Recognition of Binary Image Represented by a String of Numbers.

Kallol Bhattacharya* Krishnendu Goswami Dipankar Biswas

Institute of Radio Physics and Electronics,

University of Calcutta

92 A.P.C. Road

Kolkata – 700009

kallolbhattacharya@yahoo.com, diiibiswas@yahoo.co.in

Abstract

Recognition of binary images through the use of a string of numbers is outlined. The string of numbers representing the image leads to a large amount of compression and this compressed image comprising of strings of numbers can be successfully transmitted and reproduced with desired fidelity. Recognition of binary images in the form of Bengali alphabets has been successfully achieved for different fonts and sizes.

1. Introduction

Computer based recognition of binary images has gained immense importance in the present day, in fact it has become a necessary tool for a lot of important operations. Some of the usually encountered binary images for recognition are in the form of finger prints, printed and hand written scripts of international and regional languages ,recorded voice signals and strings of numbers. References [1] through [8] summarize some of the established methods of recognition of the mentioned binary images.

Recently, we have communicated a new method for representation of binary images through a string of numbers [9] and [10].

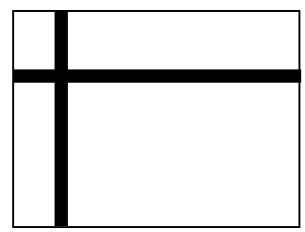
In this paper, we will outline a new technique for the recognition of binary images represented by strings of numbers with a brief introduction of representation of an image through numbers [9, 10].

2. Procedure

2.1 Generation of String representation of an image

For representation, as shown in Fig.1, the image shown in (a) is fitted in a tight fitting box and is divided into m X n segments and each segment is designated with an independent prime number. The segments having at least one black pixel is designated by a larger font in Fig. 1b, which leads to a definite set of prime numbers out of the total m X n. The product of this subset of prime numbers is a unique number for that set of black pixels in their unique positions, which represent the image in the minimum form.

If the product of the prime numbers is too large to be handled by the computer, then the products of different segments of prime numbers are concatenated with delimiters to form a string, which represents the image uniquely. For further compression, numbers repeated in the string are bunched together to form a compact string [9].



(a)

2	3	5	7
11	**13**	**17**	**19**
23	29	31	37
41	43	47	53

'm X n' = 4 X 4

Product = 87112454

(b)

+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1
+1+1+210+1+1+223092870+223092870+223092870+223
092870+223092870+223092870+223092870+223092870
+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+21
0+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1
+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+21
0+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1
+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+21
0+1+1+1+210+1+1+1+210+1+1+1+210+1+1+1+210+1+1
+1+210+1+1+1+210+1+1+e+2160+1620+x+36+y+36

Typical string generated for m X n = 36 X 36

(c)

Fig. 1. The binary image and the prime numbers for two sets of segments 'm X n'

This unique string of numbers can be transmitted along with its reference coordinates and by deciphering the prime numbers present in the transmitted string, we can regenerate the original image plotting the black pixels in their original positions.

By changing the number of segments, the data compression can be tailored and it can be greater than 98% for certain cases which is at least comparable (if not more) to other compression techniques (like JPEG).

Applying the method for English alphabet D, the following results are observed:

Original Image	**Received and reproduced image**	**M X n**	**Compression (Our method)**	**(JPEG) compression**
		18 X 18	**97.8**	87.4
		54 X 54	**92.6**	87.4

Fig. 2. Reproduction of English alphabet with m X n = 18 X 18 and 54 X 54 after compression and transmission.

From Fig. 2 it can be seen that the compression achieved is better than JPEG, which is lossy but most popular in Internet because it offers a good compromise between the size and quality.

The next figures (Fig. 3 and Fig. 4) show the flowcharts for String generation and reproduction

