A New Method of Fractal Barcodes Identification

K. Kiani, E. Kosari, and M. R. Simard,

Abstract—This article introduces and explains a new method of 2D coding based on L-Systems Fractal Hypothesis which has a better security and capacity for coding. The coding, image processing and decoding of two dimensional codes by Hopfield Neural network are studied step by step in this article. Different case studies for a new barcode shape show that the current approach provides more reliable method in the early stage of design process.

Keywords: Barcode , Fractal , Image Processing ,L-System

I. Introduction

A barcode is an optical machine-readable representation of data, which shows data about the object to which it attaches. By prevailing of barcodes for their good accuracy and quickness, storing more data became easier than before.

Many studies have accomplished on increasing barcode data storing capacity suggesting the increase of barcode digits or defining multiple barcodes by setting them adjacently.

However, mostly had problems; including the increase of coding costs, barcode size and difficulties in reading and decoding.

Following these problems, the idea of 2D barcodes is raised. 2D barcodes are able to store more data in smaller sizes. There are some different types of 2D barcodes such as QR-Code, Maxi Code, Data Matrix and PDF 417. One of its more common types is PDF 417 which is not like barcodes in shape consisting Black-White meshes similar to Newspaper puzzle. It can store plenty of data in a small dimension as a portable data bank. Although, increasing data volume will increase the barcode size.[1]

In 1994, a Japanese company invented a new coding system; QR. QRs are 2D matrixes that was first invented in manufacturing trucks but nowadays they are utilized for other applications because of their good storing capacity and 7-30% capability of data recovery with no problem and confusion by any damage.[2] This technique stores plenty of data in an image. By scanning the image and using decode process the data will be extracted. Data matrix can store a number of information in an image as a sign or label on the goods.[3]

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Kiani K. is an assistant professor of semnan university in the electrical engineering department IRAN. (corresponding author to provide phone: 00989122361274;; e-mail: kourosh.kiani@kouroshkiani.com).

Kosari E., is a M.Sc student in the field of electrical engineering, in Semnan university, IRAN. (e-mail: ehsan_5416@yahoo.com).

Simard M., is a M.Sc student in Tehran Azad University-south branch in the field of telecommunications engineering, IRAN (e-mail: st_mr_simard@azad.ac.ir).

Our Proposed method is using L-Systems in defining Fractal Codes. This technique provides an eligible security and complication in preventing deception while give us the capability of storing large volume of information including personal data and contact details or even a dairy of driver in codes.

Fractal is an inharmonious Geometric shape which can be divided in sectors as subsets of a reference.[4]

L- System is presented by Lindenmayer, a biologist, in 1968, to model the growth processes of Plant development and morphology of a variety of Multi cellular organisms. It can also be used to generate self-similar fractals such as iterated function systems.[5]

In this article we will show the Fractal Coding procedure by L-system. The advantage of using Fractal curves is that its' shapes could be used in defining 2D Codes in a favorable security and capacity. Also the Hopfield Neural Network is used for decoding of Fractal Codes by recognizing the lines. A Hopfield network is an integrated artificial neural network that serves as content-addressable memory systems with binary threshold units. By any input the most similar stored pattern in network will be red and chosen as output. Its function is very similar to human brain in remembering an image or a memory by watching a part of it.

II. Drawing the Hilbert Curve using L-System:

A Hilbert Curve is a continuous fractal space-filling curve first described by the German mathematician David Hilbert in 1891, as a variant of the space-filling curves discovered by Peano in 1890. [4]

Below is the 6 order of Hilbert curve:

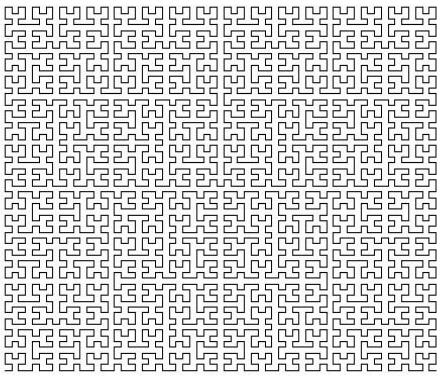

Fig1.A Six order Hilbert curve

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III. Data encoding step:

First separate the numerical coordinates in each matrix then regarding the codes define the line between spots.
Here we use fractal pattern which gives us 64 data bits. As a result the digit 1 is the sign of having the Line and digit 0 shows absence of the Line. Whereas the main codes will be defined in barcode, we need 8 bits code. For further security in coding other ways could be used for showing bit0 or 1 on the Hilbert curve.
Below shows an encoded 5 order Hilbert curve.

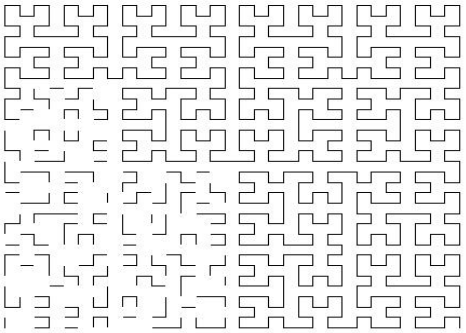

Fig2.Encoded 5order Hilbert curve

Remember that 5 order of Hilbert curve has 1024 numerical coordinates which can show 170 characters. 6 order of Hilbert Curve has 4096 numerical coordinates which can show 682 characters and also there are 16834 numerical coordinates and ability of having 2730 character for 7 order Hilbert Curve.

