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Daniel James

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A COMPREHENSIVE ANALYSIS OF IMPORTANT IMPACT ON PROTECTING IMAGE COMMUNICATIONS WITH M MODULO *N* GRACEFUL LABELING

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ABSTRACT

This research aims to show that the binomial tree is M modulo N Graceful. To safeguard visual massage, we employ the recommended picture scrambling technique using M modulo N Graceful Labeling. Spearman Rank correlation is used to evaluate the degree of association between encryption and decryption. The results show that our proposed scrambling method is more complex than current scrambling techniques, with a significant impact on protecting messages while making it difficult to decrypt and obtain the original without fully comprehending the concept.

Keywords: Graceful labeling, M modulo *N* graceful labeling, Image scrambling, Correlation analysis, Binomial tree.
Subject Classification: 68R10, 94C15.

1. INTRODUCTION

Graph theory is essential in many sectors of daily life. Graph labeling, one of the core areas of graph theory, is utilized in a wide range of fields, including coding theory, x-ray crystallography, radar, astronomy, circuit design, communication and network, and database administration [2, 3]. The modern web is moving more and more toward multimedia material, the majority of which is made up of images. But with the expansion of multimedia applications, security is now a crucial component of picture storage and transfer, and encryption is the technique to guarantee security [1]. Picture scrambling is a top-notch technique for protecting image data by rendering the image visually unintelligible and difficult for unauthorized users to decipher [6].

Ramachandran examined the experimental findings and noted that the significant anomalous of sorting transformation allows the novel picture scrambling technique based on (1, N)-Arithmetic labeling of trees to give a high level of security. [8]. Different types of picture scrambling techniques were covered by Prarthana Madan Modak et al, who came to the conclusion that the better an image is scrambled, the better the information is hidden. [6]. A technique for creating random Hamiltonian paths within digital images equivalent to permutation in picture encryption was created by Wei Zhang et al. [13].

Gnanajothi established the concept of odd gracefulness [4]. The suggestion to graceful label with one modulo three was made by Sekar [9]. Bamboo trees and coconut trees are considered as examples of one modulo N graceful labeling fulfilled trees, according to Ramachandran and Sekar, who proposed the notion. [10]. Ragukumar et.al defined and showed that we show that binomial trees B_k is graceful for every $k \geq 0$. Velmurugan et al., introduced M modulo *N* graceful Labeling and proved that path and star are M modulo *N* graceful graph [11, 12]. Because of the significant abnormality of sorting transformation, the novel picture scrambling technique developed on graceful tree labeling may give a high level of security, according to the findings of an experiment by Mithun.P., et al. [5].

We set out to demonstrate in this study that the binomial tree is M modulo *N* Graceful Labeling. To safeguard visual massages, we use M modulo *N* Graceful Labeling of the binomial tree in image scrambling. Using correlation, we developed a scrambling method that has a significant influence on safeguarding messages while also being difficult to decrypt and acquire the original without understanding the entire idea since it is more complex than currently used scrambling methods.

2. M MODULO *N* GRACEFUL LABELING ON BINOMIAL TREE

Definition: 2.1 The Binomial tree B_0 consists of a single vertex. The Binomial tree B_k is an ordered tree defined recursively. The Binomial tree B_k consists of two Binomial trees B_{k-1} that are linked together: the root of one is the child of the root of the other.

