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An Efficient Approach for Image Compression using Segmented Probabilistic Encoding with Shanon Fano[SPES].

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Abstract:Store-and-generate techniques compress a given test image and regenerate the original test image during test with the help of a decompression. Recent technological breakthroughs in high speed processing units and communication devices have enabled the development of high image compression schemes. This paper presents Segmented Probabilistic encoding with Shanon Fano compression. Is a technique for constructing a prefix code based on a set of symbols and their probabilities. It does guarantee that all codeword lengths are within one bit of their theoretical ideal I(x) = − log P(x). The SPES technique is based on spatial domain of the image and is suitable for compression of medical images. The main objective of this technique is to show the better compression than other compression technique. An efficient compressing technique, SPES with Shanon Fano has been suggested in this paper.

Keywords - SPES, compression, Shanon Fano coding.

INTRODUCTION:

Image compression plays very vital role while storing and transmitting. Compression [2] is the process of removing nonessential information from the image to reduce the quantity of image. The main objective of image compression is to reduce the size of the image and reconstruct the image, which is same as original image. They are two main types of image compression [2] techniques are there i.e. Lossless compression and Lossy compression. Lossless means compress the image without losing the original data. Lossless image formats are BMP,PNG. Lossy means compress the image with loss of original data but can reconstruct the image which is same as original image. Lossy image formats are JPEG[6] (Joint Photographic Experts Group) and 2000 Joint Photographic Experts Group 2000.This paper presents new compression technique i.e Lossless SPES with Shanon Fano[3] technique and Lossy SPES with Shanon Fano technique. This proposed technique is compared with other standard compression formats and showing the better compression technique than the other compression techniques.

Lossless compression image formats [6]:

BMP (bitmap) is a bitmapped graphics format used internally by the Microsoft Windows graphics subsystem (GDI), and used commonly as a simple graphics file format on that platform. It is an uncompressed format.

TIFF (Tagged Image File Format) (last review 1992) is a file format for mainly storing images, including photographs and line art. It is one of the most popular and flexible of the current public domain raster file formats. Originally created by the company Aldus, jointly with Microsoft, for use with PostScript printing, TIFF is a popular format for high color depth images, along with JPEG and PNG. TIFF format is widely supported by image-manipulation applications, and by scanning, faxing, word processing, optical character recognition, and other applications. The most common general-purpose lossless compression algorithm used with TIFF is LZW, which is inferior to PNG and until expiration in 2003 suffered from the same patent issues that GIF did.

Lossy image compression formats [6]:

JPEG (Joint Photographic Experts Group) (1992) is an algorithm designed to compress images with 24 bits depth or grayscale images. It is a lossy compression algorithm. One of the characteristics that make the algorithm very flexible is that the compression rate can be adjusted. If we compress a lot, more information will be lost, but the result image size will be smaller. With a smaller compression rate we obtain a better quality, but the size of the resulting image will be bigger. This compression consists in making the coefficients in the quantization matrix bigger when we want more compression, and smaller when we want less compression.

JPEG 2000 (Joint Photographic Experts Group 2000) is a wavelet-based image compression standard. It was created by the Joint Photographic Experts Group committee with the intention of superseding their original discrete cosine transform based JPEG standard.

JPEG 2000 has higher compression ratios than JPEG. It does not suffer from the uniform blocks, so characteristics of JPEG images with very high compression rates.

Segmented Probalistic Encoding with Shanon Fano Technique:

In all the techniques the compressed file is maintained in two parts. The first part is bit table and second is data table [4]. The bit plane is collection of 1's and 0's to represent whether a pixel is repeated or not. The second part is data table, which holds only the necessary pixel values. The bit table and data table are merged into one file. To further compress, another loss less technique Shanon Fano coding [3] is applied and final form of compressed file is generated.

This technique is based on spatial domain [5][4] of the image and is suitable for compression of medical images. The main objective of this technique is to take advantage of repeated values in consecutive pixels positions. For a set of repeated consecutive values only one value is retained.

