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Correlative Analysis of EZW and SPIHT Compression Algorithms using Sevenlets Wavelet Technique

B. B. S. Kumar, P. S. Satyanarayana

***Abstract:** The research is carried out to find wavelets in image processing of CT(computerized Tomography) JPEG(Joint Photographic Experts Group) medical image for a Lossy Compression. The EZW(Embedded Zerotree Wavelet) and SPIHT(Set Partitioning Hierarchical Trees) algorithms method is implemented to identify the quality of image by DWT(Discrete Wavelet Transform). Quality analysis is processed based on parameters measure such as CR(Compression Ratio), BPP(Bits Per Pixel), PSNR(Peak Signal to Noise Ratio) and MSE(Mean Square Error). Comparison is made to justify having a good image retaining for seven wavelets, how they correlation each other. Using seven wavelets as assigned a new term Sevenlets in this research work. Medical images are very significant to retain exact image with minimizing loss of information at retrieving. The algorithms EZW and SPIHT give better support to wavelets for compression analysis, can be used to diagnosis analysis to have better perception of image corrective measure.*

***Keywords:** CR, CT, DWT, EZW, MSE, PSNR, SPIHT, JPEG and Lossy Compression.*

I. INTRODUCTION

The objective of a research to examine on medical image of JPEG format using a algorithms EZW and SPIHT. The seven wavelets is examine for compression using algorithms. The results are compared and identified of image clarity based on parameters measure such as CR, BPP, PSNR, MSE. Wavelets are filters which gives higher resolution for both time and frequency domain. The work is carried out on still image using different wavelet families such as Haar, Daubechies, Coiflets, Symlets, Discrete Meyer, Biorthogonal and Reverse Biorthogonal [20], [21].

A. Sevenlets

Sevenlets word is used in musical notes to particular rhythms. It counts many in terms of numbering which are things with data existence with information. The word Sevenlets used to count the wavelet names which are mathematical functions representation of oscillations with certain amplitude it starts from zero to high and high to zero or increasing from zero and decreasing to zero from high level. In this research seven wavelets are used so the name given as Sevenlets wavelet such as Haar, Daubechies, Coiflets, Symlets, Discrete Meyer, Biorthogonal and Reverse Biorthogonal.

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* Correspondence Author
B.B.S.Kumar*, Ph.D Research Scholar, JU, Bangalore, India, Email:bbskumarindia@gmail.com
Dr.P.S.Satyanarayana, Retd. Professor & HOD, Dept. of ECE, BMSCE, Bangalore, India, Email: pssvittala@gmail.com

II. WAVELETS

Wavelet [4] is a mathematical function in the form of frequency attributes representing of data. It is process of signal analyzing in spatial domain according to scaling. In 18th century Joseph Fourier is discovered signal processing of sines and cosines presenting other functions. Fourier presentation doesn't explain the signals in the spatial domain at different scaling functions with varying resolutions. Using wavelets can describe signal processing of data at simultaneous representing all the frequency attributes of defined intervals or in a window for larger and smaller data. But Fourier is having the advantages when signal is discontinuity and sharp spikes.

Wavelets having the properties of signal processing as reversing, shifting, multiplying and integrating of phenomenon of convolution, all the wavelets can added with known and unknown signal data to retrieve exact values of portions.

A. DWT

Discrete Wavelet Transform [17], [18] is having more advantage then the Fourier transform, the image is represented in time and frequency domain. Fourier transform is reveals only frequency attributes of characteristics. Henceforth for DWT it is significant in analyze the image for multiple resolutions, having functionalities of scalability, orthogonality, translatability, separability and multi resolution compatibility. It enables to provide the information for synthesis and to analysis, less time for execution. Simple processing method for a signal at various frequency bands with various multiple resolutions. The 2D(Two Dimensional) image signal is decomposed at desired levels of detail and coarse information into subbands frequencies shows from the Fig.3 & 4 and easier to decorrelation of image pixels, having better energy compaction.

