International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

5G Enabled Moving Robot Captured Image Encryption with Principal Component Analysis Method

T.Venkata Krishna Moorthy[1], Srinivas Bachu[2], Gajula Ramesh[3*], Dasaratha Rami Reddy[4], S.Vamsee Krishn[5], M.Dharani[6]

[1]Associate Professor
Dept. of ECE, Sasi Institute of Techonology & Engineering,
Tadepalligudem, Andhrapradesh, India.
Krishna454@sasi.ac.in
[2]Dept. of ECE, Siddhartha Institute of Technology & Science, Narapally,
Hyderabad, Telangana,India.
bachusrinivas@gmail.com
[3]Associate Professor
Dept. of CSE, GokarajuRangaraju Institute of Engineering & Technology,
Hyderabad,India..
ramesh680@gmail.com, India
[4]Associate Professor
Dept. of CSE, BVSR Engineering College,
Chimakurthy, India. E-mail: dasradh@gmail.com
[5]Asst. Professor,
Department of ECE, Konerulakshmaiah educational foundation,
Vaddeswaram, AP, India.
vamseekrishna@kluniversity.in
[6]Associate Professor
Department of ECE, School of engineering,Mohan babu university,
Tirupati, India.
dharani.m@vidyanikethan.edu

Abstract— Estimating the captured image of moving robots is very difficult. These images are vital in analyzing earth's surface objects for many applications like studying environmental conditions, Land use and Land Cover changes, and change detection studies of worldwide change. Multispectral robot-captured images have a massive amount of low-resolution data, which is lost due to a lack of capture efficiency due to artificial and atmospheric reasons. The image transformation is required in a 5G network with effective transmission by reducing noise, inconsistent lighting, and low resolution, degrading image quality. In this paper, the authors proposed the machine learning dimensionality reduction technique i.e. Principle Component Analysis (PCA) and which is used for metastasizing the 5 G-enabled moving robot captured image to enrich the image's visual perception to analyze the exact information of global or local data. The encryption algorithm implanted for data reduction and transmission over the 5G network gives sophisticated results compared with other standard methods. This proposed algorithm gives better performance in developing data reduction, network convergence speed, reduces the training time for object classification, and improves accuracy for multispectral moving robot-captured images by the support of 5G network.

Keywords-5G Network, dimensionality reduction, multimedia, multispectral Moving robot captured images, Machine learning algorithm, Moving Robot**.**

I. INTRODUCTION

Digital image adjustment isa challenging task in engineering applications in various applications. Analyzing and processing analog and digital signals, as well as storing, filtering, and other operations on signals, are the focus of the mathematical and electrical engineering field of signal processing[1]. In today's digital world, enormous amounts of compressed digital data are sent and received daily. Modern high-speed networks are currently carrying a majority of digital data that is directly tied to human activity. This Technology fastest-evolving internet technology is 5G-Netowrking. In order to deliver superior information for achieving successful outcomes using 5G networks, the high data volume of the multimedia image is

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

reduced for improved visual perception without losing information and statistical aspects of the local or global image[2]. In remote sensing, Earth surface objects are captured by Moving robot captured that are run by governments and companies all over the world are known as Moving robot-captured images, sometimes known as Earth observation imagery, space-borne photography, or simply Moving robot-captured photos. The multispectral/Hyperspectral Moving robot captured images composed of several numbers of bands, which acquired the information from the same object. So, automatically the redundant information appears in all the bands[3]. The images are difficult to process and store the information due to this redundant information. No need for all the bands from input images; based on applications, the suitable bands are selected for pre-processing images. Data compression is a crucial issue for large multispectral imageries,increasing the computational strain in terms of data storage and transmission. Obtaining large data is also quite expensive, and these data are frequently employed for additional analysis and processing tasks like target detection or categorization. Suitable compression is required for remote sensingapplications like the Internet of Things and data transfer via 5G wireless networks to analyze the data for forecasting or prediction of real-time applications[4].Elizabeth A et.al[2020] suggested SVD transformation for digital images to reduce the image size with good quality. The reduction can be made by applying singular value decomposition to digital images with pixel saturation matrices for color and grayscale level values. The compression of the mage even while retaining the number of pixels [5]. Muhammad Ihsan Jambak et. al [2019] evaluated SOM to reduce the data dimension of text documents before they were clustered by k-Means was compared to that of Singular Value Decomposition (SVD). This reduction process can be done by multiplication of the matrix solutions to a minimum to SVD producing good representation of large data [6]. Elaiwat et al. [7] implemented Curvelet transform features to develop a reliable, single-modality feature-based face recognition method. In this study, the scientists identified the crucial features of a face using curvelet coefficients, which are developed by the sparse representation of the object. MK Hasan, et.al [2022] implemented IoMT devices for medical applications through 5G technology. It reducesinterface, packet loss, and handoff delays with the improvement of functionalities of the centralized mobileentities[8].

