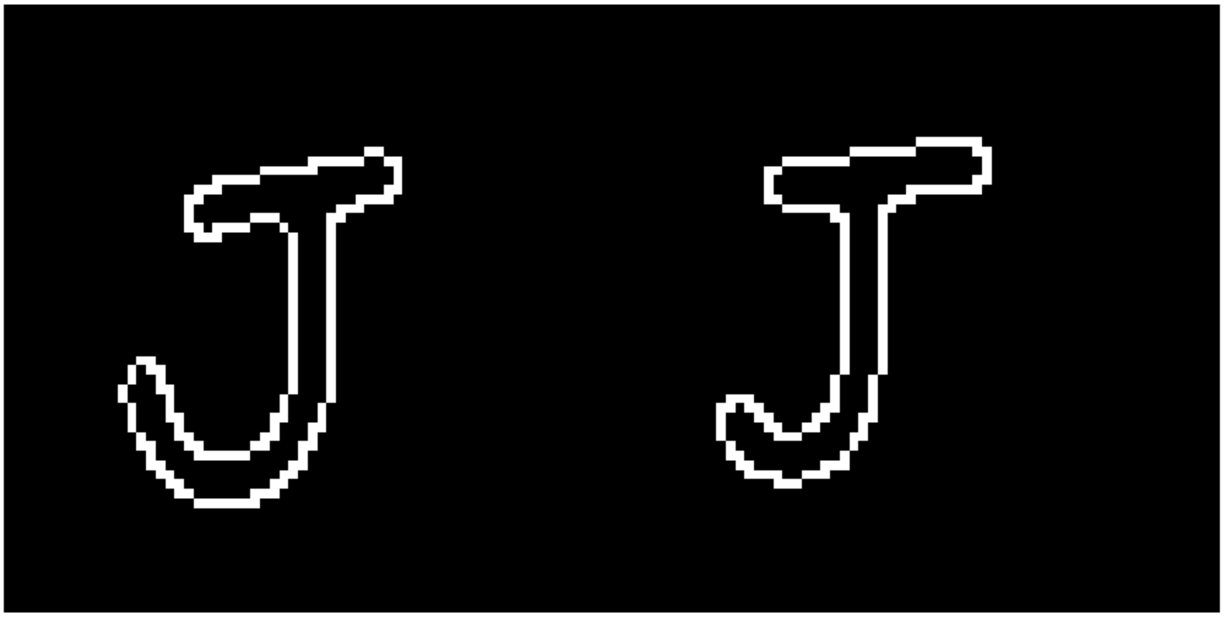
Result 18   Given Test Image is H   Predict Image is H



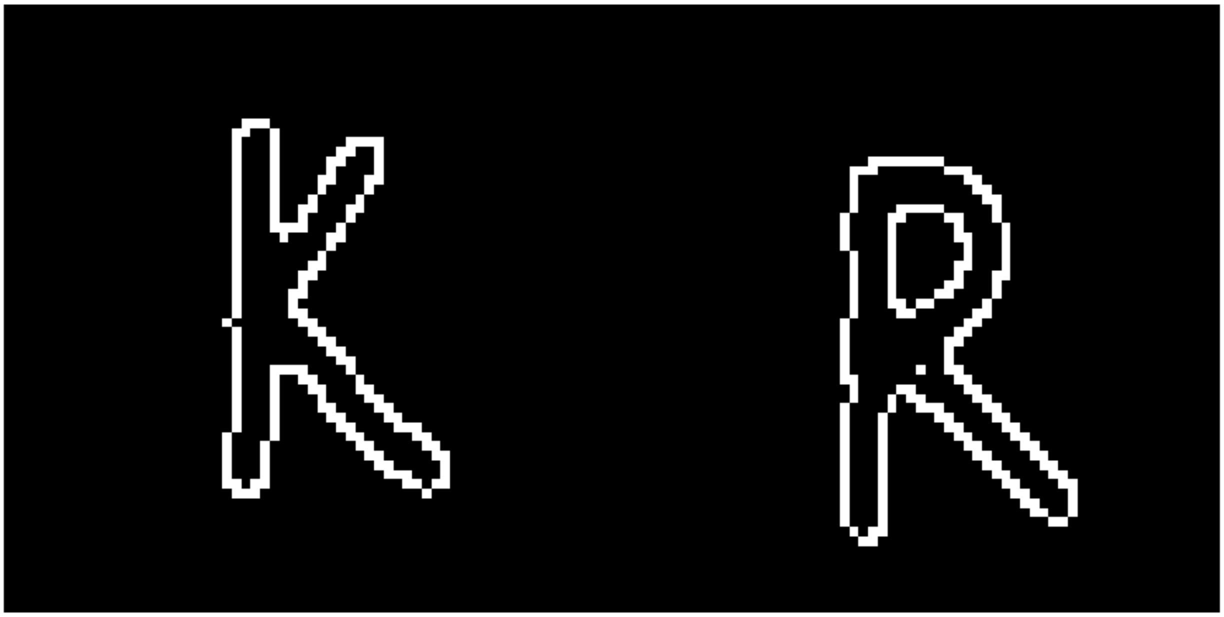
Result 19   Given Test Image is I   Predict Image is 1



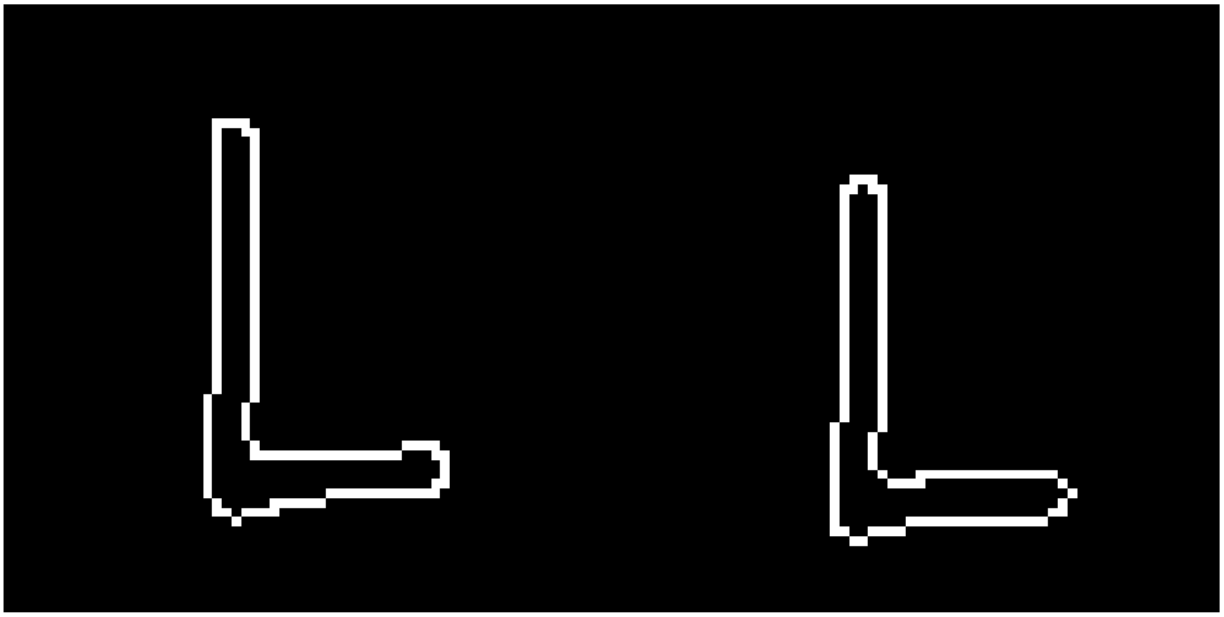
Result 20   Given Test Image is J   Predict Image is J



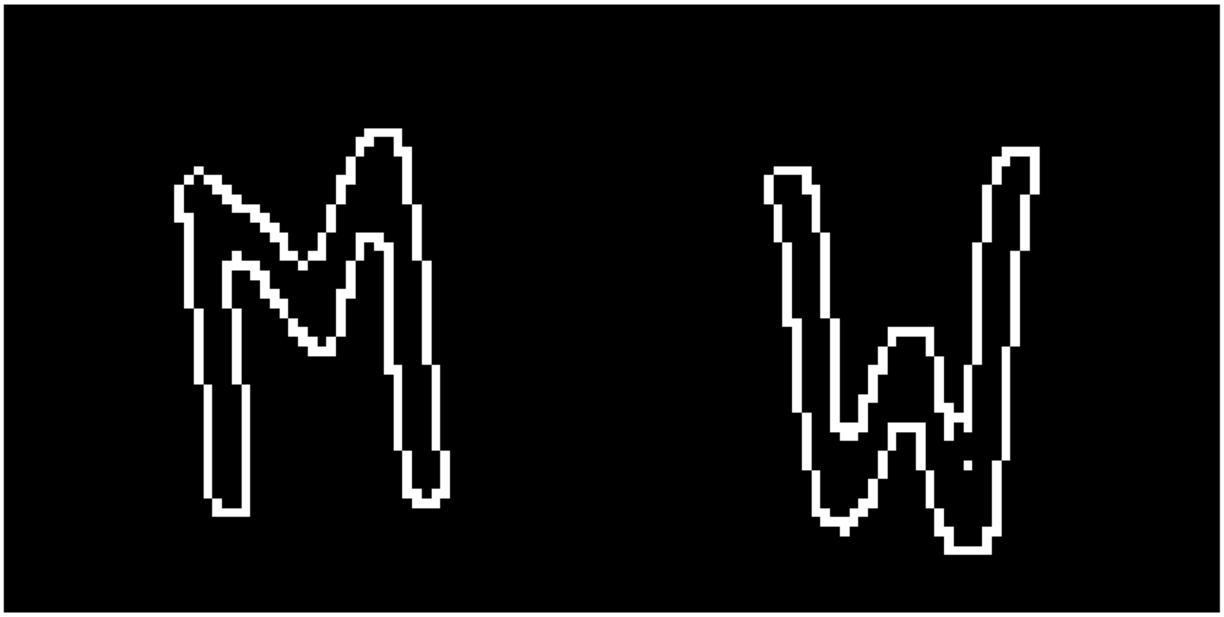
Result 21   Given Test Image is K   Predict Image is R



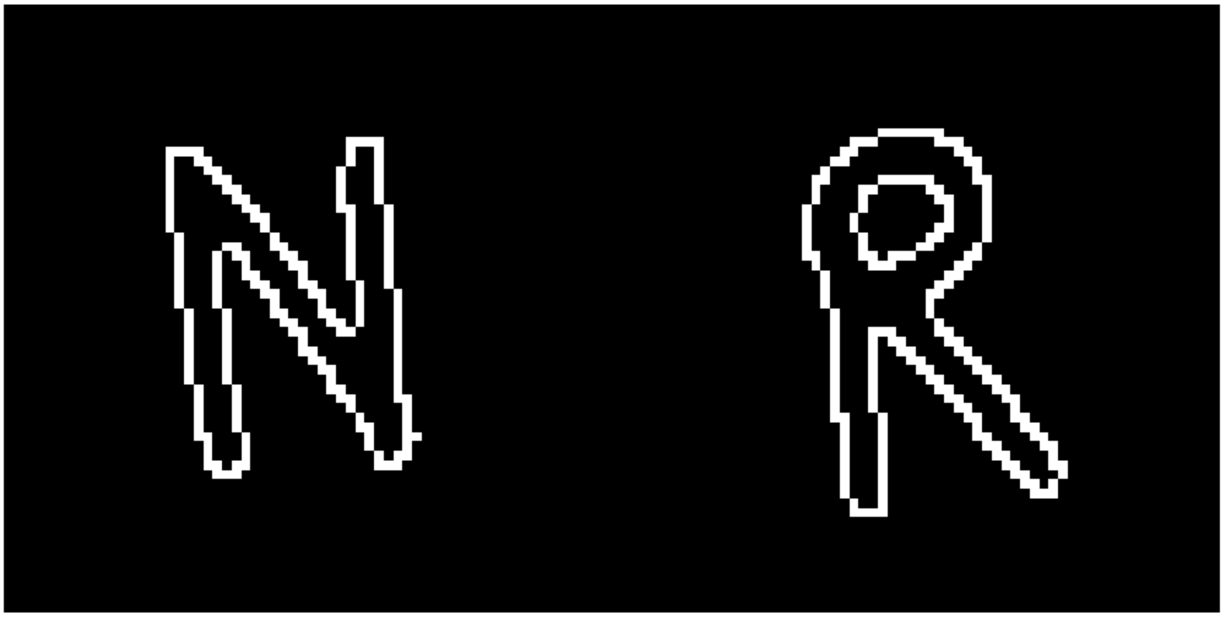
Result 22   Given Test Image is L   Predict Image is L