METHOD OF APPROACH:

In SPES Technique, image is segmented, on each segment probabilistic encoding is applied, desegment the image i.e. merge all the segments and finally Shanon Fano technique is applied on desegmented image to get better compression.

In the Probabilistic encoding, two codes are used to build the Bit Table [5]. The codes are as given below

Code 1 (one) is used to indicate that current pixel is different from previous pixel. In this case the current pixel is moved to the Data Table

Code 0 is used to indicate that the current pixel is exactly same as previous pixel. This eliminates the storage of current pixel.

After generating and merging the Bit Plane and Data Table, Shanon Fano coding is applied and final form of compressed file is generated.

Reconstruction of the Image in SPES Plane Technique

In the reconstruction of the image, first the intermediate file is generated from the compressed file [4][5]. The Bit Table and Data Tables are extracted from the intermediate file. By checking each bit of Bit Table either a fresh byte from the Bit table is read and written to the reconstructed image file or earlier byte itself is written based on the current bit checked.

Shanon Fano coding:

Compression is the process of removing nonessential information from the message to reduce the quantity of data.[1][3] The principles of image compression require an understanding of the fundamental concepts of information theory, which were laid down by Claude Shannon in the late 1940s, with later contributions by many authors, notably Norbert Wiener and A.I. Khinchin. The technologies (hardware and software) were very hot topics in the 1980s because of limitations in storage space (as difficult as it may be to believe now, a common size for a PC hard drive was 30 MBytes in the mid-late 1980s). The topic heated up again in the late 1990s for internet applications because of limitations in transmission bandwidth.

An image can be considered to be a message consisting of different gray values obtained from some set of well-defined possible values. In words, we can define the importance of the data in the message by noting that “the norm isn’t “news” but a rare occurence is.”[1][3] In 1947, Shannon strictly defined the quantity called “information” to satisfy two basic requirements that make intuitive sense. In so doing, he began the study of information theory, which is a part of applied probability theory. Though Shannon’s original definition of information is very intuitive, it must be generalized to provide a more complete description of the concept. The concept of information may be interpreted as the minimum number of questions with a binary answer set (the only possible outcomes are yes/no or 1/0) that must be answered before the correct message may be determined.

Shannon defined information by establishing intuitive criteria that the concept should obey and finding a mathematical expression that satisfies these requirements.

It is very important to note that Shannon’s definition of information assumes that the outcomes of a particular experiment are random selections from some particular probability distribution. If we flip a “256-sided” fair coin a large number of times (say N = 512 × 512 = 262, 144 “flips”), we can generate an “image” with N pixels, each with 256 “outcomes” (gray levels) that will be approximately equally populated. If the gray level of some specific pixel is 4, then the gray levels of its neighbors are (by assumption) as likely to be 199 or 255 as 3 or 5. Such a system for generating data may be called a discrete memory less source or DMS because an individual output from the system (pixel gray value) is independent of previous outputs. However, we know that adjacent pixels in pictorial images of real scenes usually belong to the same object and tend to have similar gray levels. Thus the gray values of adjacent pictures are usually correlated.