Multispectral /Hyper Spectral Robot Captured Image

The Moving robot sensors capturedimage have various resolutions, which collect data from the earth's surface of objects and then combine all the bands to form as multispectral or hyperspectral images, which collect data from across the electromagnetic spectrum[9][10]. The primary focus of this imaging is to carry out pixel operations in the scene image in order to identify or categorize the object or detection process. The different types are scanners capture information, such as whisk broom, push broom, and band sequential scanners for spatial and spectral information. The scanning method is to acquire images of a region with different frequencyresolutions to provide unique information depending on the applications. There are typically 4 types of resolutions available, including spatial, spectral, temporal, and radiometric resolutions[11].

Table 1: Multispectral/Hyperspectral Moving robot captured images Resolution and bit rate

S.No	Moving robot captured images	Swath (in Km)	Data Rate (Mbps)	Spatial Resolution
1	NOAA	2400	**0.665**	1.2K
2	Landsat-7/8	185	260.92 Mbps on S-band frequency 384 Mbps on X-band	15-30m
3	SPOT4	60	10	32
4	SPOT5	60	2.5	128
5	QUICK BIRD	18	2.6	320
6	IKONOS	11	3.2	320
7	PLEIADES	20	0.7	4500

1. Dimensional Reduction

The dimensionality reduction technique refers to converting the higher dimensions dataset into lesser dimensions dataset ensuring that it provides similar information. These methods are frequently used in machine learning to solve classification and regression issues while producing a more accurate predictive model. The reduction can be made by changing the parameters of input features, variables, or columns present in a given dataset features. It is generally used in various fields likesignal processing, bioinformatics, speech recognition, data visualization, cluster analysis, image processing applications etc. The main advantage of dimensionality reduction is reducing the object features. So, removing the redundant features it takes less computation time is required for reduced dimensions of features. The total information is obtained into a smaller size of data, which is easily accessible and also stored [11].

2. Proposed Principal Component Analysis (PCA) algorithm

Machine learning is one of the rapidly growing areas of Engineering with broad-ranging applications, which refers to automated detection of useful patterns in data.The four parts of

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

learning, whether done by a human or a machine, are data storage, abstraction, generalization, and evaluation. Image processing is any form of input image information processing to accurate results by Image transform, retrieval, and filter operations to theimage[12]. This preprocessing can be done by computer algorithms to perform image processing on various input images. A machine learning algorithms are used for reduce the complexity in classification to analyze the existing set of labeled data [13][14]. The algorithm analyses a training set made up of a number of attributes and the desired output, also known as the goal or prediction attribute, in order to predict the outcome. The categorization method places pixels in the image into classes or interest-related categories. Numerous crucial applications in weather and climate studies involve the identification of clouds in Moving robot captured data. Despite being a subset of artificial intelligence, machine learning has a wide range of connections with other fields, such as mathematics, physics, theoretical computer science, and more. Machine learning places a strong emphasis on automated techniques. The machine learning algorithms are to develop learning algorithms automatically without involvement humans. This algorithms based on supervised, unsupervised learning, and reinforcement learning[15]. Some data may be lost due to dimensionality reduction

- Singular Value Decomposition
- Linear Discriminant Analysis
- Principal Component Analysis