III. EZW

It is helpful and efficient EZW algorithm in image compression techniques [1]. In this technique can select desire bit rate and can image exactly encode for required bit rate, it is completely embedded in bit stream for image compression coding. The successive methods to implement EZW algorithm is Successive approximation quantization of wavelet coefficients, Huffman coding and compact binary maps are provided by zero-tree coding.

A. Embedded Coding

EZW algorithm is good and effective compression algorithm technique. From the Fig.1, the methodologies having a wavelet transform, quantizer and entropy coder. The image transform is Discrete Wavelet Transform(DWT) is decomposed for required levels and creates the image wavelet coefficients at different scaling function [8], [11].

The quantizer will quantizes into image transformed matrix values of integers in sequence.

From entropy coding having processing methods, the firstly progressive encoding having normal choice for compression in wavelet image transformed method, only the higher sub bands add to detail. Secondly the larger wavelet coefficient is more significant than the smaller wavelet coefficients.

EZW is introduced by J. M. Shapiro. By EZW algorithm in 1993 when wavelet coefficient on coarse scale is not important to change in threshold value T. For all the wavelet coefficient to similar orientation in the similar spatial location on finer scale is not important to change in threshold value T. On similar spatial orientation the trees make together a parent-child relationship with wavelet coefficient of subbands from the Fig.2, 3 & 4. The parent–child relationship dependencies for all process with better performance of zero-tree coders in image compression. At decomposition level the image into four parts in frequency subbands, by wavelet transform filters is sub sampled horizontal and vertical subbands, they are LL(Low-Low), LH(Low High), HL(High Low) and HH(High High). To get subsequently coarser the LL subband is decompose. The figure EZW compression technique shows the coarse scale coefficient is defined the parent and all the coefficients which are on similar spatial orientation location at the finer scale of orientation are defined children.

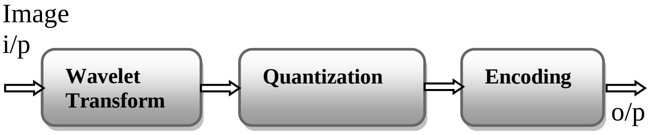

Fig.1. Compression Technique

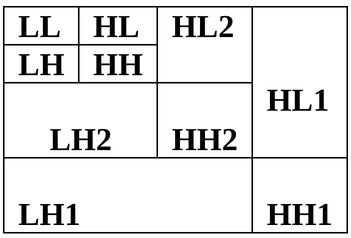

Fig.2. Parent-child Relationship dependencies

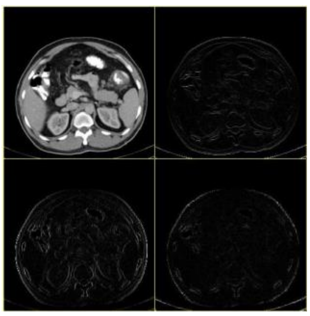

Fig.3.2D DWT Decomposition Level-1

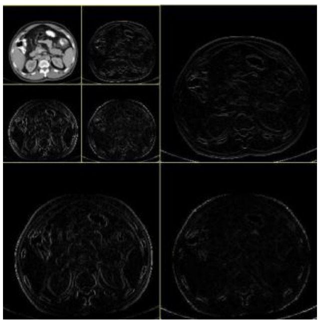

Fig.4.2D DWT Decomposition Level-2

IV. SPIHT

In 1996 by Amir Said and A.Pearlman are Brazilian engineer developed the SPIHT algorithm [16]. Both EZW and SPIHT works on wavelet coder of zero-tree coding. SPIHT wavelet coder techniques algorithm based on three coefficient location such as LIP(List of significant Pixels), LSP(List if Insignificant Sets) and LIS(List of Insignificant Pixels) were organized with respectively to coordinates. The each coefficient location processed by two steps iteration is sorting pass and refinement pass. The organized lists is outcome of sorting pass and real coding is outcome of refinement pass, which are fully embedded in bit stream. SPIHT algorithm produces the better quality images coding is limited to power 2 resolution of pixel. Having power consumption is low, complexity is less bit, and stream outcome is compact. The demerit of SPIHT it locates significant coefficient position implicitly. This build uneasy to operations performance in compressed data of region selection, hence depends perfectly correct position of transformed significant values.