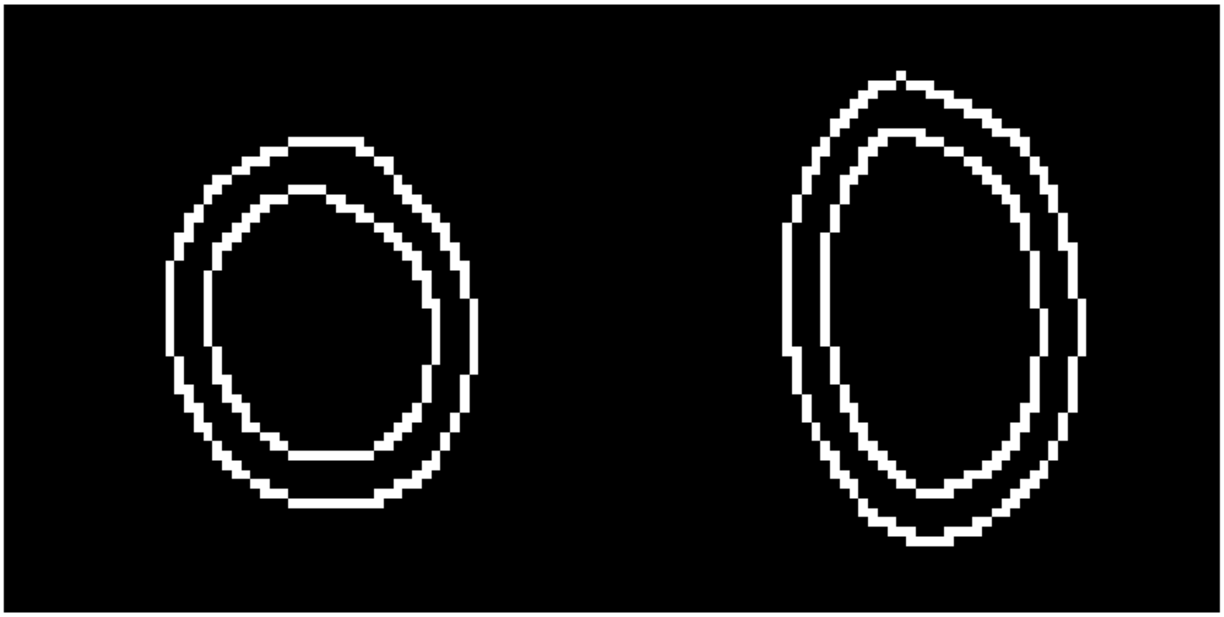
Result 23   Given Test Image is M   Predict Image is W



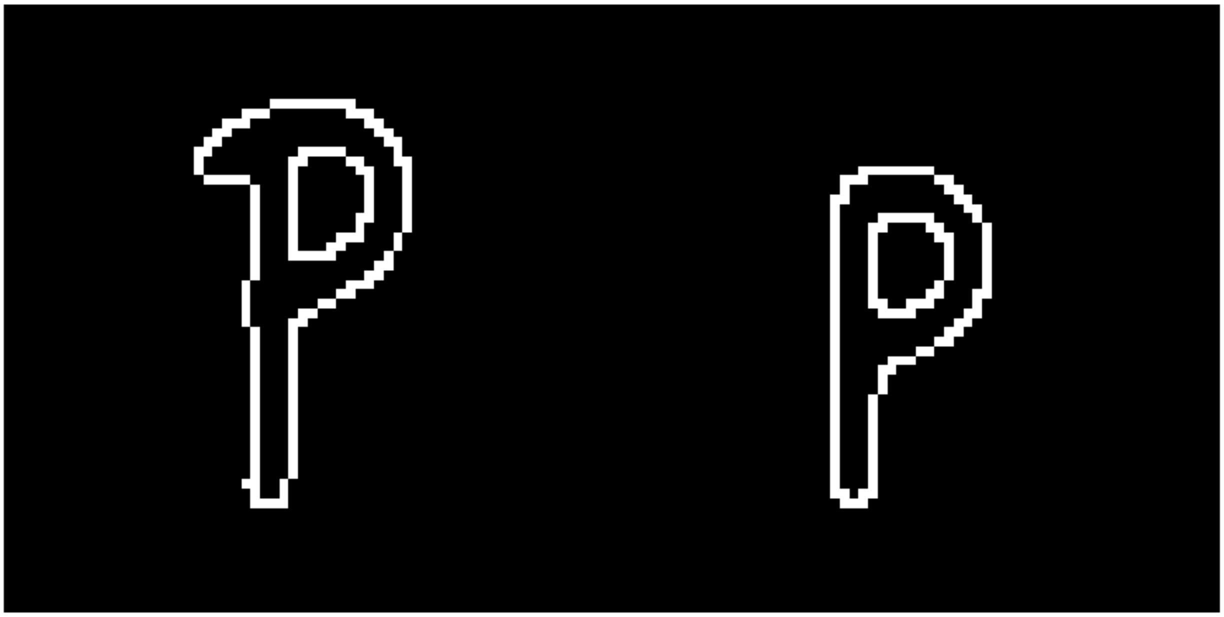
Result 24   Given Test Image is N   Predict Image is S



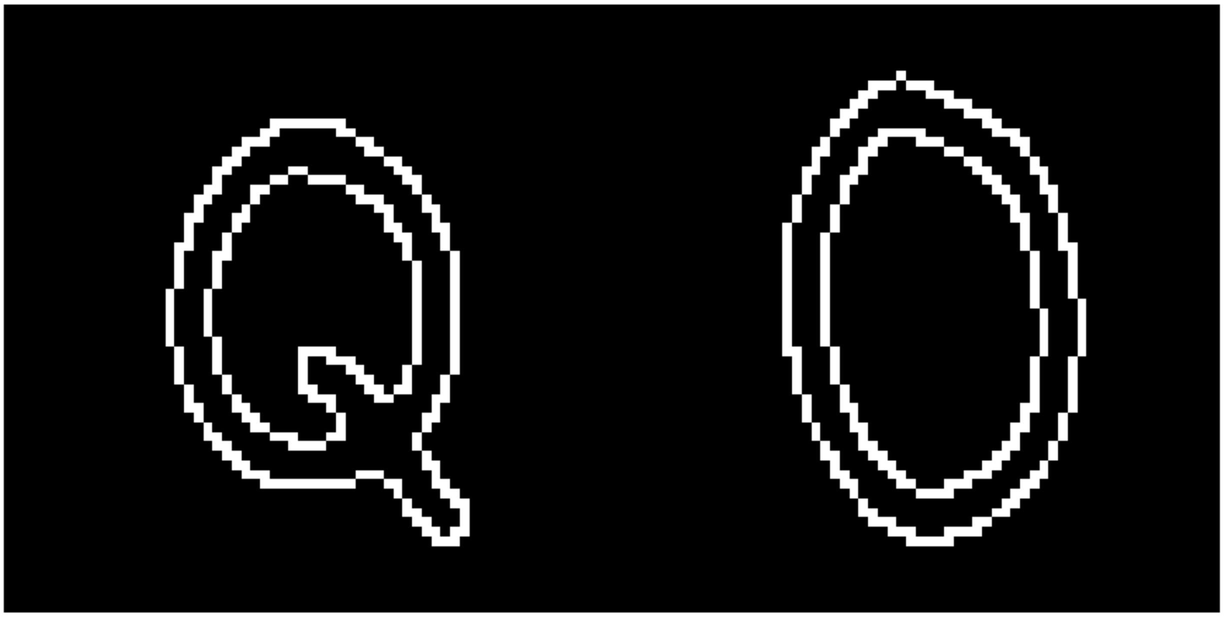
Result 25   Given Test Image is O   Predict Image is 0



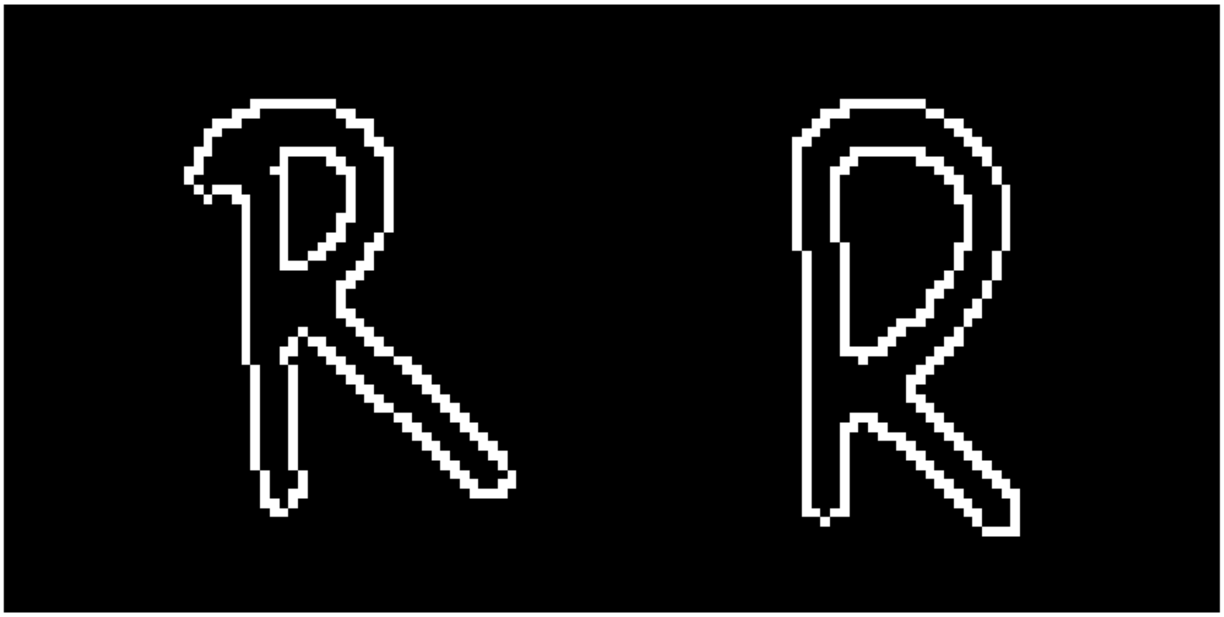
Result 26   Given Test Image is P   Predict Image is Q