The linear algebraic method of SVD can be applied to automatically achieve dimensionality reduction. It Singular value decomposition (SVD) applies the orthonormal eigenbasis of an orthonormal square normal matrix's eigendecomposition to any matrix, which is based on A real or complex matrix[16]. In SVD process, the breaking down a matrix A into the form

$$A=U \sum VT \quad [1]$$

The Singular Value Decomposition is so named due to the singular values that are identified and isolated from matrix A. in this method. Generally for reducing the size of image can be done by the SVD and removing the singular values. This technique is very helpful for less number of multispectral images, but not given sophisticated results for more number of bands. The Linear Discriminant Analysis (LDA) technique is developed to transform the features into a lower dimensional space, which maximizes the ratio of the between-class variance to the within-class variance, thereby guaranteeing maximum class separability[17].The principal component analysis is also same as LDA, which developed by second order statistics implemented for compression operations[18].

4.1 Principal Component Analysis

The Moving robot captured images contain multiple bands based on application. These individual images have different resolution. The original image can be expressed interm of matrix as

$$X_{n,b} = \begin{pmatrix} x_{11} & \cdots & \cdots & x_{1,n} \\ \cdot & & & \\ \cdot & & & \\ x_{6,1} & \cdots & \cdots & x_{6,n} \end{pmatrix} \quad [2]$$

Where n: No. of the pixels

b the number of bands

The individual band considered as vector, the corresponding matrix given as

$$X_{n,b} = \begin{pmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ x_n \end{pmatrix} \quad [3]$$

Here K: no. of bands

The Principal Component Analysis applied for dimensionality reduction technique based on eigenvalues of the covariance matrix

$$C_{b,b} = \begin{pmatrix} \sigma_{1,1} & \cdots & \sigma_{1,6} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \sigma_{6,1} & \cdots & \sigma_{6,6} \end{pmatrix} \quad [4]$$

where $\sigma_{i,j}$is the covariance of each pair of different bands.

$$\sigma_{i,j} = \frac{1}{N-1} \sum_{P=1}^{N} (DN_{p,i} - \mu_i)(DN_{p,j} - \mu_j) \quad [5]$$

Where $DN_{p,i}$, DNp,j : is a digital number of a pixel p in the band I & j

μ_i and μ_j are the averages

From the above equation, the eigen values (λ) are calculated by

$$\det(C - \lambda I) = 0 \quad [6]$$

Where C : the covariance matrix

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

I : Diagonal identity matrix

The principal components can be expressed in matrix form

$$Y6 = \begin{pmatrix} y_1 \\ . \\ . \\ y_6 \end{pmatrix} = \begin{pmatrix} w_{1,1} & \dots & w_{1,6} \\ : & & \\ w_{6,1} & \dots & w_{6,6} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ : \\ x_6 \end{pmatrix} \quad [7]$$

Where Y : the vector of the principal components,

W : Transformation matrix,

X : the vector of the original data.

Compression Technique:

4.2 RSA public-key cryptographic algorithm

Asymmetric key cryptography's most well-known and effective algorithm is RSA. For public-key cryptography, several different algorithms were put out. Some of them started out promisingly but eventually proved to be breakable.The images encryption is crucial in many areas such as online transmission, multimedia, medical and military communications. The Moving robot captured images are being stored and transmitted over the internet and wireless networks in large amounts without any data loss and security[19].

The SPIHT procedure is a particularly efficient entropy-coding method. Demonstration programmes using context-based adaptive arithmetic coding and binary-uncoded (very simplistic) coding demonstrate this (sophisticated).SPIHT codes the individual bits of the image wavelet transform coefficients following a bit-plane sequence. PROGRES-SPIHT is a progressive resolution, extremely fast version of SPIHT that has full capability of random access decoding It is an excellent choice for remote sensing and GIS applications, where rapid browsing of large images is necessary[20].

i) Autocorrelation Function

To discover patterns in data, one can use the autocorrelation function. The autocorrelation plot will show distinctive patterns for each original image. The encryption correlation plot should appear random and devoid of any discernible patterns for a decent algorithm. This lessens the cypher image's vulnerability to statistical analysis assaults[21].

$$r_{xy} = \frac{E((x-E(x)(y-E(y))}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i-E(x))^2}\sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i-E(y))^2}} \quad [8]$$

ii). Structural Similarity Index Measure (SSIM)

SSIM is used to calculate for measure similarity of the images. The initial distortion or Uncompressed of free image predicts the Image Quality.