V. IMAGE COMPRESSION

The image compression is the technique of encoding and reduces the image file to lesser size than the original file. Without affecting the quality of image and degrading when it is compressed. Compression methods are used to occupy the less space in the memory allocation of image to store with reduced bytes [2], [7].

The data compression used to resize to take less disk space then the uncompressed image, lesser image bytes transfers quickly than the larger image file.

Image compression plays very significant role in a transmission to transmit a data at faster rate in minimizing size to avoid any delay.

JPEG format is used for experiments; it is a lossy image compression technique and internationally accepted as a standard, invented by “Joint Photographic Experts Group”. Image compression is classified as lossy and lossless compression. In lossy compression method some percentage of original image information is lost and cannot be retrieved probably affecting the image quality. But it will retrieve as same original image appearance. In lossless image compression method the image is not varied as it is original image is retrieved without any loss of information data.

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Using JPEG format can varying image with required percentage and retrieved as original image. But using other image formats cannot examine because space restoring is high there are lossless compression methods that is why testing cannot be done. Compression provides using less bandwidth and space on disk, transmission and downloading at faster rate, decompressed when required and expansions at restoration [12], [13].

The image compression is measure based on compression ratio (CR) and Bit Per Pixel (BPP) ratio. The image compression ratio is defined the ratio between the original uncompressed size and compressed size. For example original storage size image to be compressed file from 100 MB to 10 MB has a CR of 100/10 = 5, hence the ratio 5:1 or ratio 5/1.

BPP defines the number of bits taken memory in one pixel after compressed image. For monochrome image, the BPP is equal to 8, for truecolor image represents RGB(Red Green Blue) the BPP is 24.

A. CR

Compression Ratio(CR)=(Original Uncompressed Image File size)/(Compressed Image File size).

If the compression is ratio higher the image is degraded having poor quality at reconstructed image.

B. BPP

Per pixel the number of bits of data information is stored in the image. 8 bits per pixel or 1 byte per component, 24 bits per pixel for 256 levels of each component and different colors of 16 million cannot be distinguished by human eye.

C. PSNR

Its computes the Peak Signal to Noise Ratio (PSNR) between the two images such as original and compressed images, this ratio is used for quality measurement in decibels, from the Eq.(1).

$$PSNR = 10\log_{10}255^2/MSE \quad (1)$$

Peak error occurs during the image compression it is process of quality measurement between the retrieved image of lossy and lossless compression, between the original and error in the compressed image. If PSNR is lower than the measure of quality is degraded and PSNR is higher the quality of image is good at the time of compression.

D. MSE

It's defined as an increasing squared error between the original and compressed image. From the Eq.(2), where M and N are the number of rows and columns of input images.

$$MSE= \sum_{M,N} [I_1(m,n)- I_2(m,n)]^2/M*N \quad (2)$$

The PSNR and MSE are used to define the errors comparing during quality of image compression, PSNR is constitutes the peak error. The higher value of MSE represents error is higher and image quality is poor, MSE should be lower value than the error is minimized the image quality will be good.

VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

Image size : 512x512, gray scale, Computerized Tomography(CT) image .

