

Full Length Research Paper

Automatic letter sorting for Indian Postal Address Recognition System based on PIN codes

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The present work deals with the recognition of Indian postal letter sorting system based on PIN code. The optical camera catches the front and back view of each postal letter at a time. The vision system ensures from address and to address along with postal department stamp, seal etc., In this paper, an attempt has been made to recognize PIN codes by using Connected Component (CC) approach, Artificial Neural Networks (ANN) and Barcode approaches. The six nearest neighbour CCs technique instead of 4 or 8 CCs has been adopted to recognize handwritten numerals. The ANN classifier technique has been used to recognize the numerals in the PIN code. In this paper, the development of exact barcode to each PIN code is introduced for sorting the postal letters automatically. The letters travel up to barcode scanner, if the PIN code is written on the envelope, equivalent barcodes are developed and printed on the each of the postal letters in the bottom line by the barcode printer, if PIN codes are not written on the envelope, by comparing a lookup table of place and PIN code, equivalent barcode to PIN code will be printed on the bottom of the postal letter. Then the automatic letter sorting system is employed to sort the letters using the barcodes. The conveyor belt which is having gates at each check points works on the basis of on/off condition, enables the letter to travel up to exact location of the destination box. A comparative study has been made for the above approaches and the results are displayed. The experiments were performed on automatic postal letter sorting machine which is situated near to Meenambakkam Airport, Chennai. The experimental results reveal that barcode approach yields 99.5% of accuracy.

Key words: Pre-processing, classification, smoothing, neighboring pixels, barcode, PIN code.

INTRODUCTION

Visual pattern recognition has long been an interesting problem. Several systems are available for postal automation in USA, UK, France, Canada and Australia. But, very less work has been done towards the automation of Indian postal system. One of the important tasks in postal automation is to locate destination address block (DAB) and to extract the PIN code from the address part. There are several difficulties in locating DAB on the envelope, because, an envelope is composed of not only DAB, but also several other meaningful blocks such as return address block, postage

stamp block, graphics etc. Moreover, there exist wide variation due to several kinds of writing instruments, writing habits, the document surface feature and format of the different postal documents. In some Indian postal documents there are PIN-code boxes e.g. post-card, inland letters etc. Also, there exist Indian postal documents without printed PIN code box.

The hand written PIN code recognition in Indian postal letters has a long history and the eminent peoples like; B. B. Chowdary, S. N. Srihari and U. Pal have proposed different models. These methods find local properties of arcs, lines, starting or end points etc. The applications of the system are document processing, banking systems, OCR etc. Depending on the writer's environment, pen, paper quality, the writing style differs (Chaudhuri and Pal, 1998). At present, an operator reads the place of address by human vision system and the letters are sorted. This method is very slow. In this paper, an automatic mail

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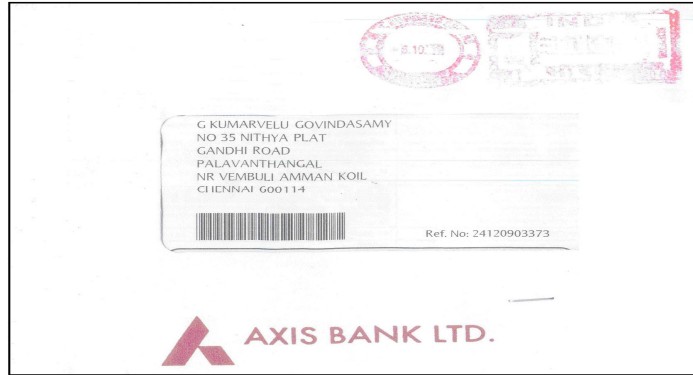


Figure 1. Ginal image.



Figure 2. Rotated image 45°.

sorting system for recognizing PIN code based on barcode is proposed and the results are compared with existing system like CC and ANN approaches.

PRE-PROCESSING OF ADDRESS IMAGE

The pre-processing stage in document understanding primarily involves the following steps: (1) Converting Colour image to gray value, (2) Filtering, (3) Binarization, (4) Thinning, (5) Skew correction, (6) Slant removal and (7) Removal of underline etc., (Chaudhuri and Pal, 1997).

