

# Cryptography Techniques for Image Security and Authentication using Cellular Automata Algorithms

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## Abstract

*This Security and authentication are the two important criteria for any industrial product controlled through electronics. Microcontrollers interfacing along with electronic circuits, Controls various aspects of industry equipment. One among them is the communication and transfer of data between the equipment. In certain situations a need arises to secure the data and a proper authentication is required. From a small encoding and decoding methods to a high level Encryption and decryption algorithms are in use to secure data. Presently many smart devices are available in the areas of Communications, image processing, Mechatronics etc. One of the security authentication methods used for smart devices is I-Button technology. Many authentication techniques are used to secure data. Visual cryptography is one method which creates signatures by applying nonlinearity into the data. The signatures consist of cipher and the key. At the receiving end if the key and the cipher match then the authentication is done. Through this visual cryptography technique the users hide information securely based on key authentication. This paper presents a novel approach in visual cryptography using pextral coding algorithm in the framework of cellular automata. In this method a 3 x 3 matrix pextral icon is considered. A two dimensional pextral icon is a convex polygon formed of pixels in a nine neighborhood enclosing the central pixel. This central pixel is similar to a pixel considered for an image in visual cryptography where each pixel is expanded nonlinearly into four sub pixels. Now in cellular automaton dropping one, two or three pixels in the given matrix forms 16 convex polygons. Out of these 16 polygons, few will have mirror symmetry. Two such mirror symmetry polygons were considered and the central pixel of these polygons will form the image pixel. An algorithm is developed to generate two signatures on an image/jpeg image. Combining the two signatures will reconstruct the original image. Results show that no loss of information and improved security.*

## Keywords

*Visual cryptography, cellular automata, polygons, signatures, pextral, pixels.*

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## 1. Introduction

Present smart devices in the market uses Digital communication for communication between the two devices.

With the advent of VLSI technology and research in Nano technology many smart devices are available. Smart devices used for communication purposes must have data security provision so that during the transmission the data is not hacked. The data for communication is in the form of Text or image information. During the transmission this data has to be secured. One of the methods used for data security is data encryption. Many encryption algorithms are used for data security purpose. Visual cryptography is one of the methods.

Visual cryptography uses the non-linearity on the text or image data and split the data into signatures. The encryption process consists of splitting the plane text or image information into key transparency and cipher transparency. The secret is shared between these two transparencies. The key and cipher transparencies are indistinguishable i.e. in the form of white noise. In visual cryptography the decryption is through the human visual systems. Image is a multimedia component sensed by human. During the decryption the human visual system acts as an OR function. If two transparent objects are stacked together, the final stack of objects will be transparent. But if any of them is non-transparent, then the final stack of objects will be non-transparent. Like in truth table of OR function, a 0 OR 0 = 0, considering 0 as transparent and 1 OR 0=1, 0 OR 1 =1, 1 OR 1=1, considering 1 as non transparent. The original schemes are 2 out of 2 schemes, N out of N scheme, K out of n schemes. The key and the cipher transparencies are generated introducing non-linearity in the plane text or image information. By pixel expansion the non linearity can be achieved. The each pixel of a plane text or image is expanded into 4 sub pixels. In (k) out of (n) visual cryptography scheme is a type of cryptographic technique where a digital image is divided into (n) number of shares by cryptographic computation. In the decryption process only (k) or more than (k) number of shares can reveal the original information [Here can form the original image]. Less than (k) number of shares can not reveal the original

information. In Visual Cryptography algorithms a given image or plain text is divided into  $(n)$  number of shares where minimum  $(k)$  numbers of shares are sufficient to reconstruct the plain text/image data. In this paper we propose to use cellular automata of dimension 2 as graphic crypto systems i.e. crypto systems to encrypt image define by pixels. These crypto systems have several differences compared to the visual schemes proposed to date. For this reason, we denote this cryptography as graphic cryptography. The proposal begins by considering an image data, uses a cellular automata algorithm of dimension 2 and ends with encrypted message with two signatures which we call as key and cipher image and the decryption of original message back. The rest of this paper is organized as follows. Below visual cryptography is reviewed in order to compare the cellular automaton that we propose and visual one. Some definition and properties of cellular automata are presented in our proposal of a visual representation using cellular Automaton. Visual cellular automata are discussed in detail and we present conclusions.

