

## Automatic Letter Sorting for Indian Postal Address Recognition System based on PIN Codes

<sup>1</sup>C.M.Velu, <sup>2</sup>Dr. P.Vivekanandan

<sup>1</sup>Research Scholar, Department of Mathematics, Anna University, Chennai – 602 103, India. (cmvelu41@gmail.com)

<sup>2</sup>Professor and Director, Knowledge Data Centre, Anna University, Chennai – 600 025, India.(vivek@annauniv.edu)

### **Abstract:**

*The present work deals with the recognition of Indian Postal Letter sorting system based on PIN Code. 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) approach 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 proposed for sorting the postal letters automatically. If the PIN code is written on the envelope, equivalent barcodes are developed and printed on 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. 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 Meenambakkam Airport, Chennai, India. The experimental results reveal that the proposed barcode approach yields 99.5% of accuracy.*

**Keywords:** Pre-processing, Classification, Smoothing, Neighboring pixels, Barcode, PIN code.

### **1. Introduction**

Visual Pattern Recognition is 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 exists wide variation due to several kinds of writing instruments, writing habits, the document surface feature and format of the different postal documents. In the Indian postal department, PIN code boxes are also available in some of the postal documents like Post-Card, Inland letters to write PIN codes within the boxes.

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, Optical Character Recognition (OCR) etc. Depending on the writer's environment, pen, paper quality, the writing style differs [1]. 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 sorting system for recognizing PIN code based on barcode is proposed and the results are compared with existing system like CC approach and ANN approaches.

In Section 2, Pre-processing of address image is done. Section 3, presents postal address segmentation. Section 4, discusses PIN code recognition. Conclusion and results are drawn in section 5.

## 2. 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., [2]. 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 inputs for a sample postal letter is considered in Fig. 1 and its rotated output image of  $45^\circ$  is shown in Fig.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);
% 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);
```



Fig. 1. Original image



Fig. 2 Rotated image 45°

## 2.1 Foreground Detection

One of the important problems in document understanding is separating the foreground from the background image. To overcome this difficulty, an edge detection algorithm is run on the image and uses 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 for segmentation of the image is shown in Fig. 3 and its background is removed using the threshold approach and it is shown in Fig. 4.