The steps in PIN code recognition are:

1. Collect the original image.
2. Zoom the address to bigger size.
3. Crop the sub-image of the destination address.
4. Enhance the sub-image by applying proper threshold, to get binary value of the sub-image.
5. Apply thinning algorithm.
6. Correct Skewing of individual line segments.
7. Correct the Slant of the sub-image.
8. Extraction of baseline and upper reference line.
9. Find the corners of the image.

10. Scan components left to right.
11. Apply CC labelling.
12. Segment each digit as an object in a PIN code.
13. Correct the digit, if it is having broken pixels.
14. Have different style of each digit in database.
15. Reject the digit, if it is not in the database.
16. Submit the rejected digit to the digit splitter/classifier.
17. Reject any PIN code that yields one or more rejected objects.
18. Develop, histogram of zero-crossings and pixel counts.

The Pre-Processing is done by the following MATLAB 7.0 code, after running, one of the input for a sample postal letter is considered in Figure1 and its rotated output image of 45° is shown in Figure 2.

```
% Pre-processing of an image
clc; clear all; close all;
%Reading the image
img = imread ('c1.bmp'); figure; imshow (img);
%To convert into gray value
imgGray = rgb2gray(img);
Figure; imshow(imgGray);
```

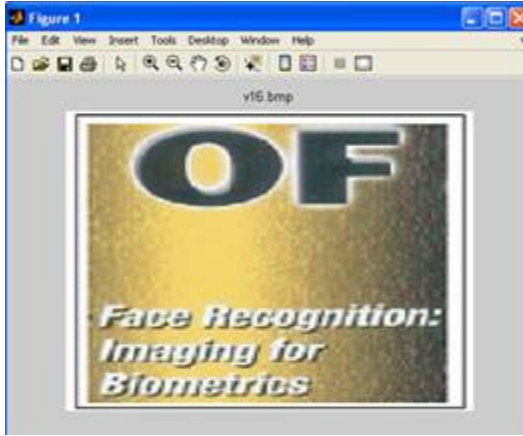


Figure 3. Original image.

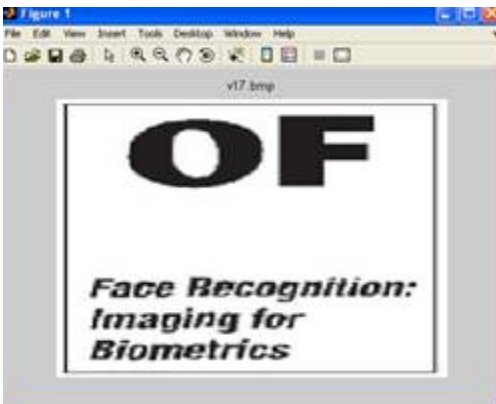


Figure 4. Background removed.

```
% Manual CropPING of an image
imgCrop = imcrop(imgGray);
Figure; imshow(imgCrop);
% Resizing of an image
imgLGE = imresize(imgCrop, 5, 'bicubic');
Figure; imshow(imgLGE);
% Rotation of the image
imgRTE = imrotate(imgLGE, 35);
Figure; imshow(imgRTE);
% Binary Image
imgBW = im2bw(imgLGE, 0.90455);
Figure; imshow(imgBW);
```

Foreground detection

Separating the foreground from the background image is one of the important problems in document understanding. To overcome this difficulty, run an edge detection algorithm on the image and use the properties

of the edges to determine whether a pixel is part of foreground or background. This is necessary for postal recognition. The MATLAB 7.0 code that segments the image as shown in Figure 3 and its background is removed using the threshold approach is shown in Figure 4.

```
% MATLAB code for separating foreground from
background
Clc; Close all; A=imread('t2.jpg');
%Conversion of RGB to Ycbr
B=rgb2ycbcr (a);
%Threshold to cb component;
Mask=b (:, :, 2) > 120;
Imshow (a), title ('image');
imshow (mask), title ('Segmented image');
```

Image interpolation

Painting is an artistic way of representing an image. If any scrap occurs in the image, the scrap of an image can be corrected through interpolation. The MATLAB 7.0 code is used to correct the degraded input image in Figure 5 by linear interpolation and the output image is shown below in Figure 6. Usually, partial loss of image information is very common such as:

- Occlusion caused by non-transparent objects
- Data loss in wireless transmission
- Cracks in ancient paintings due to pigment aging/weather
- Insufficient number of image acquisition sensors, etc.

The sequences of Pre-Processing steps and Segmentation approaches are shown in Figure 7.