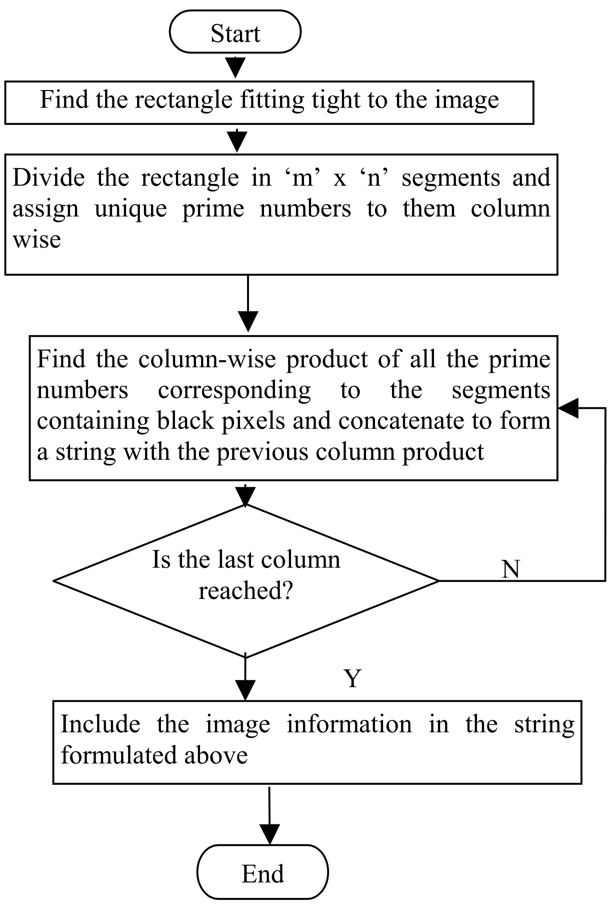


Fig. 3. Flowchart for image representation

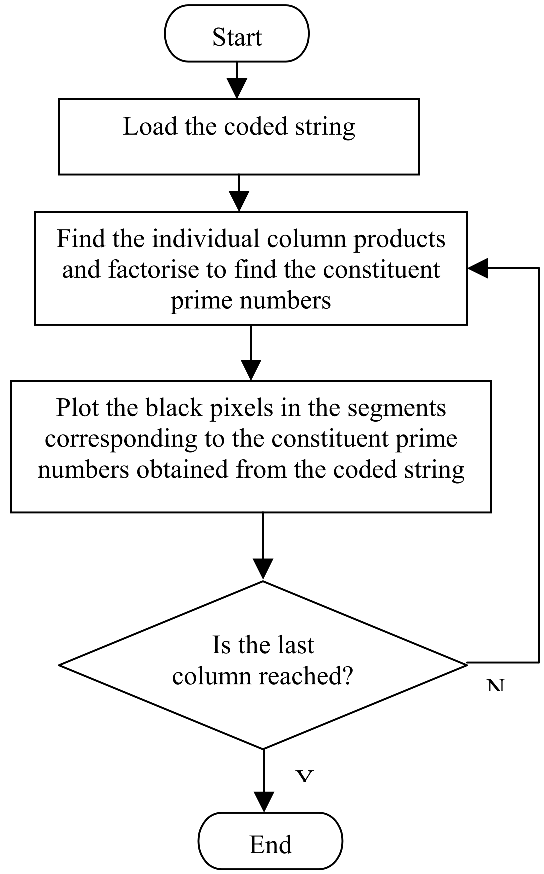


Fig. 4. Flowchart for image reproduction

2.2. Recognition of image based on string of numbers

The string of numbers can be used for recognition of binary images. A mean string where each element is a mean of the prime number products of the corresponding columns, is found for the set of test samples, during the learning phase of recognition. The sample to be recognized is expressed in the same way and the string that is the corresponding columns products of this is compared with the means generated earlier using standard deviation principles for recognition.

To extend and establish the concept to recognition of binary images, namely, Bengali alphabets, through strings of numbers, the following experiments have been performed.

An alphabet of the Bengali character set ক of Adarsha Lipi Con font is taken in ten different sizes ranging from 30 to 120, where each font size varies from the other in steps of 10 points. These samples are then scanned with a 18 × 8 segment size. This means that there would be 18 products of prime numbers where each product would represent the information content of a particular column that is broken down into 8 segments (rows). We have further broken down each product into two, such that each product now represents the product of the first four prime numbers. Thus in effect, we can say that the image is broken down into segment size of $18 \times 4 \times 2$. So in practice, we would be having 36 such prime number products for each sample. Thereafter, the mean of the products of each individual column of the 36 numbers for the 10 samples is calculated along with their standard deviation. It is to be noted that each font size is normalized by the tight fitting box mentioned earlier. The following flowchart in Fig 5 clearly explains this.

