ICIC Express Letters
Part B: Applications
Volume **10**, Number **10**, October **2019**

ICIC International ©2019 ISSN 2185-2766
pp. **895–901**

CONSUMER SERVICE NUMBER RECOGNITION USING TEMPLATE MATCHING ALGORITHM FOR IMPROVEMENTS IN OCR BASED ENERGY CONSUMPTION BILLING

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Received May 2019; accepted August 2019

Abstract. *In recent years, the pictures captured by camera-based Smartphones and other portable devices have gained increasing attention in the field of computer vision. These pictures may provide valuable cues about the image content. It is essential for human and computer to understand the information in scenes. The text recognition from these scenes is indispensable. Optical Character Recognition (OCR) has been utilized for quick data entry in several applications. The smart metering requires additional infrastructure and consistent broad band connections for electricity consumption billing. The existing infrastructure improvement by spending more capital is a challenging task for developing countries. In this paper, we extend our work in the energy consumption billing process to make the system user friendly. We utilized OCR for quick data entry in server side of electricity billing process.*
Keywords: Energy consumption billing, OCR, Optical character recognition, Template matching algorithm, Text recognition

1. **Introduction.** Computer vision aims to reproduce the effect of human vision by understanding and electronically perceiving an image. Text recognition from camera images and videos is essential and in high demand for indexing, annotation, video retrieval and content analysis. OCR is the method of converting the text present in image to computer-readable or editable text [1]. OCR has been widely used in the data entry field, number plate recognition, making textual versions of traditional handwritten documents, etc. [2]. The recognition rate of OCR depends on the trained data or referred templates [3]. The open source OCR software is available like Tesseract which works most popular operating systems like MAC, Linux, and Windows [4]. OCR has diverse applications, and hence it remains to be an interesting research area.

The OCR system has two data acquisition methods namely on line and off line character recognition. The offline character recognition has been further classified as printed and handwritten character recognition system [5]. The handwriting nature may differ for each person. They may be in the form of spaced discrete, mixed cursive and discrete, discretely

DOI: 10.24507/icicelb.10.10.895

written run-on or pure cursive characters [6]. In this work, we implemented the printed character recognition method using template matching algorithm for electricity billing process. The template matching algorithm gives better recognition rate for non-complex background images and reduces the complexity in text recognition.

Review of existing work. The electricity utility providers install the single or three phase digital energy meters in the consumer premises to measure the electricity consumption. The meter readers visit the consumer premises in the regular interval to assess the electricity usage. The meter readers noted the consumed units in a notebook or load it as a data manually in a hand-held device and electricity usage has been computed and updated in the central server manually. It requires the huge number of labor and longer duration to complete the entire billing process. The inaccessibility of energy meters due to door locked condition may allow the electricity utility provider to generate higher tentative billing. Evidently, the efficiency of the manual mode depends upon the integrity of the meter readers and the data entry operators in server side giving rise to scope for motivational under or over billing.

Kulkarni and Kute [7] discussed about recognition of seven segment numerals on LCD display and they can be applied for the automated reading applications. The algorithm outlines a 7-step process consisting of four types of operations such as object detection, noise removal, image segmentation and numeral recognition based on pixel density feature extraction. The recognition rate of their method is 79% under illumination variation and tilted conditions.

Bahmanyar et al. [8] described the challenges in the smart metering implementation. The first challenge in the deployment of Advanced Metering Infrastructure (AMI) is from the economic perspective. The AMI design, installation, and maintenance involve many concerns and need several billion dollars investment for maintenance and deployment.

The novel scheme has been proposed in our previous work for electricity consumption billing using OCR [9]. We obtained better recognition rate as 96.69% for seven segment numeral present in the image of energy meter display [10]. In both of our work, the consumers will capture the photograph of respective meter's display panel by their own mobile phone camera. The images sent by consumer do not have consumer service number in its display and it carries only kWh information. It leads misuse of the proposed method to send the irrelevant meter reading of the consumer also the consumers those who do not have mobile camera they could not send the information to utility server. In this proposed work, we modified the display panel by pasting the consumer service number. The consumers instructed to capture the energy meter display along with consumer service number. The new method will help the consumers those who are not having mobiles with camera option. The proposed approach reduces the task of manual data entry and makes the electricity billing process reliable. In this paper, we explained the proposed approach in Section 2 by stating the general billing process and steps involved in text recognition & in Section 3 we have shown the results of the steps involved in OCR. Finally, in Section 4 some concluding remarks are given.