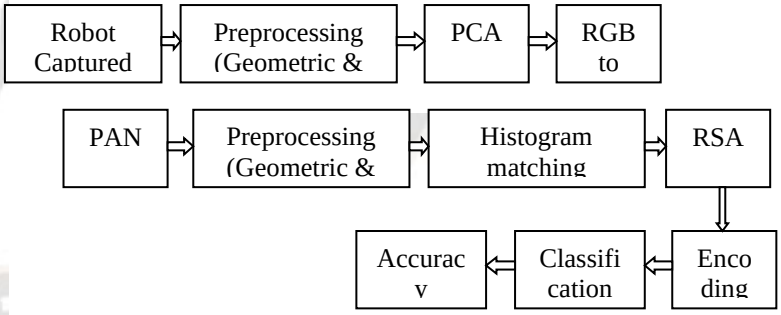
$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_x^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad [9]$$

iii). Mean Squared Error (MSE)

It is used to calculate the level of error in statistical models that include data and picture input. The total squared difference between the two photos makes up this amount.

$$MSE = \frac{1}{n}\frac{1}{m}\sum_{i=1}^{n}\sum_{j=1}^{m}(Y(i,j) - \hat{Y}(i,j))^2 \quad (10)$$

Classification is the one of the process in image processing to identify and grouping objects into predetermined categories. In data management, image classification enriches the details of object, separation of data according to set requirements for conventional objectives.Imageclassification is an important role for many aspects of global change studies and environmental applications. Cloud detection and frequency analysis are crucial for both practical weather forecasting and eco-climatologically research. The main intensity of this aims to improve the accuracy in finding or analyzing with the detection of cloud pixels is sufficiently use for higher operational use.



3. Results and Discussion:

Fig. shows the multispectral images, collected from NOAA-HRPT Receiver from Sri Venkateswara University, tirupathi. This image has5 various bands and it contain large data in size. This image apply to principal component analysis for dimensional reduction. Fig.1 shows input NOAA-MS image. After geometric and radiometric correction the basic dimensional reduction technique (Brovey) applied to input MS image. The corresponding image shown in Fig.2

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
Article Received: 05 May 2023 Revised: 30 June 2023 Accepted: 29 July 2023

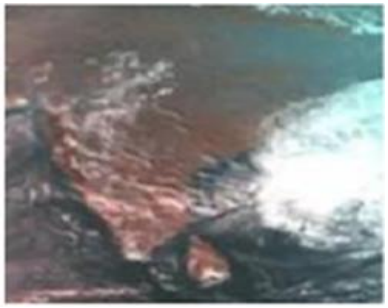


Fig1: NOAA-Multispectral Image

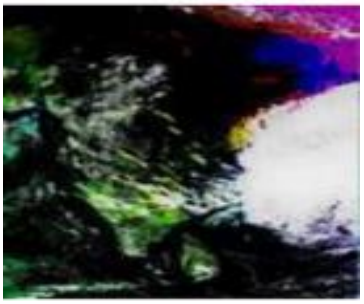


Fig 2: Brovey Transformation

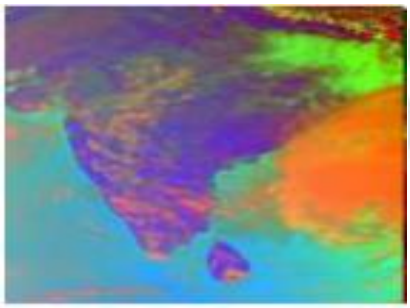


Fig 3: HIS Method

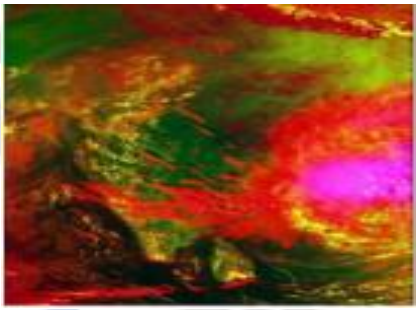


Fig4: Proposed Method

The color Transformation (HIS) image represented in Fig.3. The combination of PCA and pan sharpening Histogram matched (proposed) image shown at Fig.4. In this process, the total image bands are reduced with removed of redundant information in multiband. After compression of image,

Table 1: Eigenvectors of the variance-covariance matrix.