IV. Barcode reader:

It's an instrument that transfers the image of barcode to a computer for processing and decoding.
There are three models barcode readers. Fixed barcode reader, portable barcode reader and wireless barcode reader.
We have used a 2D fixed scanner which scans the image of barcode for processing in a computer.

V. Decoding Barcode:

Decoding is reading of data from scanned image as bits and then excluding the primary raw information.
Firstly for preparing the scanned image we should preprocess it.

Preprocessing:
At this stage for recovering the image quality a median filter is used to remove the salt and pepper noises.
A median filter is a nonSlinear digital filter which we use it by defining a 3*3 matrix widow at image. By scanning a mask for the image, each 8 pixels adjacent to the center of the window will be included in the median operator.[6]
The next stage is changing recovered image to a black-white picture. Then by recognizing the lines, 0 &1 bits are determined. The scanned image will has a different size and will be angular comparing with its original image. For solving this problem fist corners of image will be found and then the turning angel will be determined and then induced reversely to the image.[7] To sizing the image, diameter of scanned image will be determined and compared with original image.

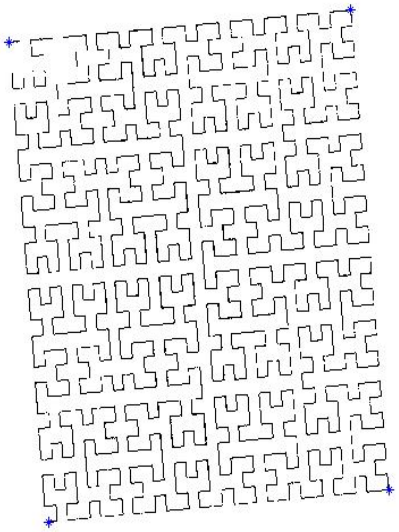

Fig3.Scanned barcode with determined four corners

In above image a scanned barcode with determined four corners is shown. The amount of rotation angle is calculated with following equations:

$$\theta 1 = \text{arctg}((y_4 - y_1)/(x_4 - x_1))$$
$$\theta 2 = \text{arctg}((y_2 - y_3)/(x_2 - x_3))$$
$$\theta = \max(\theta 1, \theta 2)$$

Then black points of the image then morphologically with operator of Erosion, a basic operator, defined in a 5*5 matrix window and implicated to image. This will strengthen black lines of image to be better determined.[6]

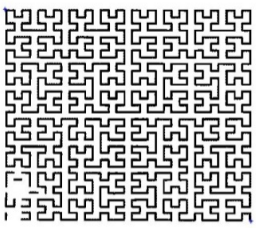

Fig4.preprocessed barcode image

The next stage is removing redundant white margin of recovered image. Referring the Hilbert curve process of decoding will be started from down-left pixel of the image and 11*11 pixels windows are framed while the window length equals distance of two Hilbert's' coefficients. By scanning the image according to Hilbert coefficients and applying the result image to Hopfield neural network, Line determination process will begin.
Hopfield neural network will be applied for storing some patterns and their recovering. Training method of this neural

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network will be as follow: first 2D images of the lines, vertically and horizontally with noise, as the size of selected window on decoding introduced in neural network. Resulted vectors will give us the weighting function of neural network as below equation:
The main advantage of using this neural network is to make the decoding process better in resistance against noises which may be introduced while capturing and scanning the image.

$$W = \frac{1}{N}\sum_{K=1}^{P} Z_K Z_K - \frac{P}{N} I$$

Calculating the weighting vectors which is a 121*121 matrix (as same as scanned image), 11*11 sub-images deduces from scanned image will be applied in neural network. The neural network will map the input image to one of its previously stored images and so the input image is classified.[8]
Then the process output is a bit stream which the preliminary data can be achieved after converting every 8 bits into its Ascii characters and so the decoding is completed.
The main advantage of using this neural network is to make the decoding process better in resistance against noises which may be introduced while capturing and scanning the image.

VI. Conclusion

In this paper we proposed a new barcode using fractal L systems. Also the implementation process including barcodes encoding, barcodes reading, enhancement of scanned image and decoding Hilbert fractal barcodes using a Hopfield neural network has been explained. The application of the approach is exemplified by numerical solutions provided to support the analysis. Results show significant adaptability in implementing the proposed method.

References

[1] PEI Jiao, LI Fang-wei, Two-dimensional Bar Code PDF417 Decoding Technology , Journal of Chongqing, 2003.
[2] phonesOhbuchi, H Hanaizumi, Barcode readers using the camera device in mobile, 2004.
[3] E Ouaviani, A Pavan, M Bottazzi, A common image processing framework for 2D barcode reading, 1999.
[4] Barnsley, M. F., Demko, S., Iterated function systems and the global construction of fractals, The
Proceedings of the Royal Society of London A399 (1985) 243–275.
[5] P Prusinkiewicz, Graphical applications of L-systems, 1995.
[6] R. Gonzales, R.Woods, Digital Image Processing, Prentice Hall, second edition, 2001.
[7] M. Unser, P. Thevenaz, L. Yaroslavsky, Convolution based interpolation for fast, high-quality rotation of images,IEEE Transactions on Image Processing vol.4, no.10, 1995, pp.1371-1381.
[8] Ovidiu Pârvu, Andrei G. Bălan , A method for fast detection and decoding of specific 2d barcodes
17th Telecommunications forum TELFOR 2009.

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