2. **The Proposed Approach.**

The consumer has to take a photograph and send it as an MMS to the utility server. The photograph should cover the consumer service number and the kWh information. The server will process the obtained image and retrieve the energy consumption information using text recognition and store it against the consumer service number.

The consumer service number will be recognized using the template matching algorithm based OCR. The kWh information is recognized using MSER and labeling method based OCR (MLOCR) by using our previous approach that provides better accuracy [10]. In this paper, the recognition process of consumer service number has been explained. The

consumer service number recognition with the aid of kWh information extraction process [10] helps to generate the electricity bill for all the consumers.

The consumer service number provided by the utility service provider will be patched up with energy meter display. The service number will be printed in with white background to minimize the complexity in the text recognition process. The consumer service number is prefixed with alphabet 'A'. So it can be used as a variable for storing the kWh information that is recognized using MLOCR [10]. The general block diagram of the OCR based electricity billing process of our previous work [9] has been shown in Figure 1. Figure 2 shows the steps involved in consumer service number recognition of proposed method.

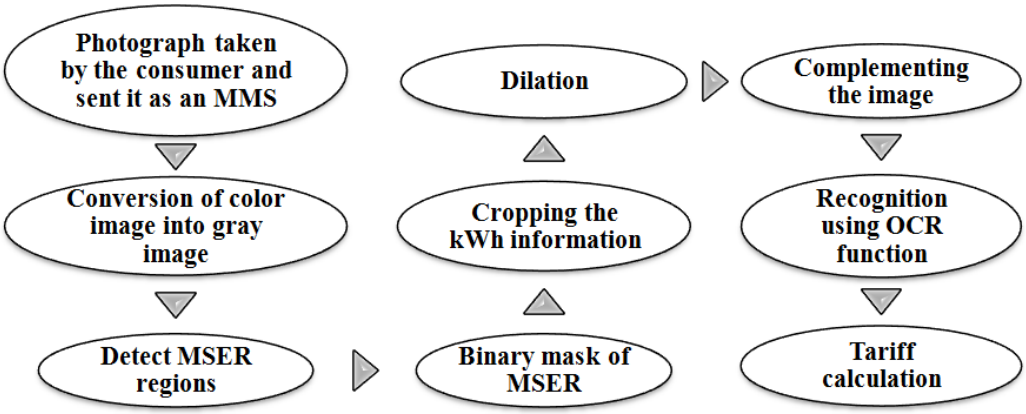


FIGURE 1. OCR based electricity billing process

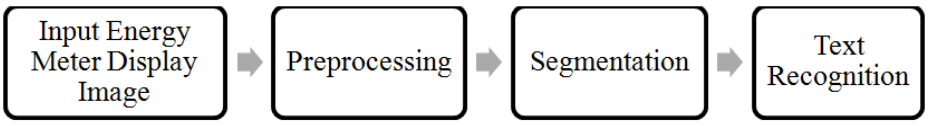


FIGURE 2. Steps involved in consumer service number recognition

The following algorithm describes the text recognition process of consumer service number from the image of energy meter display.

Algorithm: The following are the steps involved in the proposed approach.

Step 1: Load the digital image of energy meter display.

Step 2: Crop the consumer service number identification area.

Step 3: Preprocess the cropped image.

Step 4: Segment the individual characters from the digital image using CCA method.

Step 5: Recognize the text present using template matching method.

Step 6: Make the service number as variable to store the energy consumption value.

2.1. **Image acquisition.** The consumers have to use their mobile camera to capture the image of energy meter display. The photograph taken by them should cover both the consumer number and kWh information present in the meter. The mobile phone will store the photograph in JPEG format and customer has to send it to the server using MMS. The camera should have the minimum resolution of 2 MP for obtaining better recognition rate. The consumer should do this process at periodic interval as per the directions of electricity distributors.