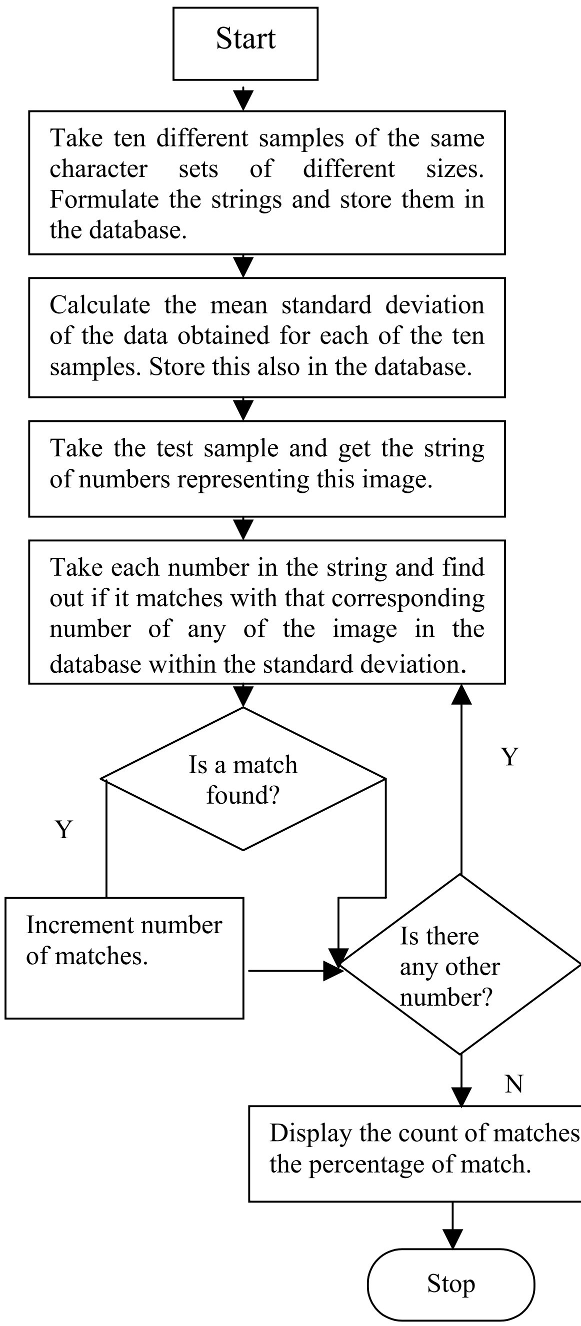


Fig. 5. Flowchart for image recognition

To establish the recognition procedure, the mean curve was compared a) to a larger size of the same font, b) with other fonts of the same alphabet, c) with an almost similar alphabet and d) a dissimilar alphabet.

3. Results

In Fig 6, we show the mean curve obtained from the 10 different font sizes of the same font of Bengali alphabet.

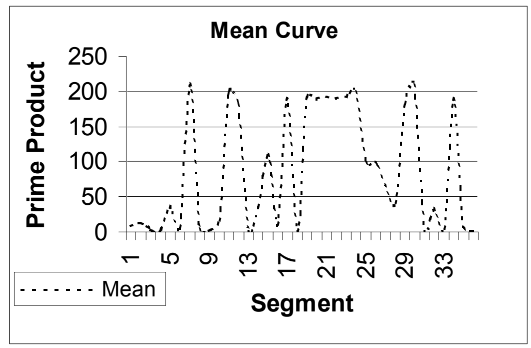


Fig. 6. Mean curve of the 10 different test samples of ক.

When a larger size of the same font is compared with the average, it gives 91.11% match with the mean as shown in Fig 7.

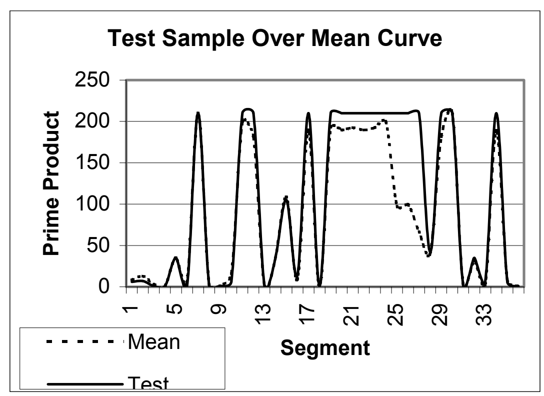


Fig. 7. A comparison of column products of 140-point font size of a test sample of ক in Adarsha Lipi Con font with the mean column product curve of the same font.

When a different font of the same Bengali alphabet is compared with the mean, it gives 86% matching as shown in Fig 8.

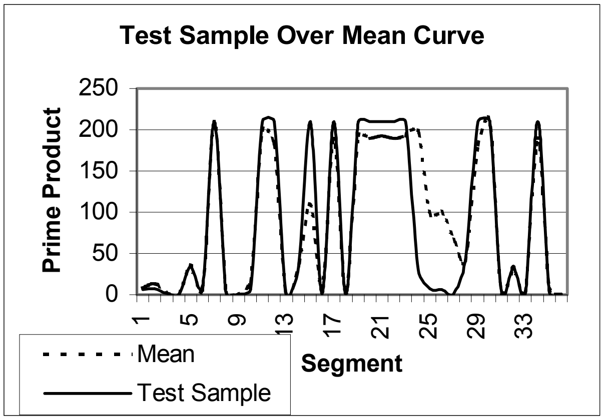


Fig. 8. A comparison of column products of 140-point font size of a test sample of ক in Lip Con Expand font with the mean column product curve of Adarsha Lipi Con**.**

When we compare a different Bengali alphabet very close to the one shown in Fig 6, we get a match of 61.12% only. The comparison curves are shown in Fig 9.