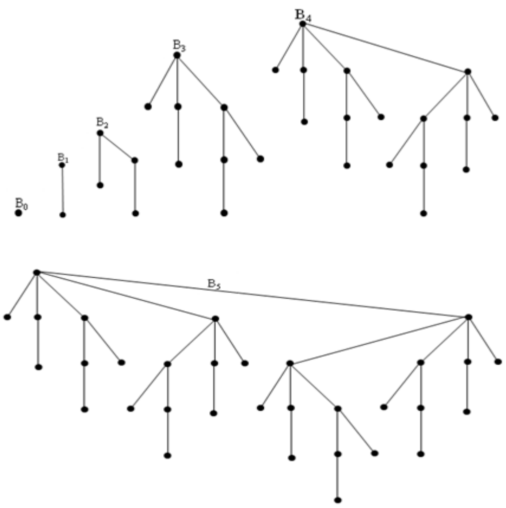


Figure.1 Binomial trees B_0 to B_5

Definition: 2.2 A graph G [V(G),E(G)] with p vertices and q edges is said to be **M modulo *N* Graceful Labeling** (where *N* is positive integer and M= 1 to *N*) if there is a function f from the vertex set of G to $\{0, M, N, N+M, 2N, \ldots, N(q-1), N(q-1)+M\}$ in such a way that (i) f is 1-1 ,(ii) f induces a bijection f^* from edge set of G to $\{M, N+M, 2N+M, \ldots, N(q-1)+M\}$ where $f^*(u, v) = |f(u) - f(v)|$ for all u, v ∈ V(G). A graph G satisfied M modulo *N* graceful labeling is known as M modulo *N* graceful graph.

Theorem: 2.3 Binomial tree (B_t, $t \geq 0$) is M modulo *N* Graceful Labeling for all positive integer *N* and M = 1 to *N*.

Proof: Let a binomial tree (B_t , $t \geq 0$) has $\sum_{i=0}^{t} {}_tC_i$ vertices and edges are $\sum_{i=0}^{t} {}_tC_i - 1$. Take the vertices are $u_1, u_2, \ldots, u_s$, $s = \sum_{i=0}^{t} {}_tC_i$

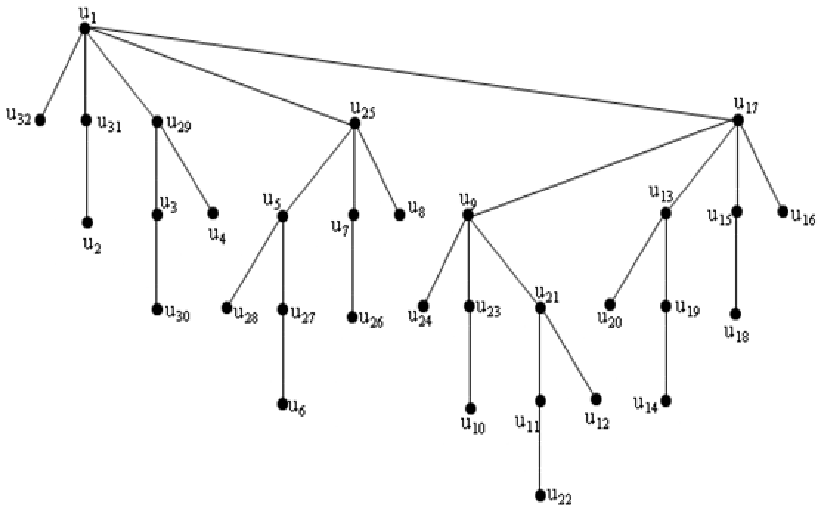


Figure.2 Vertices of Binomial trees B_5

Now we define the M modulo N Graceful Labeling of binomial tree (B_t , $t \geq 0$) as follows,

If t is even

$f(u_i) = N(2^t\text{-}1\text{-}i) + M$, i = 1 to $\sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)}$.

$f(u_{r+i}) = N(2^t\text{-}1\text{-}r\text{-}i)$, i = 1 to $\sum_{j=1}^{(t/2)} tC_{(2j-1)}$, $r = \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)}$

$\{f(u_i)$, i = 1 to $\sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)} \cup f(u_{r+i})$, i = 1 to $\sum_{j=1}^{(t/2)} tC_{(2j-1)}$, $r = \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)}\}$ = $\{N(2^t\text{-}2) + M$, $N(2^t\text{-}3) + M$, …, $N(2^t\text{-}1\text{-} \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)}) + M\} \cup \{N(2^t\text{-}2\text{-} \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)})$, $N(2^t\text{-}3\text{-} \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)})$, …, $N(2^t\text{-}1\text{-} \sum_{j=1}^{\left(\frac{t}{2}\right)+1} tC_{2(j-1)} \text{-} \sum_{j=1}^{(t/2)} tC_{(2j-1)})\} \subseteq \{0, M, N, N + M, 2N, \ldots, N(q\text{-}1), N(q\text{-}1) + M\}$. Hence each vertex assigns a distinct labeling.