Result 27   Given Test Image is Q   Predict Image is 0

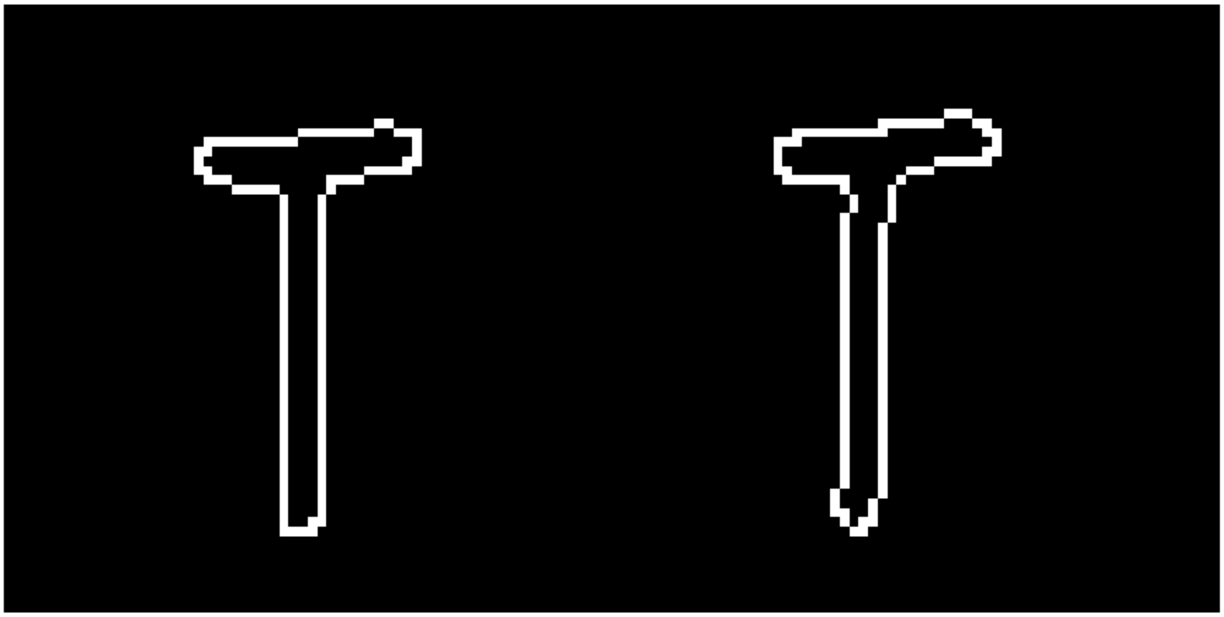


Result 28   Given Test Image is R   Predict Image is R

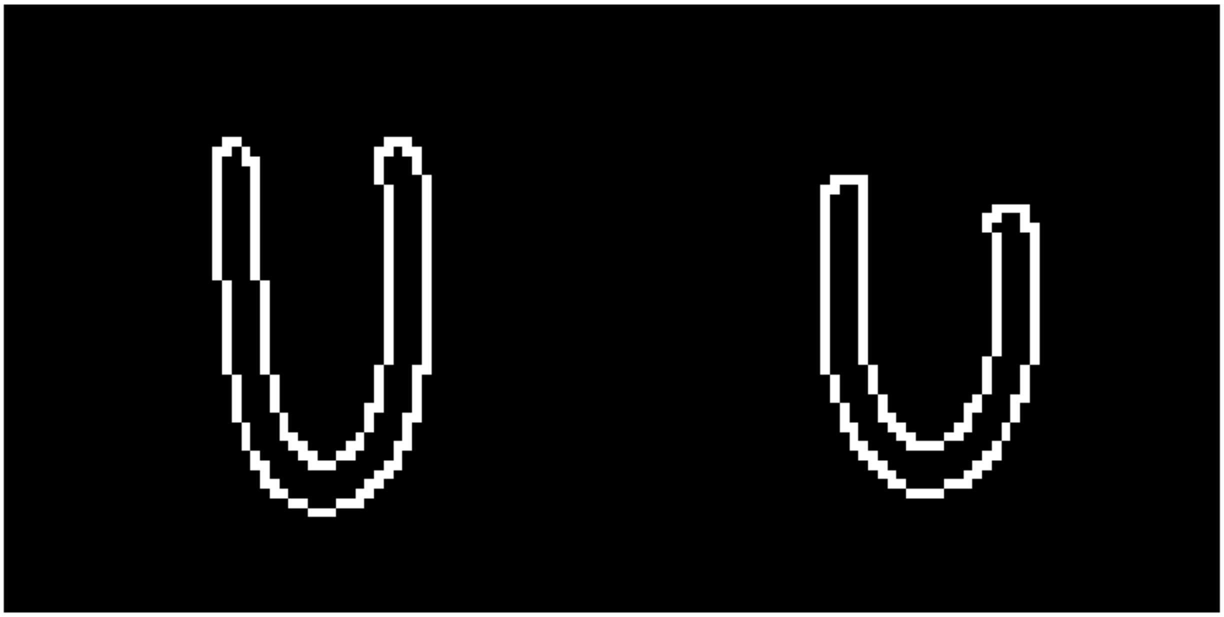


Result 29   Given Test Image is S   Predict Image is G

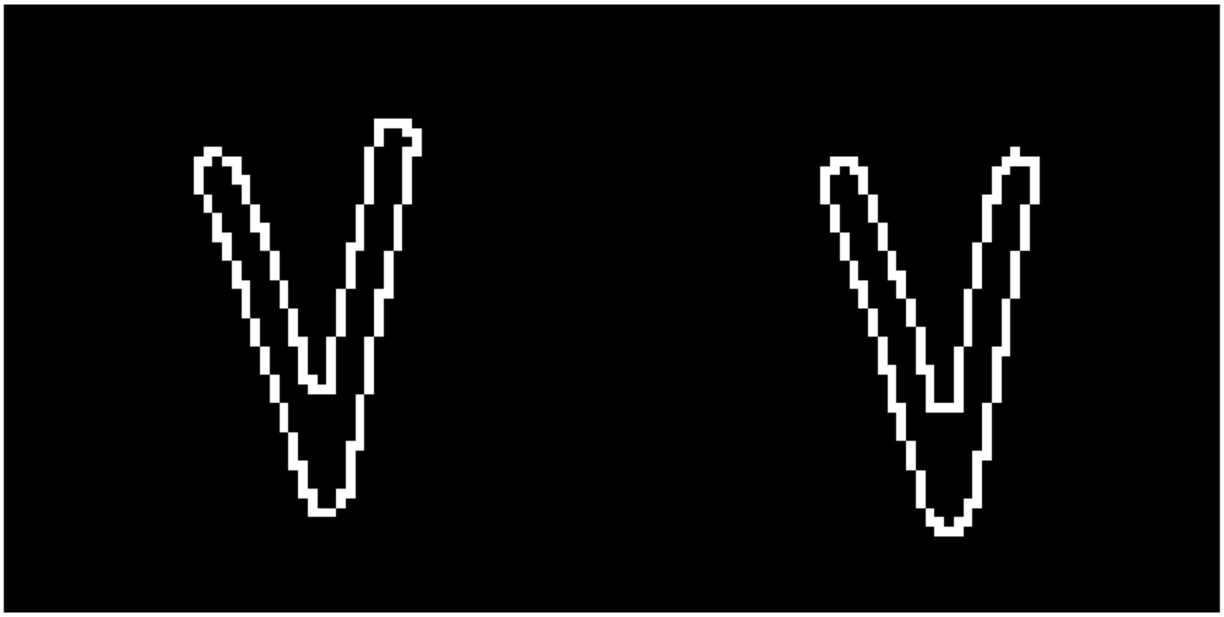
Result 30   Given Test Image is T   Predict Image is T



Result 31   Given Test Image is U   Predict Image is V

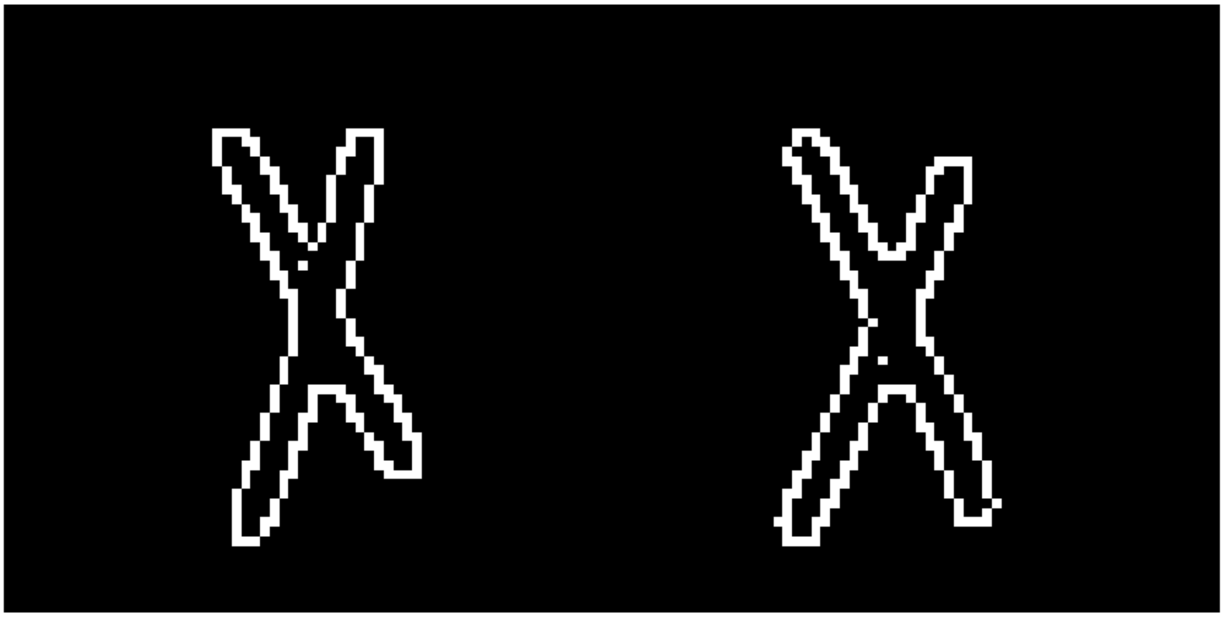


Result 32   Given Test Image is V   Predict Image is W

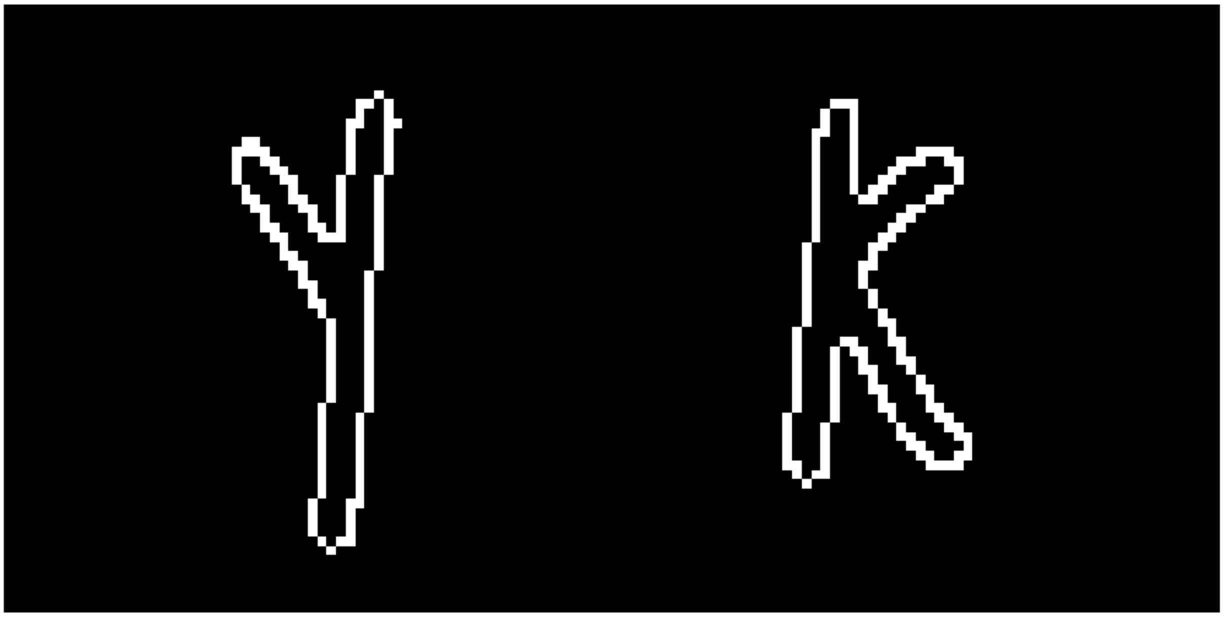


Result 33 Given Test Image is W Predict Image is W

Result 34 Given Test Image is X Predict Image is X



Result 35   Given Test Image is Y   Predict Image is K



```
%% Calculating Accuracy of Model
totalTestImg = ntestCol;
accuracy = predTrue / ntestCol;
sprintf("We achives a accuracy of (in % ) ")
```

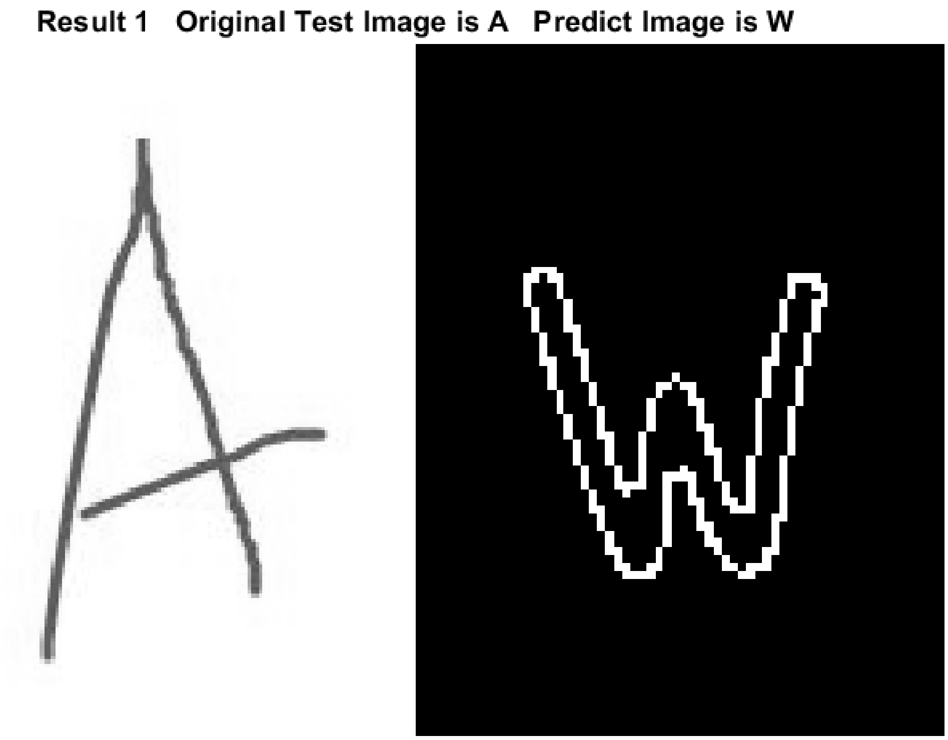
```
ans = 
"We achives a accuracy of (in "
```

```
disp(accuracy*100)
```