2.2. **Pre-processing.** The preprocessing step involves cropping the consumer service number area, noise removal, grayscale conversion and binarization process which is useful for increasing the segmentation performance. Initially, the RGB image is converted into a grayscale image. The grayscale image is binarized using Otsu's method [11].

2.3. **Cropping.** The MMS image consists of kWh information and customer service number. The first step is to crop the consumer service number and then apply template matching algorithm based OCR for extracting the text from the cropped image. The second step is to crop the area of kWh information available with MMS image and it is extracted using MLOCR method [10]. The MATLAB function 'imcrop (ImgName)' has been used to perform this operation. The cropping operation is performed interactively using the mouse.

2.4. **Grayscale conversion.** The syntax 'I=rgb2gray (colorImageName)' has been used to convert the true color RGB image into the grayscale image 'I'. The 'rgb2gray' is the inbuilt function that converts RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance.

2.5. **Binarization.** The Otsu's method is one of the widely used methods to convert the gray-level image into a binary image.

The Otsu's method [11] searches for the threshold that minimizes the intra-class variance, defined in Equation (1) as a weighted sum of variances of the two classes.

$$\sigma_\omega^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t) \tag{1}$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and $2\sigma_1^2$ is the variance of these classes. Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance, Equation (2).

$$\sigma_b^2(t) = \sigma^2 - \sigma_\omega^2(t) = \omega_1(t)\omega_2(t)\left[\mu_1(t) - \mu_2(t)\right]^2 \tag{2}$$

The Otsu's algorithm steps are:

- Compute the histogram and probabilities of each intensity level
- Initialize $\omega_i(0)$ and $\mu_i(0)$
- Step through all threshold values $t = 1, \ldots$ to maximum intensity.
  - Update $\omega_i(0)$ and $\mu_i(0)$
  - Compute the maximum $\sigma_b^2(t)$ which corresponds to the desired threshold.

2.6. **Segmentation.** The top-down methods recursively segment large regions in a document into smaller sub-regions. The segmentation stops when some measure is met, and the ranges obtained at that stage frame the final segmentation results. The hybrid method is the strategy that combines both top-down and bottom-up strategies. The Run-Length Smearing Algorithm (RLSA) is one of the most widely used top-down algorithms. It is used on binary images (setting 1 for white pixels and 0 for black pixels), by linking together the neighboring black pixels that are within a certain threshold [12].

In the proposed method, the segmentation process, the particular areas which do not contain connected black pixels having the vertical length less than a preset value are replaced by white pixels so that only the digits are left together in a single image form. This image is then segregated into individual images by detecting an area in which all the black pixels are connected.

2.7. **Text recognition.** The pattern recognition techniques have feature based [13], template matching [14], statistical/structural [15], neural network based [16] and fuzzy-based model [17] for recognizing the object [18] and algorithms used in face recognition are also helpful for effective human-computer interaction [19].

The consumer number identification process uses the template matching based technique for character recognition because of the lesser number of characters requirement. It is adequate to recognize the alphabet A, and numerals 0 to 9. The local templates have been created for the above-said characters with the image size of 42×24 pixels in bitmap image file (.bmp) format, and the same has been matched with segmented characters.

The recognized word contains the service number (prefixed with alphabet 'A') of the consumer, and the same can be utilized as a variable for storing the kWh information that has been extracted from MLOCR method. The flowchart of template matching algorithm is shown in Figure 3. Figure 4 shows the reference templates used in the text recognition process.