If t is odd

$f(u_i) = N(2^t\text{-}1\text{-}i) + M$, i = 1 to $\sum_{j=1}^{(t+1)/2} tC_{2(j-1)}$.

$f(u_{r+i}) = N(2^t\text{-}1\text{-}r\text{-}i)$, i = 1 to $\sum_{j=1}^{(t+1)/2} tC_{(2j-1)}$, $r = \sum_{j=1}^{(t+1)/2} tC_{2(j-1)}$

$\{f(u_i)$, i = 1 to $\sum_{j=1}^{(t+1)/2} tC_{2(j-1)} \cup f(u_{r+i})$, i = 1 to $\sum_{j=1}^{(t+1)/2} tC_{(2j-1)}$, $r = \sum_{j=1}^{(t+1)/2} tC_{2(j-1)}\}$ = $\{N(2^t\text{-}2) + M$, $N(2^t\text{-}3) + M$, …, $N(2^t\text{-}1\text{-} \sum_{j=1}^{(t+1)/2} tC_{2(j-1)}) + M\} \cup \{N(2^t\text{-}2\text{-} \sum_{j=1}^{(t+1)/2} tC_{2(j-1)})$, $N(2^t\text{-}3\text{-} \sum_{j=1}^{(t+1)/2} tC_{2(j-1)})$, …, $N(2^t\text{-}1\text{-}\sum_{j=1}^{(t+1)/2} tC_{(2j-1)}) \text{-}\sum_{j=1}^{(t+1)/2} tC_{(2j-1)})\} \subseteq \{0, M, N, N + M, 2N, \ldots, N(q\text{-}1), N(q\text{-}1) + M\}$. Hence each vertex assigns a distinct labeling.

From both cases when t is even or odd, each edge assigns a distinct labeling as {M, *N* + M, 2 *N* + M, …, *N* ($\sum_{i=0}^{t}$ ($_tC_i$) -2) + M } = {M, *N* + M, 2 *N* + M,….., *N* (q-1) + M }.

Hence Binomial tree (B_t , t≥0) is M modulo *N* Graceful Labeling for all positive integer *N* and M = 1 to *N*.

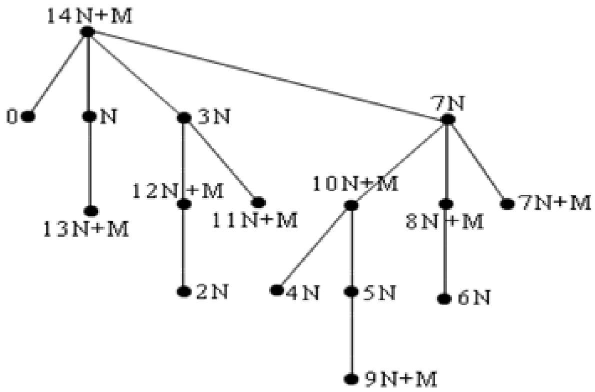
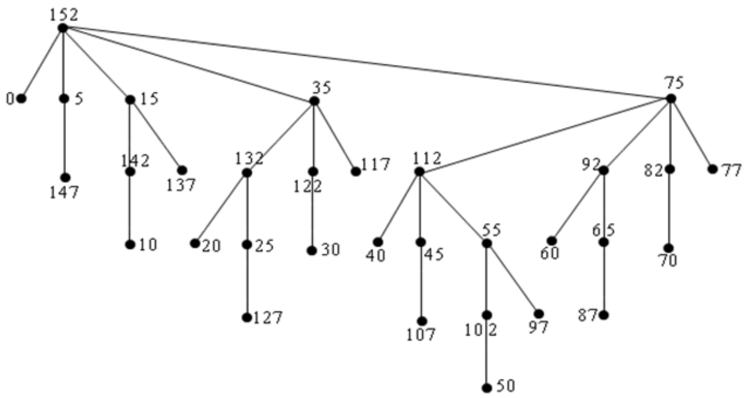


Figure.3 M modulo *N* graceful labeling on Binomial tree B_4.