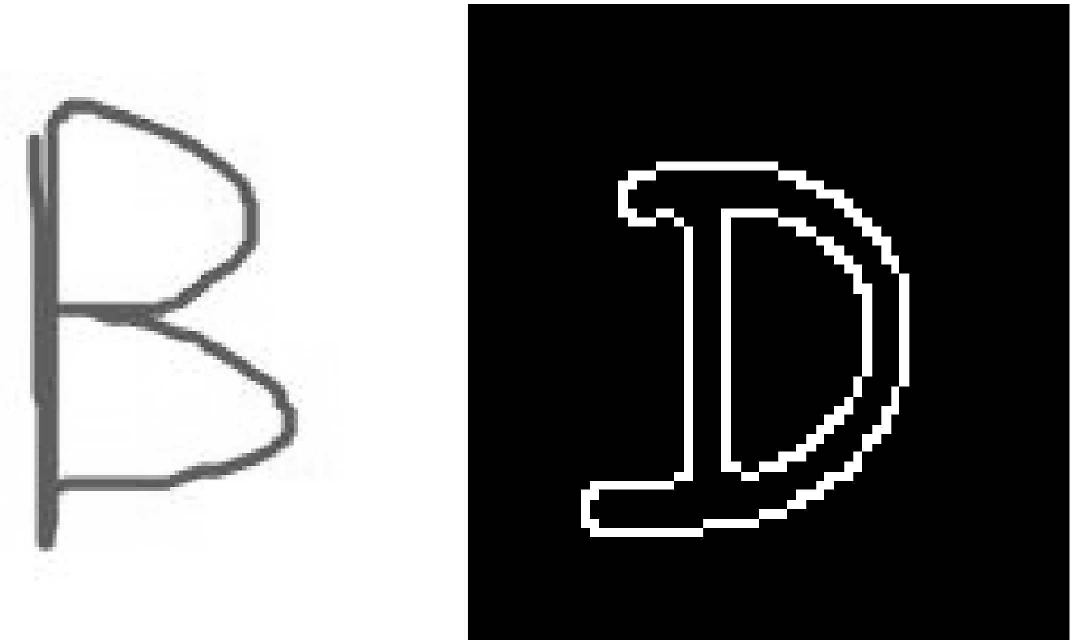
```
   29.2593
```

Performing on self generated dataset

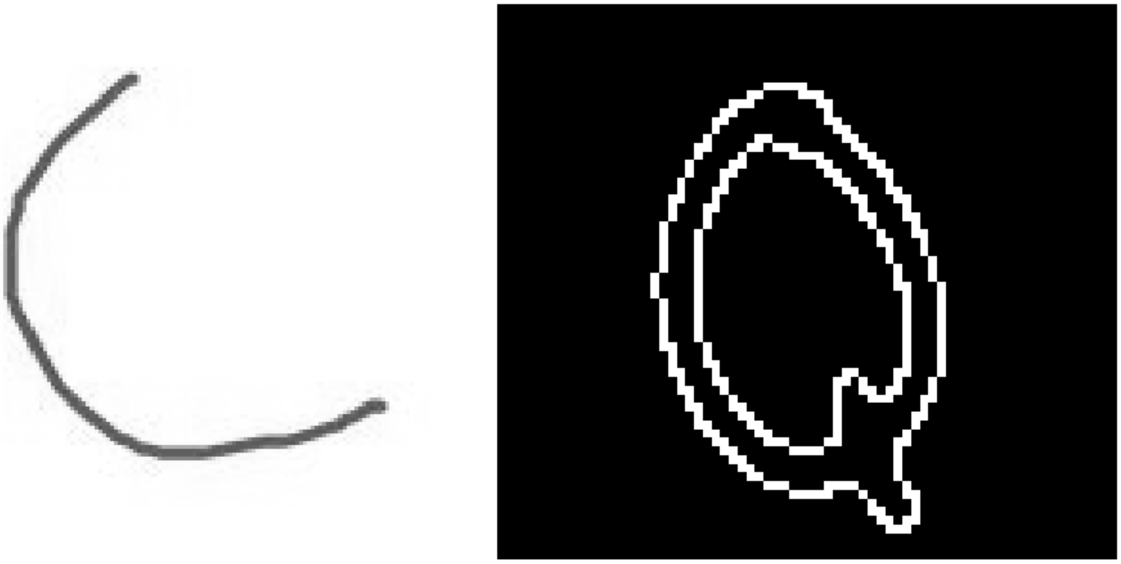
```
newFiles = imageDatastore(strcat('D:\Lakshay\M.Tech\Sem 1\EE608_Digital Image Processing\DIP Pr
n_newFiles = size(newFiles);

for i = 1:n_newFiles(1)
    timg = im2gray(imread(newFiles{i}));
    tsmall = imresize(timg, [64 64]);
    tFil = medfilt2(tsmall);
    tedge = edge(tFil, "canny");
    ftimg = reshape(fftshift(fft2(tedge)), 64*64, 1);

    err = (train_img_FT_Mat - abs(ftimg)).^2;
    err = sum(err, 1);
    [minErr ,idx] = min(err,[],'all', 'linear');

    predictImg = reshape(train_imgMat(:, idx), 64, 64);
    predImgKey = int8(idx/40) + 1;
    if predImgKey == 37
        predImgKey = 36;
    end
    figure; montage({timg, predictImg}), title("Result " + i + "   Original Test Image is " +ch
end
```



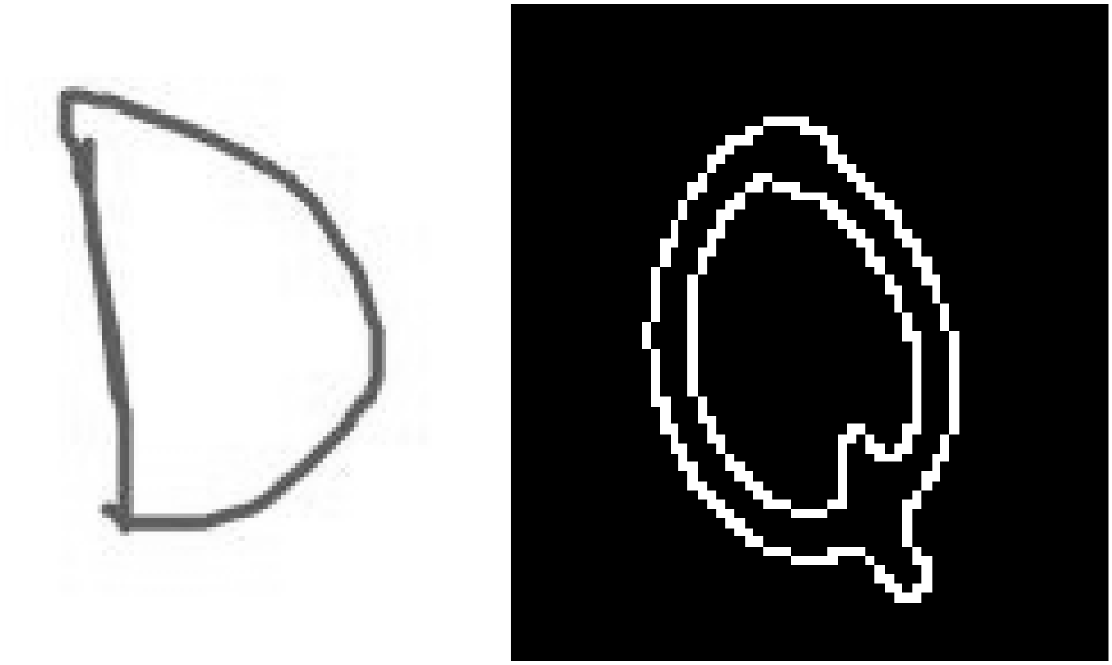
Result 2   Original Test Image is B   Predict Image is D



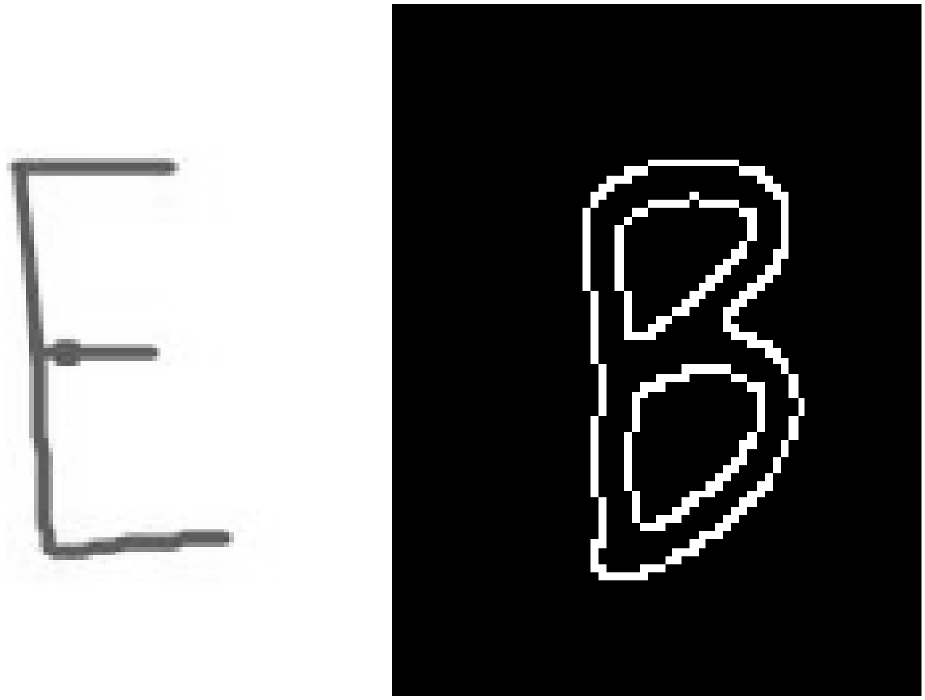
Result 3   Original Test Image is C   Predict Image is Q



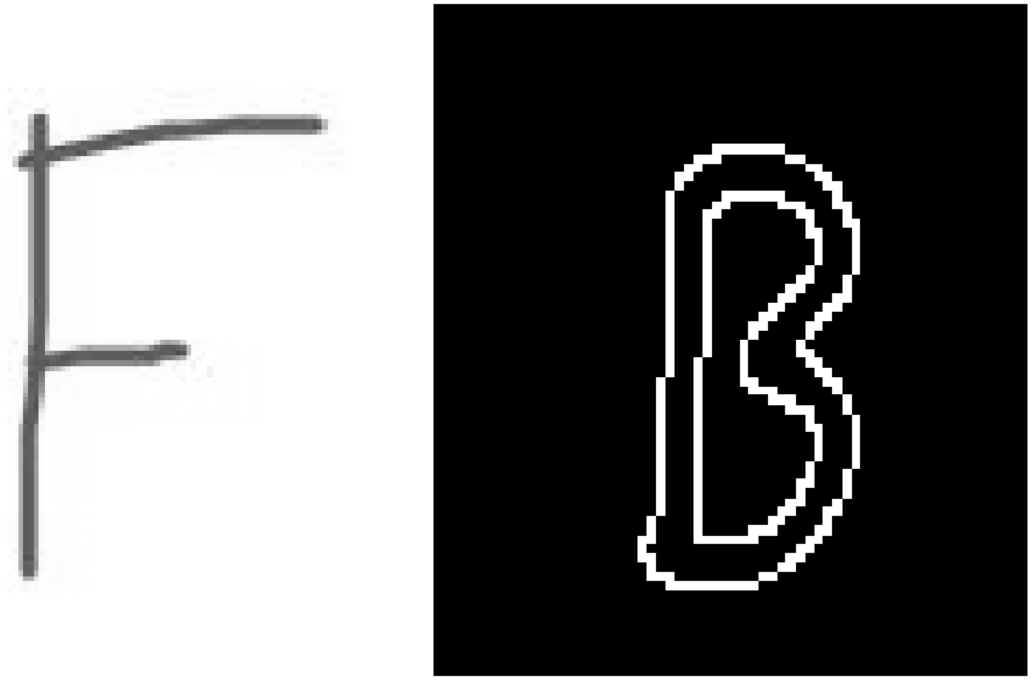
Result 4 Original Test Image is D Predict Image is Q