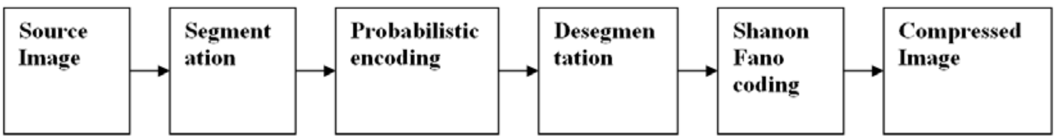


Figure 5.1: SPES Image Compression Model

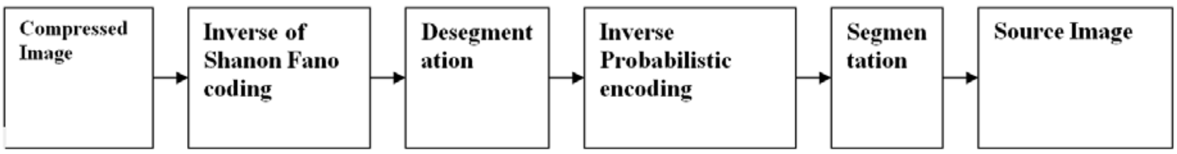


Figure 5.2. SPES Image Reconstruction Model

Shannon–Fano coding, named after Claude Elwood Shannon and Robert Fano,[3] is a technique for constructing a prefix code based on a set of symbols and their probabilities. It does guarantee that all codeword lengths are within one bit of their theoretical ideal $I(x) = -\log P(x)$.

In Shannon–Fano coding, the symbols are arranged in order from most probable to least probable, and then divided into two sets whose total probabilities are as close as possible to being equal. All symbols then have the first digits of their codes assigned; symbols in the first set receive "0" and symbols in the second set receive "1". As long as any sets with more than one member remain, the same process is repeated on those sets, to determine successive digits of their codes. When a set has been reduced to one symbol, of course, this means the symbol's code is complete and will not form the prefix of any other symbol's code.

The algorithm works, and it produces fairly efficient variable-length encodings; when the two smaller sets produced by a partitioning are in fact of equal probability, the one bit of information used to distinguish them is used most efficiently.

Shannon–Fano coding is used in the IMPLODE compression method, which is part of the ZIP file format, where it is desired to apply a simple algorithm with high performance and minimum requirements for programming.

Shannon-Fano Algorithm:

A Shannon–Fano tree[3] is built according to a specification designed to define an effective code table. The actual algorithm is simple:

1. For a given list of symbols, develop a corresponding list of probabilities or frequency counts so that each symbol's relative frequency of occurrence is known.
2. Sort the lists of symbols according to frequency, with the most frequently occurring symbols at the left and the least common at the right.
3. Divide the list into two parts, with the total frequency counts of the left part being as close to the total of the right as possible.
4. The left part of the list is assigned the binary digit 0, and the right part is assigned the digit 1. This means that the codes for the symbols in the first part will all start with 0, and the codes in the second part will all start with 1.
5. Recursively apply the steps 3 and 4 to each of the two halves, subdividing groups and adding bits to the codes until each symbol has become a corresponding code leaf on the tree.

Consider the following example, The source of information A generates the symbols {A0, A1, A2, A3 and A4} with the corresponding probabilities {0.4, 0.3, 0.15, 0.1 and 0.05}. Encoding the source symbols using binary encoder and Shannon-Fano encoder gives:

Source Symbol	Pi	Binary Code	Shannon-Fano
A0	0.4	000	0
A1	0.3	001	10
A2	0.15	010	110
A3	0.1	011	1110
A4	0.05	100	1111
Lavg	**H = 2.0087**	**3**	**2.05**

The Entropy of the source is

$$H=-\sum_{i=0}^{4} \pi \log_2 \pi=2.0087 \text{ bit/symbol}$$

Since we have 5 symbols ($5<8=2^3$), we need 3 bits at least to represent each symbol in binary (fixed-length code). Hence the average length of the binary code is

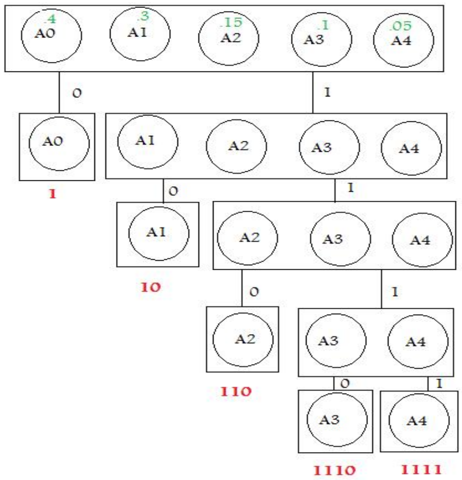
$$L_{avg}=\sum_{i=0}^{4} \pi\, li=3(0.4+0.3+0.15+0.1+0.05)=3$$