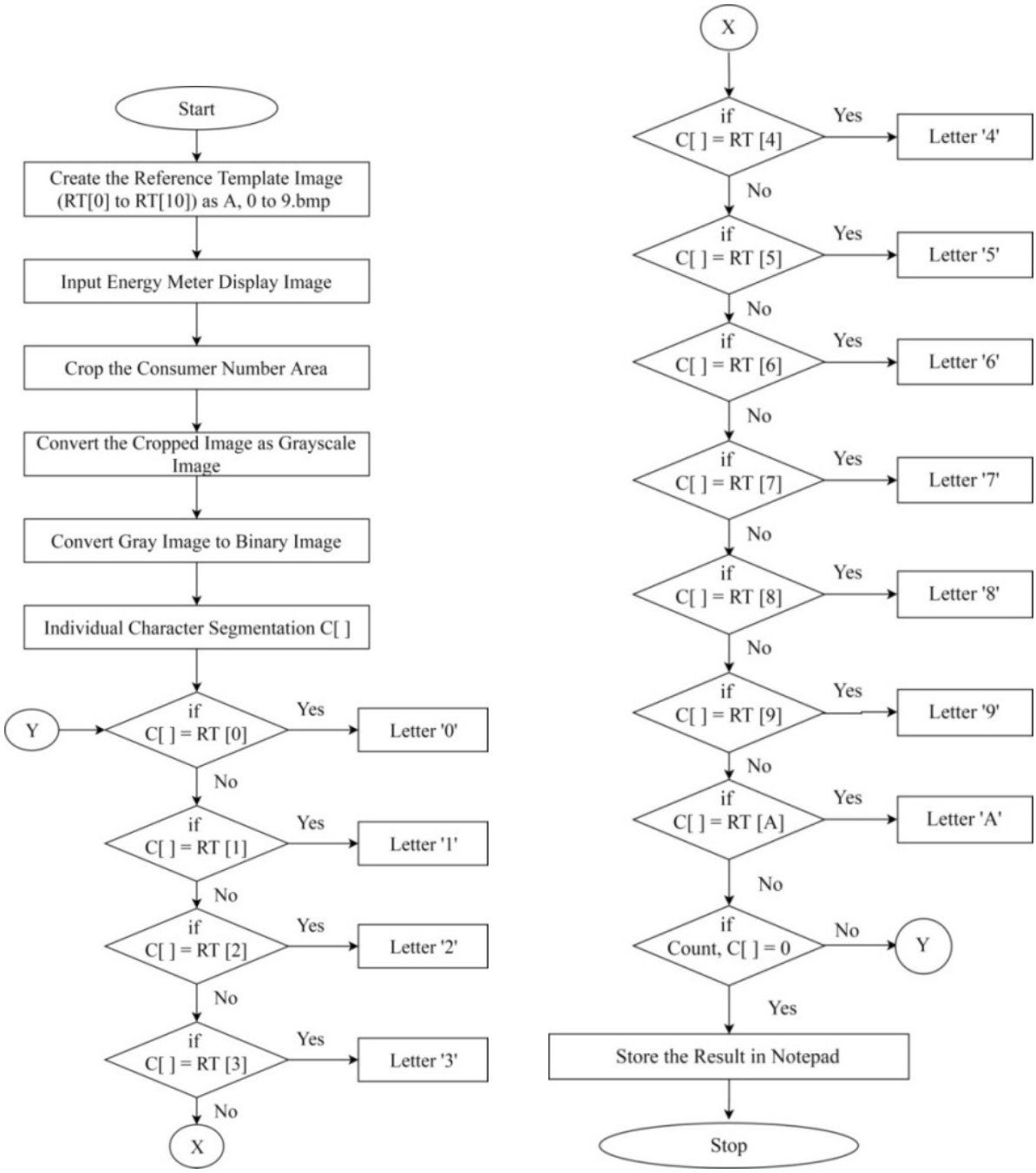


FIGURE 3. Flowchart of template matching algorithm

The preprocessed and segmented character will pass through step by step to check the correlation as shown in flowchart. The final result will be stored in notepad file.

3. **Results and Discussion.** Figure 5(a) shows the energy meter display with consumer service number. The consumer should send the image as MMS to the utility server. The printed number that is pasted on the energy meter display is the consumer service number. Initially, the printed consumer number will be cropped as shown in Figure 5(b).