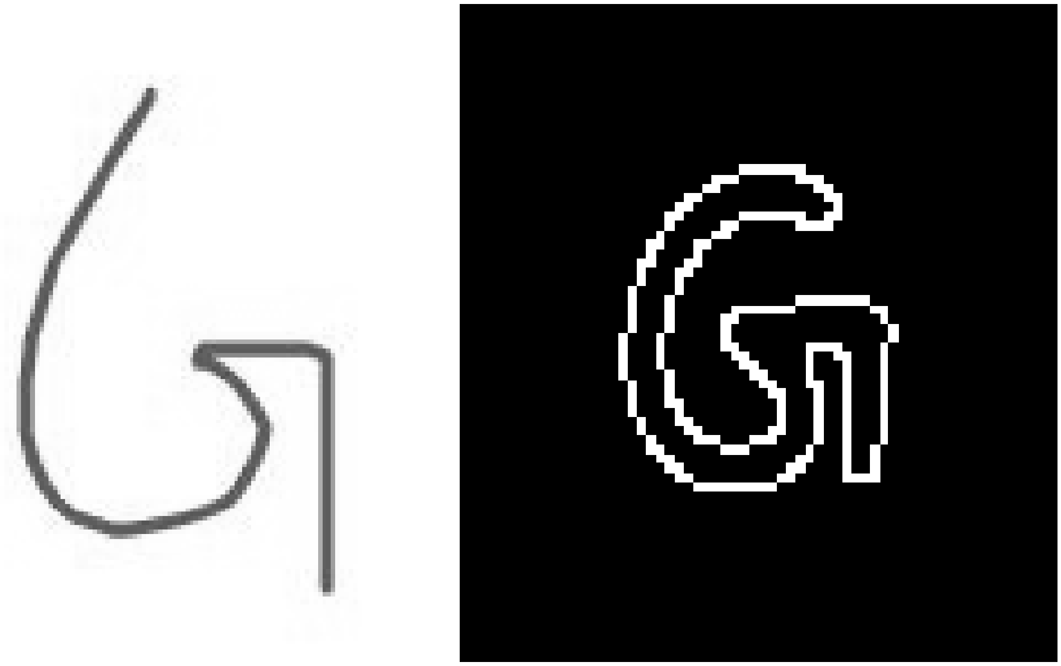
Result 5 Original Test Image is E Predict Image is B



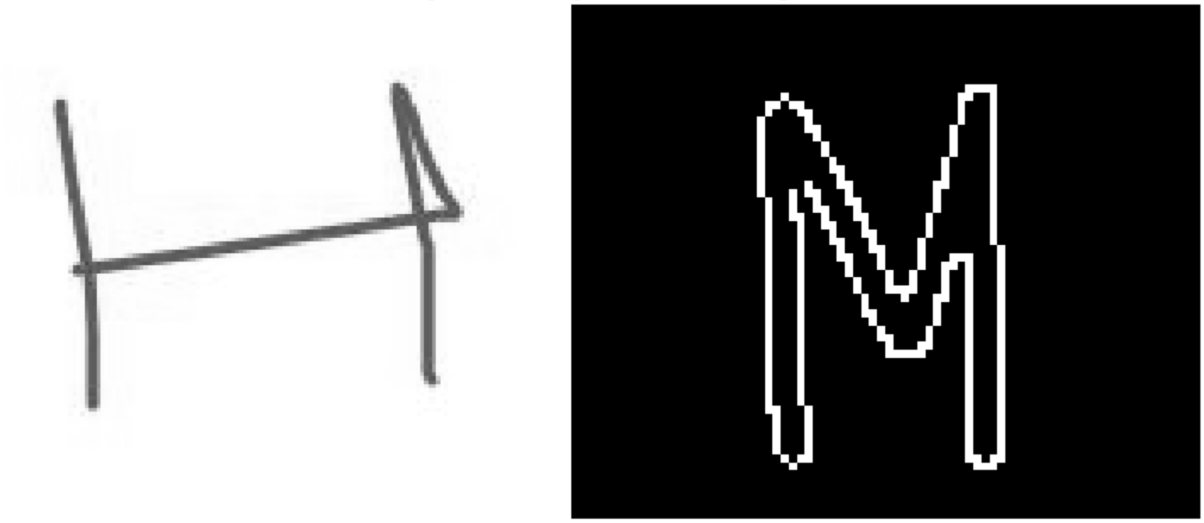
Result 6 Original Test Image is F Predict Image is B



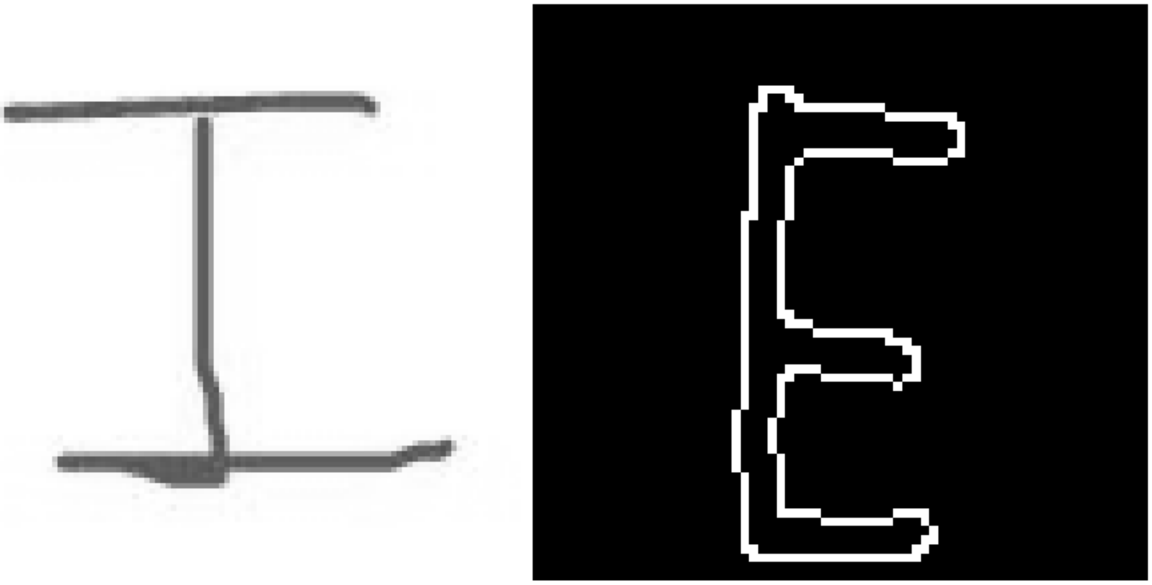
Result 7 Original Test Image is G Predict Image is G



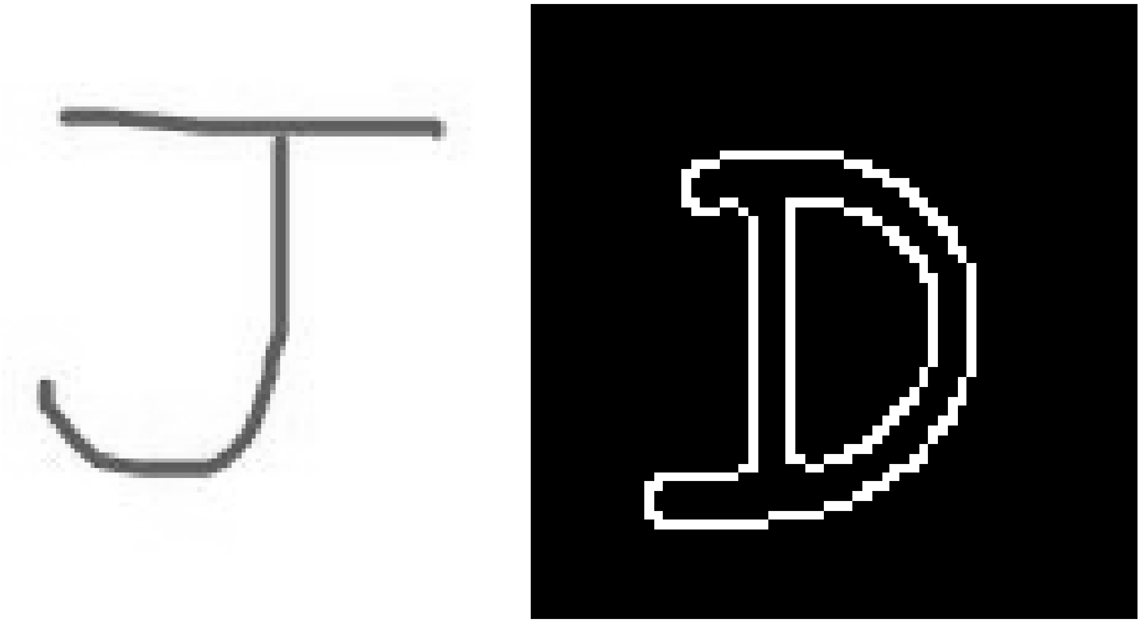
Result 8   Original Test Image is H   Predict Image is M



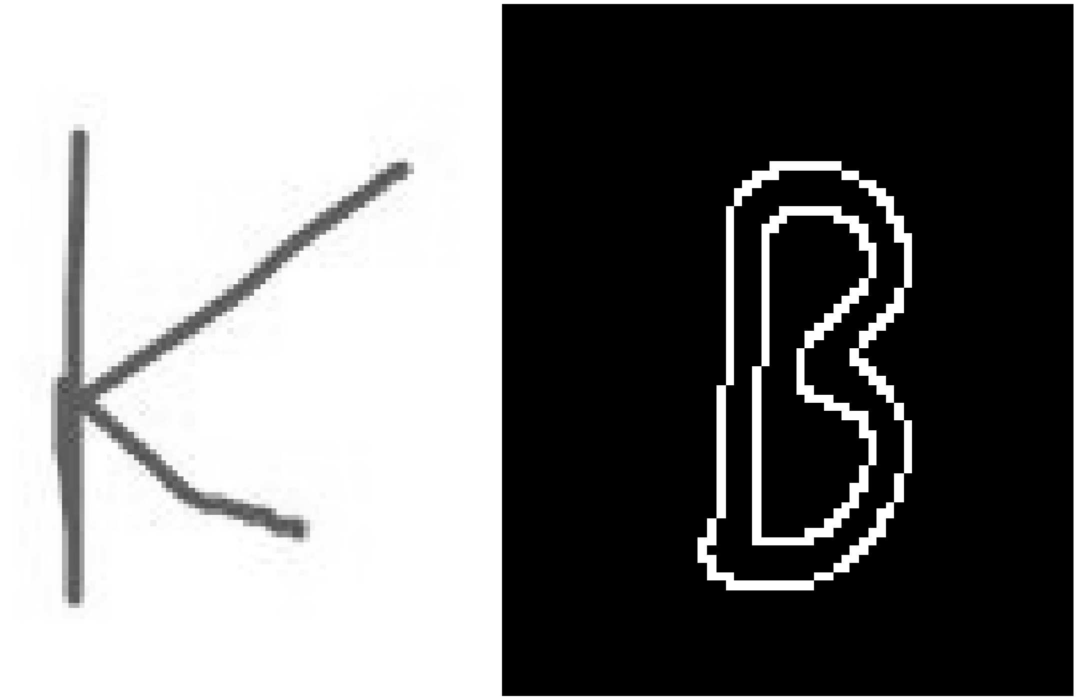
Result 9   Original Test Image is I   Predict Image is E