bit/symbol

Thus the efficiency of the binary code is

$$N = \frac{H}{L_{Avg}} = \frac{2.0087}{3} = 67\%$$

Shannon-Fano code is a top-down approach h. Constructing the code tree, we get



The average length of the Shannon-Fano code is

$$L_{avg}=\sum_{i=0}^{4}\pi li=0.4*1+0.3*2+0.15*3+0.1*4+0.05*4=2.0$$

5 bit/symbol

Thus the efficiency of the Shannon-Fano code is

$$N = \frac{H}{L_{Avg}} = \frac{2.0087}{2.05} = 98\%$$

PERFORMANCE COMPARISONS OF SPEST

The size required storing the medical images such as chest x-ray, image of brain, head scan; knee joint image, shoulder image etc are collected. These images are compressed by applying different compression techniques viz Raw, BMP, JPG, TIFF and Lossless SPES[5,7] formats to get the minimum size required to store the images. The image sizes obtained after application of different compression techniques are analyzed. The size required to store the images purely depends on the compression technique. Figure 1 depicts the number of bytes required to store different medical images for the different compression techniques. You can clearly see that LLSPES compression technique consumes the least amount of storage space when compared with all the other available compression techniques for the sample medical images chosen as shown in the **Figure 1.** Hence we can conclude that Lossless SPES technique is best suited to store the medical and other images as amount of size required is least when compared against other techniques.

	RAW	BMP	TIFF	JPEG	LL SPESS
brain	12610	9044	17068	15094	10559
chest xray	18225	19920	21800	16180	18347
foot	16740	17944	17756	16144	10154
knee joint	18225	14940	23852	17193	14834
Head Scan	15625	16328	20260	15184	7647
shoulder	18225	14740	22076	16962	8362

Figure 1 : Size of Different coding techniques versus image comparison using LossLess Modified SPES Techniques

In **Figure 1,** the values of the size of different medical images are plotted for the different compression techniques. You can see that the proposed lossless SPEST technique [5]provide much better compression size in most cases compared to standard JPEG,TIFF and other techniques.

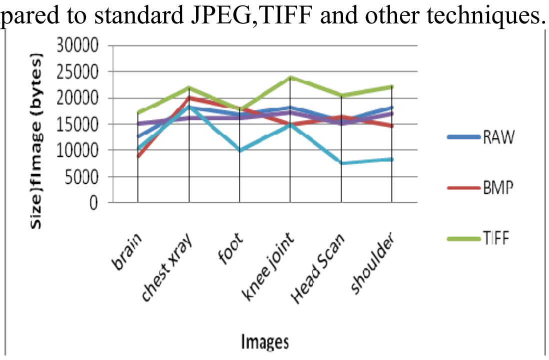


Figure 2:Shows the size of different images

Figure 3 depicts the number of bytes required to store different medical images of different segment size for the different compression techniques[8]. The size required to store the different medical images for different segment image remains same. There is no change or reduction in the size with increasing segment size and the size required to store the image is constant for different segment size for each of the compression techniques. But in the case of LL-SPES compression technique, you can clearly see that the size required to store the image reduces with increase in segment size. The size required to store a 3*3 segment image is more than that of size required for 5*5 segmented image and size required to store a 5*5 segment image is more than that of size required for 7*7 segmented image. Hence we can conclude that in Lossless SPES technique [5] the size required to store segmented images reduces with increase in the segment size.

Similarly in **Figure 4,** the values of the size of different segmented medical images are plotted for the different compression techniques. You can see that the proposed lossless SPEST technique provide much better compression size in most cases compared to standard JPEG,TIFF and other techniques.

Figure 5 depicts the number of bytes required to store different medical images for the different compression techniques. You can clearly see that LossySPES compression technique consumes the least amount of storage space when compared with all the other available compression techniques for the sample medical images chosen as shown in the **Figure 5**. Hence we can conclude that LossySPES technique is best suited to store the medical and other images as amount of size required is least when compared against other techniques.