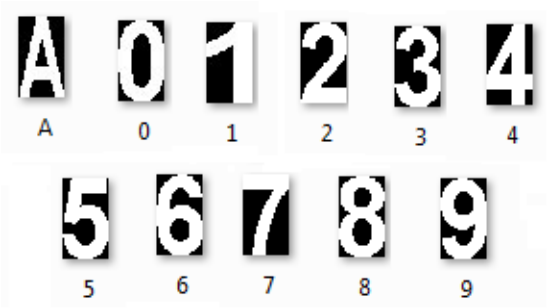
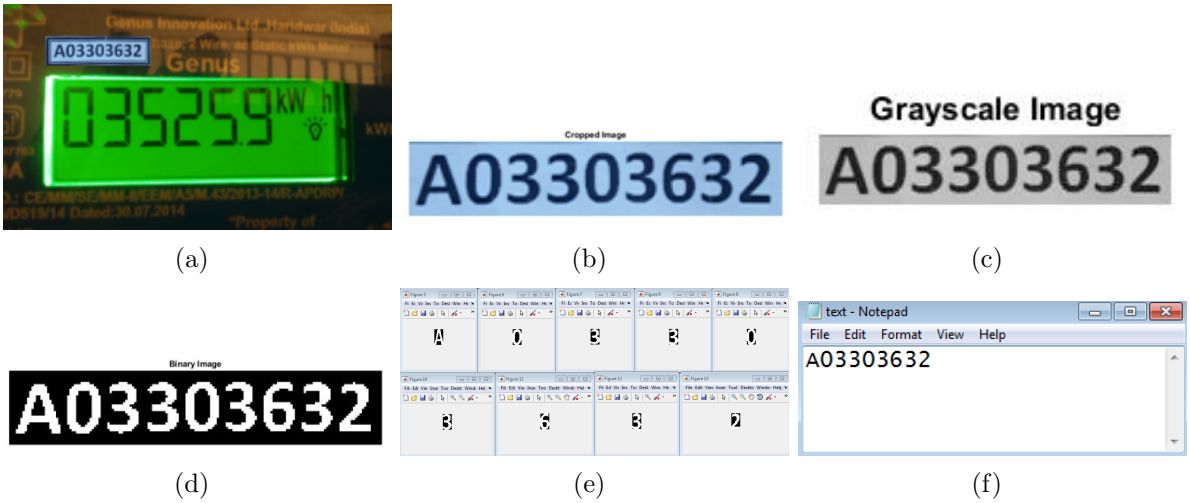


FIGURE 4. Reference templates for text recognition



(a) (b) (c)

(d) (e) (f)

FIGURE 5. (a) Energy meter display with consumer service number, (b) cropped image, (c) grayscale image, (d) binary image, (e) segmented characters, and (f) recognized output

The cropped image is converted as grayscale image as that distinct from 1 bit bi-tonal black and white images. The grayscale image has been shown in Figure 5(c). Figure 5(d) shows the binary image that is converted from grayscale image. Binary images may also be called as the two-level or bi-level image. For each pixel, the binary image has only two possible values that are black and white. It means that each pixel stored as a single bit, i.e., the value will be either 0 or 1. Figure 5(e) shows the segmented characters of the binary image. The character segmentation is the process to separate the word as isolated characters to perform template matching. Each isolated character is normalized into 42×24 pixels. The created reference templates are correlated with the isolated characters of consumer service number. The recognized characters will be stored in text document as shown in Figure 5(f). The recognized service number will be utilized to store the kWh information.

The above procedure has been performed with the help of MATLAB coding. The 'Calibri' type of font style has been used for the generation of consumer service number.

4. **Conclusion.** In today world, images place a significant role in the area of data mining. Superimposed text in images gives much information. Recognition of text in images is of greater demand. Text recognition in complex background images is still a very challenging task in computer vision. In this paper, the recognition process of consumer service number has been explained. The template matching technique based OCR has been used in the text recognition process. The consumer service number printed in white background has been recognized. The recognized alpha numeral will be used as a variable and the kWh

information in the same image will be recognized using MLOCR technique. In future, the deep learning network based text recognition with novel dataset of seven segment display images can be implemented to address the various illumination conditions.

REFERENCES

[1] A. Singh, K. Bacchuwar and A. Bhasin, A survey of OCR applications, *International Journal of Machine Learning and Computing*, vol.2, no.3, pp.314-318, 2012.