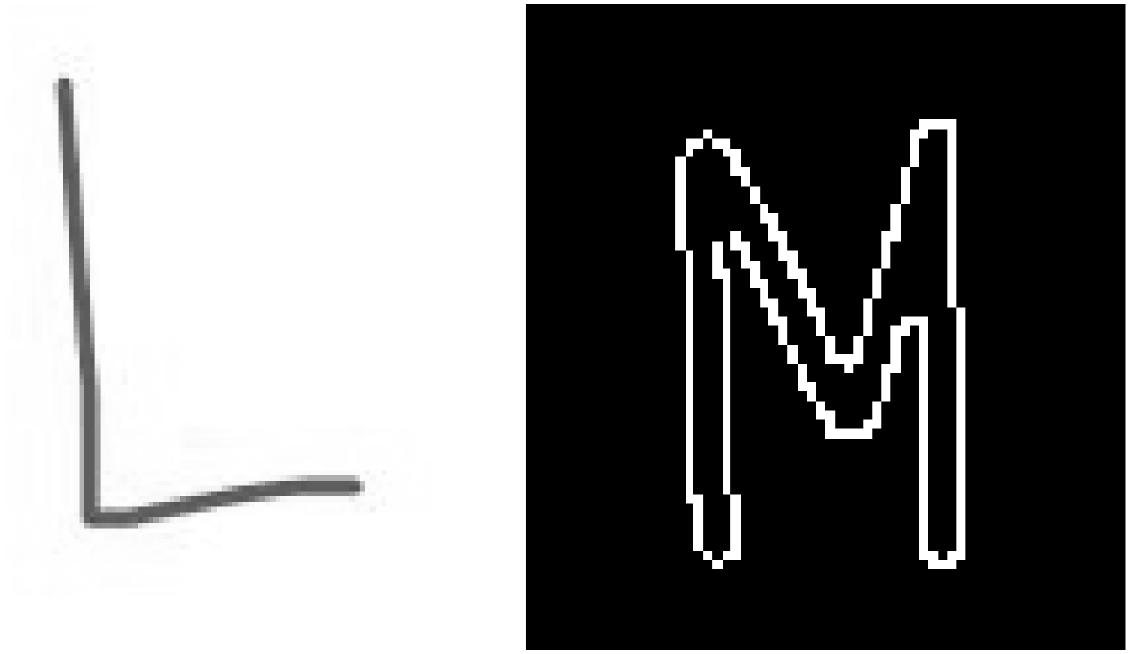
Result 10   Original Test Image is J   Predict Image is D



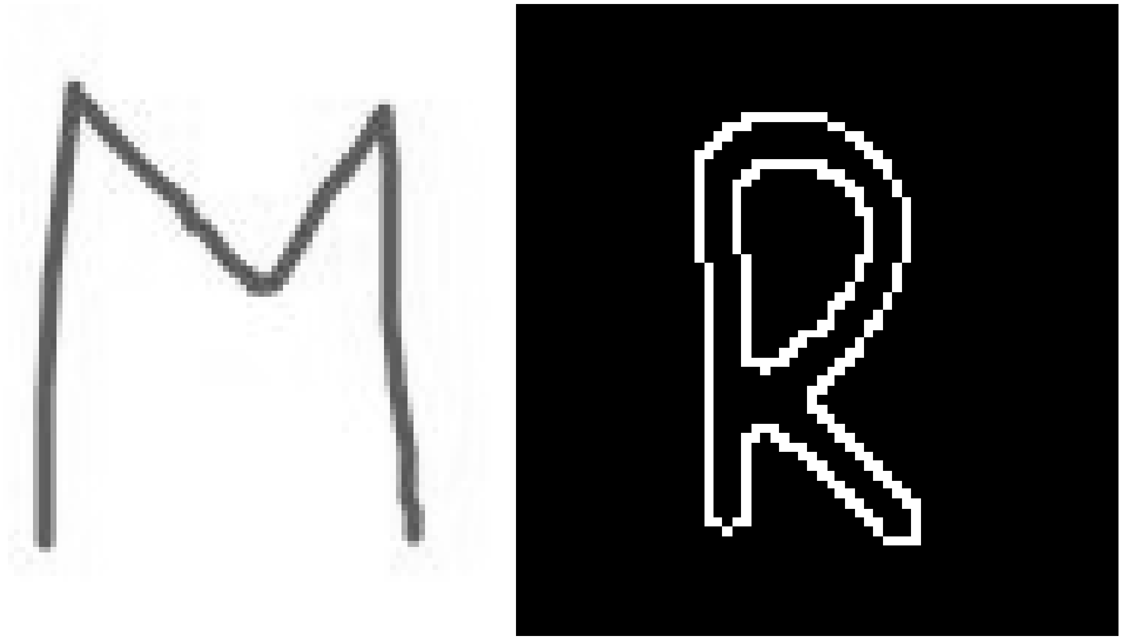
Result 11   Original Test Image is K   Predict Image is B



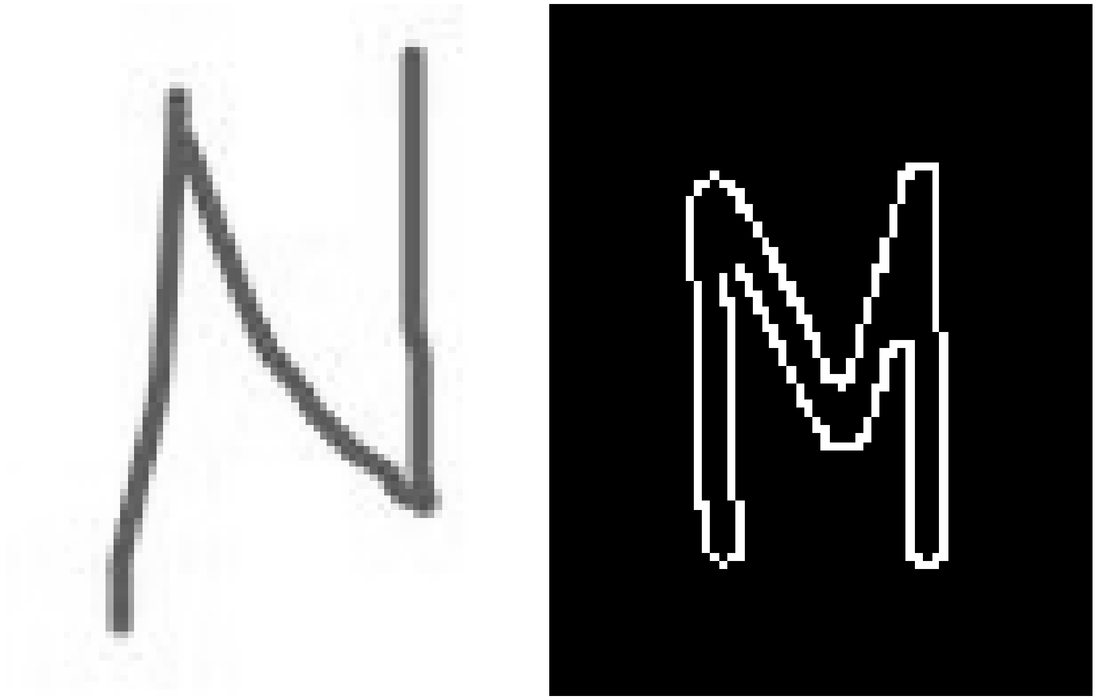
Result 12   Original Test Image is L   Predict Image is M



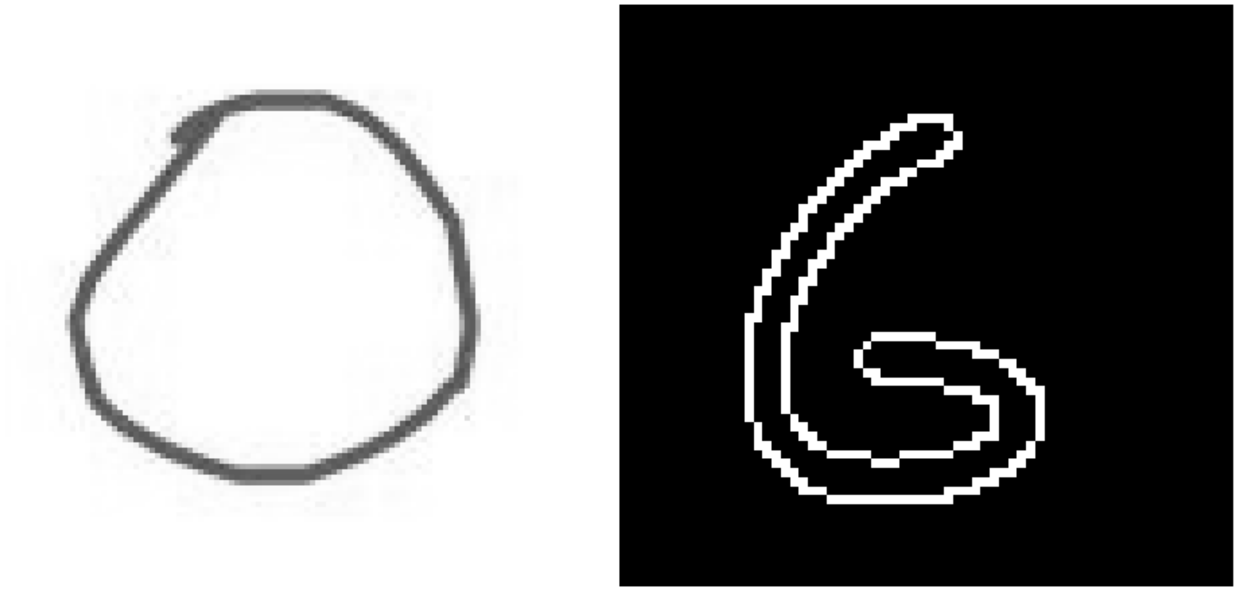
Result 13   Original Test Image is M   Predict Image is R



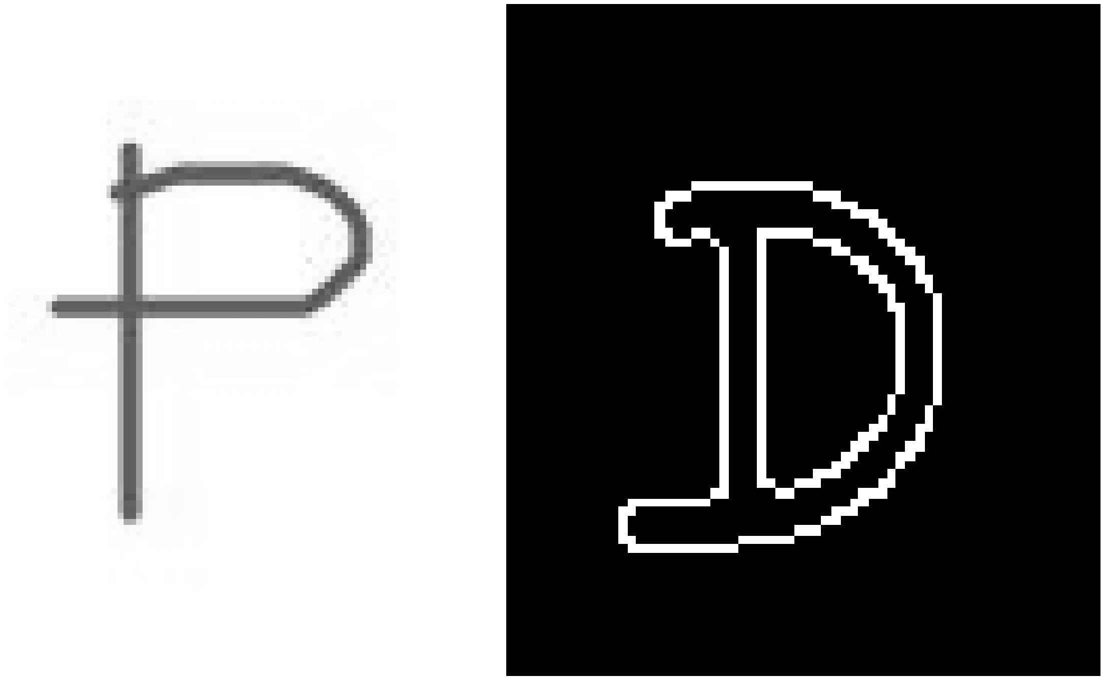
Result 14   Original Test Image is N   Predict Image is M