Slant correction of PIN code

The slant transform was introduced as an orthogonal transform contain in saw-tooth waveforms or 'slant' basis vectors. The slant is estimated in equation (1) and slant angle is shown in Figure 8.

$$\theta = \tan^{-1} \left(\frac{n_1 - n_3}{n_0 + n_1 + n_3} \right) \quad (1)$$

where, n_0, n_1, n_2, n_3 are 0, 45, 90, -45°, respectively.

Centroid measuring

The algorithm for measuring centroid of an object using the boundary distances are given as follows:

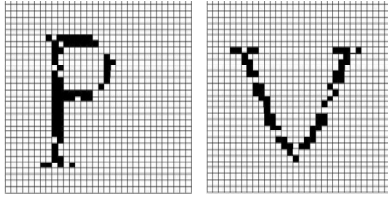


Figure 5. Degraded image.

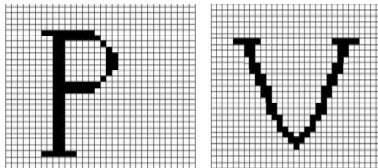


Figure 6. Interpolated image.

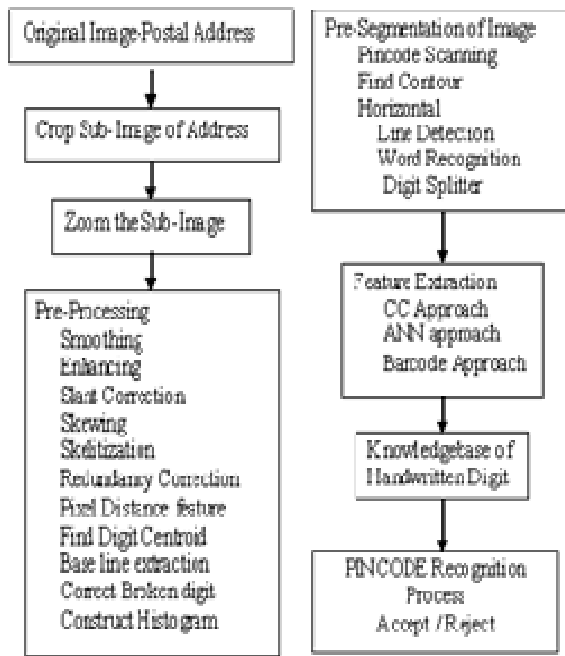


Figure 7. Sequence of pre-processing and segmentation.

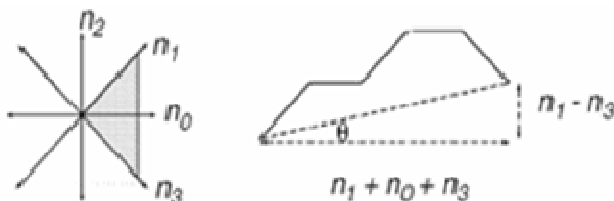


Figure 8. Average slant of chain code.

Get_distances (point cenroid)

```

Array d [1..res]
i=1;
for a=0 to 2π step (2π/incr)
inc=(cos(a), sin(a));
len=char_height;
cloc = centroid + len - inc
while (len >=0) and the image
location doc is white
len=len-1
cloc = centroid + len - inc
end
while
d[i]=len
i=i+1;
end for
return d
    
```

SEGMENTATION

This includes several segmentation procedures operating on the address image at different levels like line, word, character, etc., the segmentation processes are:

- i. Line segmentation process to extract the different line components of the address image.
- ii. Word extraction process to extract the word segments including the PIN code string.
- iii. Character and sub-character segmentation to yield character and/or sub-character segments.
- iv. Clustering algorithms to enable the assignment of different CCs to specific line fields and subsequently to specific word fields.

Contour representation

A variant of stroke width algorithm is applied to the PIN code digits, is at least three pixels wide. This ensures proper contour extraction as shown in Figure 9. Then, the image is zoomed. Later, the chain code of the image contour is derived and stored in appropriate data structure (Kim and Govindaraju, 1998).