```
% MATLAB code for separating foreground from background  
Clc; Close all; Clear 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');
```

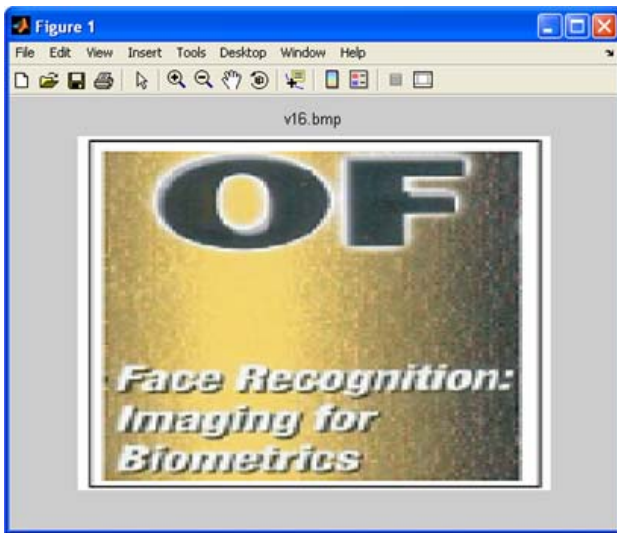


Fig. 3 Original image

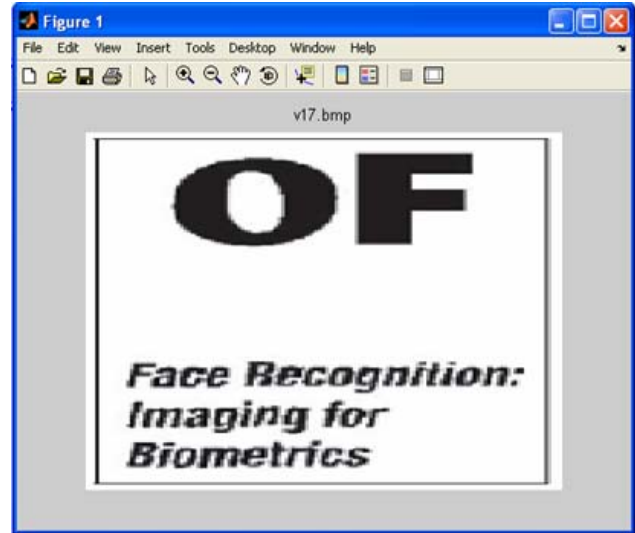


Fig. 4 Background removed

## 2.2 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 Fig. 5 by linear interpolation and the output image is shown below in Fig. 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.

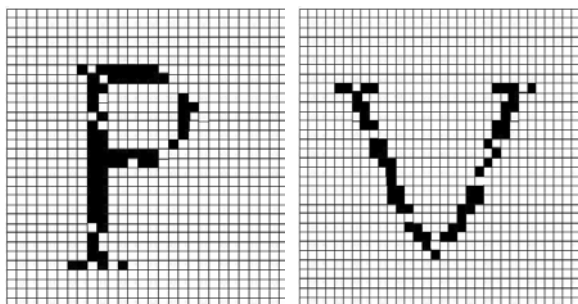


Fig. 5 Degraded image

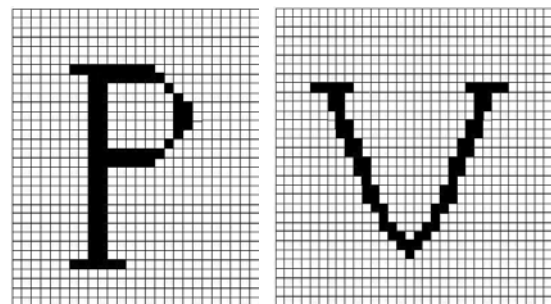


Fig. 6 Interpolated image

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

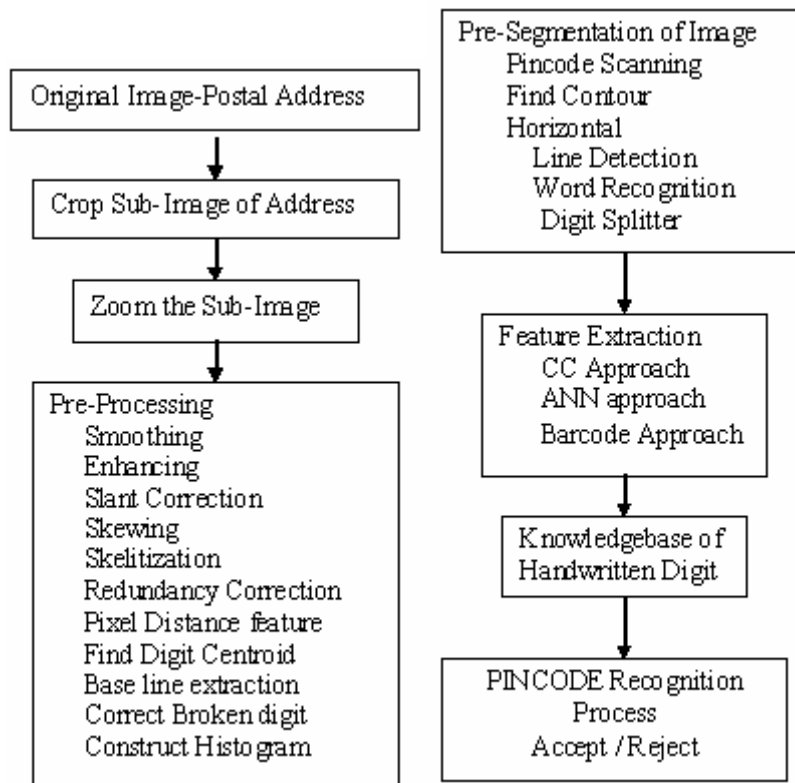


Fig. 7 Pre-Processing and Segmentation.

### 2.3. 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 angle is estimated from equation (1) and slant angle is shown in Fig. 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  $0^\circ, 45^\circ, 90^\circ, -45^\circ$  degrees respectively.

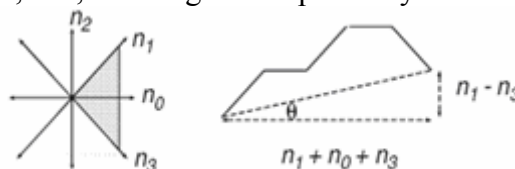


Fig. 8 Average Slant of chain code

### 2.4. Centroid Measuring

The algorithm for measuring centroid of an object using the boundary distances are shown below.

#### 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
endwhile
d[i]=len
i=i+1;
end for
return d