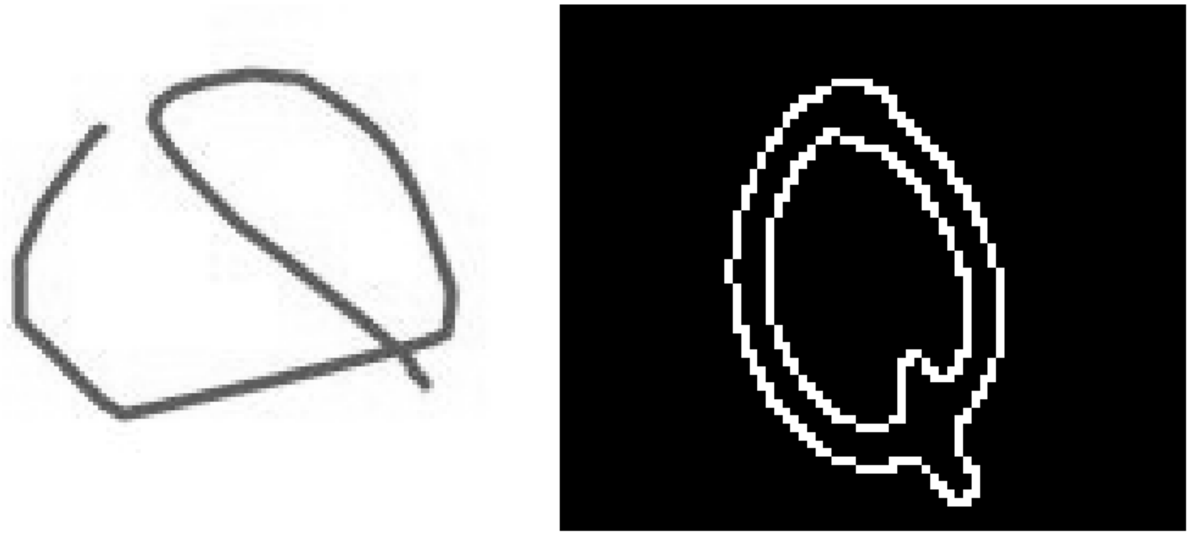
Result 15   Original Test Image is O   Predict Image is G



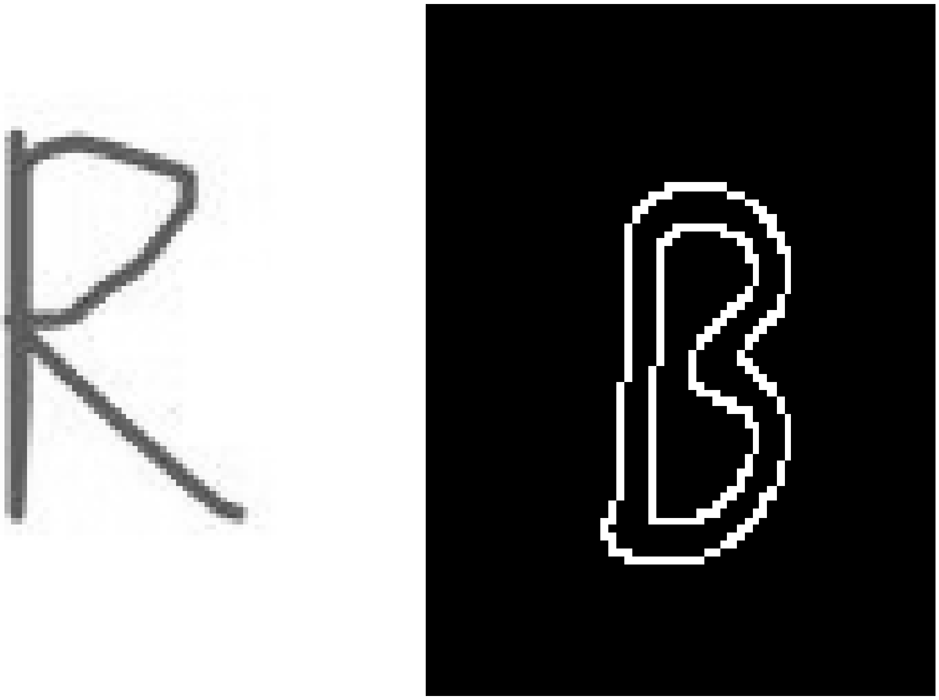
Result 16   Original Test Image is P   Predict Image is D



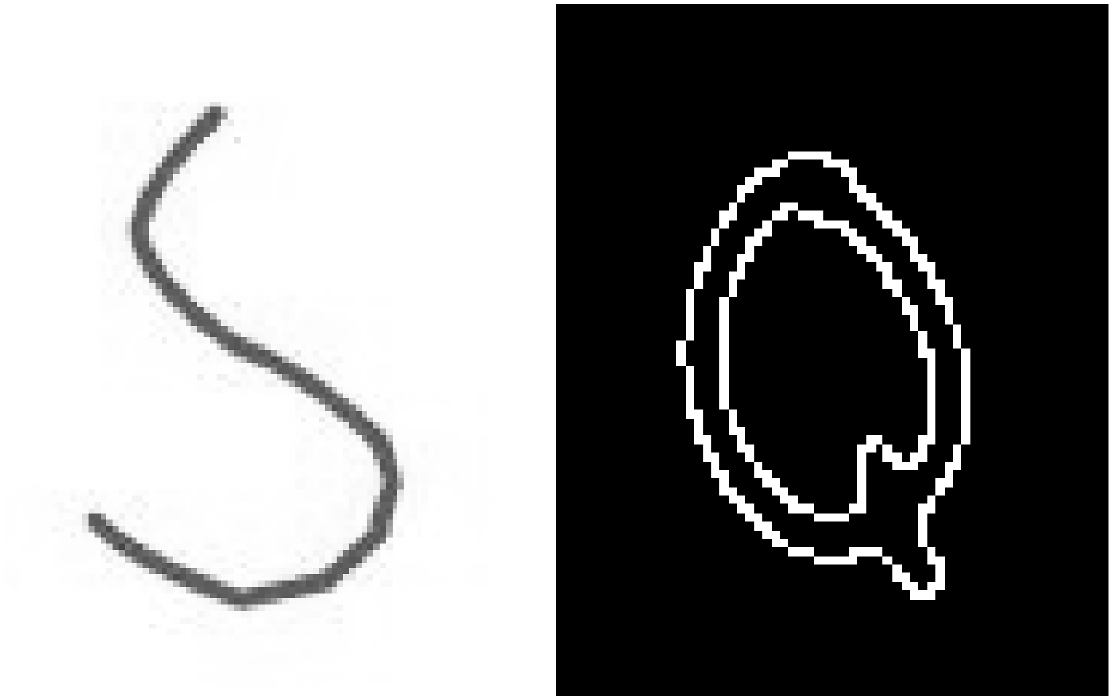
Result 17   Original Test Image is Q   Predict Image is Q



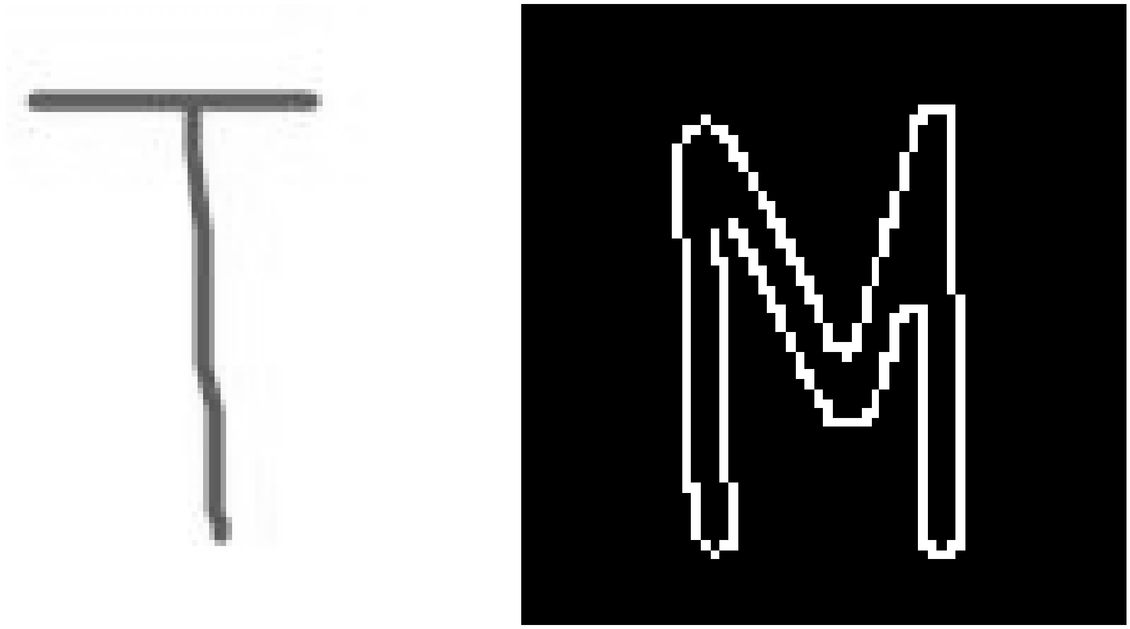
Result 18   Original Test Image is R   Predict Image is B



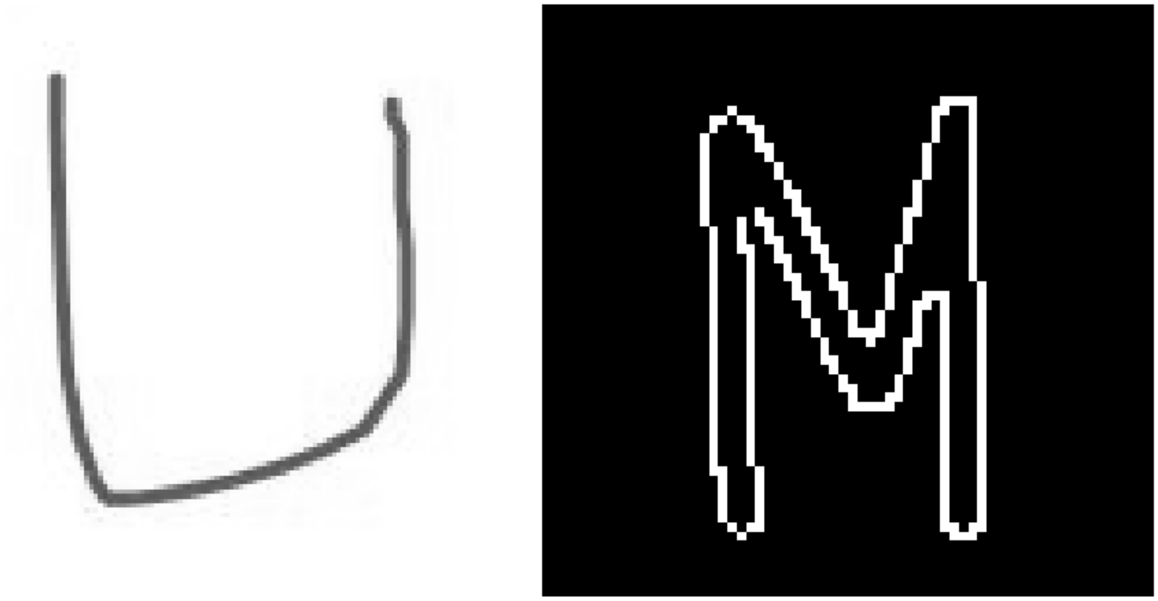
Result 19   Original Test Image is S   Predict Image is Q