	TIFF			JPEG			RAW			BMP			LL SPESS		
	3*3	5*5	7*7	3*3	5*5	7*7	3*3	5*5	7*7	3*3	5*5	7*7	3*3	5*5	7*7
Brain	17068	17068	17068	15094	15094	15094	12610	12610	12610	9044	9044	9044	10559	9520	8426
Chest Xray	21800	21800	21800	16180	16180	16180	18225	18225	18225	19920	19920	19920	18347	16791	17602
Foot	17756	17756	17756	16144	16144	16144	16740	16740	16740	17944	17944	17944	10154	8298	8525
Knee Joint	23852	23852	23852	17193	17193	17193	18225	18225	18225	14940	14940	14940	14834	15255	13096
Head Scan	20260	20260	20260	15184	15184	15184	15625	15625	15625	16328	16328	16328	16345	14883	15465
Shoulder	22076	22076	22076	16962	16962	16962	18225	18225	18225	14740	14740	14740	14915	13739	13656

Figure 3 : Size of Different segmented(3*3,5*5,7*7) versus image comparison using LossLess SPES Techniques

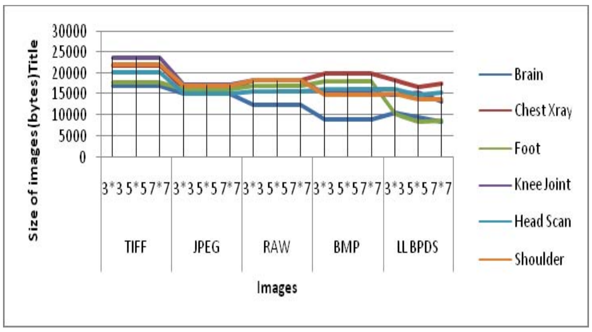


Figure 4 Size of the different segmented images

Image Name	RAW	BMP	TIFF	JPEG	LSY SPES
brain	12610	9044	17068	15094	9279
chest xray	18225	19920	21800	16180	7993
foot	16740	17944	17756	16144	8854
knee joint	18225	14940	23852	17193	9739
Head Scan	15625	16328	20260	15184	7975
shoulder	18225	14740	22076	16962	9230

Figure 5 Size of Different coding techniques versus image comparison using SPES Techniques

In Figure 6, the values of the size of different medical images are plotted for the different compression techniques. You can see that the proposed lossless SPEST technique provide much better compression size in most cases compared to standard JPEG,TIFF and other techniques.

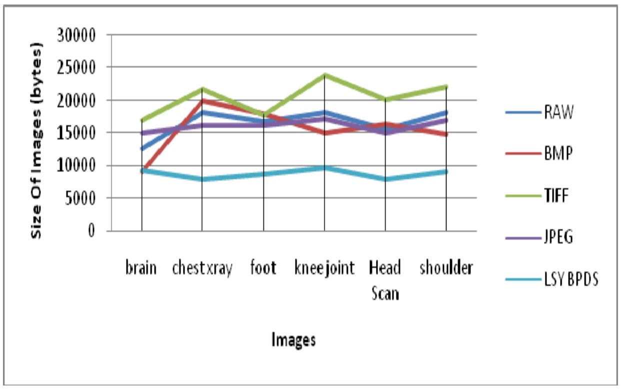


Figure 6 :Size of different size

Figure 7 depicts the number of bytes required to store different medical images of different segment size for the different compression techniques. The size required to store the different medical images for different segment image remains same. There is no change or reduction in the size with increasing segment size and the size required to store the image is constant for different segment size for each of the compression techniques. But in the case of Lossy-SPES compression technique, you can clearly see that the size required to store the image reduces with increase in segment size. The size required to store a 3*3 segment image is more than that of size required for 5*5 segmented image and size required to store a 5*5 segment image is more than that of size required for 7*7 segmented image. Hence we can conclude that in Lossy-SPES technique the size required to store segmented images reduces with increase in the segment size.