[2] E. K. Kaur and V. K. Banga, Number plate recognition using OCR technique, *International Journal of Research in Engineering and Technology*, vol.2, no.9, pp.286-290, 2013.

[3] F. Mohammad, J. Anarase, M. Shingote and P. Ghanwat, Optical character recognition implementation using pattern matching, *International Journal of Computer Science and Information Technologies*, vol.5, no.2, pp.2088-2090, 2014.

[4] R. Smith, An overview of the Tesseract OCR engine, *Proc. of the 9th International Conference on Document Analysis and Recognition (ICDAR)*, pp.629-633, 2007.

[5] J. Kaur and N. S. Sethi, A review paper on character segmentation in handwritten text document written in Gurumukhi script, *International Journal of Advanced Research in Computer Science and Software Engineering*, vol.5, no.3, pp.429-431, 2015.

[6] D. Nasien, S. S. Yuhaniz and H. Haron, Recognition of isolated handwritten Latin characters using one continuous route of Freeman chain code representation and feed forward neural network classifier, *World Academy of Science, Engineering and Technology*, vol.4, no.7, pp.475-481, 2010.

[7] P. H. Kulkarni and P. D. Kute, Optical numeral recognition algorithm for seven segment display, *Conference on Advances in Signal Processing (CASP)*, Pune, India, pp.397-401, 2016.

[8] A. Bahmanyar, S. Jamali, A. Estebsari, E. Pons, E. Bompard, E. Patti and A. Acquaviva, Emerging smart meters in electrical distribution systems: Opportunities and challenges, *The 24th Iranian Conference on Electrical Engineering (ICEE)*, Shiraz, pp.1082-1087, 2016.

[9] K. Karthick and S. Chitra, Novel method for energy consumption billing using optical character recognition, *Energy Engineering: Journal of Association of Energy Engineers*, vol.114, no.3, pp.64-76, 2017.

[10] K. Karthick and S. Chitra, A novel method for energy consumption billing using labeling method based OCR, *International Journal of Printing, Packaging & Allied Sciences*, vol.4, no.3, pp.1773-1783, 2016.

[11] N. Otsu, A threshold selection method from grayscale histograms, *IEEE Trans. Systems, Man, and Cybernetics*, vol.8, pp.62-66, 1979.

[12] F. Wahl, K. Wong and R. Casey, Block segmentation and text extraction in mixed text/image documents, *Computer Vision, Graphics and Image Processing*, vol.20, pp.375-390, 1982.

[13] C. K. Kent and N. Salim, Features based text similarity detection, *Journal of Computing*, vol.2, no.1, pp.53-57, 2010.

[14] N. R. Pai and S. K. Vijaykumar, Design and implementation of optical character recognition using template matching for multi fonts/size, *International Journal of Research in Engineering and Technology*, vol.4, no.2, pp.398-400, 2015.

[15] L. Heutte, T. Paquet, J. V. Moreau, Y. Lecourtier and C. Olivier, A structural/statistical feature based vector for handwritten character recognition, *Pattern Recognition Letters*, vol.19, no.7, pp.629-641, 1998.

[16] D. V. Rojatkar, K. D. Chinchkhede and G. G. Sarate, Design and analysis of LRTB feature based classifier applied to handwritten Devnagari characters: A neural network approach, *International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, pp.96-101, 2013.

[17] M. Hanmandlu, A. V. Nath, A. C. Mishra and V. K. Madasu, Fuzzy model based recognition of handwritten Hindi numerals using bacterial foraging, *The 6th IEEE/ACIS International Conference on Computer and Information Science*, pp.309-314, 2007.

[18] S. Asht and R. Dass, Pattern recognition techniques: A review, *International Journal of Computer Science and Telecommunications*, vol.3, no.8, pp.25-29, 2012.

[19] A. Dahmouni, N. Aharrane, K. El Moutaouakil and K. Satori, Multi-classifiers face recognition system using LBPP face representation, *International Journal of Innovative Computing, Information and Control*, vol.13, no.5, pp.1721-1733, 2017.