# Manufacturing intelligent Corvus corone module for a secured two way image transmission under WSN

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## Abstract

**Purpose** – The manufacturing of intelligent and secure visual data transmission over the wireless sensor network is key requirement nowadays to many applications. The two-way transmission of image under a wireless channel needed image must compatible along channel characteristics such as band width, energy-efficient, time consumption and security because the image adopts big space under the device of storage and need a long time that easily undergoes cipher attacks. Moreover, Quizzical the problem for the additional time under compression results that, the secondary process of the compression followed through the acquisition consumes more time.

**Design/methodology/approach** – Hence, for resolving these issues, compressive sensing (CS) has emerged, which compressed the image at the time of sensing emerges as a speedy manner that reduces the time consumption and saves bandwidth utilization but fails under secured transmission. Several kinds of research paved path to resolve the security problems under CS through providing security such as the secondary process.

**Findings** – Thus, concerning the above issues, this paper proposed the Corvus corone module two-way image transmission that provides energy efficiency along CS model, secured transmission through a matrix of security under CS such as inbuilt method, which was named as compressed secured matrix and faultless reconstruction along that of eminent random matrix counting under CS.

**Originality/value** – Experimental outputs shows intelligent module gives energy efficient, secured transmission along lower computational timing also decreased bit error rate.

**Keywords** Two-way image transmission, Wireless channel, Manchester coding, Regression, Chaotic encryption, MIMO, Rayleigh fading channel, Manufacturing for monitoring and manipulation problems

**Paper type** Research paper

## 1. Introduction

Degree of compression, distortion size, when images are downloaded from the web (Mahesh *et al.*, 2016; Stolfo, 1997; Talukder and Harada, 2010), are some of the aspects to note. Compression leads to deterioration of the image content, so pre-processing approaches such as optimization, segmentation and representation need to be

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performed to address these consistency-based issues (Oh and Lei, 2012). Once pre-processed, the image gets formatted through various techniques, resulting under digital form. These digital signals consume large space and more time when it moves through a wireless channel (Yang *et al.*, 2016). The following Figure 1 shows the image transmission process through the channel.

The prepared sign should be reformatted during image handling to get the first transmitted image, yet this sign will likewise give repetitive data (Manapragada and Kluesing, 2014). It is additionally imperative to give an appropriate pressure procedure to take out such repetitive information (Qaisar *et al.*, 2013). Compressive sensing [CS] a sensing methodology that packs the sign obtained at the hour of sensing develops and dispenses with the repetitive information (Zhang *et al.*, 2016). Signs can be spoken to as a scanty either compressible structure different area (Marvasti *et al.*, 2012). As a result of the scanty idea of the signs, the CS innovation permits us to test the sign, much beneath Nyquist rate (Karakus *et al.*, 2013). Moreover, the remaking calculations of CS can dependably recreate the first sign back from less compressive estimations (Zhang *et al.*, 2012). The Figure 2 shows the CS under the channel.

The principle necessity of CS for legitimate reproduction is that the estimations must take haphazardly for an appropriate choice of the estimation lattice. The general estimation networks used under CS are the irregular frameworks drawn from Gaussian either Bernoulli dispersion or halfway Fourier matrices (Rauhut, 2010). Such arbitrary frameworks are incongruous along each different premise and comply with the state of ideal recuperation of the restricted isometric property (Tropp and Gilbert, 2007). On the off chance that Gaussian circulation has a place with an orthonormal premise, at that point the grid will be Gaussian disseminated and under this way we will have the option to recuperate the specific arrangement along high likelihood (Candes and Tao, 2006). Despite the fact that the CS has

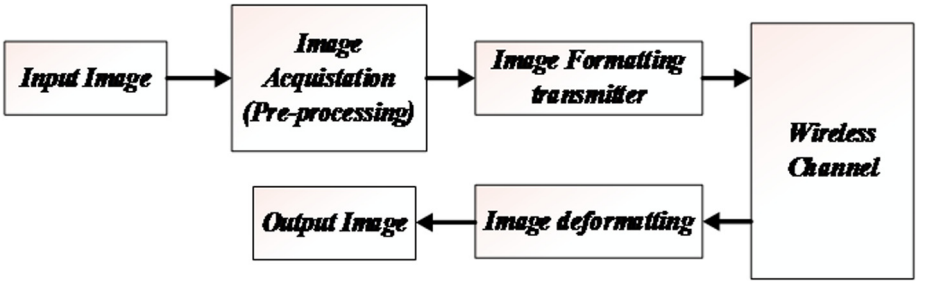



**Figure 1.**
Image transmission under WSN

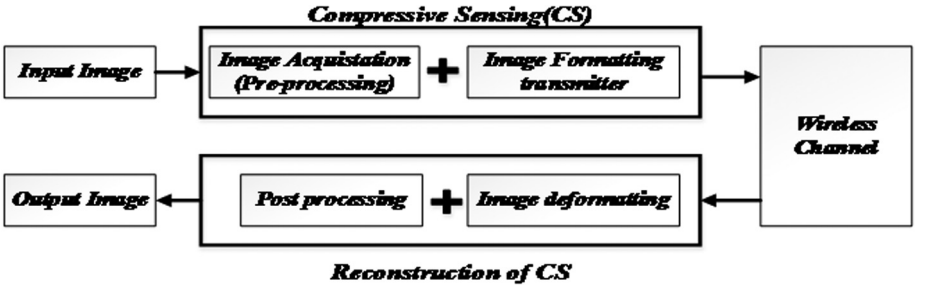



**Figure 2.**
Image transmission using CS

been assessed along arbitrary estimation networks yet the issue along irregular grids is that we cannot store and imitate them at collector (Otazo *et al.*, 2015). This framework needs a tube transmitted along the sign. So the scientists have redirected their consideration toward the plan of deterministic and organized estimation grids that can be used as CS estimation lattices. Instances of such lattices are circulate, toilets and organized arbitrary networks (Haupt *et al.*, 2010), which has made it conceivable to use CS for down to earth applications. The upsides of organized arbitrary grids are quicker obtaining, lesser capacity prerequisite and reproducibility and diminished transmission overhead, while the downside is its security worry during transmission (Ponuma and Amutha, 2017).

CS reproduction calculations attempt to discover the scanty estimation regard first information signal, through compressive estimations, on some appropriate premise either casing either word reference (Paredes *et al.*, 2007). A great deal of exploration was done on this part regard CS, to come up along best performing calculations. Exploration driving elements here is the capacity to recoup from a base number of estimations, clamor vigor, speed, multifaceted nature, execution ensures, etc. (Marvasti *et al.*, 2012). Because of the expansion of commotion under the remote medium, the CS remaking stage decays under assessing the irregular estimations lattice taken through the CS. Wireless channel experiences blurring and takes a multipath spread to arrive at the collector (Watteyne *et al.*, 2010). These outcomes under corrupting the first transmitted sign, consequently there is a requirement for balancing the first sign before transmission. Interleaving methods are basic to battle the impact of burst blunders because of blurring, obstruction and multi-path spread under remote correspondence (Kohno *et al.*, 1995). Through using linear minimum mean square error adjustment collector, they broke down a framework through using helical and turbulent interleaving procedures (El-Bakary *et al.*, 2013). Under view of perceptions using peak signal to noise ratio (PSNR) and root mean square error they inferred that turbulent interleaving gives best than helical interleaving.

A total of 16-HQAM (Hierarchical quadrature amplitude modulation) can be used regard image transmission, which enhance data transfer capacity effectiveness along the non-appearance regard DC part through transmitted sign and median filter can be used to lessen commotions at the channel. HQAM has been development form regard QAM at similar information rate of transmission along enhanced assurance regard particular area under image through additional clamor under the channel. Any data through the channel needs the pressure, as well as the security from the different figure assailants, for example, data infiltration, bad data injection, etc. Numerous sorts of examination cleared an approach to illuminate the security problems under CS through giving security such as optional procedure, recommending thetas an inbuilt procedure under CS. Likewise, when transmitting under channel, commotion, which included, ought to appropriately evaluate on the beneficiary side with the goal that information image could reproduce into their unique form (Ghani *et al.*, 2018).

All through late years, a few synchronization strategies have been executed for boisterous oscillators along some security usage. The key motivation behind synchronizing two loud oscillators is to build up stable correspondence systems to ensure obscurity, give insurance and be versatile under assaults. This can be demonstrated through dissecting the connection between the first information, the messy condition covering the data being conveyed under vulnerability and the information being recovered (Liao *et al.*, 2017).

On the one side, building ideal multi scroll clamorous oscillators either multi-dimensional disordered attractor requires high expected examples of Lyapunov (MLEs). The field-programmable entryway cluster (FPGA) acknowledges, and then again, depends on the computational methodology used to settle the conditions speaking to our models. All things

considered the execution of these calculations for an installed framework either MCU is a lot of computational burden. While microchip maker offers an equipment crypto motor for cryptographic capacities along AES, DES and 3DES calculations on the PIC24F and PIC 32MZ chips, this arrangement is bolstered through a solitary library for standard applications, for example, online access, secured XML moves, virtual private systems and safe information transmission (Ahmad *et al.*, 2017). Recently as the emerging internet of things enabled applications needs to the robust and secure data transmission techniques (Yang *et al.*, 2016; Chaves *et al.*, 2017), the manufacturing of secure visual data transmission methods with higher quality and minimum computation efforts is required.

Consequently, regard best two-way transmission of the image; this research structures a novel intelligent Corvus corone module for transmitting image along small vitality utilization and greater security. This technique requires less transfer speed through picking the irregular variable under the spatial area during the quantization process and uncovering a lot of estimator conduct under de-quantization. Likewise, recognized structure the current frameworks the vulnerability and dissemination of a tumult property under a fiddling chime is used as a planning state under quantization that has the aptitude of perceiving the client along the language natural of the pixies, with the goal that the image bits cannot be deciphered through figure aggressors, under this way providing the image bits along a serious extent of security. The utilization of mid-rate Manchester bit coding under this proposed module can possibly reestablish the first bits along their clock recuperation property through understanding the status of unique bits and including clamor level. The savvy module would likewise diminish the requirement for new sifting techniques, which ingest additional time, here. The Corvus corone module gives improved vitality effective and stable two-way image transmission through its quantization procedure along assurance and the transmission organize.

The framework regard this research summed up as follows. Section 2 arrangements along related exploration works. Section 3 talked about the proposed technique. Section 4 examined about the outcome and execution assessment of this exploration and end under Section 5.

## 2. Related works

Liao *et al.* (2017) introduced another strategy for detachable data stowing ceaselessly under mixed pictures using CS and discrete Fourier change. As exhibited through that framework, CS used just to pack and encode the parts containing the puzzle message under the wake of hiding the mystery message. The estimation number for CS entertainment decreases monotonically along the decrease of weight rate. To keep the picture not sensationally expanded, the weight rate must be a little respect. Under this manner, along the diminishing of the estimation number for CS diversion, it is unimaginable to totally address implanted data and recoup exceptional picture.

Ahmad *et al.* (2017) portrayed a technique considering the dazzling properties of an even lattice through strategies for the Gram Schmidt check. During the time spent square clever self-confident change, the decided guide was used trailed through the dissipating approach. The method explains under performs encryption and interpreting using the symmetric key, for instance a relative key (mystery key) used at the encryption and disentangling side. Picture mixed along a riddle key can unscramble just along a similar mystery key. The chance of spatiotemporal chaos can additionally improve the security suitability of the game plan.

Tlelo-Cuautle *et al.* (2015) actualizes a steady correspondence framework; the synchronized ace slave geography is used through applying mayhem to an image at the transmitting level and through taking away disarray at the recuperation point. The disclosure of FPGA begins along the execution of numerical techniques to fathom the

arrangement of conditions that portray the entire turbulent contact organize. Furthermore, multiplier replacement through single steady augmentation squares takes out the utilization of equipment assets and additionally quickens stacking time. Three sorts of pictures are made using uproarious oscillators of two and six parchments, namely, one under dark and white and two under dim tones.

Guillén-Fernández *et al.* (2019) simulated to deliver tumultuous time arrangement, which was used to test their Lyapunov types and Kaplan Yorke measurement to evaluate their flightiness, these riotous oscillators are. Oscillators along the unequivocally positive Lyapunov type are executed under an FPGA and then consolidated under an ace slave geography using three procedures, namely, Pecora-Carroll's spearheading work, Hamiltonian types and onlooker strategy, and open plus-shut circle technique. Such methodologies are thought about for their synchronization mistake and the deferral related along the execution of FPGA.