Digit splitter in a PIN code

The digit splitter operates by attempting to separate leftmost digit and recognize from a CC (Kim and Govindaraju, 1998; Wahl et al., 1982). If successful, it attempts to recursively recognize all digits one by one. The procedure is as follows:

1. Recognize the component as a single digit. If successful, return.
2. Otherwise, generate a list of probable digits.

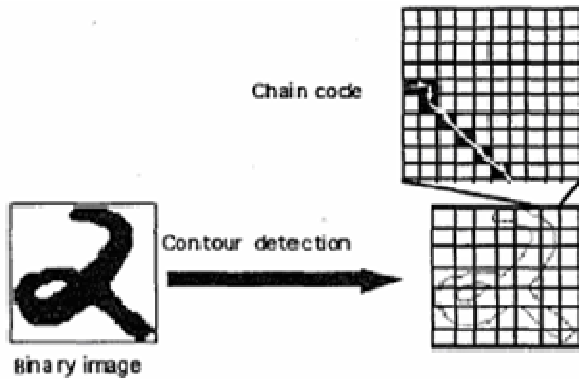


Figure 9. Feature extraction from contour chain code.

3. Attempt up to 3 probable digits until a confident recognition of the leftmost object is achieved. If not, return a rejection result.
4. If the left hand digit has been recognized, recursively process the remaining right hand component.
5. If the right hand component yields a confident recognition, concatenate it to the result for the left hand digit and return the symbol string, otherwise resume step 3.

PIN CODE RECOGNITION

The PIN code recognition is done by the following methods:

1. Six Connected Component Labelling (CCL) method
2. Artificial Neural Network (ANN) classifier;
 - a. Multi-Layer Perceptron (MLP) classifier
 - b. Multi-Level Counter Propagation Network (ML-CPN)
3. PIN code recognition by barcode

Six CC method

In this method, all CCs in an image are assigned a unique label. The points in a CC form a candidate region for an object. The CCs are found by tracing contours using the following algorithm (Otsu, 1979). Sorting of components is by the average value of contour perimeter horizontal ordinate. Recognition of punctuation marks is based entirely on 3 features of component contours are: length, cumulative straightness of segment between stroke tips and slopes of segments (Plamondon and Srihari, 2000; Park et al., 2000; Suen and Tan, 2005).

CC labelling algorithm (CCLA) to segment a binary image

Use a binary image

Scan along a row until a point p with $I(p) = 1$ is found.
 Examine the 4 neighbors (N, W, NW, NE)
 If $I(N) = I(NW) = I(NE) = I(E) = 0$, assign a new label to p
 If only one neighbor has a label, assign this label to p .
 If more neighbors have a label, assign one to p and make a note of label equivalence.
 Scan all rows.
 Determine which labels are equivalent
 Replace equivalent labels within the image.

Recursive CCLA algorithm

Scan the image to find an unlabelled unit valued pixel and assign it a new label L .
 Recursively assign a label L to all its unit valued neighbors.
 Stop, if there are no more unlabelled unit valued pixels.
 Go to step 1.

Pseudo code for CCL algorithm

```

Label(r,c);
Store(r,c,L);
If p[r][c-1] is 1 and unlabelled, Label(r,c-1);
If p[r][c+1] is 1 and unlabelled, Label(r,c+1);
If p[r-1][c] is 1 and unlabelled, Label(r-1,c);
If p[r+1][c] is 1 and unlabelled, Label(r+1,c);
K=1;
If p[r][c] =1
{
  if(p[r-1][c]=1 && p[r][c-1]=0)
  label[r][c]=label[r-1][c];
  if(p[r-1][c]=0 && p[r][c-1]=1)
  label[r][c]=label[r][c-1];
  if(p[r-1][c]=1 && p[r][c-1]=1)
  label[r][c]=label[r-1][c];
  if(p[r-1][c]=0 && p[r][c-1]=0)
  {
    label[r][c]=k;
    k=k+1;
  }
}

```

CCLA for 6-connectivity

The main goal is to find clusters of pixels that are similar and connected to each other. First, assign a value to each pixel. Define similar values, identify like pixels and unlikely pixels. First, pickup a pixel arbitrarily in the image and assign it a label. Then assign same label to any neighbor pixel with the same value of the image function, continue labelling neighbors until all the neighbors are assigned. If all the images are labeled, stop the process (Plamondon and Srihari, 2000; Park et al., 2000; Suen and Tan, 2005).

Algorithm

- (1) Scan the image from left to right and top to bottom.
- (2) If the pixel is unit valued, then
 If only one of its upper or left neighbors has a label, then copy the label.
 If both have the same label, then copy the same label.
 If both have different labels, then copy the upper pixel's label and enter the labels in an equivalence table as equivalent labels.
 Otherwise assign a new label to this pixel and enter this label in the equivalence table.
- (3) If there are more pixels to consider, then go to step 2.
- (4) Find the lowest label for each equivalent set in the equivalence table.
- (5) Scan the picture. Replace each label by the lowest label in its equivalent set.