```

### 3. Segmentation

This includes several segmentation procedures operating on the address image at different levels like line, word, character, etc., The segmentation processes [12] 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.

#### 3.1 Contour representation

A variant of stroke width algorithm is applied to the PIN code digits, and the digit is at least three pixels wide. This ensures proper contour extraction as shown in fig. 9. Then, the image is zoomed. Later, the chain code of the image contour is derived and stored in appropriate data structure [5].

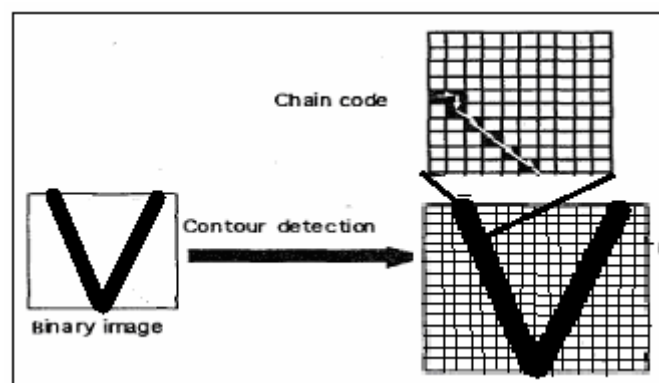


Fig. 9. Feature extraction from contour chain code.

#### 3.2 Digit Splitter in a PIN Code

The digit splitter operates by attempting to separate leftmost digit and recognize from a CC. If it is successful, it attempts to recursively recognize all digits one by one [5,10]. The procedure is as follows:

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

## 4 PIN CODE RECOGNITION

The PIN code recognition is done by the following three 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

### 4.1. Six CC Method

In this method, all CCs in an image are assigned a unique label. The points in a CC form are a candidate region for an object. The CCs are found by tracing contours using the following algorithm for six connectivity. Generally, 4-neighborhood connectivity are used for object identification and 8-neighborhood connectivity is used for background recognition. Both the 4-neighborhood connectivity and 8-neighborhood connectivity requires a-priori knowledge about which pixels are object pixels and which pixels are background pixels [6, 7]. Using a six-connected neighborhood, numerals are classified. Based on the six-connected neighborhood in the fig. 10, by using CCs of an image labelling is done as shown in the fig. 11. Labelling is developed for the image of figure 10 and it is shown in fig. 11 and figure 12 in different forms.

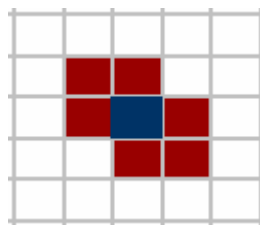


Fig. 10. An image and its CC image

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

Fig. 11 CCs Labelling

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

Fig. 12 Image labelling

After thresholding a gray image, binary image, is converted. Based on the regions in the image identify the following:

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

#### 4.1.1. CCLA for Six 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 labelled, stop the process [7,8,9].

### Algorithm for Six Connectivity

1. Scan the image from left to right and top to bottom.
2. If the pixel is unit valued, then
  - a. If only one of its upper or left neighbors has a label, then copy the label.
  - b. If both have the same label, then copy the same label.
  - c. If both have different labels, then copy the upper pixel's label and enter the labels in an equivalence table as equivalent labels.
  - d. 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.