Fig.5. Tumor CT Original Image

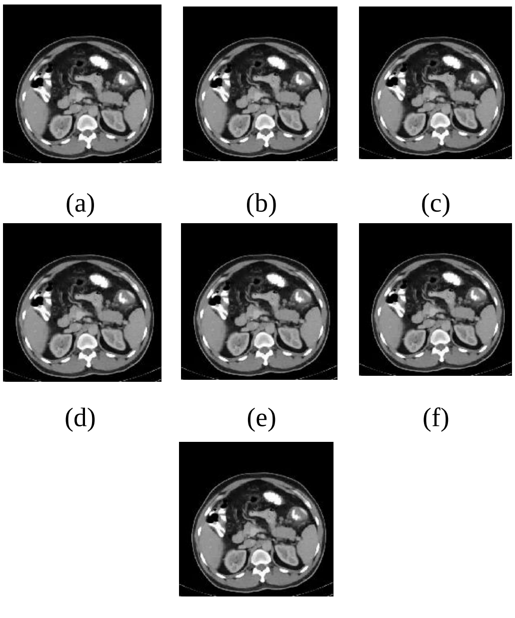

Fig.6. EZW Compressed Image (a)haar (b)db2 (c)sym4 (d)coif2 (e)dmey (f)bior3.9 (g)rbio3.9

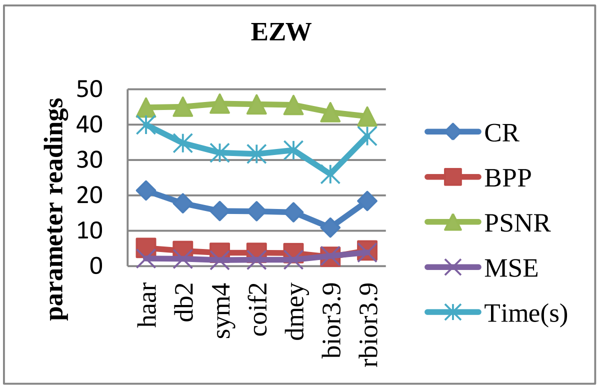

Fig.7. SPIHT Compressed images (h)haar (i)db2 (j)sym4 (k)coif2 (l)dmey (m)bior3.9 (n)rbio3.9

Table -I: Quantitative analysis of EZW

Wavelets	Parameters(SPIHT)				
Name	CR	BPP	PSNR	MSE	Time(s)
Haar	8.4	2.02	39.43	7.41	13.57
db2	6.4	1.54	40.17	6.25	13.13
sym4	5.61	1.35	40.93	5.25	12.37

coif2	5.69	1.36	40.89	5.29	12.59
Dmey	5.54	**1.33**	40.92	5.26	13.91
bior3.9	7.18	1.72	42.68	3.51	13.93
rbior3.9	6.13	1.47	37.69	11.06	13.47



(h) (i) (j)



(k) (l) (m)

(n)

Fig.8. EZW Graphical Representation

Table -II: Quantitative analysis of SPIHT

Wavelets	**Parameters(EZW)**				
Name	**CR**	**BPP**	**PSNR**	**MSE**	**Time(s)**
haar	**21.38**	5.13	44.87	2.12	39.983
db2	17.75	4.26	45.11	2	34.79
sym4	15.57	3.74	45.98	1.64	32.04
coif2	15.52	3.73	45.75	1.73	31.73
dmey	15.21	3.65	45.59	1.79	32.78
bior3.9	10.88	**2.61**	43.55	2.87	26
rbior3.9	18.41	4.41	42.32	3.81	36.79

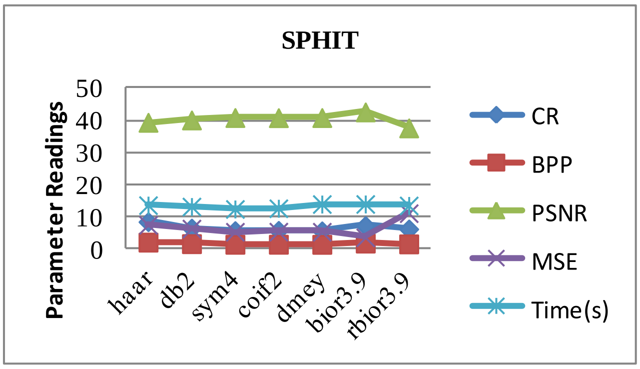

Fig.9. SPIHT Graphical Representation

For experimentation results the JPEG medical image format is used, it is a lossy compression technique, it is an DICOM(Digital Imaging and Communications in Medicine) CT image gathered from hospital. Hence DICOM image is converted to JPEG image using software. A CT images a series of merged X-ray images at different angles taken around the body and processed by computer to make images of cross-sectional of the blood vessels, soft tissues and bones inside the body. Detailed information is given by CT scan images then the X-rays images. DICOM standard was formed by the NEMA(National Electrical Manufacturers Association) for distribution and view the medical images such as ultrasound, MRI (Magnetic Resonance Image) and CT scans.