Example. 1 2 modulo 5 graceful labeling on Binomial tree with t = 5.



3. IMAGE SCRAMBLING BY USING M MODULO *N* GRACEFUL LABELING

3.1 Process of Image scrambling by using M modulo *N* graceful labeling.

Step 1: Let the total number of pixels of image as *N* = (R × C) = 2^t (No of Vertices in Binomial tree), where R and C are number of rows and columns.

Step 2: Naming the Pixels either row wise or column wise.

Let x = 0 to R-1 and y = 0 to C-1

Define Image to Pixel and Pixel to Place Value x*C + y (x + R*y) with respect to row(column) respectively.

Step 3: Encryption is defined as follows

i.e. E: $\{P_{\text{original Pixel value}}\} \to \{P_{\text{Shuffling based on Row or column with M modulo } N \text{ Graceful Labeling}}\}$

Let x = 0 to R-1 and y = 0 to C-1

Let μ = $L[BT(u_{(x*C+y)+1})] \pmod{N}$ i.e., Value of M in M modulo *N* Graceful Labeling on Binomial tree

Encryption based on Row $E[P_{(xy)}] = \begin{cases} P_{(x*C+y)-\mu} & \text{if } x*C + y - \mu, \text{ is positive} \\ P_{N+(x*C+y)-\mu} & \text{if } x*C + y - \mu, \text{ is negative} \end{cases}$

Encryption based on Column $\mathbf{E}[P_{(xy)}] = \begin{cases} P_{(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is positive} \\ P_{N+(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is negative} \end{cases}$

Step 4: Decryption is defined as follows

D: $\{P_{\text{Shuffling based on Row or column with M modulo } N \text{ graceful labeling}}\} \longrightarrow \{P_{\text{original Pixel value}}\}$

Let x = 0 to R-1 and y = 0 to C-1

Decryption based on Row

$$\mathbf{D}\left[\begin{cases} P_{(x*C + y) - \mu} & \text{if } x*C + y - \mu, \text{ is positive} \\ P_{N+(x*C + y) - \mu} & \text{if } x*C+ y - \mu, \text{ is negative} \end{cases}\right] = \mathbf{E}^{-1}\left[\begin{cases} P_{(x*C + y) - \mu} & \text{if } x*C + y - \mu, \text{ is positive} \\ P_{N+(x*C + y) - \mu} & \text{if } x*C + y - \mu, \text{ is negative} \end{cases}\right]$$

$$= P_{(x*C+ y)} = P_{(xy)}.$$

Decryption based on Column

$$\mathbf{D}\left[\begin{cases} P_{(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is positive} \\ P_{N+(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is negative} \end{cases}\right] = \mathbf{E}^{-1}\left[\begin{cases} P_{(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is positive} \\ P_{N+(x + y*R) - \mu} & \text{if } x + y*R - \mu, \text{ is negative} \end{cases}\right]$$

$$= P_{(x+R* y)} = P_{(xy)}.$$

Step 5: Estimate the degree of relation between encryption and decryption values by using Rank Correlation.

Step 6: Using Step 5, to test the standard of methodology.