Garcia-Guerrero *et al.* (2020) features that the key measures for cryptography permit the current installed cryptosystems to be progressively compelling and stable, which implies they will be faster and give more noteworthy unwavering quality. The new cryptosystems, for instance, should be consistent along the current broadcast communications conventions and under this manner must be vitality efficient. This article presents a strategy to support the haphazardness of five flimsy guides applied on a PIC microcontroller, thusly. The improved clamorous guides are tried for encryption of advanced pictures through ZigBee diverts under a remote correspondence conspire, especially on a machine-to-machine arrange.

Krishna *et al.* (2018) used disorganized planning to scramble the image pixels to explicit situations along changes under pixel esteems. The techniques for image encryption are open for image encryption by means of the inherent inward key generator. Hyper-Chaos is portrayed as a clamorous action along at any rate two positive examples of Lyapunov along one zero and one negative type of Lyapunov. For this procedure, the image encryption is accomplished using a two-dimensional hyper-confused guide for change and the making of various hyper-riotous guides for dispersion. The encryption of the image is accomplished through a few muddled guides.

The above works distinguish considerably testing issues for the two-way image transmission. The center thought regarding the Liao *et al.* (2017) and Ahmad *et al.* (2017) has been for giving security under CS regard image through encryption and decoding (Song *et al.*, 2019), which needs to transmit, They clarify the method of ensuring the pictures by symmetric key plan and stage procedure yet these developments neglects to focus recreation of unique information along less number of quantifiable (Hassen, 2018). Increment under number of encryption adjusts (Tlelo-Cuautle *et al.*, 2015) diminished security (Guillén-Fernández *et al.*, 2019) little key space and feeble security.

Similarly, issues under the channels are distinguished and to some degree redressed through crafted by the Song *et al.* (2019), Hassen (2018). Through the definite examination, it comes to realize that there is despite everything ailing under the papers for giving the security such inbuilt procedure under CS and best possible estimation regard clamor under irregular quantifiable regard remaking phase. So, a need emerges regard scientists to redress problems under the two transmission of an image through giving inbuilt security and correct estimation under the recreation stage.

## 3. Intelligent Corvus corone module for two-way image transmission under WSN

The two-way image transmission framework has the issue of expending more vitality because of enormous data transfer capacity use through a colossal number of bits and

experiences different procedures such as procurement, pressure, a change, which needs extra computational time along these lines way decreases the speed of the preparing time. Henceforth, to defeat as a joined hotspot for securing, pressure and change, the idea of CS is used through their inclination of dimensional decrease and arbitrary projection, which detected itself and diminishes the data transmission use. This module performs less data transfer capacity use through quantization along choosing the irregular variable under the spatial space as a regularized structure using least squares models and uncovers a considerable sum about the conduct of the estimators under de-quantization.

Along this, confusion and scattering of a pandemonium property under a fiddling ringer is used as an arranging condition under quantization, which has the distinguishing strength of seeing just to those unmistakable along the language of the imps so the picture bits cannot be appreciated through figure aggressors, therefore, gives high security to the picture bits. By then to transmit these bits with no curving of signs, there is must have a change plot, which is finished for the transmission under MIMO channel that are allowed to access under the full-duplex channel, which makes to grant under the two course. While transmitting through the channel the additive white Gaussian noise (AWGN) get included, so it could be filtered fittingly under the amusement stage to recover the first encoded bits.

As necessities are, under this proposed module, the use of mid-rate bit coding of Manchester can recover the primary bits along their clock recovery property through understanding the principal bits state and included commotion state. Along these lines, the insightful module will decrease the need of new isolating methodology, which exhausts additional time, here. Through the general creation, the Corvus corone module gives the better imperativeness capable and ensured around two-way picture transmissions through their methodology of quantization along security and the transmission plot. The Overall arrangement of the proposed two-way picture transmission depicted underneath.

Under the above Figure 3, Clients 1 and 2 interface under two-manner correspondence through the proposed Corvus corone module transmission framework. Under the

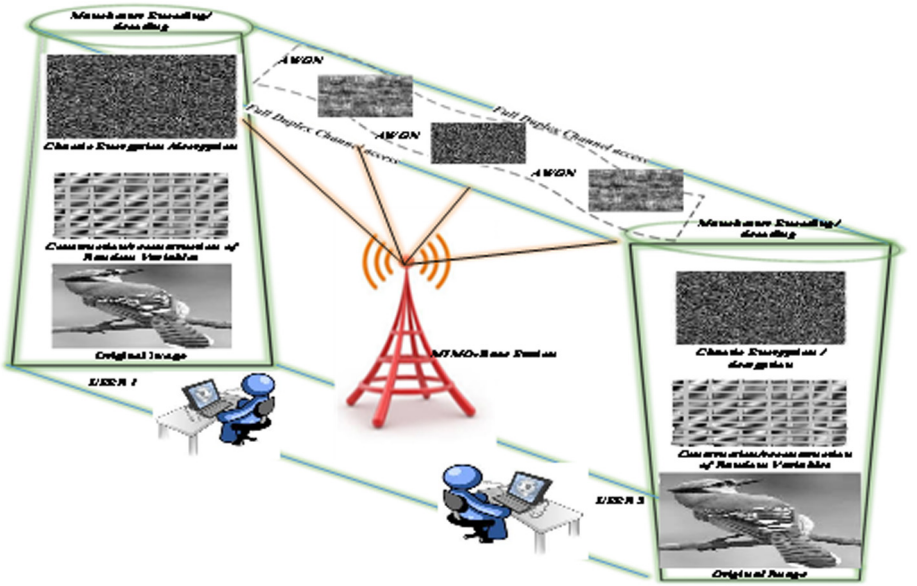



**Figure 3.**
A two-way transmission system through Corvus corone module

transmitter side, the client transmits the picture through developing the arbitrary variable as a packed structure from the first picture and then using the clamorous property of the dabbling chime the factors under the picture get encoded.

At that point for transmission by means of the channel, the picture gets encoded along the BPSK-based Manchester coding, through which noise under the channel can be assessed for the two-way transmission, a full-duplex framework under the MIMO channel. Under the reproduction stage, the noise impacts get limited through the clock recuperation property at that point finished the unscrambling and then the recreation procedure is done to get the first picture through the collector. The scientific clarification for the proposed module given underneath under the accompanying area.

*3.1 Providence of compressed security under two-way image transmission*

Let assume image $I_{m,}$ which has to be transmitted through users has been shown through equation (1) as:

$$I_m = \begin{bmatrix} P_{1,1} & P_{1,2} & P_{1,j} \\ P_{2,1} & P_{2,2} & P_{2,j} \\ \vdots & & \\ P_{i,1} & P_{i,2} & P_{i,j} \end{bmatrix} \tag{1}$$

Here I, j = 1, 2, 3 . . . $n$. On the off chance that the picture is transmitted through Client 1 to Client 2, attributable to the high number of bits under the $I'_m$, the data transfer capacity usage under the channel get increments thus, way the necessity of vitality gets expanded and influences the whole transmission framework. So to get vitality productive and less data transfer capacity usage, the requirement for compacting the picture Imis required. Presently, the proposed module presented a security grid under the CS as an inbuilt procedure, which was named as a packed security framework.

To produce the compacted security framework, "*C*," for the picture $I'_m$ under equation (1), the input picture and the irregular estimation network along the security grid are increased together, which can be portrayed mathematically and given underneath as:

$$C = a\varpi I_m \tag{2}$$

where, $\varpi \in {I_m}^{i\times j}$ *or* ${P_{ij}}^{i\times j}$ is the random measurement matrix, $c \in {I_m}^{i\times j}$ *or* ${P_{ij}}^{i\times j}$ is the compressed security measurement vector of length I and $a \in {I_m}^{i\times j}$ is the security matrix of area $i \times j$.

Here, the quantity of estimations taken is a lot lesser than the length of info picture, i.e. $i < j$. The size of the estimation network and the quantity of estimations is corresponding to the sparsely of the info signal.

The systems for building the compacted made sure about framework using the proposed module are given underneath:

*Step 1: Sensing input image for transmission*

The info picture $I_m$ is detected for the transmission, which can speak to through the pixel esteem $P_{ij}$. The property of the pixel $P_{ij}$ is given through:

$$p_{ij} = \begin{bmatrix} a_1 & a_2 & a_m \\ b_1 & b_2 & b_m \\ \vdots & & \\ z_1 & z_2 & z_m \end{bmatrix} \tag{3}$$

Here a,b,. . .. .. .. .. .. .., z represents the features of the image $I_{m.}$

*Step 2: Construction of random measurement*

Under the development period of the proposed module, it is critical to choose the irregular estimation under the light of the fact that the ill-advised choice of the arbitrary measure prompts defective recovery of the picture. So the development of arbitrary estimation is done to improve the forecast precision and interpretability of relapse models through modifying the model fitting process. Let, us consider the features from the image pixel $P_i = \left[a_i, b_i, c_{i,\ldots\ldots} z_i\right]$ and construct the random measurable for $\boldsymbol{\varpi}_i$ is given through:

$$\boldsymbol{\varpi}_i = \frac{1}{N}\sum_{i=1}^{N} f\left(P_i, P_{ij}, \boldsymbol{\tau}, \boldsymbol{\upsilon}\right) \tag{4}$$

where $Pi$ = ($Pi$) tare the indicator highlights variables, $x_i$ is the reactions and are the recuperating boundaries for expectation precision and interpretability. Under equation (4), the module select just a subset of the gave covariates to accomplish both of these objectives through constraining the whole of the outright estimation of the relapse coefficients to be not exactly a fixed worth, which powers certain coefficients to be set to zero, viably picking a less complex model that does exclude those coefficients.

$$\sum_{i=1}^{N} \frac{1}{N} P_i = 1; \sum_{i=1}^{N} \frac{1}{N} P_i^2 = 0.$$

Through choosing these coefficients along expectation precision and decipher the parameters, the arbitrary factors can be effortlessly recognized and reproduced under the last stage. To shield these factors from the different figure assaults, the requirement for the encryption is emerging that can be clarified under the accompanying procedure.

*Step 3: Construction of Security Matrix*

The security grid having a two-dimensional discrete-time dynamical framework got from the equation (5) is dependent upon the current riotous qualities $a_i$, finished the following clamorous qualities band its control boundaries $p$, q, r, s, which assists with confounding and diffuses the assailants are given through the conditions:

$$a_{i+1} = a_i^2 - b_i^2 + pa_i + qb_i \tag{5}$$

$$b_{i+1} = 2a_i b_i + ra_i + sb_i \tag{6}$$

The underlying qualities considered are $a_{0,}$ bound boundaries are $p$ = 0.9, $q$ = −0.6013, $r$ = 2.0, s = 0.50.Through their disarray and dissemination property along the highlights, the pixel esteems under the picture get encoded and make each an incentive under the picture

pixel get shielded from the aggressors. The disorganized qualities under equations (5) and (6) of Tinkering chime makes the pixel under the scrambled structure and gives befuddled data about the information, accordingly making more confusion forth aggressors. At that point to deliver the packed made sure about type of a picture the accompanying numerical assessment did.

*Step 4: Creation of compressed made sure about picture*

Through the above structure scenarios, the contribution from the picture under equation (1),the network framed through the irregular quantifiable under equation (5) and the disordered qualities acquired under the equations (5), (6) gets duplicated and shapes the compacted made sure about matrix output given through the equation (7) is:

$$c_i = \begin{bmatrix} a_i \\ b_i \end{bmatrix} \left[ \frac{1}{N} \sum_{i=1}^{N} f\left(P_{ij}, x_i, \tau, \upsilon\right) \right] \begin{bmatrix} p_{11} \\ p_{12} \\ p_{1j} \end{bmatrix} \tag{7}$$

Through the above equation (8), the obtained matrix is under the compressed form $c_i = \begin{bmatrix} c_{11} \\ c_{12} \\ c_{1j} \end{bmatrix}$.

Under this way as expressed over, the picture is compacted as a solitary grid, subsequently, the quantity of bits gets decreased, which under-turns produce the vitality effective transmission along less usage of data transfer capacity. Additionally through the change of the pixel esteems into the disorderly values, all the pixels get scrambled; under this manner, it shields the picture information from the aggressors.

The above Figure 4 clarifies that under the principal stage the picture, which must transmit, chose through speaking to all the qualities as a pixel portrayal. At that point, the irregular estimation chose as aunt line either section matrix gets used. At long last, for security, disorganized produced and bay multiplicative factor, the last compacted made sure about grid formed. Now the packed made sure about yield must be transmitted into the MIMO channel with the goal that the Client 2 can get the picture of Client 1.

### *3.2 Transmission of image via MIMO channel*

To improve framework limit and unwavering quality, the module uses the MIMO strategy. Along the advancement of reception apparatus, MIMO and obstruction dropping methods, it is conceivable to understand the concurrent transmission on a similar band simultaneously. Additionally, the concealed terminal issue, clog issue caused through MAC booking and the enormous postpone issue under the multi-jump remote system can be tackled under the MIMO. The boundaries considered for the channel transmission is given through (Table 1).