In **Figure 8,** the values of the size of different segmented medical images are plotted for the different compression techniques. You can see that the proposed lossy-SPEST technique provide much better compression size in most cases compared to standard JPEG,TIFF and other techniques.

Figure 8 depicts the number of bytes required to store different medical images for the different compression techniques. You can clearly see that LossySPES compression technique consumes the least amount of storage space when compared with all the other available compression techniques for the sample medical images chosen as shown in the **Figure 1**. To get better compression result applied Shanon Fano on LossLessSPES images. You can clearly see that LossyShonon compression technique consumes the least amount of storage space when compared with Shanon on RAW and LLSPES as shown in the **Figure 9.** Hence we can conclude that LossLessShonon technique is best suited to store the medical and other images as amount of size required is least when compared against other techniques and can the reconstruct original image.

Image Name	**TIFF**			**JPEG**			**RAW**			**BMP**			**LSY SPES**		
	3*3	**5*5**	**7*7**	**3*3**	**5*5**	**7*7**	**3*3**	**5*5**	**7*7**	**3*3**	**5*5**	**7*7**	**3*3**	**5*5**	**7*7**
Brain	17068	17068	17068	15094	15094	15094	12610	12610	12610	9044	9044	9044	9279	8146	7507
Chest Xray	21800	21800	21800	16180	16180	16180	18225	18225	18225	19920	19920	19920	7993	8259	9786
Foot	17756	17756	17756	16144	16144	16144	16740	16740	16740	17944	17944	17944	8854	7228	7599
Knee Joint	23852	23852	23852	17193	17193	17193	18225	18225	18225	14940	14940	14940	9739	8800	9518
Head Scan	20260	20260	20260	15184	15184	15184	15625	15625	15625	16328	16328	16328	7031	6264	7374
Shoulder	22076	22076	22076	16962	16962	16962	18225	18225	18225	14740	14740	14740	7975	7169	7692

Figure7: Size of Different segmented(3*3,5*5,7*7) versus image comparison using Lossy SPES Techniques

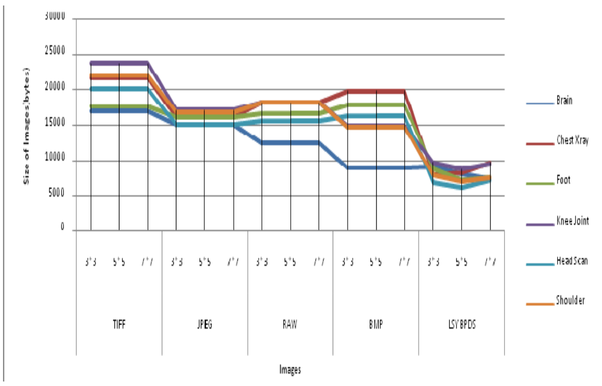


Figure 8

Image Name	**RAW**	**Shanon on Raw**	**LL-SPESS**	**LL SHONON**
brain	12610	10610	10559	9535
foot	16740	10237	10154	9038
knee joint	18225	15509	14834	14589
Head Scan	15625	14527	16345	14298
shoulder	18225	15211	14915	14201

Figure 9 **:**Size of Shanon Fano with RAW versus image comparison using Shanon Fano with SPES Techniques

Similarly in Figure 10, the values of the size of Shanon Fano on RAW and Shanon Fano on LLSPESS medical images are plotted. You can see that the proposed Shanon Fano on lossless SPEST technique provide much better compression size in most cases compared to RAW and other techniques.