Six CC possible solution

Use 4-neighborhood for object and 8-neighborhood for background, which requires a-priori knowledge about which pixels are object and which are background. Using a six-connected neighborhood, numerals are classified. Based on the six-connected neighborhood in the Figure 10, by using CCs of image labelling is done as shown in the Figure 11 for this image labelling code is developed as shown in Figure 12.

After thresholding an image, identify the following in the image, based on the regions. Also, find:

- How many like and dislike binary objects are in the image,
- Where are the distinct "binary object" components,
- "Cleaning up" a binary image,
- Recognize binary objects through their response to image masks,
- Describe the shape or structure of two dimensional binary objects.

Region growing

The image CC labelling aims to identify set of pixels which could be interpreted as an object of the observed scene. An image algorithmic representation can be a graph; therefore, its CCs will define image objects.

Region growing algorithm

```
BEGIN
WHILE (an initial not merged region exists) DO
  Chose an initial region R (to be growing) ;
  WHILE (in wave neighborhood of the R initial regions exist) DO
```

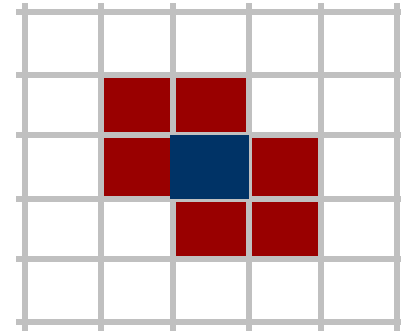


Figure 10. An image and its CC image.

C	C	C	C	C
C	B	B	C	C
C	B	A	B	C
C	C	B	B	C
C	C	C	C	C

Figure 11. CCs Labelling.

3	3	3	3	3
3	2	2	3	3
3	2	1	2	3
3	3	3	2	3
3	3	3	3	3

Figure 12. Image labelling.

```
WHILE (initial region Rc candidate for region fusion exists) DO
  IF (Homogeneity criterion true) THEN fuse R and Rc;
  ENDIF
ENDWHILE
Update region R parameters;
ENDWHILE;
DOWHILE ;
END.
```

Image objects can have different gray-level values. Therefore, before CCs calculation, a multi-thresholding can be performed. An image multi-thresholding consists of histogram 256 gray-level image, pixels grouping into N level CC labelling gives to all pixels of the same component, same label. This operation is usually applied to a binarized image. A sequential calculation principle uses two concepts for moving objects, since the postal letters move fastly on a conveyer belt, one has to consider the scanning of address from pixel (0, 0) to pixel (255,255) in row major order.

The first mandatory scanning will give temporal labels to all pixels and detect their equivalence; the second,

optional, scanning is used for final label updates; this latter step can be useful for CC display and data ranking.

Ranking algorithm

```

BEGIN
WHILE (region R for dilation exists) DO
WHILE [(isolated pixels exist) & (dilation number < region
minimal size)] DO
Dilate the R region;
FOR all dilated pixels DO
Compare pixel and region luminosity;
IF (comparison satisfied) THEN pixel - region;
ELSE the pixel is not isolated any longer;
ENDIF
ENDFOR
ENDWHILE
ENDWHILE
FIN

```

During the processing multi-threshold image $I(i,j)$ and the labels $l(i,j)$ ($0 < i, j \leq 255$) are scanned in parallel. Pixel functional neighborhood definition black central square represents current pixel, four white squares represents "future" pixel, and four others are "past" pixel as shown in Figure 13. The region growing is shown in Figure 14.

ANN Classifier

The standard back propagation ANN is used. A three layered ANN with an input layer of 64 neurons, a hidden layer consisting of 100 neurons and an output layer consisting of 52 neurons was used for the feature vector of size 64. The BPN rule was used for learning.

MLP Classifiers

Two Multi Layer Perceptron (MLP) classifiers have been used for word recognition. The two MLPs uses a holistic approach. MLP algorithm is a combination of two networks using different features. Input feature set 1 consists of mesh features, chain features, crossing features and distance features, while input feature set 2 consists of gradient features. MLP-A is implemented by combining the two networks at architectural level, which uses the outputs of the neurons in two hidden layers as new input features (Cheng-Lin, 2004). The PIN code values are digitized as '0' or '1' and it is fed as input to the MLP Classifier as shown in Figure 15.