## **2. Related Work**

Shyamalendu Kandar [1] has proposed a K-N secret sharing scheme for encryption using random number generator. The technique is said to have less mathematical calculations with other traditional techniques besides its high computational complexity. Sozan Abdulla [2] proposed a new cryptographic algorithm for color images by taking  $(n)$  pictures as input and generated  $n-1$  images. Decoding is performed by selecting a subset of these  $n-1$  images by placing them as a stack. The original image is same as that of the reconstructed image. Shyamalendu Kandar et. al [3] proposed a visual cryptographic scheme for color images by dividing the images into shares which are generated by using a random number and these shares are watermarked in invisible mode. The technique proved to have less mathematical calculation when compared to other schemes. Pavan Kumar Gupta et. al proposed a variable length symmetric key based cryptographic scheme for color images based on secret key which is used for dividing the image into number of shares. Krishnan et. al proposed a scheme for securing color images. The images are protected and for encryption as well as decryption a binary image is used as a key. Color space models are used for decomposition of the images. Such a scheme is proved to be efficient in communication of natural images across different channels. Liu et. al proposed a color visual cryptographic model of Naor and Shamir without any pixel expansion and termed it as  $(k,n)$ -VCS. Feng

Liu [7] proposed an extended VCS by taking meaningful shares which are the random shares, termed it as embedded EVCS and shown that the proposed system is competitive when compared to traditional techniques.

## **3. Problem Definition**

The image data like finger prints, human eye information are considered for user authentication. For example in India we are using smart devices like Adhar card. Security aspect plays a major role in protecting the image and also plain text information. Many schemes were developed to safe guard the image or plain text information. To provide enough security to this image data in these smart devices, the image data is divided into two keys/signatures. One of the keys is stored on client side and other on the server side. At the server, the two keys/signatures are combined to get the original image information which authenticates the user. Visual cryptography uses the pixel expansion to divide a given image into number of shares. A combination of these shares will get back the original image. So the image is encrypted and decrypted to safe guard the information for better security. Various techniques are applied in visual encryption and decryption of an image/plain text. Peak signal to noise ratio (PSNR) of the output image will be less which is a setback in visual cryptography. For example, when we retrieve the image, a white Gaussian noise is being added in the image resulting in loss of contrast as white pixel is represented by light gray pixels and the black pixels represented by dark gray pixels. In Visual cryptography, Watermark technique is another technique applied for the purpose of security which employs Fourier transform. Because of the random patterns and secret sharing behavior such a technique face problem in changing and removing the watermark.

## **4. Proposed System**

The proposed system overcomes the issues present in visual cryptography by considering a new approach "A Notion of pextral coding using cellular Automaton Algorithms". Visual cryptography uses each pixel of any image data and expanded into four sub pixels. The same pixel expansion technique is applied in cellular automaton.

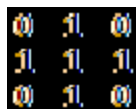
### **A. Visual Cryptography**

Visual Cryptography is a special type of encryption technique to obscure image-based secret information which can be decrypted by Human Visual System (HVS). It is a kind of secret-sharing scheme that

encrypts the secret image in to (n) number of shares. It is imperceptible to reveal the secret information unless a certain number of shares (k) or more are superimposed. As the decryption process is done by human visual system, secret information can be retrieved by anyone if the person gets at least k number of shares. The original schemes are 2 out of 2 scheme, (n ) out of (n) schemes, k out of n schemes. In 2 out of 2 scheme method, the transparencies consisting of pixels are subdivided into 4 sub pixels. Black is opaque and the White is transparent. One pixel expanded into 4 sub pixels is termed as share. The 2 out of 2 scheme has 6 possible shares. The 2 out of 2 scheme includes creation of transparencies. During creating transparencies, each pixel of secrete considered separately. The first transparency (Key) is created randomly and the second transparency (Cipher) is created depending on the key and the secrete. Initially the white pixels are constructed and the exact matching of pixels in both transparencies must be achieved. Again black pixels are constructed and complementary pixels in both transparencies must be matched. In N out N scheme, a secret is distributed over N transparencies and all (N) transparencies are required for decryption. In k out of N schemes, any of (k) combination shares are required to get back the original image. Visual cryptography for natural images is also implemented using the above techniques.

**B. Pextral coding**

Using cellular automaton, the concept of pixel expansion is considered using pextral coding technique. Pextral coding uses a 3X3 cellular matrix as shown in the figure 1. Figure 1: A 3X3 cellular matrix



**Fig 1. A 3X3 cellular matrix**

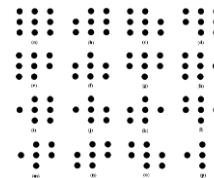
In our proposed system a triangle image is considered in a binary form as shown in the figure 2.