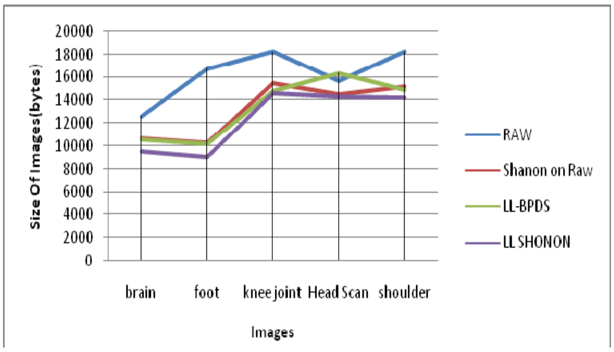


Figure 10:Shows the size of different images

Figure 11 depicts the number of bytes required to store different medical images of different segment size for the different compression techniques. The size required to store the different medical images for different segment image remains same. There is no change or reduction in the size with increasing segment size and the size required to store the image is constant for different segment size for each of the compression techniques. But in the case of Lossy-SPES and Lossless Shanon Fano compression technique, you can clearly see that the size required to store the image reduces with increase in segment size. The size required to store a 3*3 LossLess Shanon segment image is more than that of size required for 3*3 LossLess SPES segmented image and size required to store a 5*5 segment image is more than that of size required for 5*5 LossLess SPES segmented image. Hence we can conclude that in applied Lossy-Shonon on Lossy SPES technique is better technique to get the better compression in size and to store segmented images reduces with increase in the segment size.

In Figure 12, the values of the size of Shanon Fano on RAW and Shanon Fano on LLSPESS segmented (3*3,5*5,7*7) medical images are plotted. You can see that the proposed Shanon Fano on segmented lossless SPEST technique provide much better compression size in most cases compared to RAW and other techniques.

Figure 14 depicts the number of bytes required to store different medical images for the different compression techniques. You can clearly see that LossySPES compression technique consumes the least amount of storage space when compared with all the other available compression techniques for the sample medical images chosen as shown in the **Figure 1**. To get better compression result applied Shanon Fano on LossySPES images. You can clearly see that LossyShonon compression technique consumes the least amount of storage space when compared with Shanon on RAW and LSYSPES as shown in the Figure 13.

Image Name	RAW			LL SPES			LL SHONON		
	3*3	5*5	7*7	3*3	5*5	7*7	3*3	5*5	7*7
Brain	12610	12610	12610	10559	9520	8426	9535	8613	8014
Chest Xray	18225	18225	18225	18347	16791	17602	18440	17139	17845
Foot	16740	16740	16740	10154	8298	8525	9038	7709	7806
Knee Joint	18225	18225	18225	14834	15255	13096	14589	12956	13354
Head Scan	15625	15625	15625	16345	14883	15465	14298	13205	13168
Shoulder	18225	18225	18225	14915	13739	13656	14201	12420	12522

Figure11 :Shows size of different segmented (3*3,5*5,7*7)versus image compression using Lossless shanon Fano

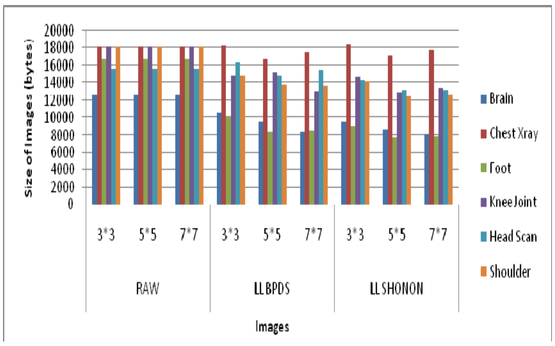


Figure 12 :Size of different segmented images

Image Name	RAW	Shanon on Raw	LSY SPES	LSY SHONON
brain	12610	10,610	9279	8567
chest xray	18225	18390	7993	8331
foot	16740	10237	8854	7992
knee joint	18225	15,509	9739	9827
Head Scan	15625	14527	7031	8093
shoulder	18225	15211	7975	9326