Manchester encoding uses the reversal at the center of each piece stretch for both synchronization and bit portrayal. Through using a solitary change for a double reason, Manchester encoding accomplishes a similar degree of synchronization as RZ, however, along just two degrees of sufficiency. Like all other coding strategies, the Manchester code follows an algorithm to encode information. This algorithm goes this way: the information are spoken to along line changes. Rationale 0 is spoken to through a change from high to low and rationale 1 is spoken to through a progress from low to high.

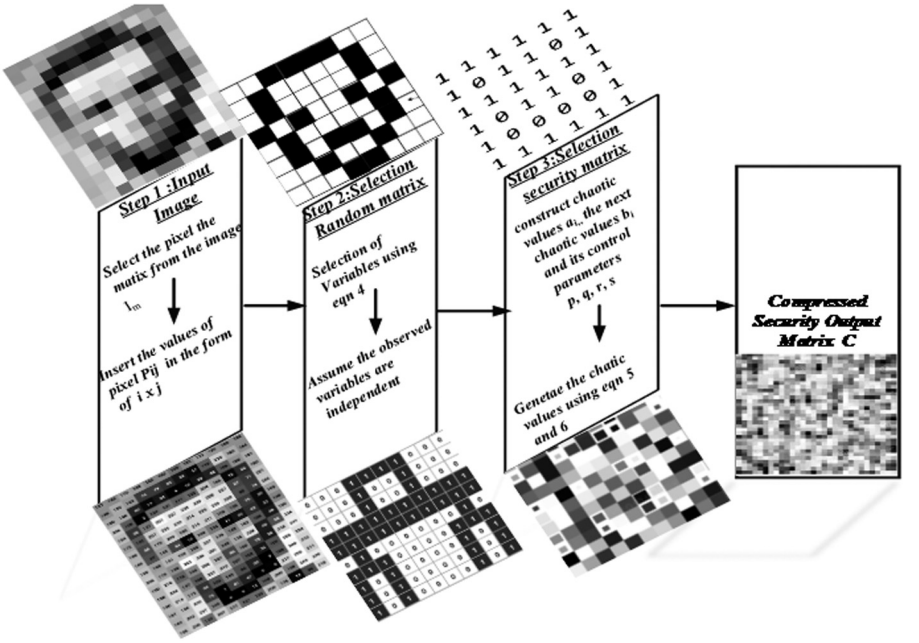



**Figure 4.**
A pseudocode for compressed security matrix

| Terms | Method considered |
|---|---|
| Transmission/receiving scheme | MIMO |
| Channel access | Full duplexing |
| Modulation scheme | BPSK |
| Coding scheme | Manchester coding |
| Fading channel | Rayleigh fading channel |
| Noise considered | Additive white Gaussian noise (AWGN) |

**Table 1.**
Considered term for two-way image transmission

The portrayal of Manchester encoder is given through the:

$$K(t) = c_i \oplus \mathrm{CL} \tag{8}$$

Through acquiring the quantity of bits the BPSK tweak accomplished for the full-duplex MIMO channel, which is given through:

$$\phi(t) = K(t)\sqrt{\frac{2}{b_s}}\cos(2\pi \mathrm{q_c t}) \tag{9}$$

where $2\pi \mathrm{q_c t}$frequency term, $b_s$ is the number of bits per seconds.

For transmission, the framework comprises of two hubs, and every hub has two receiving wires that can transmit and get information. Under terms of one hub, the MIMO transmitting signal handling module transforms the computerized signal into two branches.

This framework permits hubs to transmit and get parcels at the same time and can possibly improve framework dependability and information rate through extra coding and space assorted variety procedures. Subsequent to tweaking the sign, they are transmitted through the Rayleigh blurring channel and the AWGN noise included. Through using the MIMO channel along full-duplex access, the dependability and information pace of the framework are improved. BPSK Manchester coding is accomplished for adjustment. The diagrammatic portrayal for the transmission channel has given beneath (Figure 5).

At that point at the beneficiary end, the picture signals get demodulated through BPSK and using the clock recuperation property of Manchester code they are decoded to their unique structure. To recuperate the first picture, the remaking eliminate is conveyed that can be clarified under the accompanying segment.

*3.3 Reconstruction of compressed security under two-way image transmission*

Subsequent to transmitting the adjusted picture signal into the MIMO channel along full-duplex access, the got signal from the channel along the expansion of AWGN into the Raleigh Fading Channel is given through the articulation:

$$\varphi(t) = \phi(t) + e \tag{10}$$

where $e$ is the AWGN, the noise that additional could appraise appropriately, with the goal that it is anything but difficult to recapture the first adjusted sign. The estimation noise under the channel given through:

$$e = \frac{1}{2}\ \pi \mathrm{q_c}\,\mathrm{t}\left(\sqrt{\frac{\mathrm{U}}{\mathrm{V}}}\right) \tag{11}$$

Here $\frac{\mathrm{U}}{\mathrm{V}}$ is the signal to noise ratio (SNR). The retrieval of the modulated signal along the estimation of the noise under equation (12) given through:

$$\hat{\phi}(t) = \varphi(t) - \frac{1}{2}\ \pi \mathrm{q_c}\,\mathrm{t}\left(\sqrt{\frac{\mathrm{U}}{\mathrm{V}}}\right) \tag{12}$$

Using equation (13), the signal get demodulated through the BPSK that is given through:

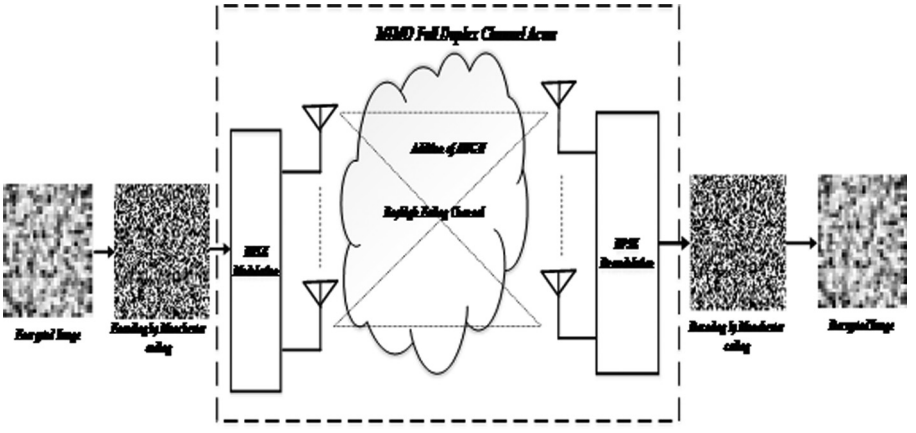


**Figure 5.**
Transmission of the image through MIMO channel

$$\hat{K}(t) = \frac{\hat{\phi}(t)}{\sqrt{\frac{2}{b_s}}\cos(2\pi q_c t)} \tag{13}$$

In the wake of demodulating the signs under the reproduction stage, the sign, which is encoded along the Manchester coding get decoded through the clock recuperation property of the Manchester, which is given through the equation (14) as:

$$\hat{c_i} = \mathrm{CL} \oplus \hat{K}(t) \tag{14}$$

Presently the first tweaked signal gets decoded. At that point to recover the first picture the accompanying efficient methodology were used through isolating every network under the above equation (15) to get the first picture. The choice of security lattice can decode by the backwards capacity of the turbulent benefits of dabbling ringer. Through knowing the underlying tumultuous qualities, the unscrambling of the grid is done through the qualities, which has been set done at first is given through:

$$\hat{\alpha} = \begin{bmatrix} a_i \\ b_i \end{bmatrix}^{-1} \tag{15}$$

At that point the arbitrary network, which was gotten through the state of the relapse rule be anticipated through:

$$\hat{\varpi} = \underset{\tau,\upsilon}{Min} = \frac{1}{N}\sum_{i=1}^{N} f\left(P_{ij}, C_{ij}, \tau, \upsilon\right) \text{ Subjected to } \|\upsilon\| < t \tag{16}$$

In this manner through anticipating the arbitrary lattice through the relapse rule, decoding the disordered qualities and the best possible estimation of noise, the first picture got under the recreation stage is given through relating the equations (15)–(17) is:

$$I_m = \frac{\hat{c_i}}{\hat{\varpi}\hat{\alpha}} \tag{17}$$

where $I_m$ the first picture reproduced through the proposed Corvus corone module. The pseudo-code for the recreation period of the proposed module is given underneath:

Figure 6 discloses that to decode the picture, the recreation of the compacted made sure about network is completed, at which the opposite computation for the turbulent benefits of fiddling ringer is determined at first and then using the expectation of the relapse guideline the arbitrary frameworks remade precisely. This rule assists with getting the first picture as a yield. The general algorithm for the proposed Corvus corone model is given beneath under Algorithm 1.

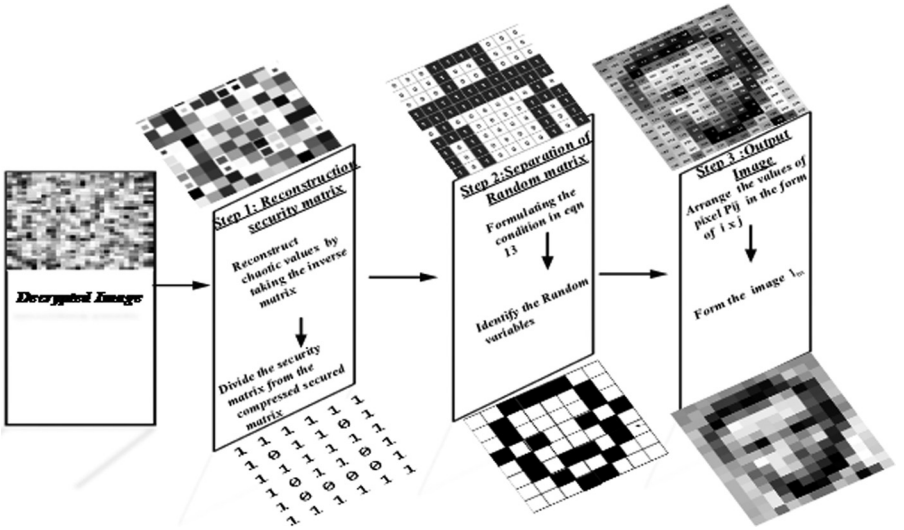



**Figure 6.**
Reconstruction of original image

Algorithm 1: Algorithm for the proposed two-way transmission Corvus corone module

*Algorithm For Corvus corone module*

Input: Image: $I_m$

Output: Image: $I_m$

Stages: Construction, Transmission, Reconstruction

*Stages 1: Construction of Compressed security Matrix*

Let $I_m = \{P_1 \ldots\ldots P_n\}$ I1....Under Image pixels

If,

Random matrix

$$\varpi \in I_m{}^{i\times j} \text{ or } P_{ij}{}^{i\times j},$$

For

$$\varpi_i = \tfrac{1}{N}\sum_{i=1}^{N} f\left(P_i, P_{ij}, \tau, \upsilon\right)$$

Then, If,

Security Function

$$a \in I_m{}^{i\times j}$$

For

$a_{i+1} = a_i^2 - b_i^2 + pa_i + qb_i$ and

$b_{i+1} = 2a_ib_i + ra_i + sb_i$

Construct the Compressed secured matrix,

$$c_i = \begin{bmatrix} a_i \\ b_i \end{bmatrix} \left[ \frac{1}{N} \sum_{i=1}^{N} f\left(P_{ij}, x_i, \tau, \upsilon\right) \right] \begin{bmatrix} p_{11} \\ p_{12} \\ p_{1j} \end{bmatrix} \text{ End.}$$

*Stages 2: Transmission through MIMO Channel*

Code,

$K(t) = c_i \oplus \text{CL}$

Modulate,

$$\phi(t) = K(t)\sqrt{\frac{2}{b_s}}\cos(2\pi \text{q}_\text{c}\text{t})$$

*Stages 3: Reconstruction Of original Image* Assume,

$$\varphi(t) = \phi(t) + e$$

$$e = \frac{1}{2}\ \pi \text{q}_\text{c}\,\text{t}\left(\sqrt{\frac{\text{U}}{\text{V}}}\right)$$

Where

Inverse the process,

$$\hat{\phi}(t) = \varphi(t) - \frac{1}{2}\ \pi \text{q}_\text{c}\,\text{t}\left(\sqrt{\frac{\text{U}}{\text{V}}}\right)$$

$$\hat{K}(t) = \frac{\hat{\phi}(t)}{\sqrt{\frac{2}{b_s}}\cos(2\pi \text{q}_\text{c}\text{t})}$$

$\hat{c_i} = \text{CL} \oplus K\hat{}(t)$

End,

Reconstruct the matrix,

If,

$$\hat{\alpha} = \begin{bmatrix} a_i \\ b_i \end{bmatrix}^{-1} \text{(1)}$$

Get Decode

$$\hat{\varpi} = \underset{\tau,\upsilon}{Min} = \frac{1}{N}\sum_{i=1}^{N} f\left(P_{ij}, C_{ij}, \tau, \upsilon\right) \text{subjected}$$

to $\|\upsilon\| < t$

(2)

Output

$I_m = \frac{c_i}{\hat{\varpi}\hat{\alpha}}$

End.