From Fig.6 and 7 two algorithms is examined by EZW and SPIHT to secure better compression using seven wavelets called Sevenlets used name as a new terminology having wavelets short name with order is Haar(haar), Daubechies(db2), Symlets(sym4), Coiflets(coif2), Discrete Meyer(dmey), Biorthogonal(bior3.9) and Reverse Biorthogonal(rbior3.9). By the observation of results table-I and II, the EZW having higher compression ratios, image may degraded but in SPIHT having lower compression ratios quality is good. In EZW compression the PSNR is high and lower in MSE and BPP is high when comparing with SPIHT compression, In SPIHT compression the PSNR and MSE is moderate, BPP is lower and better, when comparing with EZW compression [5], [6]. Execution time of processing is more in EZW then SPIHT algorithm can observe by a graphical representation. The compression is acceptable using SPIHT taking less storage memory with better quality of image.

A. EZW and SPIHT Comparison

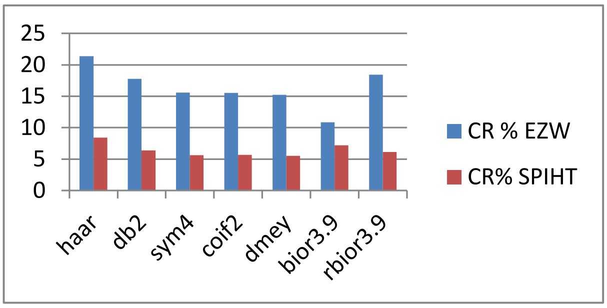

Fig.10.CR% comparison

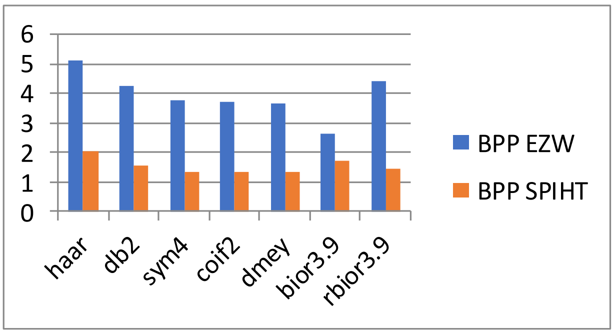

Fig.11.BPP Comparison

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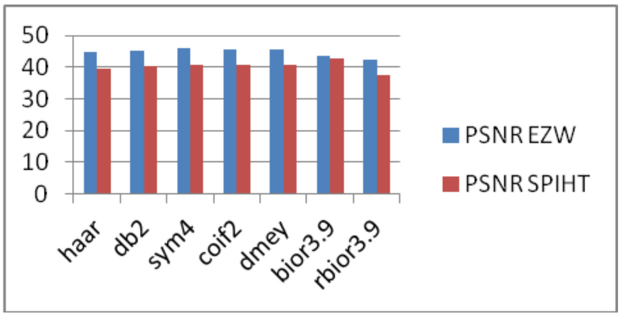