Example: 2 Image scrambling by using M modulo *N* graceful labeling

Step 1: Let the total number of pixels of image as $N = 2^4 = 16$ ([R =]4 × [C =]4)

Step 2: Naming the Pixels

Let x = 0 to 3 and y = 0 to 3

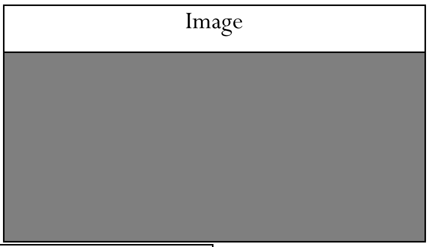


Image to Pixel(P_{xy})			
P_{00}	P_{01}	P_{02}	P_{03}
P_{10}	P_{11}	P_{12}	P_{13}
P_{20}	P_{21}	P_{22}	P_{23}
P_{30}	P_{31}	P_{32}	P_{33}

Pixel(P_{xy}) to Place value(P_{x*C+y})			
P_0	P_1	P_2	P_3
P_4	P_5	P_6	P_7
P_8	P_9	P_{10}	P_{11}
P_{12}	P_{13}	P_{14}	P_{15}

Figure.4 Describes the original image to pixel and Pixel to place value

Step 3: Encryption is defined as follows with $\mu = 3$

Shuffling based on Row $\mathbf{E}[P_{(xy)}] = \begin{cases} P_{(x*4+ y) - 3} & \text{if } x*4+ y - 3 \text{ is positive} \\ P_{N+(x*4 + y) - 3} & \text{if } x*4 + y - 3 \text{ is negative} \end{cases}$

Shuffling based on Column $\mathbf{E}[P_{(xy)}] = \begin{cases} P_{(x + y*4) -3} & \text{if } x + y*4 - 3 \text{ is positive} \\ P_{N+(x + y*4) - 3} & \text{if } x + y*4 - 3 \text{ is negative} \end{cases}$

Let x = 0 to 3 and y = 0 to 3

Image			
P_{00}	P_{01}	P_{02}	P_{03}
P_{10}	P_{11}	P_{12}	P_{13}
P_{20}	P_{21}	P_{22}	P_{23}
P_{30}	P_{31}	P_{32}	P_{33}

Row wise Encrypted image			
P_{13}	P_{14}	P_{15}	P_{0}
P_{1}	P_{2}	P_{3}	P_{4}
P_{5}	P_{6}	P_{7}	P_{8}
P_{9}	P_{10}	P_{11}	P_{12}

Column wise Encrypted image			
P_{13}	P_{1}	P_{5}	P_{9}
P_{14}	P_{2}	P_{6}	P_{10}
P_{15}	P_{3}	P_{7}	P_{11}
P_{0}	P_{4}	P_{8}	P_{12}

Figure.5 Encrypted image with respect to row and column

Step 4: Decryption of image scrambling:
Let x = 0 to 3 and y = 0 to 3

Based on Row

$$\mathbf{D}\left[\begin{cases} P_{(x*4+y)-3} & \text{if } x*4+y-3 \text{ is positive} \\ P_{N+(x*4+y)-3} & \text{if } x*4+y-3 \text{ is negative} \end{cases}\right] = \mathbf{E}^{-1}\left[\begin{cases} P_{(x*4+y)-3} & \text{if } x*4+y-3 \text{ is positive} \\ P_{N+(x*C+y)-3} & \text{if } x*4+y-3 \text{ is negative} \end{cases}\right] = P_{(x\,y)}$$

Based on Column

$$\mathbf{D}\left[\begin{cases} P_{(x+y*4)-3} & \text{if } x+y*4-3 \text{ is positive} \\ P_{N+(x+y*4)-3} & \text{if } x+y*4-3 \text{ is negative} \end{cases}\right] = \mathbf{E}^{-1}\left[\begin{cases} P_{(x+y*4)-3} & \text{if } x+y*4-3 \text{ is positive} \\ P_{N+(x+y*4)-3} & \text{if } x+y*4-3 \text{ is negative} \end{cases}\right] = P_{(x\,y)}$$

Row wise Encrypted image			
P_{13}	P_{14}	P_{15}	P_{0}
P_{1}	P_{2}	P_{3}	P_{4}
P_{5}	P_{6}	P_{7}	P_{8}
P_{9}	P_{10}	P_{11}	P_{12}