### Recursive CCLA Algorithm

1. Scan the image to find an unlabelled unit valued pixel and assign it a new label L.
2. Recursively assign a label L to all its unit valued neighbors.
3. Stop, if there are no more unlabelled unit valued pixels.
4. 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;
    }
}
}
    
```

#### 4.1.2. 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. Image objects can have different gray-level values. This should be converted into binary values for better recognition of address [4]. The postal letter is a moving object which moves 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.

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

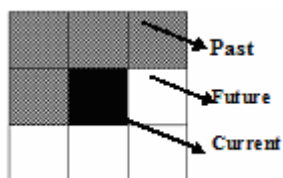


Fig. 13 Status of a Pixel.

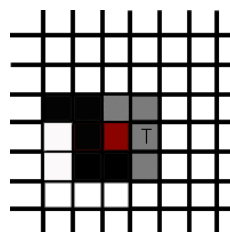


Fig. 14 Region Growing

## 4.2. 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 were used for the feature vector of size 64. The BPN rules were used for learning.

### 4.2.1. MLP Classifiers

Two Multi Layer Perceptron (MLP) classifiers have been used for word recognition. MLP algorithm is a combination of two networks namely MLP-A and MLP-B using different features. Input feature set 1 consists of 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[4]. The PIN code values are digitized as '0' or '1' and it is fed as input to the MLP Classifier as shown in Fig. 15.

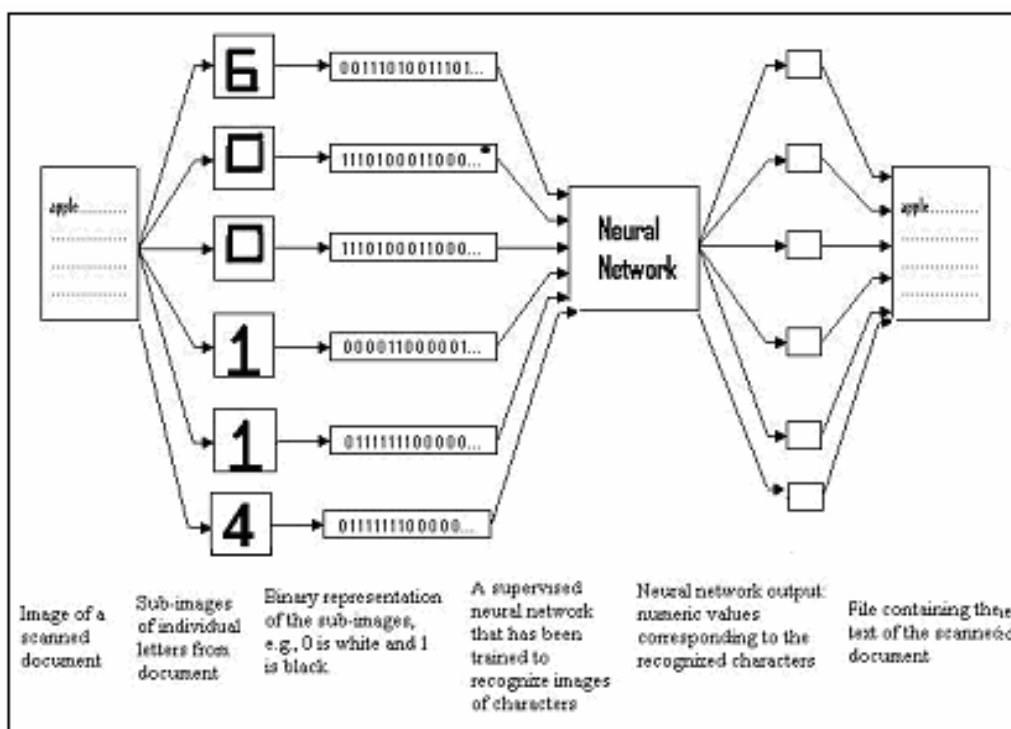


Fig. 15 ANN PIN code recognition

MLP-B is a combination of three MLPs using different sets of input features. Feature set 1 consists of pixel distance features, while feature sets 2 and 3 consist of size-normalized image pixels. First, pre-processing is done and fed to MLP-B. The combination scheme is a “hybrid” strategy which combines the output values of the MLPs[9,10].

#### 4.2.2. 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 a 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 partially inaccurate input. The ML-CPN trains rapidly. The source code is implemented in MATLAB 7.0 as shown in the following proposed ML-CPN algorithm. A sample postal letter is shown in Fig. 16 and its cropped address image is shown in Fig. 17 and the recognized address image is shown in Fig. 18. A different view of automatic letter sorting office is shown in Fig. 20.

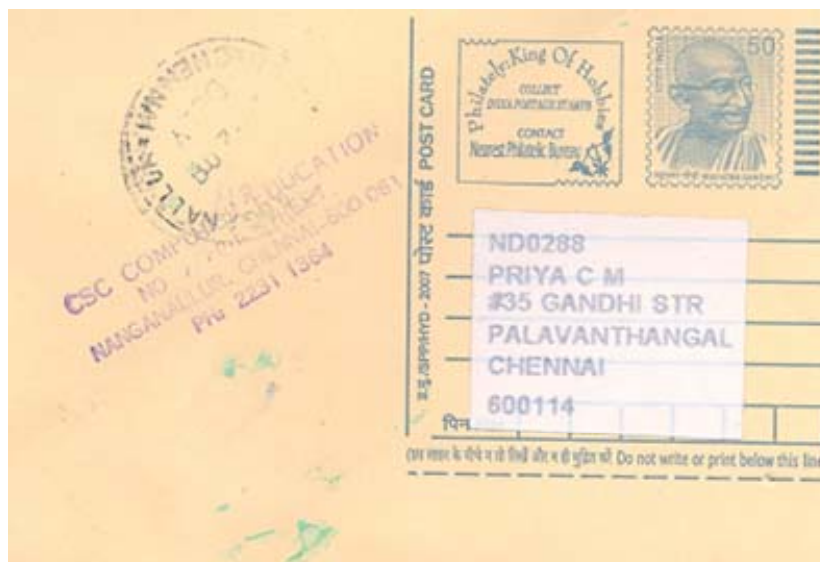