Fig.12.PSNR Comparison

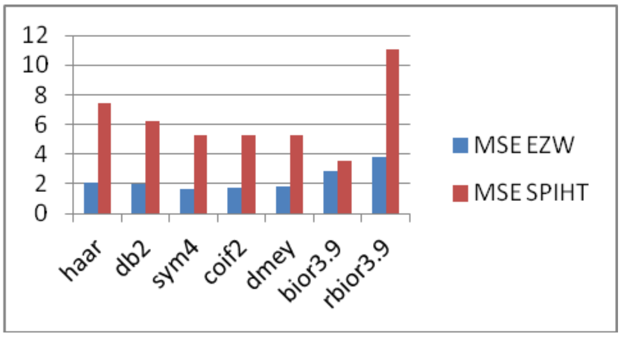

Fig.13.MSE Comparison

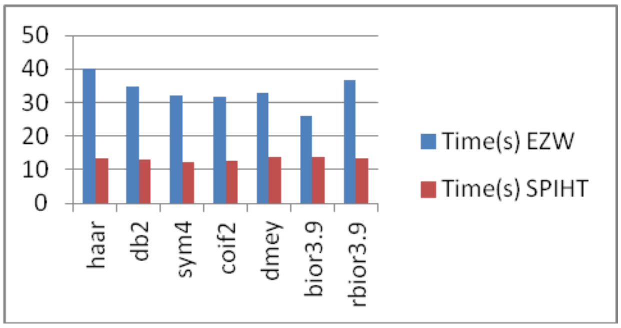

Fig.14. Time(s) Comparison

From the graphical representation of analysis the CR, BPP, PSNR and MSE describes the compression merits and demerits of EZW and SPIHT algorithms and they are correlative each other. Both methodologies techniques support the wavelets filters for multi-resolutions to improve the image clarity. Medical images are very significant the outcome retrieving require with better performances. Medical image processing techniques it's always checked the information should not be lost, it is minimized. Appropriate diagnosing must and should in image perception, and data space storage memory it's important. Based on requirement of compression percentage ratio with good reception high quality is important. To fulfill the desire compression JPEG format standards image is used. JPEG image supports variation in methods for lossy compressions. From the graphical representation the EZW and SPIHT algorithms, SPIHT having better performances in retrieving with low degradation image.

B. Compressed Image Retained Energy in %

Decomposition level: 2, Global Thresholding: 10
Image size : 512x512, gray scale, CT JPEG image .

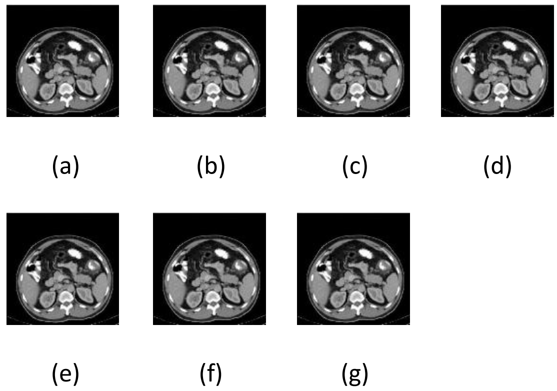

Fig.15.Compressed image of Retained Energy and Number of zeros in % (a)haar (b)db2 (c)sym4 (d)coif2 (e)dmey (f)bior3.9 (g)rbio3.9

Table -III: Compressed image of Retained Energy and Number of zeros in %

Wavelets Name	Retained Energy %	Number of Zeros %
haar	99.92	84.06
db2	99.92	87.76
sym4	99.93	89.15
coif2	99.93	88.94
dmey	99.93	84.76
bior3.9	100.00	88.47
rbio3.9	100.00	87.01

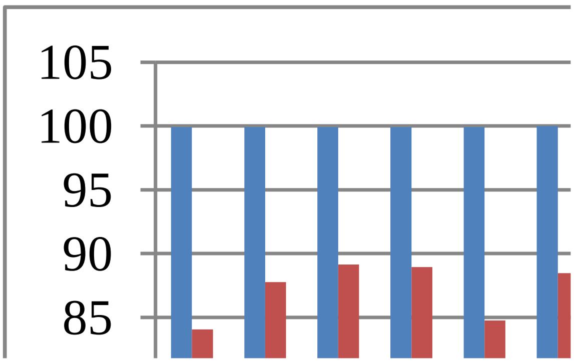

Fig.16: Image Compression of Retained Energy and Number of Zeros in %

For the wavelets having good multi resolution and energy compaction as shown from the table-III compression image of retained energy in %, at global thresholding and decomposition level two for 2D CT JPEG image, as shown in Fig.15 and graphical representation of Fig.16. Retaining energy in compression for biorthogonal and reverse biorthogonal is better than other wavelets.