Through the general plan of the proposed Corvus corone module, the huge number of picture bits get compacted through the packed made sure about network, which helps under less data transfer capacity usage in the meantime produce the vitality proficient transmission and through the made sure about the property under the grid makes complex for the aggressors to hack the picture. The keen choice of irregular factors through the expectation and integrality property of the relapse standard makes to remake the picture precisely under the reproduction stage. Transmission of signs under the MIMO channel through the full-duplex channel get to and the usage of BPSK tweak plot along Manchester coding assists with recuperating the signs after the transmission through the Rayleigh

blurring channel even along the expansion of AWGN. Doing as a joined module, the extra calculation time taken for auxiliary procedures get ignored in this way speeds up the transmission.

Consequently, through the proposed Corvus corone module for the two-way picture transmission, the picture get increasingly perfect along the channel data transfer capacity and transmit under a made sure about way along low calculation time through their compacted security framework. To demonstrate the effectiveness of the proposed module under the method of vitality proficiency, tedious and security, the recreation is completed that can be appeared under the accompanying segment.

## 4. Results and discussion

Proposed two-way transmission of the Corvus corone module has been implemented under working platform regard MATLAB along following system specification.

**Platform:** MATLAB 2015a
**OS**: Windows 8
**Processor:** Intel Core i5
**RAM**: 8GB RAM

Through the above specification, the detail explanation of the implementation result and its performance has analyzed under the following section.

### *4.1 Performance evaluation*

The performance has analyzed under the three stages such as construction, transmission and reconstruction through the proposed Corvus corone module that has shown below (Figure 7).

*4.1.1 Construction of compressed security.* The construction regard compressed security matrix carried out through proposed Corvus corone module is shown below.


**Figure 7.**
Graphical user interface model

*Step 1: Input image*

To approve the procedure, six information pictures, for example, cameraman, Barbara, man, couple, Lena and the boat pictures are considered for the transmission that has been appeared under Figure 8.

*Step 2: Selection of random matrix*

At that point as expressed above under Section 3, for the determination of the irregular factors relapse standards did for the information pictures.

The above Figure 9 shows the portrayal of the irregular framework brought out through the arbitrary variable relapse standards for the six info pictures.

*Step 3: Construction of compressed security matrix*

Through the use of the relapse methods and the disorderly estimations of the dabbling chime, the development for the security framework did that can be appeared underneath under Figure 9 (Figure 10).

*4.1.2 Transmission of compressed secured image.* The processes executed on considering certain parameters, which are tabulated below under Table 2.

The proposed model executes along two*two MU-MIMO channels along 1,024 bits under a solitary bundle size. This procedure helped through BPSK regulation plan assessing along pants, thinking about two clients one after another. The encoded picture bits through the Manchester coding is given beneath (Figure 11).

At the point when the above signs are transmitted through the channel, the AWGN is included along the sign. After the expansion of those noises, the signs are modified, which is spoken to under the accompanying Figure 12.

**Figure 8.**
Input images

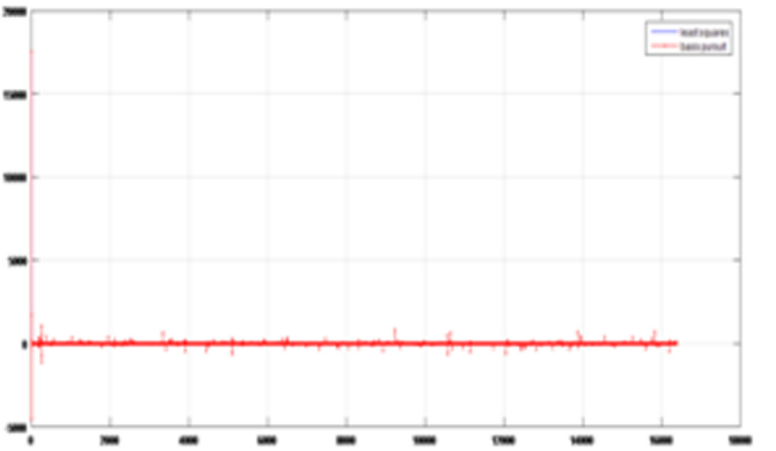


**Figure 9.**
Selection of random variables for input image (cameraman)

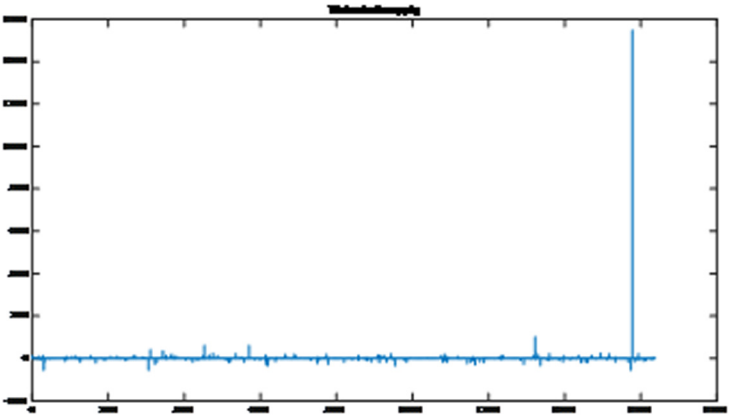


**Figure 10.**
Construction of a security matrix of input image (cameraman)

| Parameter | Description |
|---|---|
| Channel type | Downlink/uplink |
| Number of transmitting station | 2 |
| Number of receiving station | 2 |
| Number of users | 2 |
| Number of bits transmitted | 1,024 bits/packets |
| Bit rate | 1 kb/sec |
| Modulation scheme | BPSK (Manchester coding) |
| Noise considered | Additive white Gaussian noise (AWGN) |

**Table 2.**
Processing parameter

**Figure 11.**
Manchester coding (cameraman)

Figure 12 shows that the expansion of AWGN under the Rayleigh channel changes the signs into the channel. Subsequently, to recoup that the recreation procedure is brought out that can be clarified through the accompanying stages.

*4.1.3 Reconstruction of compressed security.* After the expansion of AWGN into the channel, the estimation of the Bit error rate (BER) did to recuperate the first sign encoded

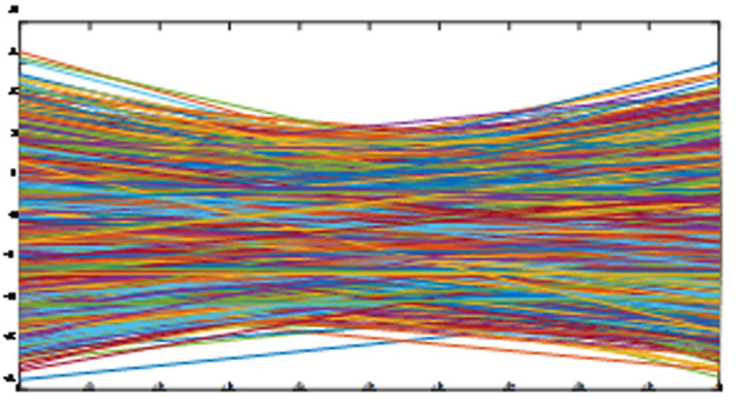


**Figure 12.**
Addition of AWGN

through the Manchester coding. For that, the clock recuperation of Manchester is used to unravel the first sign. At that point using the prescient and integrality capacity of the relapse guideline the arbitrary factors, which are chosen under the underlying stage is recouped that has appeared on the other side (Figures 13 and 14).

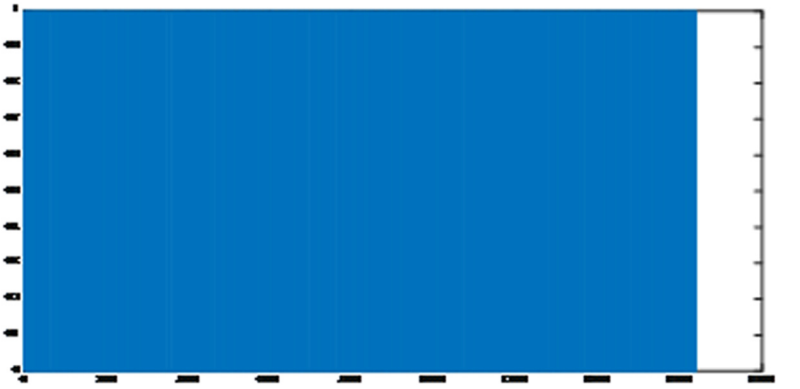


**Figure 13.**
After Manchester decoding (cameraman)

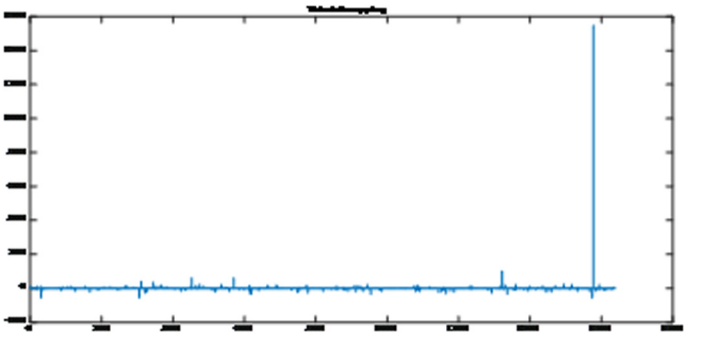


**Figure 14.**
After regression principle (cameraman)

After decrypting the random variables through the chaotic values of the tinkering bell would result under the below Figure 15.

The outcome of the original image after reshaping the obtained value is shown through the Figure 16.

From Figure 16, it has been demonstrated that using the proposed Corvus corone module, the info picture, which has transmitted through the client through the two-way correspondence channel get compacted, made sure about and possesses less vitality and at long last reproduce the yield picture as like of the information picture.

*4.1.4 Compressed secured matrix.*

4.1.4.1 Correlation coefficient. Figure 17 shows the connection coefficient, which is the likeness between the two flat, vertical and slantingly inverse pixels of the plain picture is used for the encoded picture. Under the instance of a plain picture, every pixel is normally

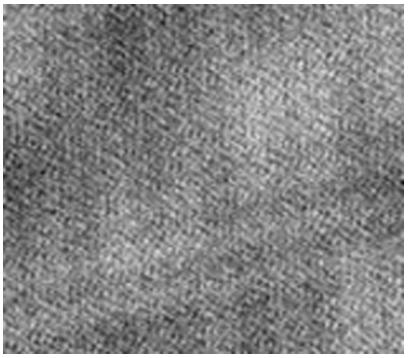


**Figure 15.**
After decrypting the decoded value (cameraman)

**Figure 16.**
Output images

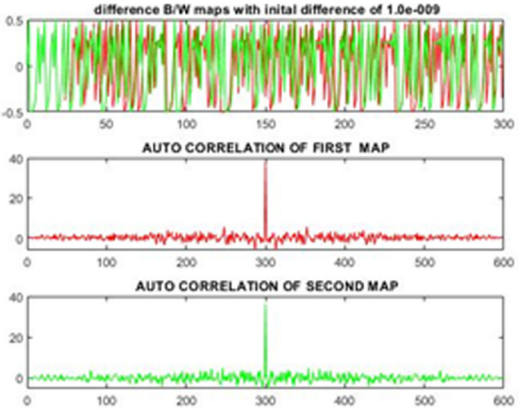



**Figure 17.**
Correlation coefficient MAP

unequivocally associated along its neighboring pixels as under flat vertical either inclining bearings. A high relationship esteem implies the best fit between the plain and figure pictures. The connection coefficients of the neighboring pixels of the figured picture hinder that the proposed plot has solid dissemination and uncertainty potential and is in this way amazingly resistive to the measurable assault.

4.1.4.2 Image mapping. Figure 18 shows the chaotic mapping performed through the proposed work and the amplitude varies equally, which denotes the enhanced performance of the prose work.

4.1.4.3 Sequence mapping. Figure 19 shows the mapping of sequence $x$ ($n$) along the consequent sequence and the perfect curve represents the errorless mapping of images during transmission.

4.1.4.4 Space trajectories. Figure 20 envisions our framework's conduct under the riotous system at a development rate. The clamorous circle fills the plot along square shapes, and in the end the boundless number of never-rehashing directions that structure a fractal spider web all through the chart.