	Comp-1	Comp-2	Comp-3	Comp-4	Comp-5
Band 1	0.21212	-0.23435	-0.33923	-0.22493	-0.14365
Band 2	0.322125	-0.43749	0.12409	-0.27934	-0.13533
Band 3	0.435672	0.63823	-0.68459	0.230211	-0.08734
Band 4	0.654326	-0.04323	-0.19854	-0.12033	-0.06543
Band 5	0.421329	-0.12589	-0.00289	-0.09732	-0.00983

Table 1 shows the Eigen vectors of the covariance matrix. The dimensional reduction can be done by using eigen vectors of the original image. These values are containing maximum information with compressed data[22][23]. Choosing suitable coefficient values of the PC component, the reduction image can be obtained with useful information.

Table 2: Quality and Speed Comparison Results

		PSNR			Comp.Time(in sec)			Decom.Time(in sec)		
Images	Entrophy	Brovey	PCA	Proposed	Brovey	PCA	Proposed	Brovey	PCA	Proposed
MS-Image-1	8.24384	33.4345	35.7874	36.4838	1.4	1.3	1	1.2	0.8	0.6
MS-Image-2	7.432203	32.6473	35.7837	39.3833	1.3	1.2	0.9	1.2	0.9	0.5
MS-Image-3	7.234933	34.5643	34.9894	38.4849	1.3	1.2	0.9	1.1	0.7	0.5
MS-Image-4	6.348394	33.8978	36.4443	37.9208	1.2	1.1	1.1	0.9	0.8	0.5
MS-Image-5	7.847334	31.309	34.8783	39.8397	1.6	1.4	1.1	0.8	0.7	0.4
MS-Image-6	6.234283	35.7878	36.8873	39.3829	1.2	1.1	1.1	0.9	0.6	0.3

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

Table 2 shows the comparison results with other existing standard methods. The performance can be measure with suitable parameters. The PSNR is one of the standard parameter for measuring the compressed quality. After dimensional reduction technique (PCA), the information is loss due to elimination of some useful information. The maximum information contain inform of low and high frequency components. This information can be recovered by sharpening technique. This resultant data is not given sophisticated result for

Table 3: Similarity Comparison Results

Images	Entrophy	Auto Correlation Coeff.			SSIM			Classification Accuracy		
		Brovey	PCA	Proposed	Brovey	PCA	Proposed	Brovey	PCA	Proposed
MS-Image-1	8.24384	0.68575	0.56373	0.75673	0.3432	0.2944	0.54384	72.98	76.94	86.84
MS-Image-2	7.432203	0.75894	0.76783	0.76833	0.4339	0.23339	0.57436	76.84	76.67	85.04
MS-Image-3	7.234933	0.57467	0.60082	0.80123	0.32343	0.45434	0.67483	76.85	77.87	87.12
MS-Image-4	6.348394	0.66478	0.67383	0.79083	0.23349	0.33483	0.60103	78.64	69.87	82.83
MS-Image-5	7.847334	0.60745	0.76878	0.82322	0.36484	0.34494	0.59044	69.76	81.93	85.91
MS-Image-6	6.234283	0.49384	0.72379	0.80018	0.4404	0.45464	0.59895	69.88	72.34	78.73

transmission of data in 5G networks. The RSA encryption algorithm applied for preprocessing image. This proposed image obtained the better PSNR value and its suitable transmission of image with low Composite and decomsite time. The PSNR value is high, the Composite and decomposite values are low compare with other existing method such as Brovey, PCA method. The entropy values are obtained with satisfied values.

The similarities can also be measured using currently used techniques by correlation coefficient (CC) and structure similarity index values(SSIM). The suggested strategy results in greater SSIM and correlation coefficient for good quality and similarity measurements. The object classification can also performed the proposed image, these objects are obtained by unsupervised classification . compared with Brovey and PCA approaches, the proposed method provides good accuracy.