**Fig 2. Triangle image in 9X6 cellular matrix**

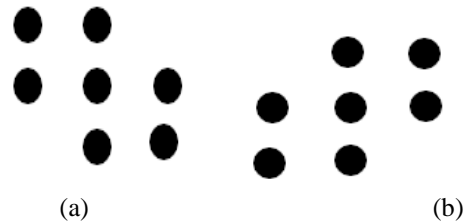
Cellular Automaton is 2-dimensional finite method (CA for short),  $A = (L; S; V; f)$ , is a 4-tuple, where L is the cellular space formed by a 2-dimensional array of size  $r*s$  of identical objects called cells. The Pextral coding

uses dropping of these cells in sequence as one, two or three cells to form 16 geometric patterns as shown in the figure 3.



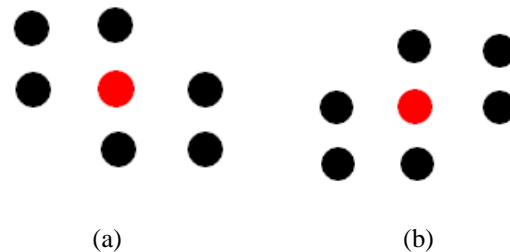
**Fig 3. 16 Geometric patterns (Polygons)**

Two geometric patterns from the above figure 3 (n) and 3 (o) out of these 16 patterns are considered as shown in the figure 4.(a) and (b)



**Fig 4. Geometric patterns with symmetry**

The information in an image is in the form of pixels. Each pixel of this information is considered and expanded by the two geometric patterns by applying pixel expansion technique similar to visual cryptography to form signature 1 and signature 2 as shown in the figure 5. (a) and (b) respectively.



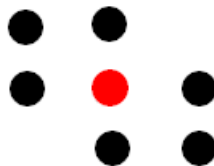
**Fig 5. Signature 1 and signature 2 for one pixel**

This is the encryption technique we proposed in this paper. The decryption process uses these two signatures and combining of these signatures get back the original pixel information of image triangle. As shown in figure 6.



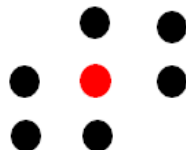
**Fig 6. Original pixel retrieval after addition of signature1 and signature 2**

For a triangle image the initial pixel considered has co-ordinates as  $\{(i, j+3)\}$  as shown in figure 7. Around this co-ordinate a cellular Automaton 3X3 matrix is shown in the figure separately with its own co-ordinates dropping two cells  $\{(i-1, j+4)\}$  and  $\{(i+2, j+2)\}$ . The other co-ordinates are  $\{(i-1, j+2)\}, \{(i, j+2)\}, \{(i-1, j+3)\}, \{(i, j+4)\}, \{(i+1, j+4)\}, \{(i+1, j+3)\}$ .



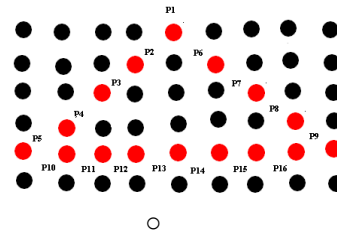
**Fig 7. Initial pixel from triangle representation**

In these figure the pixel co-ordinate  $\{(i-1, j+4)\}$  and  $\{(i+2, j+2)\}$  are dropped and the remaining pixel information represents, the part of the signature one as shown in the figure 7. Using this technique we consider the remaining pixels in a triangle image as a centre pixel of 3X3 cellular matrix whose co-ordinates are  $\{(i, j+3)\}$ . For all the pixels of a triangle the signature one is designed similarly as shown in the figure 7. Similarly dropping two pixels having co-ordinate  $\{(i-1, j+2)\}$  and  $\{(i+1, j+4)\}$ , the remaining pixel information represents the part of the signature two as shown in the figure 8. A similar technique is used by considering remaining pixels in a triangle as a centre pixel of 3X3 cellular matrix.



**Fig 8. Signature 2 representation with the initial pixel from image triangle**

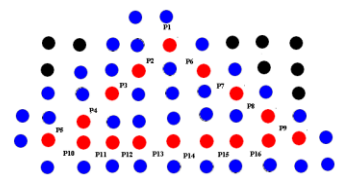
The overall frame work of this proposal: As shown in the figure 2: a 9X6 matrix is considered and Triangle image is shown. To explain the Pextral coding algorithm, same is shown in figure 9.