Column wise Encrypted image			
P_{13}	P_{1}	P_{5}	P_{9}
P_{14}	P_{2}	P_{6}	P_{10}
P_{15}	P_{3}	P_{7}	P_{11}
P_{0}	P_{4}	P_{8}	P_{12}

Decrypted image			
P_{00}	P_{01}	P_{02}	P_{03}
P_{10}	P_{11}	P_{12}	P_{13}
P_{20}	P_{21}	P_{22}	P_{23}
P_{30}	P_{31}	P_{32}	P_{33}

Figure.6 Decrypted original image with pixel from Encrypted image

Step 5:

	Based on Row (Scrambling)			**Based on Column (Scrambling)**		
Pixel Value	**Encryption Value**	**Decryption Value**		**Encryption Value**	**Decryption Value**	
P_{xy}	**E[**$P_{(xy)}$**]** P_i, i = 0 to 15	P_{xy}	P_i , i = x*4 + y	**E[**$P_{(xy)}$**]** P_i, i = 0 to 16	P_{xy}	P_i, i = x*4 + y
P_{00}	13	00	0	13	00	0
P_{01}	14	01	1	1	01	1
P_{02}	15	02	2	5	02	2
P_{03}	0	03	3	9	03	3
P_{10}	1	10	4	14	10	4

P_{11}	2	11	5	2	11	5
P_{12}	3	12	6	6	12	6
P_{13}	4	13	7	10	13	7
P_{20}	5	20	8	15	20	8
P_{21}	6	21	9	3	21	9
P_{22}	7	22	10	7	22	10
P_{23}	8	23	11	11	23	11
P_{30}	9	30	12	0	30	12
P_{31}	10	31	13	4	31	13
P_{32}	11	32	14	8	32	14
P_{33}	12	33	15	12	33	15

Table.1 Encryption and Decryption Values based on Row and Column

The following Figure [7, 8] clearly explain the relation between Encryption and Decryption Value based on row and column wise respectively.