VII. CONCLUSION

In this research work the image is examine by seven wavelets they are Haar, Daubechies, Coiflets, Symlets, Discrete Meyer, Biorthogonal and Reverse Biorthogonal called Sevenlets wavelet of DWT technique, lossy compression is done by algorithms EZW and SPIHT based on individual wavelets.

From parameters measure of CR, BPP, PSNR, MSE and execution time using of CT medical JPEG image. From the EZW compression CR is high and quality of image is degraded, BPP is higher hence storage memory space usage is more, but PSNR is high and MSE is low with higher execution time. Whereas SPIHT compression provides lower CR and BPP is good, moderate in PSNR and MSE with lesser time of execution, by comparison analysis for SPIHT the performance is better for Sevenlets wavelet filters. The Sevenlets wavelet attains better energy retaining compaction with image clarity and number of zeros for sensible compression.

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AUTHORS PROFILE

B. B. S. Kumar, involved pioneering the students in the educational and careers. BE in Electronics & Communication and MTECH in Digital Electronics from B.V. Bhoomaraddi College of Engineering, Hubli, Karnataka, India, through KUD & VTU. Ph.D research scholar, working on Image Processing using Wavelets Techniques, JU, Bangalore, India. Worked as HOD of EC at Ghousia Polytechnic for Women, Bangalore, from 2007-2008. 2008 to 2017 as Senior Assistant Professor, Dept. of ECE, Rajarajeswari College of Engineering, Bangalore. 2017 to 2019 as a Principal of RJS Polytechnic, Bangalore. 40 International & National Journals and Conference papers published in the proceedings. Book reviewed Digital Communication of Elsevier publication and International Journals Publication Reviewer & Editor. Diploma project Honored 3rd PRIZE in state level exhibition at Visvesvaraya Museum in 2008, Bangalore. Received 2 - BEST PAPER AWARDS at National Conference in KSIT NCCC-2012 & VKIT ETEC-2013. Received Research work BEST PRESENTATION AWARD 2019, JU, Bangalore. 1 – Copyrights of Ph.D research work, Life membership of ISTE.

Dr. P. S. Satyanarayana, Professor & Head, Dept. of ECE, at BMS College of Eng; Bull Temple Road Bangalore up to July 31, 2008. Took VRS after serving BMSCE from 1975 - to - 2008, ie. for 33 years of continuous service. Principal of RRIT, Hesaraghtta Road, Chikkabanavara from August 04, 2008 to August 05, 2009. Principal at City Engg College, Doddakallasandra, Off Kanakapura Road, Bangalore from January 2010 up to October 06, 2010.
Professor at RRCE, Kumbalgod, Kengeri, Mysore Road, Bangalore from October 08, 2010 to Jan 05, 2012. Working here currently with CiTech, K. R. Puram, Bangalore from July 05, 2012.
Earlier worked with BU, Karnataka University and some TN universities, AP universities as BOS Member, BOE Member. Associated in one form or the other with VTU right from its inception. Worked as BOS member from June 2002 to April2005 and as BOS Chairman & Academic Senate Member from June 2005 to April 2008.
I obtained my B. E (E & C) with FC from Mysore University through NIE Mysore in the year 1972. M. Sc (Engg;) (Control Systems Engg) degree from Madras University through PSG College of Technology, Coimbatore in 1975. Ph. D (Control Engg) from IISc in the June 1986 Council. I had completed all my work during 1982 - 1985 under Professor M. R. Chidambara at the School of Automation (Now known as Dept of Computer Science & Automation). I was Lecturer at BMSCE from 1975 to 1984. Assistant Professor up to 1992. Professor from 1992 till I took VRS. I was made HOD from 1989 and continued to be so till my VRS except for the periods 1995-96 and 1999-2003. I have produced 06 Ph. D's under VTU and one under Mother Theresa University, Kodaikkanal & two candidates pursuing Ph. D. 80 International & National Journals and Conference papers published in the proceedings. 2 text books published.