**Fig 9. Triangle Image**

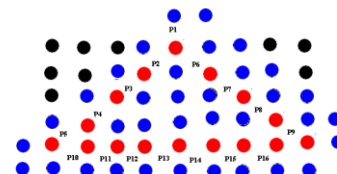
its pixels are shown from P1 to P16 in the figure 9. The co-ordinates are  $P1\{(x, y+4)\}, P2\{(x+1, y+3)\}, P3\{(x+2, y+2)\}, P4\{(x+3, y+1)\}, P5\{(x+4, y)\}, P6\{(x+1, y+5)\}, P7\{(x+2, y+6)\}, P8\{(x+3, y+7)\}, P9\{(x+4, y+8)\}, P10\{(x+4, y+1)\}, P11\{(x+4, y+2)\}, P12\{(x+4, y+3)\}, P13\{(x+4, y+4)\}, P14\{(x+4, y+5)\}, P15\{(x+4, y+6)\}, P16\{(x+4, y+7)\}$ . These pixels P1 to P16 forms the central pixel of the 3X3 cellular matrix.

Applying this central pixels to the geometric patterns as shown in the figure 4 (a). Gives the signature 1. The signature 1 is shown in figure 10.



**Fig 10. Signature 1**

Similarly applying these pixels P1 to P16 to the geometric pattern as shown in the figure 4. (b). gives signature 2 as shown in the figure 11.

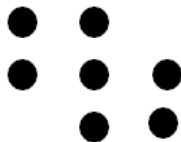


**Fig 11. Signature 2**

The combination of signature1 and signature 2 gives back the original image as shown in the figure 9. In the signature 1 and signature 2 the blue pixels represents the new pixels during the expansion of the central pixels. Certain pixels will overlap during the expansion.

### C. Pextral coding Algorithm

1. Draw the coloured image.
2. The height and width of the image should not exceed 160X160
3. Find the each pixel co-ordinate value of the image and display them and also display the 'RGB' values of that pixel to form the above shape. The centre one is the original pixel  
Ex: original pixel (3,4)
4. The surrounding values of the original(central pixel) pixel (2,3),(2,4),(2,5),(3,3),(3,5),(4,4)
5. The original pixel has same value 'RGB' of the original pixel and the surrounding of the original pixel RGB values are not same.
6. Next create an image 2 with height and width above or equal to the original image.  
The height and width of the newly created image should not be less than to the original image.
7. Send every original pixel of the image and its surrounding six values to the newly created image 2 that form signature 1.
8. Create another image 3 with height and width above or equal to the original image
9. Again expand each pixel on the alphabet in another from as shown in figure 13



**Fig 12. Pixel Expansion**

10. Take the six adjacent neighbouring pixel values of the original signal to form the above shape, the centre one is original pixel.Ex: (3,4)
11. The surrounding values of the above original pixel are (2,4),(3,3),(3,5),(4,3),(4,4),(4,5)
12. Maintain the RGB values of the original pixel, its surrounding pixels are not same and every original pixel and its surrounding six values of the newly shaped format to the newly created image 3 that form the 'signature2'
13. Create another image 4 and merge it with the pixel values of the image 2 and image 3 i.e. signature 1 and signature 2 respectively.

14. Find the pixel 'RGB' values of the image 4. Compare these values with the original image pixel 'RGB' values. If the values are same then display them and ignore the remaining
15. The formed reconstructed image and the original image be same as shown in the figure14: Original image, figure 15: signatures 1&2, figure 16: reconstructed image.



**Fig 13. Original\_img**



**Fig 14. Signatures1 & 2**



**Fig 15. Reconstructed\_img**

## 5. Conclusion

A new approach called Pextral coding using cellular automaton is presented in this paper for encryption and decryption of a colored image. A pixel expansion technique similar to visual cryptography is considered

and applied on cellular automaton using pextral coding method. Pixel information of colored image is expanded and signatures are formed for encryption. Decryption method combines these signatures to form the original colored image. The original image and the Decrypted image are found to be same. An algorithm is developed to execute this process. The output results are observed to see that the original image and the reconstructed image are same. The peak signal to noise ratio (PSNR) is determined and found to be infinite indicating the absence of white Gaussian noise in the process of encryption and decryption.

### **Future scope**

This paper is presented with two signatures. This paper can be extended for multiple signatures to retrieve original ASCII/Image information. This technique can be applied in all the areas where visual cryptography is implemented for authentication and security applications. The comparison between the two techniques can be examined in terms of Error correction mechanism, computational complexity, tolerance, inbuilt check sum errors and redundancy checks.

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