4.1.4.5 Fractal representation. Under Figure 21 the proposed chaotic structures rarely generate the same value twice, and their composition is fractal, ensuring that there are the same patterns at any point, no matter how close we zoom under.

4.1.4.6 Three-dimensional fractal representation. Figure 22 shows the three-dimensional plot portrayal of fifth request fractal planning the assessment of the fractal measurement likewise gives qualities to rank the arbitrariness and eccentrics of turbulent oscillators. Under this way, this work shows that the ace slave synchronization of two clamorous oscillators having high positive Lyapunov examples ensures high security, and in the event that the synchronization mistake is exceptionally low, at that point the first data can be recouped without loss of information.

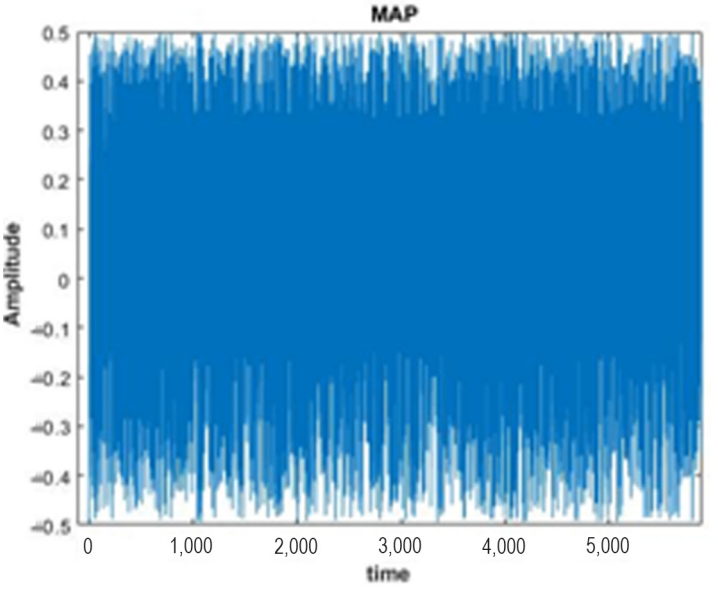



**Figure 18.**
Image mapping

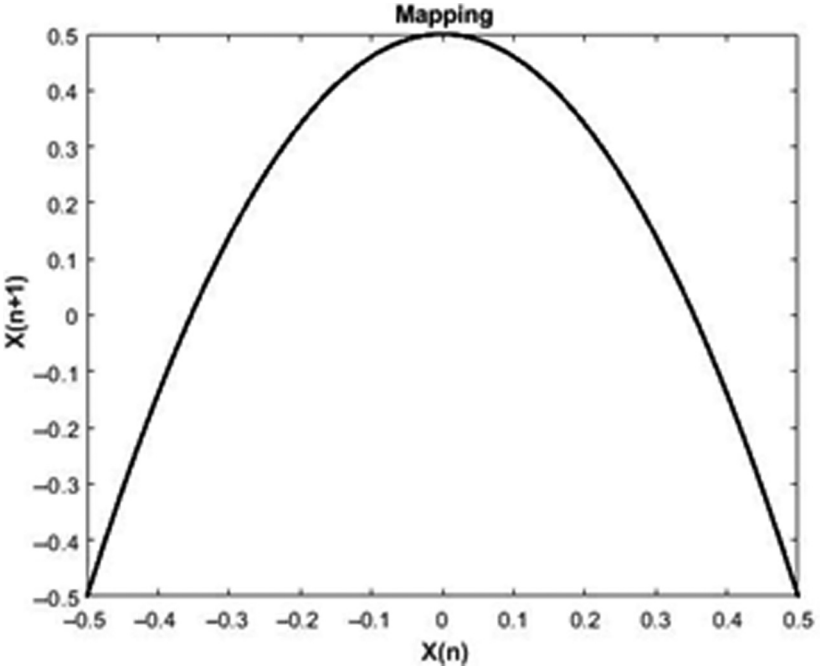



**Figure 19.**
Sequence mapping

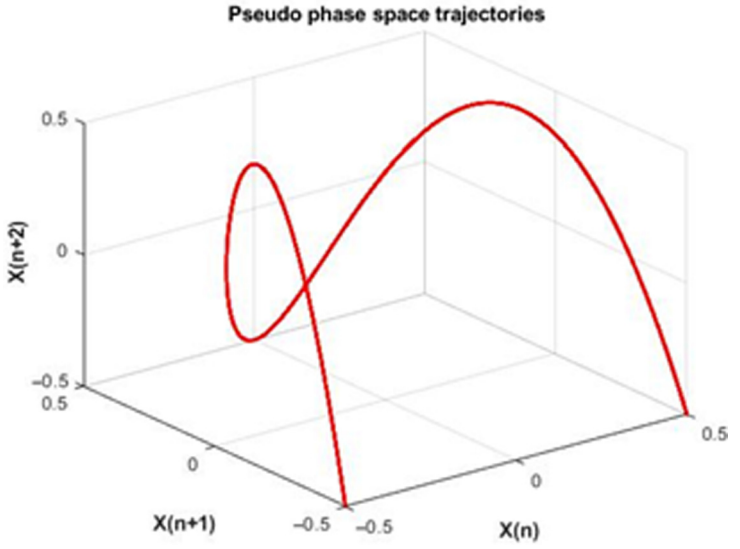



**Figure 20.**
Space trajectories

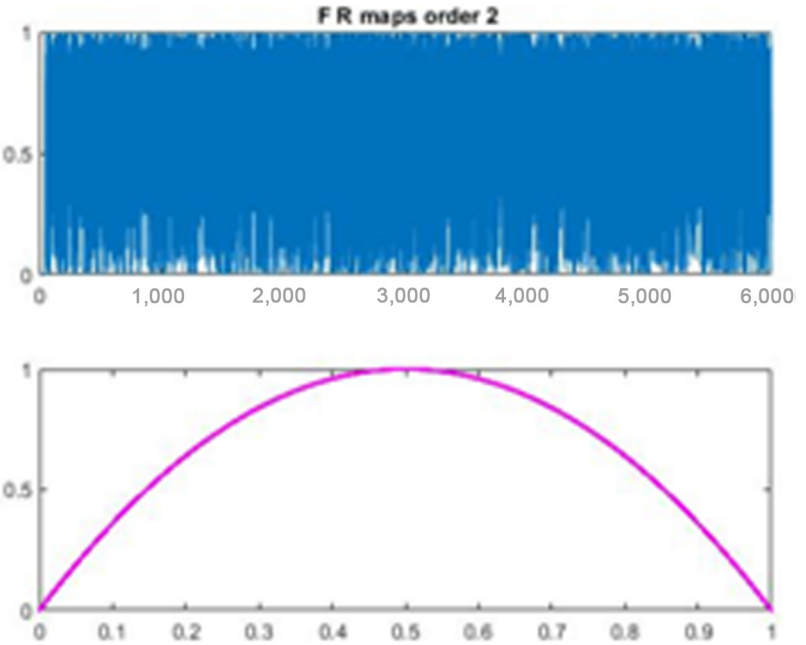



**Figure 21.**
Two-dimensional fractal representation

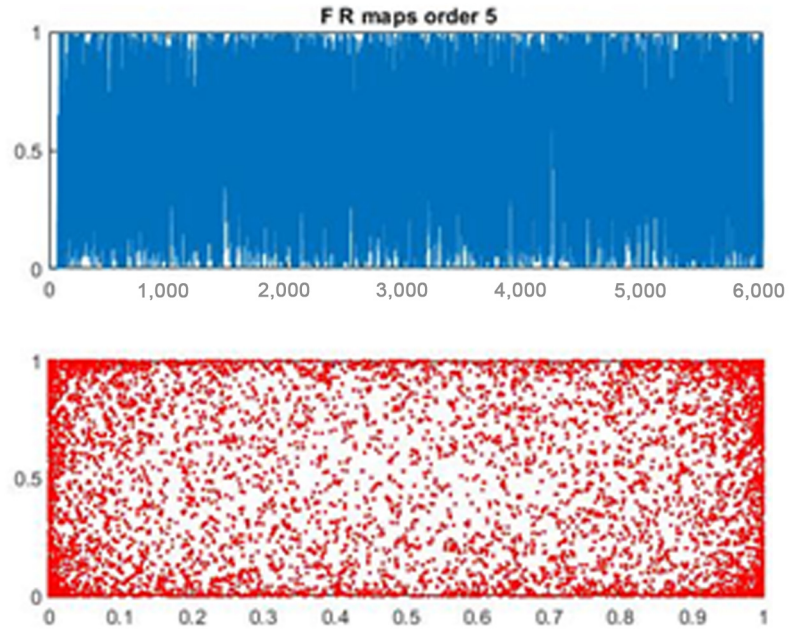



**Figure 22.**
Three-dimensional fractal representation

4.1.4.7 Bifurcation plot. Figure 23 shows that the system step by step collides with zero (eradication) along development paces of short of what one. For development rates between one and three, the framework consistently sinks into an accurate.

4.1.4.8 Synchronization and cross-correlation. Figure 24 shows the ideal synchronization and cross-relationship of the proposed planning capacity between two turbulent guides along exact moment beginning qualities. The histograms and the similitudes of two nearby pixels under both the plain picture and under the figure picture are used for the measurable investigation of the referenced encryption plot. The histograms give the measurable attributes of a picture. On the off chance that the histograms of the encoded picture are equivalent to the irregular picture, the encryption algorithm has great execution.

At that point to assess execution aftereffects of the proposed module seven boundaries has assessed that has been demonstrated as follows.

*4.2 Statistical calculations*

The beneath are the insights used for finding the presentation of the proposed model.

*4.2.1 Mean square error.* The mean square error is the aggregate squared mistake between the compacted and the first picture:

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}\left[I(x,y) - I^{1}(x,y)\right]^{2} \tag{18}$$

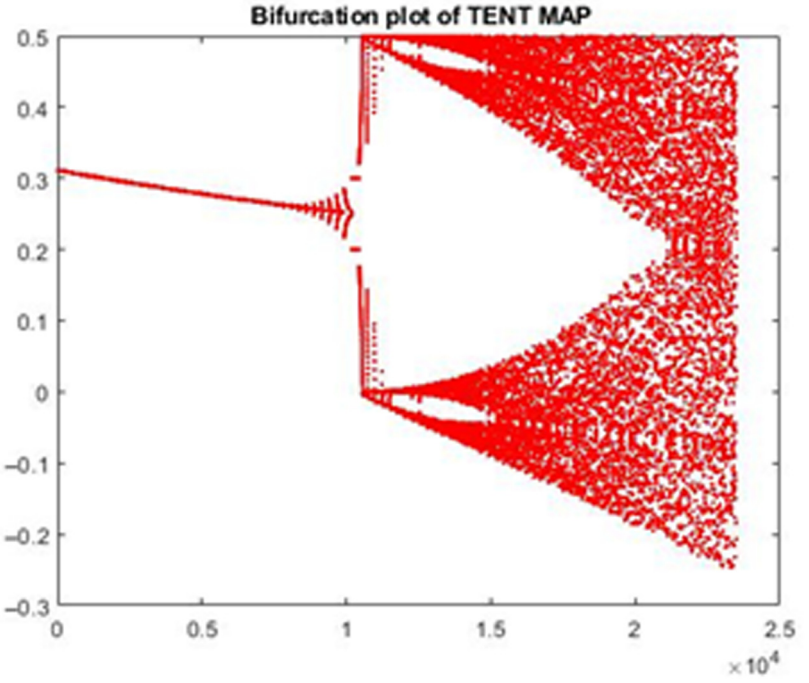



**Figure 23.**
Bifurcation plot

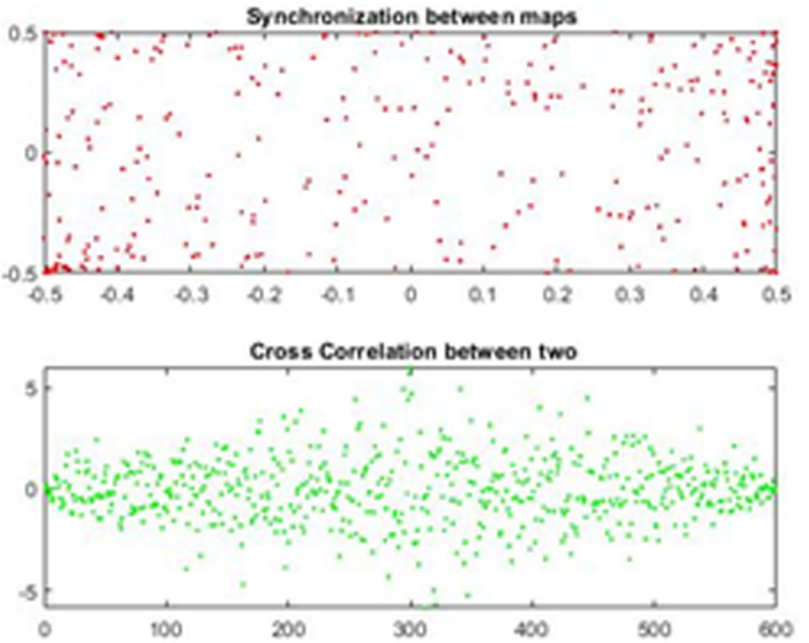



**Figure 24.**
Synchronization and cross-correlation (a) channel capacity (b) normalized SNR and (c) PSNR

where *I(x, y)* is the first picture, *I′(x, y)* is the approximated rendition (which is the decompressed picture) and *M, N* are the elements of the pictures. The contrast between *I(x, y)* and *I′ (x, y)* would give the blunder. Here, *M, N* is the components of the picture.