MLP-B is a combination of three MLPs using different sets of input features. Feature set 1 consists of pixel distance features (PDF), while feature sets 2 and 3 consist of size-normalized image pixels from different image pre-processing. The combination scheme is a "hybrid" strategy which combines the output values of

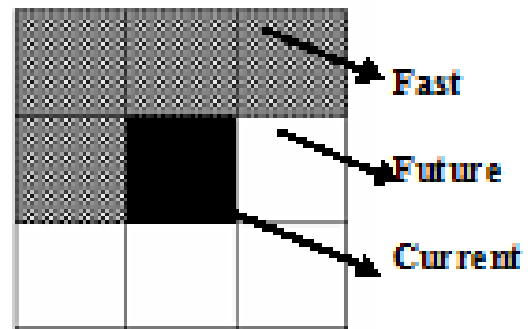


Figure 13. Status of a pixel.

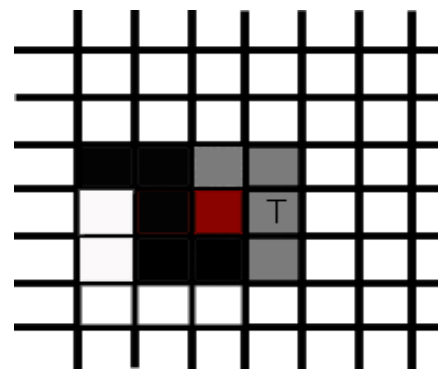


Figure 14. Region growing.

the MLPs (Suen and Tan, 2005; Wahl et al., 1982).

PIN code recognition by ML-CPN

This ML-CPN has interconnections among the units in the cluster layer. In ML-CPN, after competition, only one unit in that layer will be active and sends a signal to the output layer. The ML-CPN has only one input layer and one output layer, but the training is performed in two phases. This net may be used if the mapping from x to y is well defined. It uses only x -vectors to form the clusters on the Kohonen units during the first stage of training.

A ML-CPN can be used in interpolation mode. Here, more than one Kohonen units have non-zero activation. By using interpolation mode, the accuracy is increased and computing time is reduced. Its advantages are simple and it produces correct output even for inaccurate input. The ML-CPN trains rapidly. The source code is implemented in MATLAB 7.0 as shown in the following algorithm:

ML-CPN Algorithm

Step 1: Read the Image

Step 2: Crop the sub-image of address

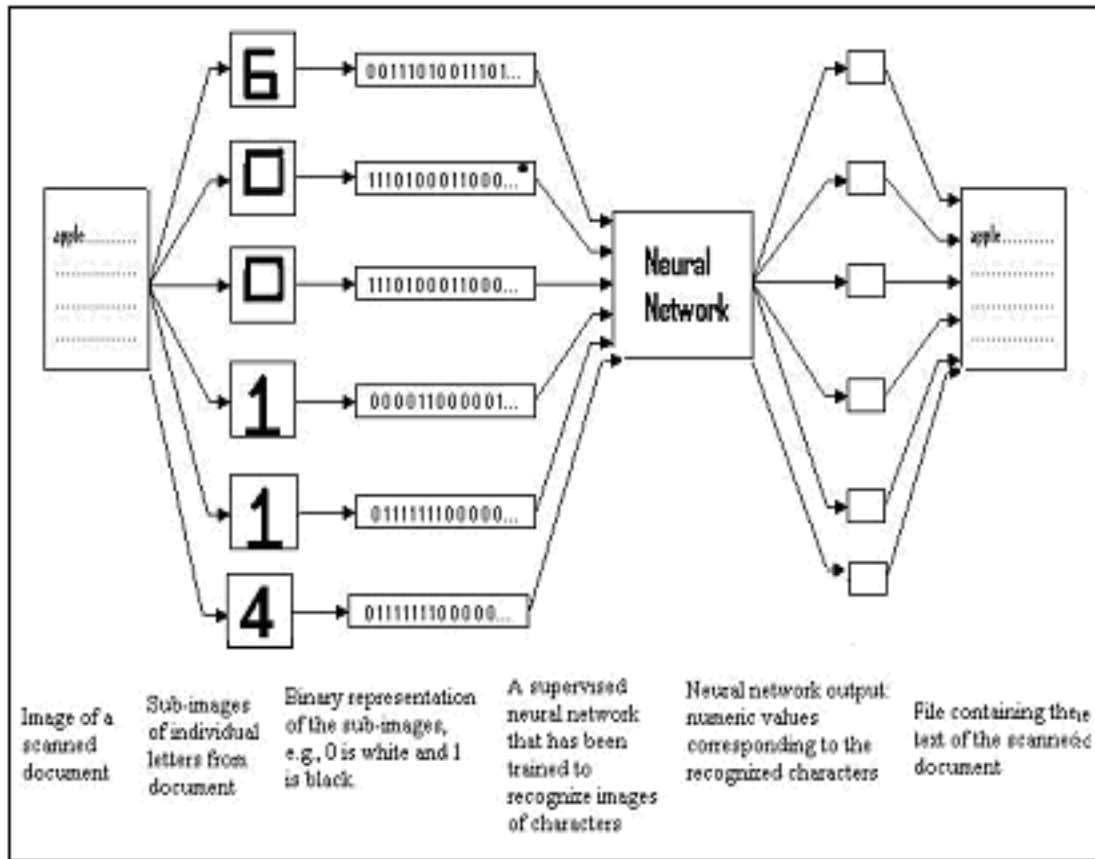


Figure 15. ANN PIN code recognition.

- Step 3: Convert it into Gray Scale value
- Step 4: Convert into Binary value
- Step 5: Detect the Edge
- Step 6: Morphology operation of Image Dilation
- Step 7: Image filling
- Step 8: Creating Vectors for the Objects
- Step 9: Train by ML-CPN
- Step 10: Testing
- Step 11: Perform Blobs Analysis
- Step 12: Plot the Objects

The cropped address image of Figure 16 is shown in Figure 17 and the recognized address image is shown in Figure 18. A different view of automatic letter sorting office is shown in Figure 20.

PIN code recognition by bar code

The barcode is transmitted through RS232 cable to the automatic postal letter sorting machine. The use of barcode enables one to realize high speed feature extraction.

In this paper, the development of exact barcode to

each PIN code is introduced for sorting the postal letters automatically. For each PIN code, equivalent barcodes are developed and printed on the each of the postal letters in the bottom line by barcode printer. Then the letters travel up to barcode scanner, if PIN codes are not written on the envelope, by comparing place in the lookup table the relevant PIN code is found and equivalent barcode will be printed on the bottom of the postal letter. By the PIN codes relevant places are retrieved from the databases, which is stored already. The conveyor belt which is having gates at each check points works on the basis of on/off condition, enables the letter to travel up to exact location of the destination box. The present mail system works as follows: the letters are traveling through a conveyor belt. In the following equivalent barcode is shown below in Figure 19 for the PIN Code 600005 and 600015, which represents Mylapore and Saidapet in Chennai, respectively.

Conclusion

The present paper deals with the recognition of PIN code by using CCLA, ANN and barcode approach. The six