Fig. 16 A Sample envelope

#### ML-CPN Algorithm

- Step 1: Read the Image
- Step 2: Crop the sub-image of address
- 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

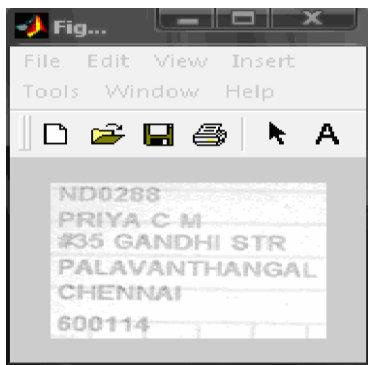


Fig. 17 Cropped image

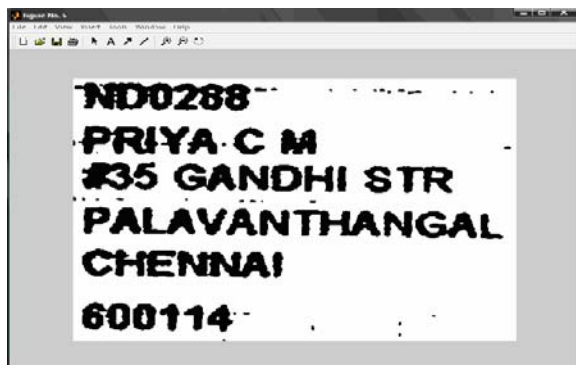


Fig. 18 Recognized address

### 4.2.3 PIN Code recognition by proposed Bar Code method

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 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 city name in the lookup table, the relevant PIN code is found and equivalent barcode will be printed on the bottom of the postal letter. For the PIN codes, relevant city names are retrieved from the databases. The conveyor belt is having gates at each check points, works on the basis of on/off condition, and enables the letter to travel up to exact location of the destination box. The present mail system works as follows: the letters are sent through a conveyor belt. As an example, the following equivalent barcodes are shown below in fig. 19 for the PIN Code 600005 and 600015, which represent Mylapore and Saidapet in Chennai, India respectively.



Fig. 19 Barcode value for PIN Code



Fig. 20. Letter sorting office

## 5. Conclusion

The present paper deals with the recognition of PIN code by using CCLA, ANN and barcode approach. The six 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, the proposed barcode approach is found equivalent to the PIN code, based on this, the postal letters are sorted. The experimental results reveal that proposed 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 recognized accurately out of 6000 samples and 30 samples could not be recognized. 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.

## 6. Future scope of the paper

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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