Figure 13:Size of Raw with Shanon and LSY BPDS and LSY Shonon

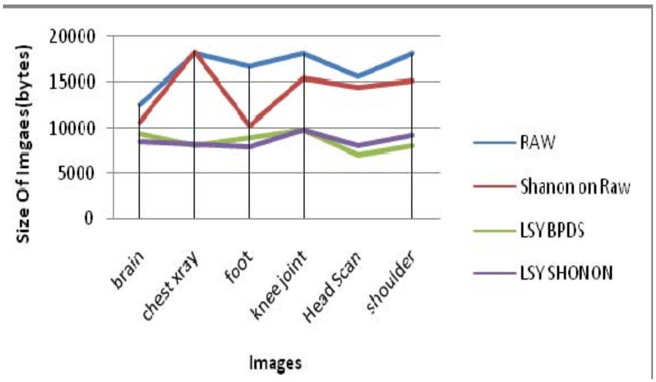


Figure 14:Shows the size of different images

Image Name	RAW			LSY SPES			LSY SHONON		
	3*3	5*5	7*7	3*3	5*5	7*7	3*3	5*5	7*7
Brain	12610	12610	12610	9279	8146	7507	9889	7556	7222
Chest Xray	18225	18225	18225	7993	8259	9786	7556	8838	10276
Foot	16740	16740	16740	8854	7228	7599	7404	6904	7057
Knee Joint	18225	18225	18225	9739	8800	9518	8990	9158	10052
Head Scan	15625	15625	15625	7031	6264	7374	7647	7405	7944
Shoulder	18225	18225	18225	7975	7169	7692	8362	8280	8594

Figure 15:Size of different segmented (3*3,5*5,7*7) image compression using lossless Shanon Fano.

Hence we can conclude that LossyShonon technique is best suited to store the medical and other images as amount of size required is least when compared against other techniques and can the reconstruct original image. Similarly in Figure 10, the values of the size of Shanon Fano on RAW and Shanon Fano on LLSPESS medical images are plotted. You can see that the proposed Shanon Fano on lossy SPEST technique provide much better compression size in most cases compared to RAW and other techniques.

Figure 15 depicts the number of bytes required to store different medical images of different segment size for the different compression techniques. The size required to store the different medical images for different segment image remains same. There is no change or reduction in the size with increasing segment size and the size required to store the image is constant for different segment size for each of the compression techniques. But in the case of Lossy-SPES and Lossless Shanon Fano compression technique, you can clearly see that the size required to store the image reduces with increase in segment size. The size required to store a 3*3 Lossy-SPES segment image is more than that of size required for 3*3 LSY-Shanon segmented image and size required to store a 5*5 Lossy-SPES segment image is more than that of size required for 5*5 LSY-Shanon segmented image. Hence we can conclude that in applied Lossy-Shonon on Lossy -SPES technique is better technique to get the better compression in size and to store segmented images.

In Figure 16, the values of the size of Shanon Fano on RAW and Shanon Fano on LLSPESS segmented (3*3, 5*5, 7*7) medical images are plotted. You can see that the proposed Shanon Fano on segmented Lossy SPEST technique provide much better compression size in most cases compared to RAW and other techniques.

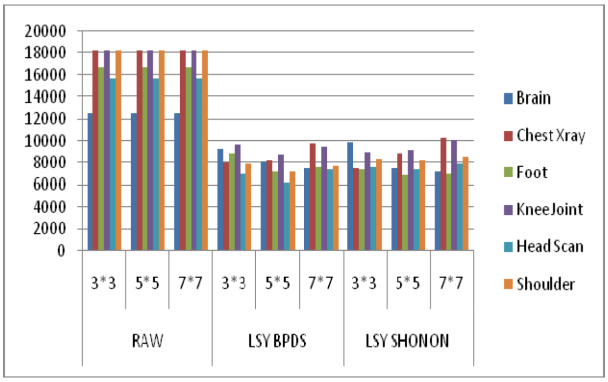


Figure 16:Shows the size of different images.

CONCLUSION:

Here I have proved that the compression format SPES is much better than JPEG and other techniques. We can conclude that Lossy-Shonon and Lossless -Shonon techniques are the best suited to store the medical and other images as amount of size required is least when compared against other techniques and can the reconstruct original image

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