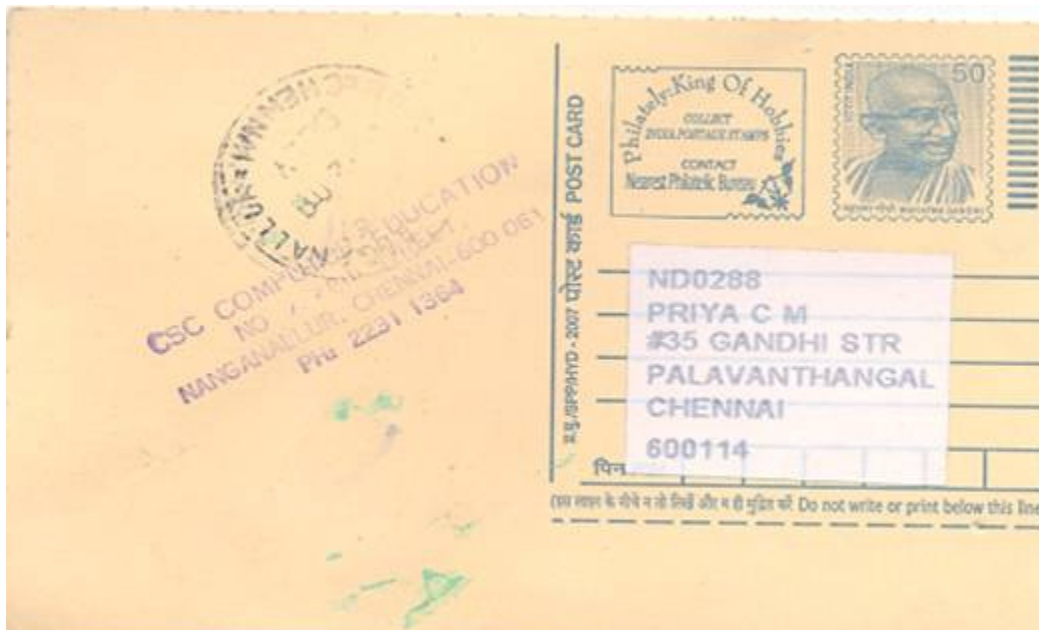


Figure 16. A sample envelope.

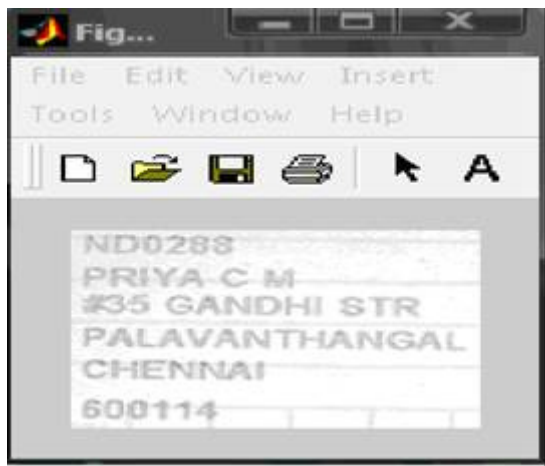


Figure 17. Cropped image.

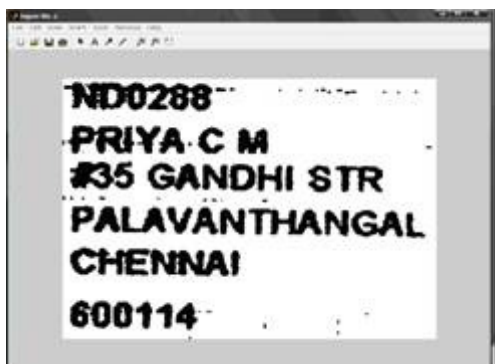


Figure 18. Recognized address.



Mylapore - 600005 Saidapet - 600015

Figure 19. Barcode value for PIN code.

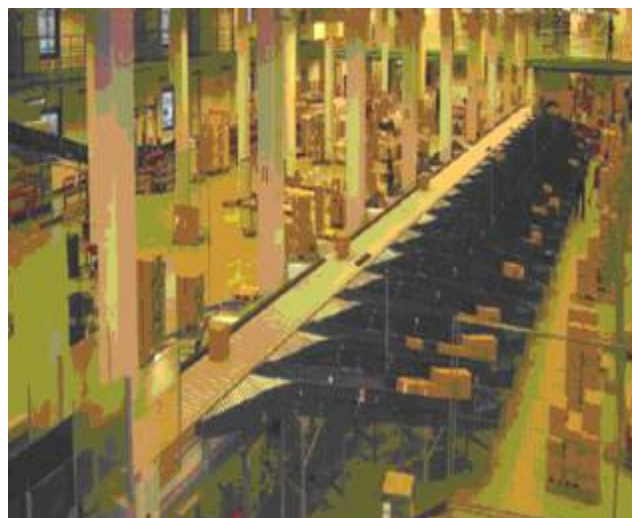


Figure 20. Letter sorting office.

nearest neighbour CC technique has been adopted to recognize handwritten numerals and yields 95% of accuracy. The ANN classifier technique has been applied

to recognize the digits in the PIN code, which produces 97% of the result. Also, barcode is found equivalent to the PIN code, based on this the postal letters are sorted. The experimental results reveal that barcode approach yields fast and accurate result with good precision of 99.5%. Further training was done on automatic mail sorting machine with 6000 samples. Among which 5970 samples were classified accurately and 30 samples could not be recognized well. The test set, however, contains a significant number of imperfectly segmented characters as well as some garbage images, thus making it a good test set for recognition.

RECOMMENDATION

This paper can be implemented to all the nationalized 18 Indian languages. Moreover, each state capital can be installed with an automatic mail sorting machine, so as to improve the postal department's efficiency.

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