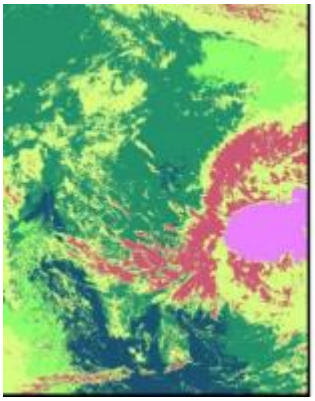


Fig 5. Classification of proposed Image

After being compressed, employing PCA methods with pan sharpening results in greater quality, good similarity, and good object classification accuracy. These pictures are appropriate for use with 5G networks. Fig.5 shows the classification of the proposed image with less size and better quality. The training samples are collected with out any loss and obtained good accuracy values compared with other dimensionality reduction methods.

Conclusion:

Machine Learning algorithms are a class of methods for automatically creating models from a data set. It is widely implemented in real-time applications. The multispectral Moving robot captured image has much data information in more bands. The study of each band is very difficult due to the lack of information, the large number of bands, and redundant data. This data use of the 5G network is difficult with these limitations. This data can be reduced with fine detail of information, which can be done by the PAN sharpening dimensional reduction method in multispectral Moving robot captured images. In The PCA algorithm, eigenvectors contain the maximum usable information in compressed data. This preprocessed image is encrypted by the SPHIT algorithm for the 5G Network. This method is very helpful for advanced communication applications for storage and speed of the data in communication applications. This algorithm is very needed in multimedia data (text, video, audio) data in a 5G network with good accuracy.

REFERENCES

[1] Gonzalez RC, Woods RE. Digital image processing. 3rd ed. Prentice-HallEnglewoodCliffs; 2002.

[2] MK Hasan, S Islam, I Memon, AF Ismail, S Abdullah, AK Budati, NS Nafi, A novel resource oriented DMA framework for internet

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 8
DOI: https://doi.org/10.17762/ijritcc.v11i8.7950
***Article Received**: 05 May 2023 **Revised**: 30 June 2023 **Accepted**: 29 July 2023*

of medical things devices in 5G network," IEEE Transactions on Industrial Informatics, Vol. 18 , Issue.12, pp:8895-8904.

[3] Venkata Krishnamoorthy T, Umamaheswara Reddy G. Fusion enhancement of multispectral Moving robot captured image by using higher order statistics. Asian Journal of Scientific Research 2018;11:162–168.

[4] Bruno Carpentieri, Francesco Palmieri, "Transmission of Digital Data in the 5G Era: Compression and Privacy", Information, 2023,Vol. 14, Issue. 135, pp: 1-18.

[5] Elizabeth A. Compton and Stacey L. Ernstberger, "Singular Value Decomposition: Applications to Image Processing", Citations Journal of Undergraduate Research, 2020, Volume 17, pp: 99-105.

[6] Muhammad Ihsan Jambak, Ahmad IkromIzzuddinJambak, "Comparison of dimensional reduction using the Singular Value Decomposition Algorithm and the Self Organizing Map Algorithm in clustering result of text documents", IOP Conference Series Materials Science and Engineering , 2019, Vol. 551, issue 1, pp:1-6

[7] Elaiwat S, Bennamoun M, Boussaid F and El-Sallam A 2014 3-D face recognition using curvelet local features. IEEE Signal Process. Lett. , Vol. 21, Issue.2, pp: 172–175.

[8] MK Hasan, S Islam, I Memon, AF Ismail, S Abdullah, AK Budati, NS Nafi,A novel resource oriented DMA framework for internet of medical things devices in 5G network, IEEE Transactions on Industrial Informatics, Vol.18, Issue. 12,pp: 8895-8904.

[9] Venkatakrishnamoorthy, T.; Reddy, G.U. Cloud enhancement of NOAA multispectral images by using independent component analysis and principal component analysis for sustainable systems. Comput. Electr. Eng. 2019, Vol.74, pp:35–46.

[10] Dharani, M., Sreenivasulu, G.: Land classification of land sat multispectral image using principal component analysis and morphological operations. J. Adv. Res. Dyn. Control Syst., 2018, Vol.10, Issue. 06, 164–174.

[11] Eastman, J.R. 'Introduction to remote sensing and image processing', Guide to GIS and Image Processing,2001, Vol. 1, Ch. 3, pp.17–34.