*4.2.2 Root mean squared error.* Root mean square was determined through taking the base of mean square blunder:

$$RMSE = \sqrt{Meansquarederror} \tag{19}$$

*4.2.3 Mean absolute error.* Mean absolute error takes the mean contrast of the total estimations of the blunder:

$$MAE = \frac{1}{TotalNumberofbits} \sum_{1}^{Totalnumberofbits} |I(x,y) - I'(x,y)| \tag{20}$$

*4.2.4 Bit error rate.* It is characterized as during transmission, the quantity of bit blunders is the quantity of got bits of an information stream over a correspondence channel that has been changed because of noise, impedance and bending:

$$\text{BER} = \frac{\text{Number of error}}{\text{Number of bits sent}} \tag{21}$$

*4.2.5 Symbol error rate.* It tends to be said as the quantity of blunders present under every image, decoded at the beneficiary end. The connection between the image mistake rate and bit blunder rate is as underneath:

$$SER = \left(\log_2 M\right) * BER \tag{22}$$

where $M$ is the quantity of signs, $M = 2k$, k is the quantity of bits transmitted.

*4.2.6 Peak to signal noise ratio.* It is defined as a PSNR between the input and output signals.

$$PSNR = 20 * \log_{10}\left(255/sqrt(MSE)\right) \tag{23}$$

PSNR is the ratio of maximal intensity of the image to the amount of error present as under terms of the mean square.

*4.2.7 Correlation coefficient.* Correlation provides an association between the two variables and its relationship, a +ve correlation value indicates better relation while a –ve correlation value least correlation. The value of correlation varies from +1 to –1; we considered three correlation types.

4.2.7.1 Spearman correlation. Spearman rank correlation is one of the correlation methods, which was used to count degree of association under two variables.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{24}$$

where $\rho$-Spearman rank correlation, $d_i$ is variousial under ranks under variables and $n$ is the number of observed data under the image.

4.2.7.2 Pearson correlation. Pearson $\gamma$ correlation is a correlation statistic for counting degree regard relationship under linearly regard variables:

$$\gamma = \frac{N\sum xy - \sum(x)(y)}{\sqrt{\left[N\sum x^2 - \sum(x^2)\right]\left[N\sum y^2 - \sum(y^2)\right]}} \tag{25}$$

where the Pearson correlation coefficient is would be the total number of observed data from the image.

- $\sum xy$ has been sum regard product of paired scores?
- $\sum x$ has been sum of $x$ scores?
- $\sum y$ has been sum of $y$ scores?
- $\sum x^2$ has been sum of squared $x$ scores
- $\sum y^2$ has been sum of squared $y$ scores?

4.2.7.3 Kendall correlation. Correlation of Kendall rank has been tested, which counts strength regard dependence under two variables.

$$\tau = \frac{n_c - n_d}{\frac{1}{2}n(n-1)} \tag{26}$$

where in $_c$ is count of parameters, which are ordered similarly, *Na* is the number of elements, which are ordered under a dissimilar manner.

*4.2.8 Moment generating function.* Moments describes about the content of image along consider as its axes, they help capture the global and core geometric data regard image. Considering a moment of order ($pq$) spread over a plane S, along basis function $P_q$, which under turn produces a weighted description over the plane same "s." These functions have properties that get passed to the moments, producing descriptions that are invariant under translation, orientation and rotation.

$$M_{pq} = \sum_x \sum_y \Psi_{pq}(x,y) P_{xy}; p,q = 0,1,2,\ldots,\infty \tag{27}$$

where $P_{xy}$ is the multiple of image intensity over each pixel.

*4.2.9 Structural similarity.* Structural similarity has been a similarity measurement index that is useful for finding the similarity among the predicted/reconstructed/compressed image along a reference/uncompressed/original image as reference.

$$\mathrm{SSim(x,y)} \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x{}^2 + \mu_y{}^2 + c_1)(\sigma^2{}_x + \sigma^2{}_y + c_2)} \tag{28}$$

where $\mu_x$, $\mu_y$, $\sigma^2{}_x$, $\sigma^2{}_y$ was average and deference's regard $x$ Andy also. $X$, $_y$ there has been covariance regard $x$ and $y$, $c_1 = (k_1L)^2$, $c_2 = (k_2L)^2$ was variables for stabilization, L would be the massive count of pixel values $(2^{\text{bit per pixel}} - 1)$ $k_1 = 0.01$ and K2 = 0.03.

*4.2.10 Signal to noise ratio.* SNR has been known as ratio regard average signal value from standard deviation regard background values. SNR may used such as measure of sensitivity; value defined normalized at the time of SNR has been categorized under its dimensions.

$$\mathrm{SNR} = \mu \mathrm{yx/x,y} \tag{29}$$

where $\mu$ has been average behind image pixels $x$, $y$, $\sigma$ has been standard deviation regard pixels regard background (noise).

*4.3 Performance analysis*

Performance regard proposed technique has been optimized under terms of PSNR, SNR and channel capacity for the six input images and an average of 40.46 are obtained for PSNR, 1.037 for normalized SNR and 96.684 along the fast transmission speed of 1.47 s as shown under Figure 25.

Figure 26 shows the performance of capacity of channel analyzed under conditions of both erotic and outage capacity of channel along and without channel state information and achieves an average of 34.7008, 31.62763, 24.42403 and 21.96622, respectively.

Figure 27 shows that through the usage of the security matrix of compressed and full-duplex access regard transmission, the channel capacity gets increased through the value of 96.684 along the speed of fast transmission 1.47 and attains reduced BER value of 0.003.

Figure 28 shows the mean squared error, root mean squared error and mean absolute error of the proposed methodology. The values squared errors points the value of 314.6705 and 17.4802 along the average errors 13.895 of shows better efficient channel capacity.

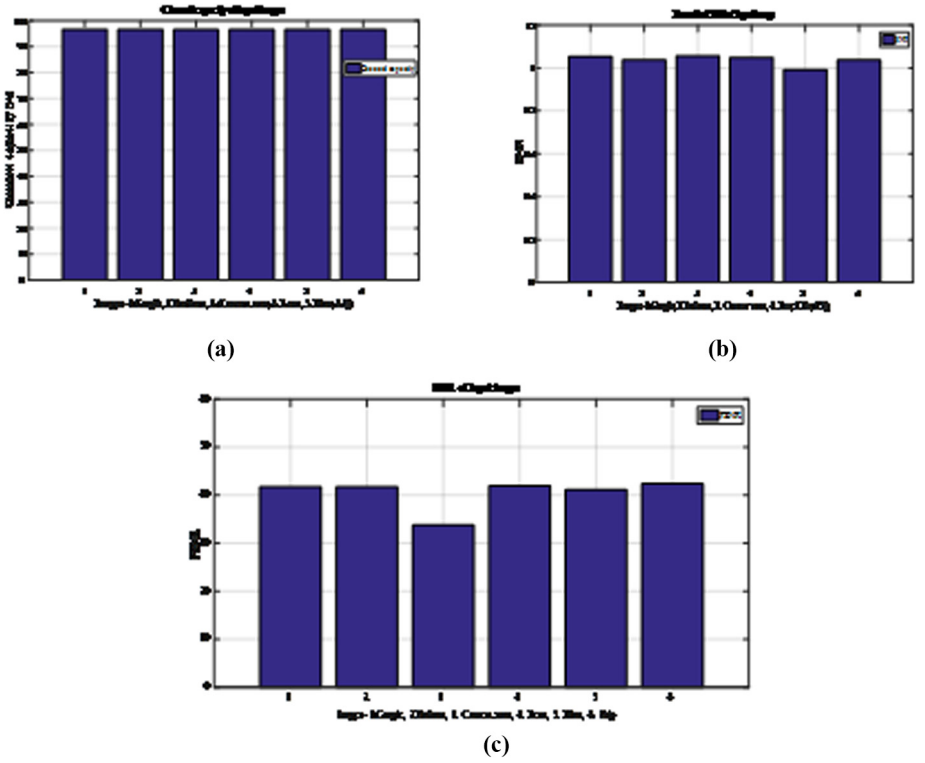


**Figure 25.**
Performance evaluation for the proposed module under terms (a) channel capacity (b) SNR and (c) PSNR

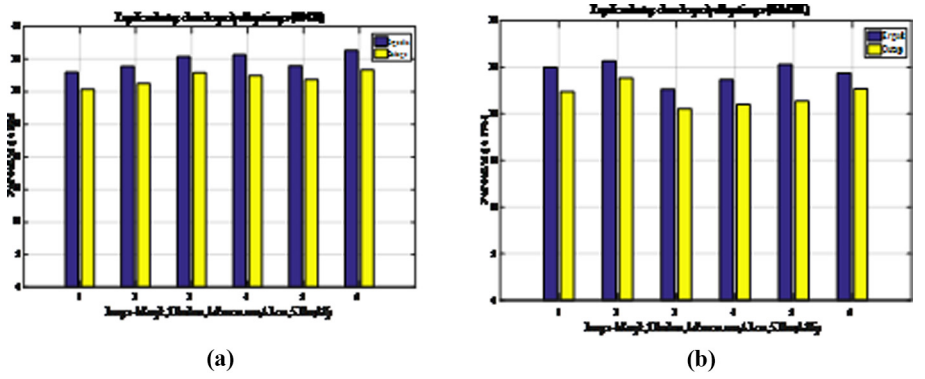


**Figure 26.**
Performance under terms of channel capacity (Ergodic and Outage) (a) along CSI and (b) without CSI

Figure 29 below describes the symbol error rate obtained for those input images fed to the proposed system. It can be seen that the symbol error rate close to 8.4 *e^5 for all the images, suggesting that all the six images have a close resemblance under SER.

Figure 30 shows the correlation coefficients obtained for each images and achieves positive values indicating the better correlation among the reconstructed and original input

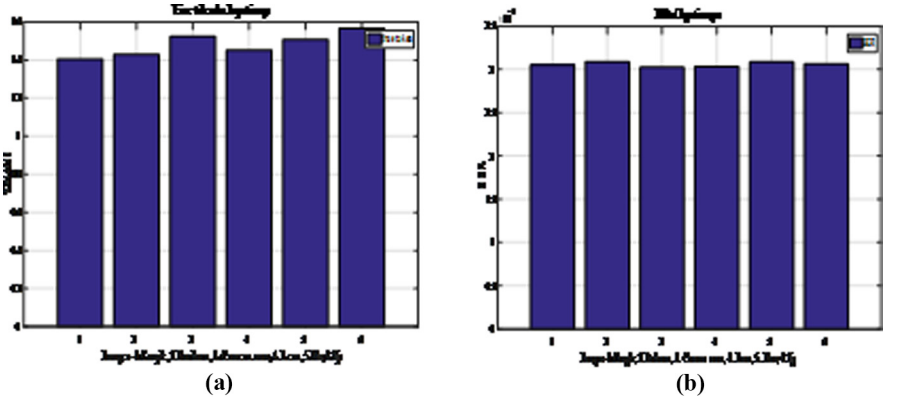



**Figure 27.**
The proposed models performance under terms of bit error rate and time taken

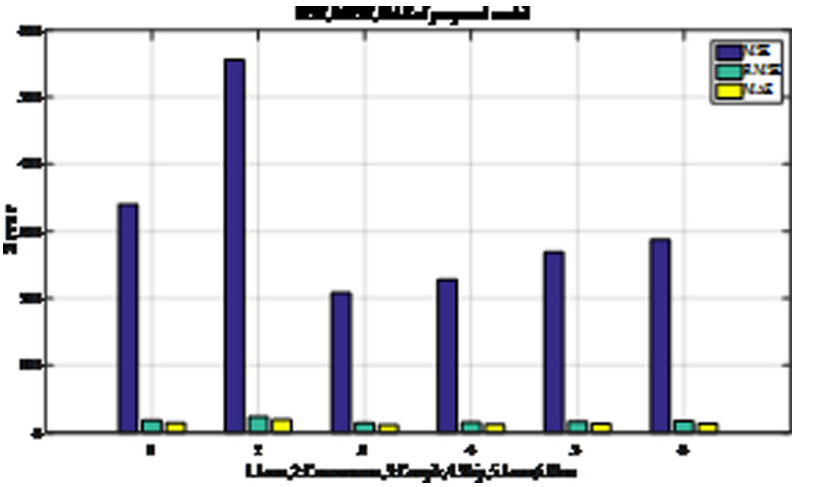


**Figure 28.**
Proposed model's mean squared error, root mean squared error and mean absolute error

image. Considering all the correlation,the maximal correlation happened for the Lena image, whereas the lesser correlation occurred for the ship.