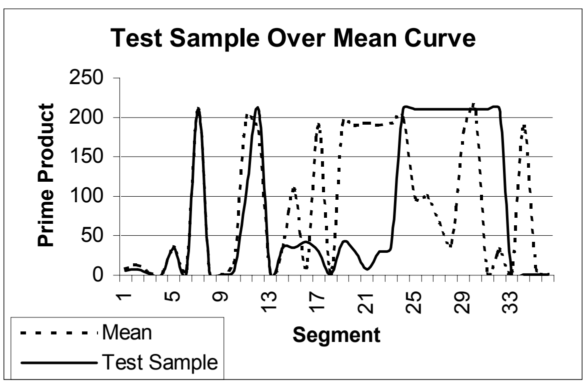


Fig. 9. A comparison of column products of 70-point font size of a test sample of ব in Adarsha Lipi Con font with the mean column product curve of ক in Adarsha Lipi Con.

A totally different sample (চ) when compared to our mean curve shows 47.22% match clearly indicating the mismatch. This is shown in Fig. 10.

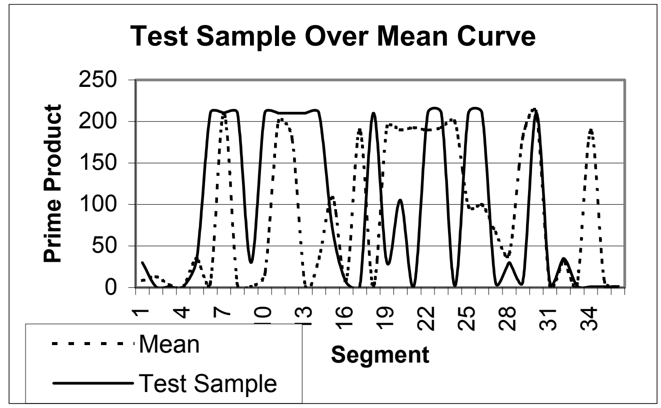


Fig. 10. A comparison of column products of 70-point font size of a test sample of চ in Adarsha Lipi Con font with the mean column product curve of the same font of ক .

4. Conclusions

Some inferences of the experiments with our algorithm for recognition are as follows:

A mean curve from the means of column products of ‘n’ samples can be drawn, which reflects very closely any one of the constituent samples.

Any test sample of the same alphabet and font, but of a different font size closely resembles (91%) the mean.

The theory of recognition when applied to the same alphabet, of different font and size yields a close match (86%).

For a different alphabet close or different in nature the algorithm clearly points the mismatch of the curves irrespective of the font size and type.

The algorithm presented in this paper is useful in compression, representation, recognition and reproduction of binary images.

The algorithm can further be extended grayscale images and the authors are working on the same.

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References

[1] Cheng-Lin Liu,Kazuki Nakashimka, Hiroshi Sako, Hiromichi Fujisawa. 2002. Handwritten digit extraction: investigation of normalization and feature extraction. Pattern Recognition.

[2] Eiki Ishidera, Daisuke Nishiwaki, Atsushi Sato. 2003. A confidence value estimation method for handwritten Kanji character recognition and its application to candidate reduction. International Journal on Document Analysis and Recognition.

[3] Bhabotosh Chanda, Bidyut B. Chaudhuri. 2003. Automatic Selection of Structuring Element for Bengali Numeral Recognition. International Journal of Pattern Recognition.

[4] M. S. Khorsheed. 2002. Recognising handwritten Arabic manuscripts using hidden Markov model. Pattern Recognition Letters.

[5] Alceu de S. Britto Jr., Robert Sabourin, Flavio Bortolozzi, Ching Y. Suen. 2003. The recognition of handwritten numeral strings using a two stage HMM-based method. International Journal on Document Analysis and Recognition.

[6] Hao Feng, Chan Choong Wah. 2002. Online signature verification using a new extreme points warping technique. Pattern Recognition Letters.

[7] E. Kavallieratou, N. Dromazou, N. Fakotakis and G.Kokkinakis. 2003. An integrated system for handwritten document image processing. International Journal for Pattern Recognition and Artificial Intelligence.

[8] Tino Lourens, Roul P. Wurtz. 2003. An Extraction and Matching of Symbolic Contour Graphs. International Journal for Pattern Recognition and Artificial Intelligence.

[9] Dipankar Biswas, Krishnendu Goswami and Kallol Bhattacharya, Communicated to Pattern Recognition Letters, under consideration

[10] Dipankar Biswas, Krishnendu Goswami and Kallol Bhattacharya, presented at the conference Computer and Devices for Communication, Institute of Radiophysics and Electronics, Kolkata, January'2004