[12] Shereena V B, Julie M. David, "Significance of Dimensionality Reduction in Image Processing", Signal & Image Processing An International Journal,2015, Vol 6, issue.3, pp:27-42

[13] Hongda Li, Jian Cui, Xinle Zhang, Yongqi Han and Liying Cao, "Dimensionality Reduction and Classification of Hyperspectral Remote Sensing Image Feature Extraction", Remote Sens. 2022, Vol. 14, pp: 1-8.

[14] Haut, J.M.; Paoletti, M.E.; Plaza, J, Plaza, A, "Fast dimensionality reduction and classification of hyperspectral images with extreme learning machines. J. Real-Time Image Process. 2018, Vol. 15, pp. 439–462.

[15] Olivier Lezoray, Christophe Charrier, Hubert Cardot, Sebastien Lefevre, "Machine Learning in Image Processing - Special Issue Editorial", EURASIP Journal on Advances in Signal Processing Volume 2008,PP:1-3.

[16] Cao, Lijie. "Singular value decomposition applied to digital image processing." Division of Computing Studies, Arizona State University Polytechnic Campus, Mesa, Arizona State University polytechnic Campus , 2006, pp: 1-15.

[17] Shuyi Li , Hengmin Zhang , Ruijun Ma c, Jianhang Zhou , Jie We n , Bob Zhang,"Linear discriminant analysis with generalized kernel constraint for robust image classification", Pattern Recognition, Volume 136, April 2023, No. 109196

[18] Jia, X., Richards, J.A.: Segmented principal components transformation for efficient hyperspectral remote-sensing image display and classification. IEEE Trans. Geosci. Remote Sens., 1999, Vol .37, Issue. 1,pp: 538–542.

[19] Juhani Nieminen , Johan Bakker, Martin Mayer, Patrick Schmid, Andrea Ricci. Exploring Explainable AI in Educational Machine Learning Models. Kuwait Journal of Machine Learning, 2(2). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/191

[20] Aradhana Sahoo, Pratyasha Mohanty, Purna Chandra Sethi, "Image Encryption Using RSA Algorithm", In book: Intelligent Systems, Proceedings of ICMIB 2021 , pp.641-652

[21] Groach M, Garg D A, DCSPIHT: Image compression algorithm, J. International Journal of Engineering Research and Applications, 2012, Vol 18(2) (2012) 560-567.

[22] Alparone, L., Baronti, S., Garzelli, A. and Nencini, F. "A global quality measurement of pan-sharpened multispectral imagery", IEEE Geoscience and Remote Sensing Letters, 2004, Vol. 1,No. 4, pp.313–317.

[23] Wang, Chih-Wen, and Jyh-HorngJeng. "Image compression using PCA with clustering." IEEE International Symposium on Intelligent Signal Processing and Communications Systems (ISPACS), 2012.

[24] M Dharani, G Sreenivasulu, "Land Classification of Land Sat Multispectral Image using Principal Component Analysis and Morphological Operations", Jour of Adv Research in Dynamical & Control Systems, 2019, Vol.10, No. 6, pp: 164-174.

[25] Dhanke Jyoti Atul et al. (2021) A Machine Learning-Based IoT for Providing an Intrusion Detection System for Security. Microprocessors and Microsystems, Volume 82, 103741. (Elsevier)

[26] Reddy, N.M., Ramesh, G., Kasturi, S.B. et al. Secure data storage and retrieval system using hybridization of orthogonal knowledge swarm optimization and oblique cryptography algorithm in cloud. Appl Nanosci (2022). https://doi.org/10.1007/s13204-021-02174-y

[27] Islam, S., Budati, A. K., Mohammad, K. H., Goyal, S. B., & Raju, D. (2023). A multi-sensory real-time data transmission method with sustainable and robust 5G energy signals for smart cities. Sustainable Energy Technologies and Assessments, 57, 103278.

[28] Budati, A. K., Islam, S., Hasan, M. K., Safie, N., Bahar, N., & Ghazal, T. M. (2023). Optimized Visual Internet of Things for Video Streaming Enhancement in 5G Sensor Network Devices. Sensors, 23(11), 5072.