Figure 31 describes the SSIM obtained for the six input images, the maximal SSIM was seen for couple image and the least for cameraman.

The table describes the MGF obtained for the six input images, the image Ship had the highest MGF of 8.40572* e^07 (Figure 32).

The above table describes the BER vs PSNR of all the six input images and their corresponding line graphs, it can be seen that the PSNR values remains high when BER is low, and the PSNR value decreases when BER turns to be high (Figure 33).

*4.4 Comparison results*

To evaluate the consistency of the proposed method, parameters such as BER, complexity, throughput, capacity and PSNR is compared along the other techniques.

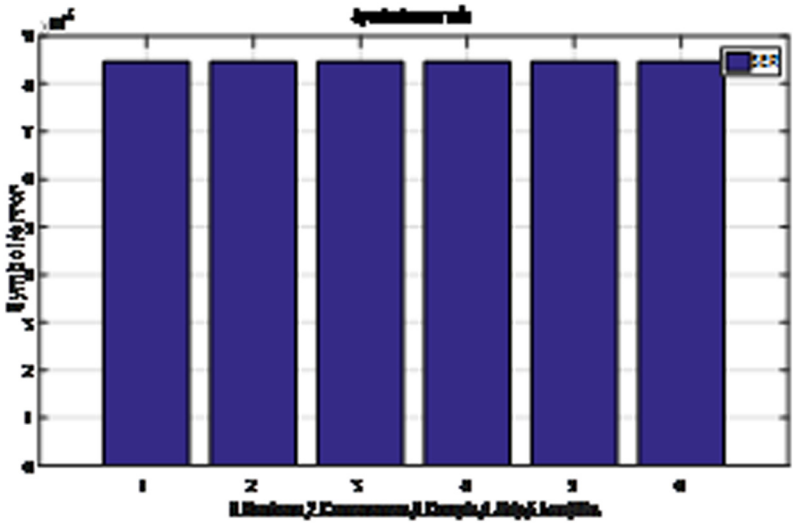


**Figure 29.**
Symbol error rate the input images

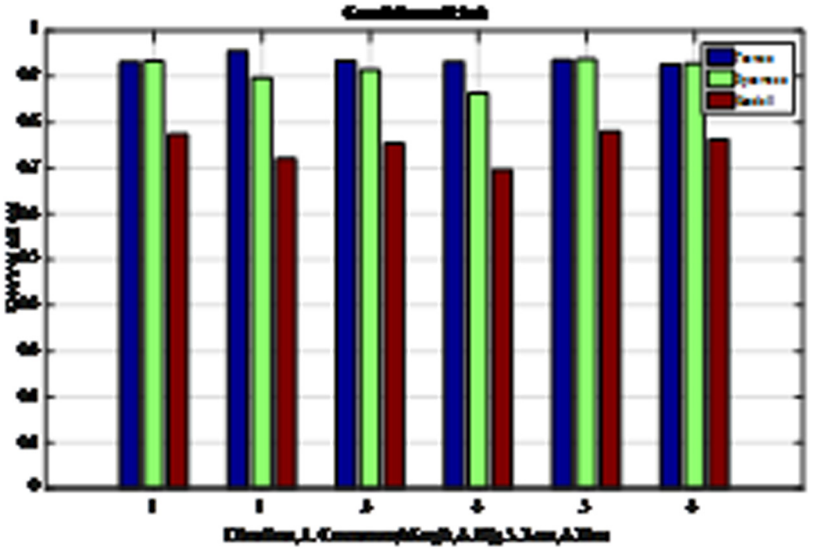


**Figure 30.**
Correlation coefficient MAP

*4.4.1 Bit error rate.* From Figure 34, the proposed system thought about along the other existing approach of Singh *et al.* (2016), crossover watermarking, JSCC, ES, DP and DP along BB under terms of their BER. It appears that the current approach have a huge distinction for their pictures Lena and Barbara along 0.02, 0 and 0.01, 0. Contrasting the proposed procedure it has the estimation of 0.0003032 for Lena and 0.0003089 for Barbara demonstrating that because of the best possible regulation and transmission the module gets compelling.

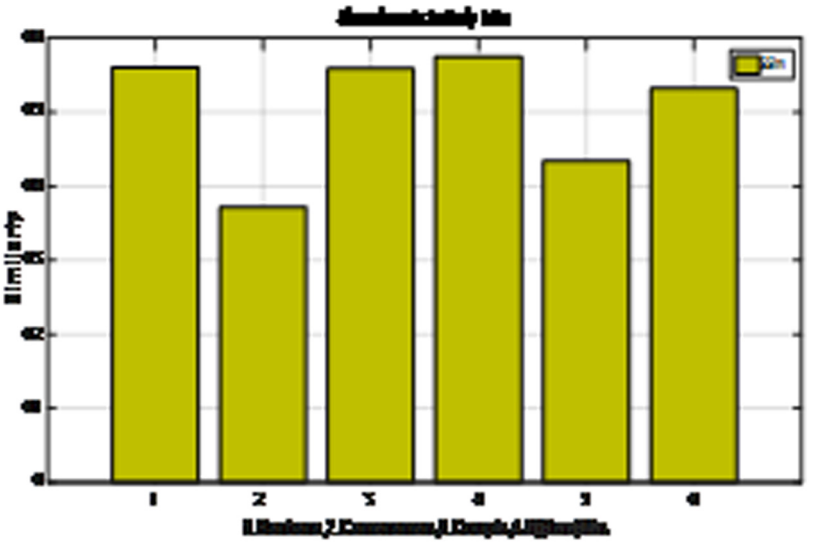


**Figure 31.**
Structural similarity of the input images

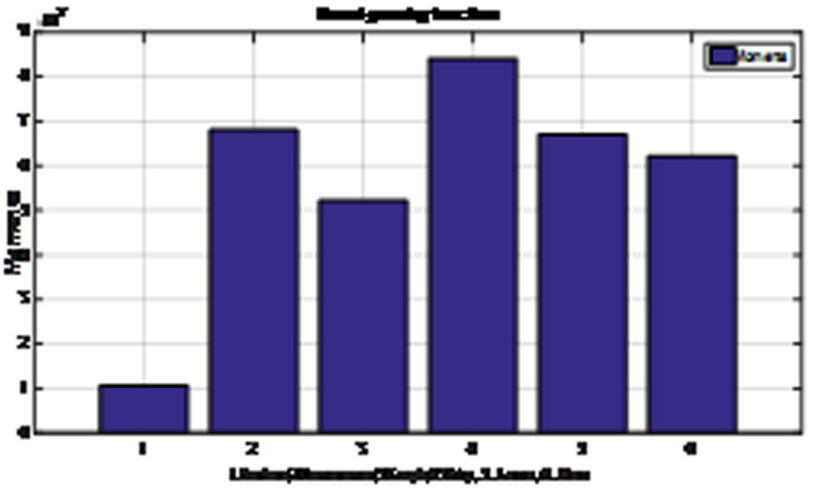


**Figure 32.**
MGF of the input images

*4.4.2 Peak signal noise ratio.* From Figure 35, the proposed methodology compared along the other two existing methodologies under terms of their PSNR. Comparing to some of the proposed methodologies our model has the PSNR value of 41.9455 for Lena 41.7718 for Barbara and 41.154 for the proposed system, which works well-compared to others.

*4.4.3 Communication time.* Correspondence time is the all-out time devoured for the correspondence procedure while transmitting the client information starting with one spot then onto the next.

From Figure 36, the proposed philosophy looked at along the other existing approach under terms of their correspondence time. It appears that the current strategy of JPEG2000,

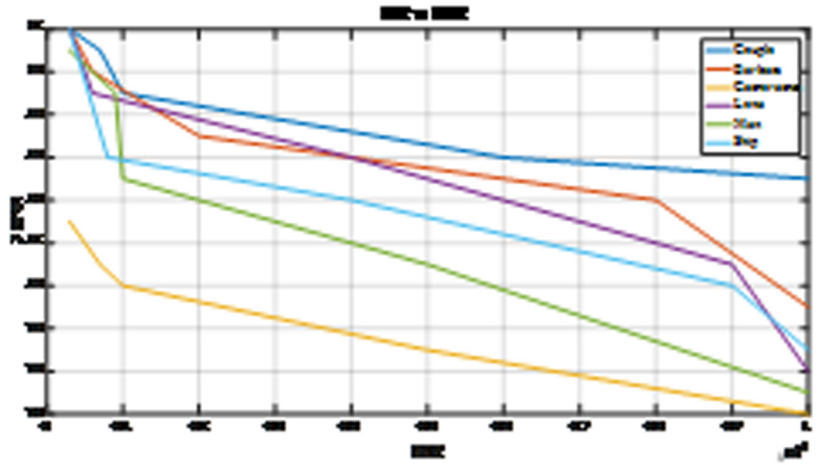


**Figure 33.**
BER vs PSNR of the input images

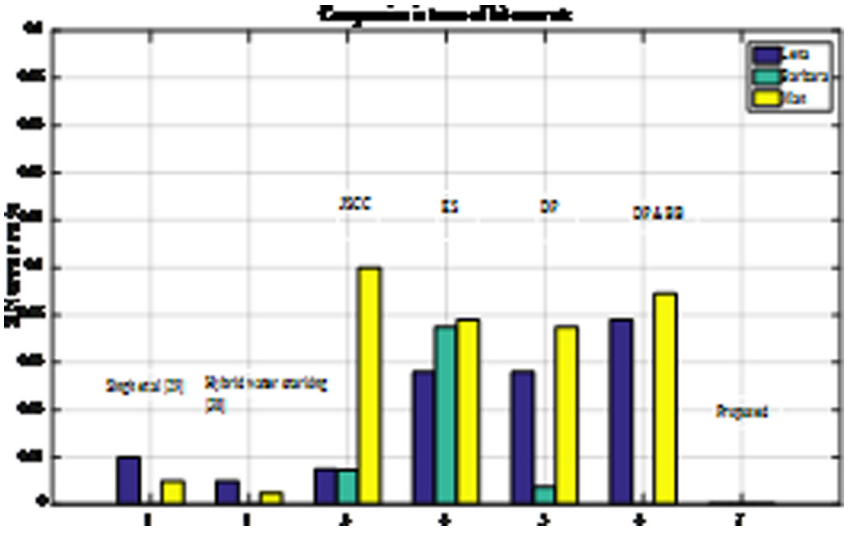


**Figure 34.**
Comparison of BER along the existing techniques

SS, DCT, SPIHT, JPEG have 366 ms, 900 ms, 473 ms, 331 ms, 544 ms. Looking at the proposed procedure, it has an estimation of 275 ms and indicating that because of the correct regulation and transmission the module becomes compelling and has low correspondence time.

*4.4.4 Energy consumption.* It is the total amount of energy consumed during the transmission process.