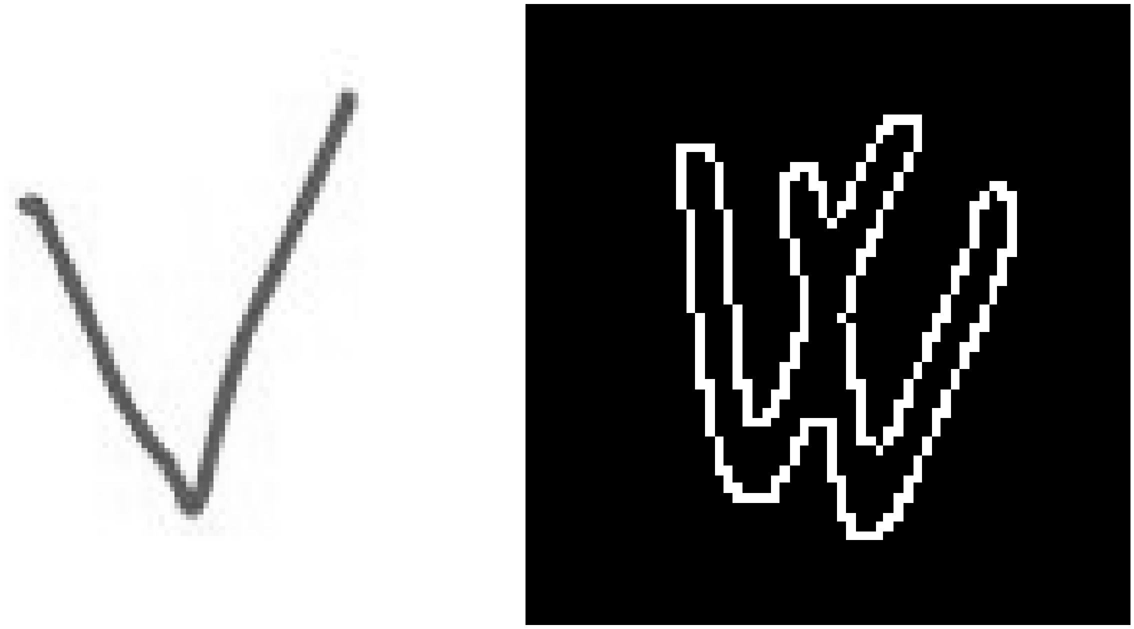
Result 20 Original Test Image is T Predict Image is M



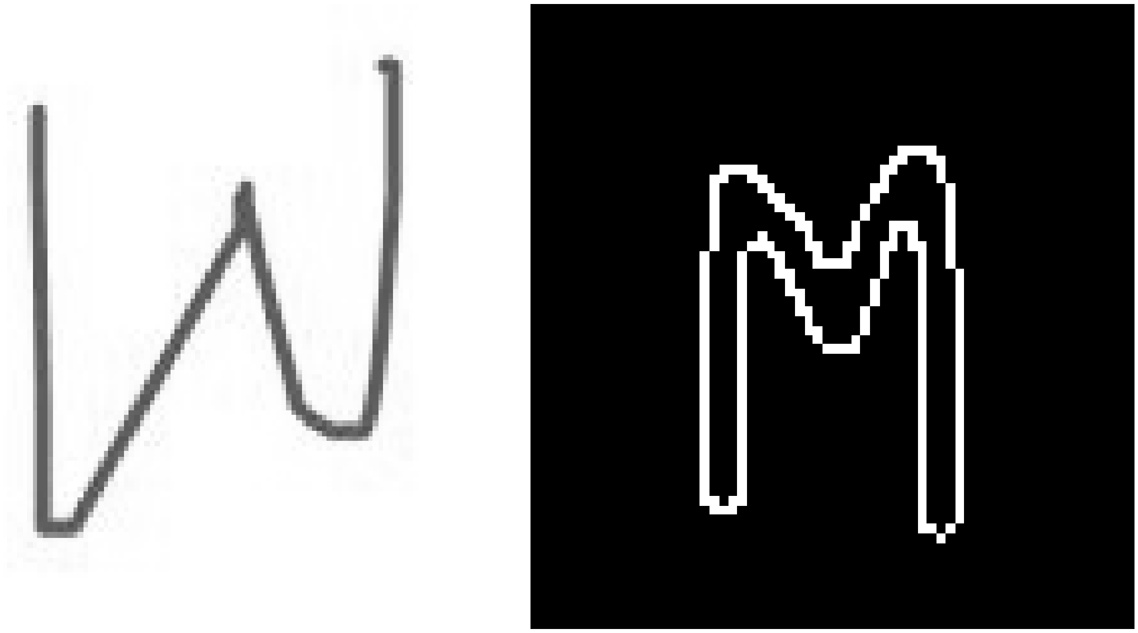
Result 21 Original Test Image is U Predict Image is M



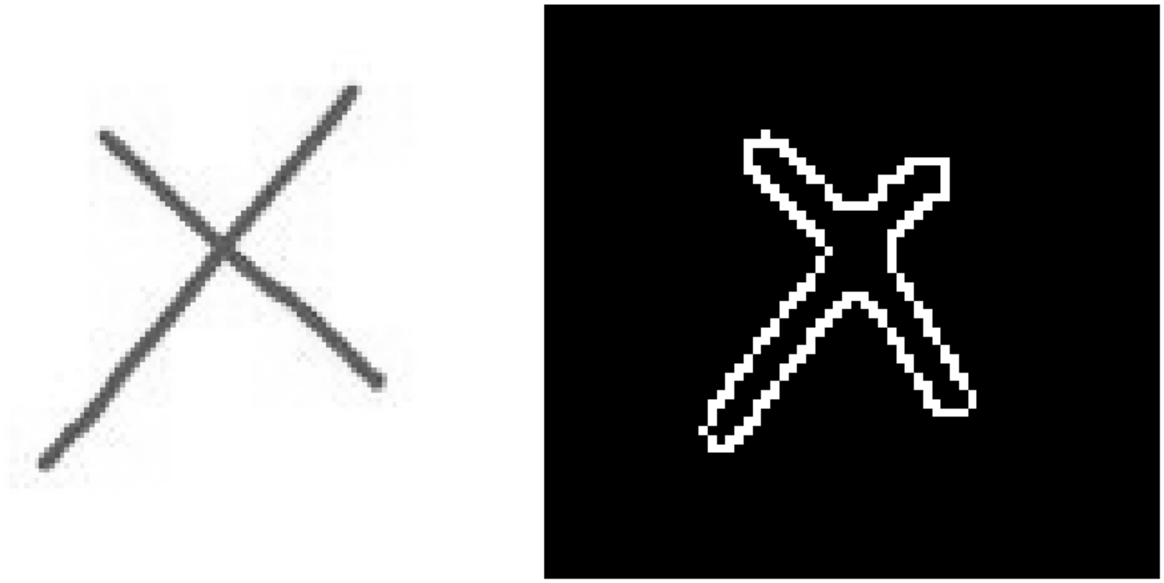
Result 22   Original Test Image is V   Predict Image is W



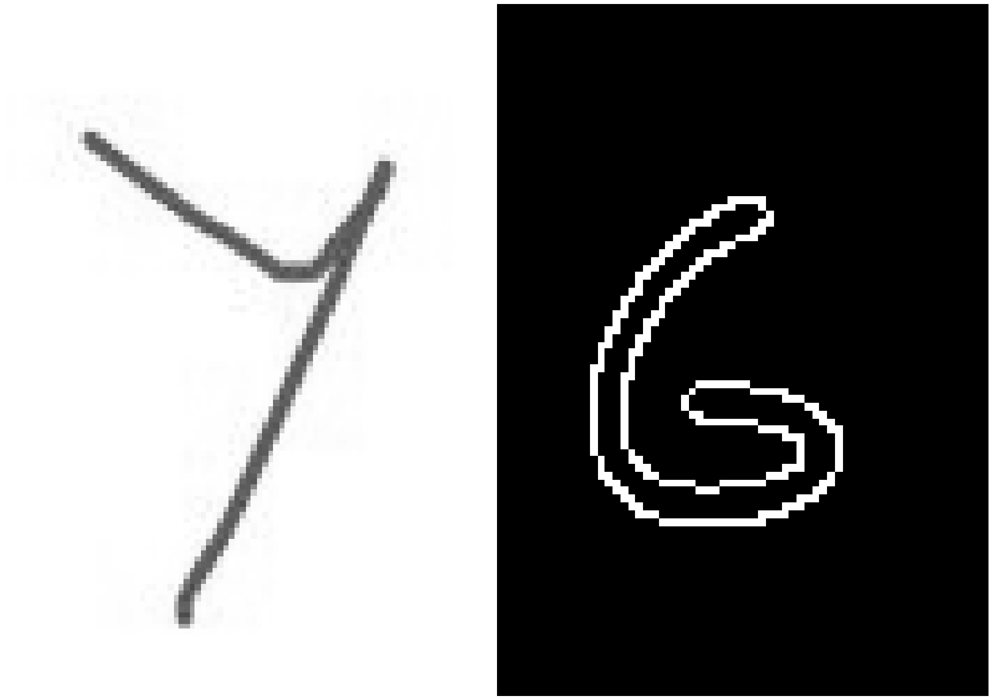
Result 23   Original Test Image is W   Predict Image is M

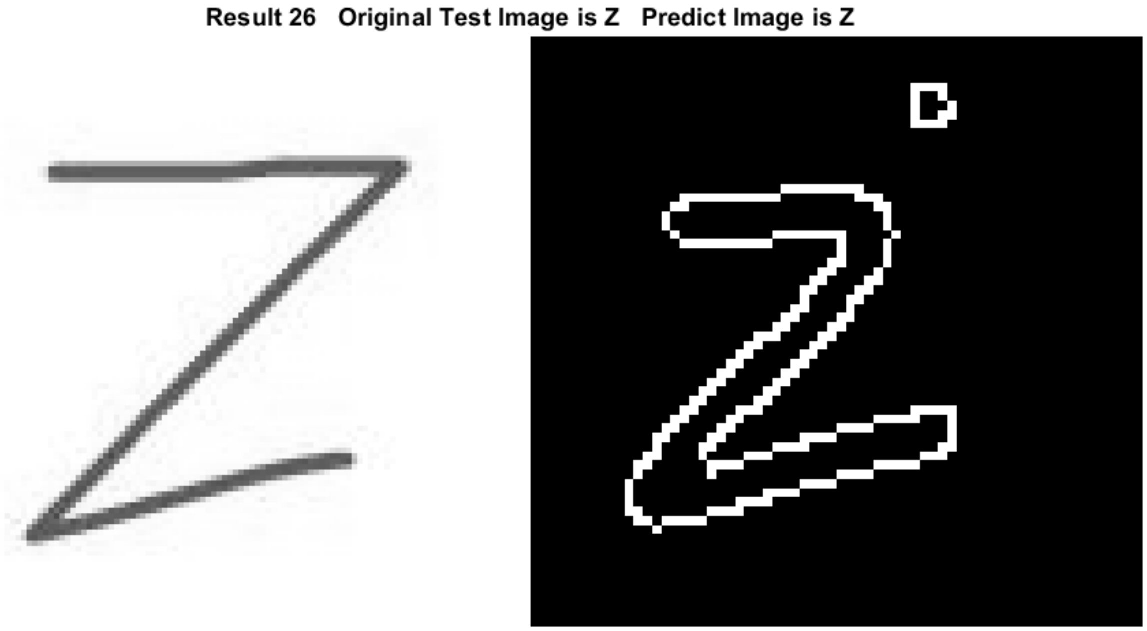


Result 24 Original Test Image is X Predict Image is Y



Result 25 Original Test Image is Y Predict Image is G





Result 26 Original Test Image is Z Predict Image is Z

Basics

```
% %% Loding images from folder
% temp = files{4}     % Files are cell array
% img = im2gray(imread(temp));
% imshow(img)
% im2 = imresize(img, [64 64]);
% imshow(im2)
% [row, col]= size(img)
```

```
% %% FT of Image
% img = reshape(digits(:, 5), 64, 64);
% figure; imshow(img)
% ftimg = fft2(img);
% ftimg_ = abs(ftimg)*255/max(max(abs(ftimg)));
% figure; imshow(fftshift(ftimg_))
```

Testing Try

```
% Predicting just on the basis of MSE of test image FT
% and the train image FT dataset
% Tidx = 330;     % Max num of col in testMat is 360- 10 for each character
% testImg = test_img_FT_Mat(:, Tidx);
% err = abs(train_img_FT_Mat - testImg);
% err = sum(err, 1)
% err'
% min(err)
% [minErr ,idx] = min(err,[],'all', 'linear');
% idx
% figure; imshow(reshape(test_imgMat(:, Tidx), 64, 64)), title("Actual Test Image")
% figure; imshow(reshape(train_imgMat(:, idx), 64, 64)), title("Predict")
```

```
% t = im2gray(imread("D:\Lakshay\M.Tech\Sem 1\EE608_Digital Image Processing\DIP Project\Test\
% figure; imshow(t)
% tsmall = imresize(t, [64 64]);
% tFil = medfilt2(tsmall);
% tedge = edge(tFil, "canny");
% % imshow(tedge)
% ftimg = reshape(fftshift(fft2(tedge)), 64*64, 1);
%
% err = abs(train_img_FT_Mat - abs(ftimg));
% err = sum(err, 1);
% % err'
% % min(err)
% [minErr ,idx] = min(err,[],'all', 'linear');
% figure; imshow(tedge), title("Input Image")
% figure; imshow(reshape(train_imgMat(:, idx), 64, 64)), title("Predict Image")
```