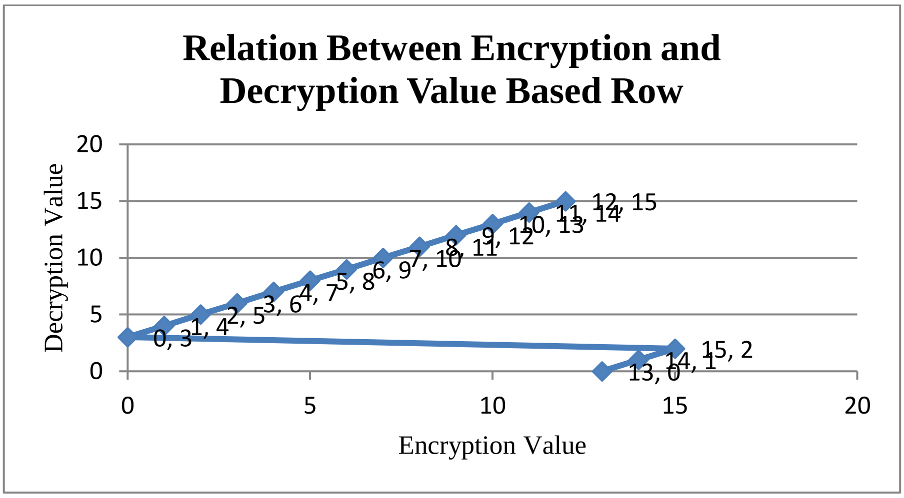


Figure.7 Relation between Encryption and Decryption Value Based Row

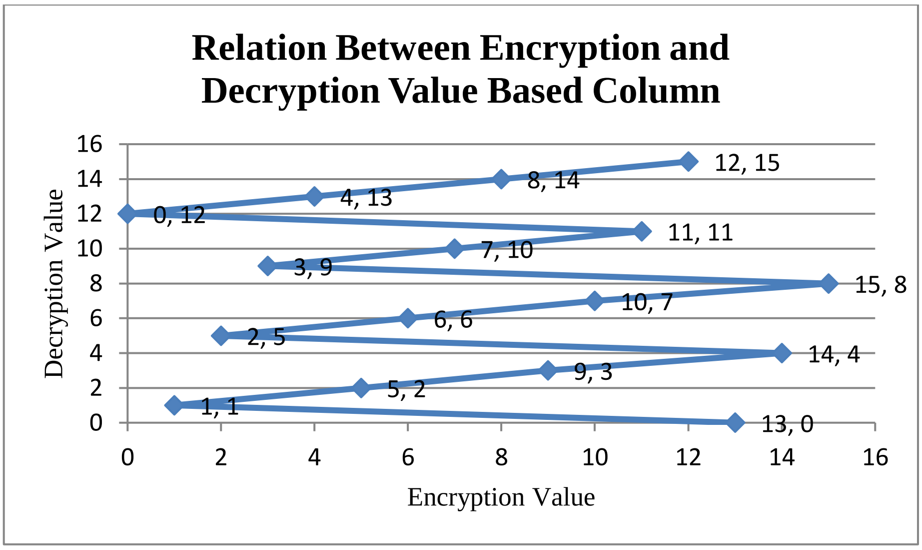


Figure.8 Relation between Encryption and Decryption Value Based Column

The following table [2,3] explains the degree of relation between Encryption and Decryption Value based on row and column wise respectively. This was evaluated by using the Data software in Excel.

Spearman Rank correlation (Based on Row Scrambling)			
Encryption Value (EV)	**Decryption Value (DV)**	**d= EV-DV**	**d²**
13	0	13	169
14	1	13	169
15	2	13	169
0	3	-3	9
1	4	-3	9
2	5	-3	9
3	6	-3	9
4	7	-3	9
5	8	-3	9
6	9	-3	9
7	10	-3	9
8	11	-3	9
9	12	-3	9
10	13	-3	9
11	14	-3	9
12	15	-3	9
		Total	624
	Spearman Rank correlation	0.08235294	

Table.2 Correlation between encryption and decryption (row wise) is 0.08235294.

Spearman Rank correlation $\rho = 1 - \frac{6\sum d_i^2}{n[(n)^2-1]}$

Here n = mn, $\rho = 1 - \frac{6\sum d_i^2}{mn[(mn)^2-1]} = 1 - \frac{6\times634}{16[(16)^2-1]} = 0.08235294$

Spearman Rank correlation (Based on Column Scrambling)			
Encryption Value (EV)	**Decryption Value (DV)**	**X= EV-DV**	**X²**
13	0	13	169
1	1	0	0
5	2	3	9
9	3	6	36
14	4	10	100
2	5	-3	9
6	6	0	0
10	7	3	9
15	8	7	49
3	9	-6	36
7	10	-3	9
11	11	0	0
0	12	-12	144
4	13	-9	81
8	14	-6	36
12	15	-3	9
		Total	696
	Spearman Rank correlation	-0.0235294	

Table.3 Correlation between encryption and decryption (column wise) is -0.0235294

Spearman Rank correlation $\rho = 1 - \frac{6\sum d_i^2}{n[(n)^2-1]}$

Here n = mn, $\rho = 1 - \frac{6\sum d_i^2}{mn[(mn)^2-1]} = 1 - \frac{6\times 696}{16[(16)^2-1]} = -0.0235294$

Step 6: From the above figure 4 and 5 and table 2 and 3, it's clear that the degree of association between encryption and decryption is very poor. Also, which indicate that Row to Column or Column to Row shuffling more effective than Row to Row or Column to Column shuffling.

CONCLUSION

This study concludes that the binomial tree is satisfied M modulo *N* Graceful Labeling so that which is known as the M modulo *N* Graceful graph. With the use of our suggested labeling approach, two different sorts of scrambling strategies, such as row- and column-wise pixel shifting in an image, were examined. Since it is more difficult to obtain the original image without knowing the precise design, encryption and decryption have very low correlations, according to the Spearman Rank Correlation research. As a result, it prohibits unwanted access to the information.

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