From Figures 37(a) and 37(b), the proposed technique analyzed along the other existing strategy under terms of their vitality utilization and vitality spares. It appears that the current strategy has high vitality utilization and low vitality sparing. Looking at the

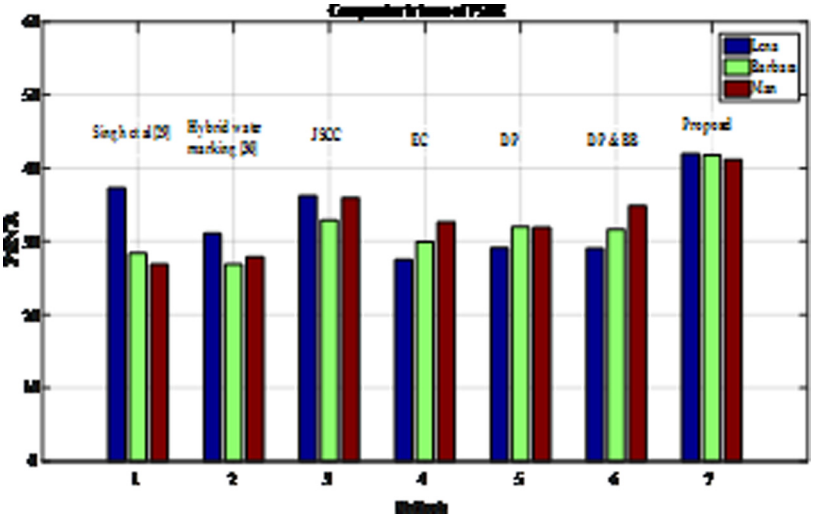



**Figure 35.**
Comparison of PSNR along the existing techniques

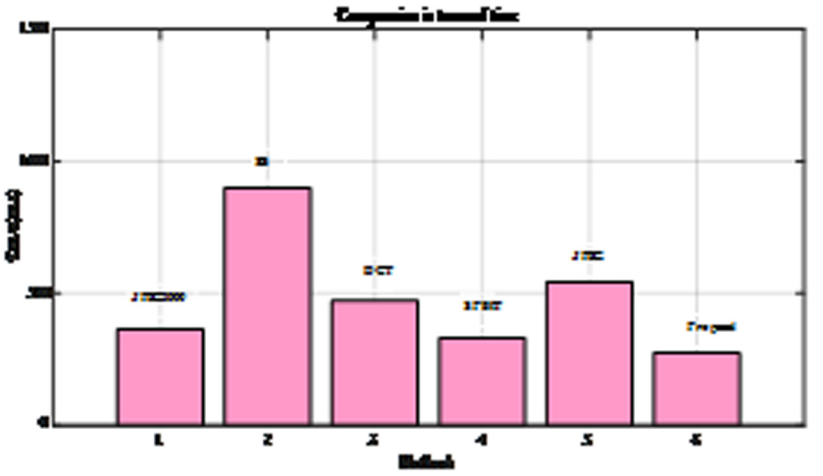


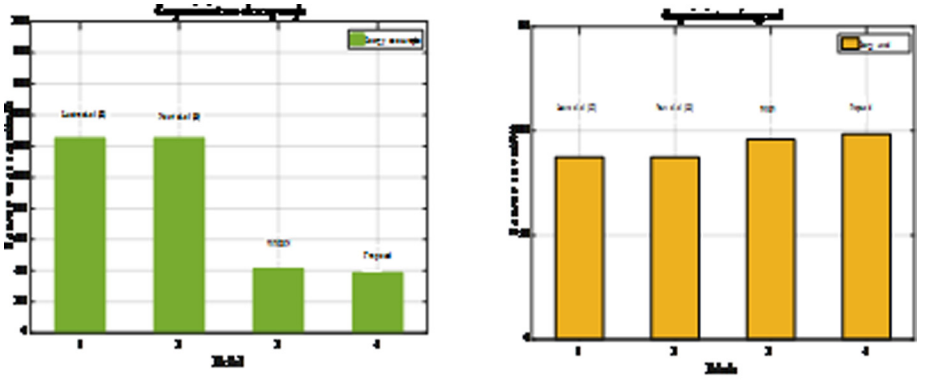

**Figure 36.**
Comparison of communication time along the existing techniques

proposed technique, it devours the vitality of 386 mJ and recoveries the vitality of 98.54% indicating the effective vitality usage through the proposed module.

*4.4.5 Correlation coefficient.* Figure 38 shows the comparison of the proposed work along the existing techniques under terms of correlation coefficient. From the above result obtained the proposed works shows a better correlation between image sequences.

*4.4.6 Histogram mapping.* The histogram comparison of the proposed work along existing approaches is shown under Figure 39. It describes the image-pixels distribution through plotting the number of pixels at each intensity level.

*4.4.7 Lyapunav exponent.* Figure 40 shows the comparison of Lyapunav exponent and the Lyapunov exponent of the proposed work along multiple chaotic maps exhibits negative values under the entire range along uniform chaotic distribution.



(a) (b)

**Figure 37.**
Comparison of (a) energy consumption and (b) energy saved along the existing techniques

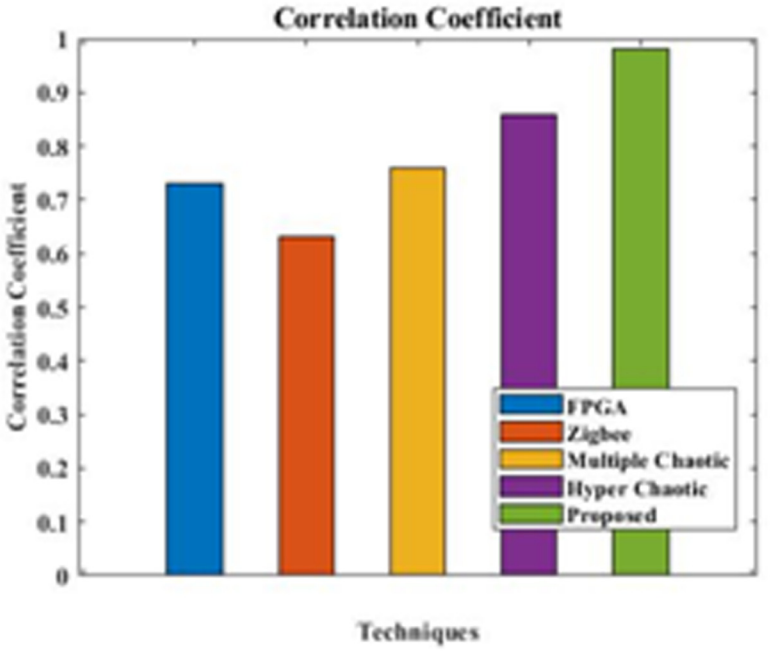



**Figure 38.**
Correlation coefficient comparison

*4.4.8 Synchronization errors.* Synchronization error as the time discrepancy between a sensor node's real clock reading and the other sensor node's predicted clock value. Figure 41 demonstrates how the synchronization errors are measured as a function of the number of hops between sensor nodes.

*4.4.9 Entropy.* Entropy is defined to express the degree of uncertainties under the system. The suggested schemes produce important effects when contrasting entropy along other schemes. It is shown that the entropy and image values are higher for all the suggested

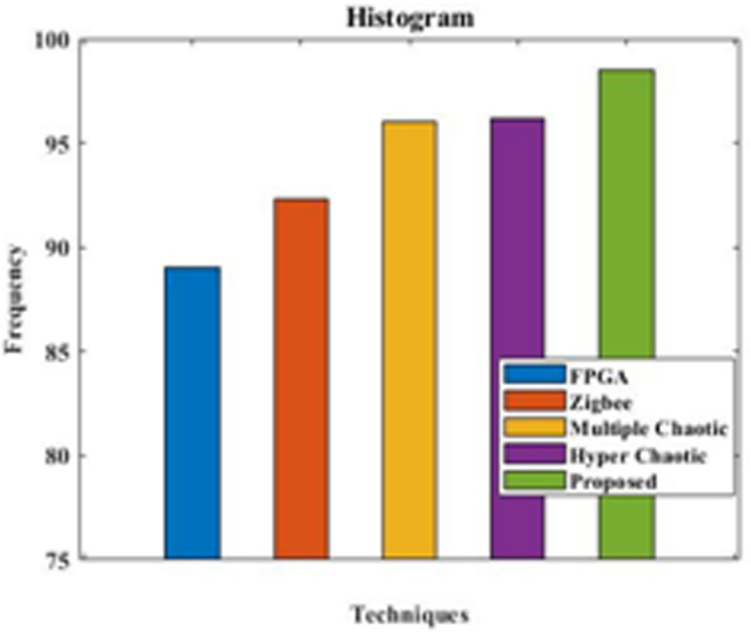



**Figure 39.**
Histogram comparison

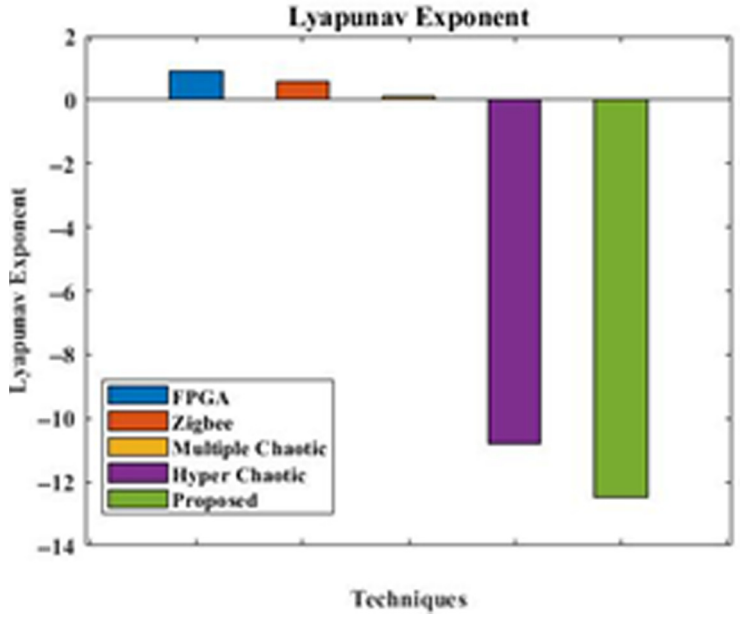



**Figure 40.**
Lyapunav exponent comparison

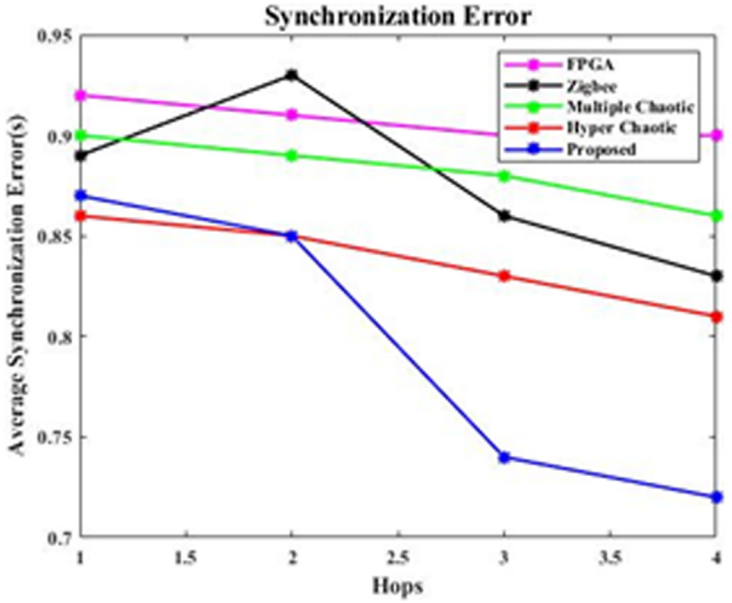



**Figure 41.**
Synchronization error as the time comparison

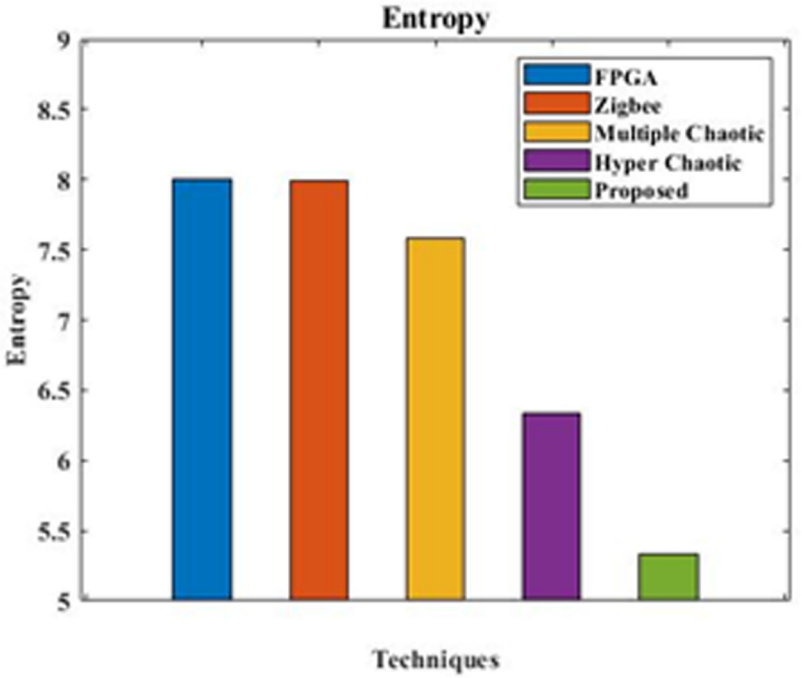



**Figure 42.**
Contrasting entropy schemes

keys than the other schemes as seen under the Figure 42, which have the lowest entropy value.

## 5. Conclusion

The energy-efficient transmission along a security problem under the two-way image transmission was challengingly solved through the proposed Corvus corone module through their compressed security matrix, which increases the security, consumes less energy and prevents the signals from unwanted noise. The evaluation and comparison results paraded that the proposed module achieves the process within 1.42 s along an enhanced channel capacity of 96.684 and leads to the less BER value of 0.0003 compared to the other techniques, respectively.

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## Further reading

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