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Video, Image and Data Compression by using Discrete Anamorphic Stretch Transform

Hari Hara P Kumar M

***Abstract*— we have a compression technology which is used to represent the more information efficiently. This kind of technology will helpful when we dealing the exponential increase of digital data. With the help of by increasing spatial coherency, we have new physics based transform to get the image compression. There is a possibility to improve the JPEG and JPEG 2000 performance by using our new technology and showed by experimentally.**

***Index Terms*— Image Compression, Image De-Compression, Discrete Anamorphic transform, Spatial Coherency, JPEG and JPEG2000, Discrete Cosine Transform, Wavelet Transform, Frequency Decomposition**

I. INTRODUCTION

To represent the information efficiently, image compression is critical when dealing with the high resolution image transmitting as well as videos and storage also. Nowadays, to reduce the data size of any image, commonly used methods are JPEG [1] and JPEG 2000 [2]. So, for image compression, the above methods are using either wavelet transform method or frequency decomposition through the discrete cosine transform method [12]. An anamorphic stretch transform (AST) is also defined as warped stretch transforms [5]. It is a physics-inspired transform that emerged from dispersive Fourier transform and photonic time stretch [3] [4]. This transform can be applied to digital data such as images or analog signals such as communication signals. By reshaping the data in such a way that the output has a property of data compression. The reshaping consists of warped stretching [6] in Fourier domain. The reshaping depends on the sparsity and redundancy of the input signal and can be obtained by a mathematical function called stretched modulation distribution or modulation intensity distribution It describes the dependence of intensity or power on the frequency and time duration of the modulation. In this paper, we take the help of Discrete Anamorphic Stretch Transform (DAST) to the image compression. DAST [7] [8] emulates diffraction of the image through a physical medium with specific nonlinear dispersive property. For a given image quality, DAST reduces the data size required to represent the image by performing space-bandwidth compression. This diffraction-based compression is achieved by a mathematical restructuring of the image but not through modification of the sampling process

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* Correspondence Author (s)
Hari Hara P Kumar M, Assistant Professor, Department of Electrical Communication Engineering, Sri Vasavi Engineering College, Andhra Pradesh, India.

II. TECHNICAL COMPARISIONS

A. *CTST vs. DAST*

The analog signal is sampled at twice the highest frequency of the signal, then that rate is called Nyquist rate in normal sampling [11] and it makes inefficient use of the available samples because frequency components below the Nyquist rate are oversampled. This uniform frequency independent sampling causes two problems:
(i) It limits the maximum frequency that can be captured with a given sampling rate i.e. to half of the sampling rate.
(ii) When the signal has redundancy, it results in a record length that is much larger than necessary
To overcome the first problem by reducing the signal bandwidth in Time-stretching performed in the analog domain prior to sampling see Fig.1

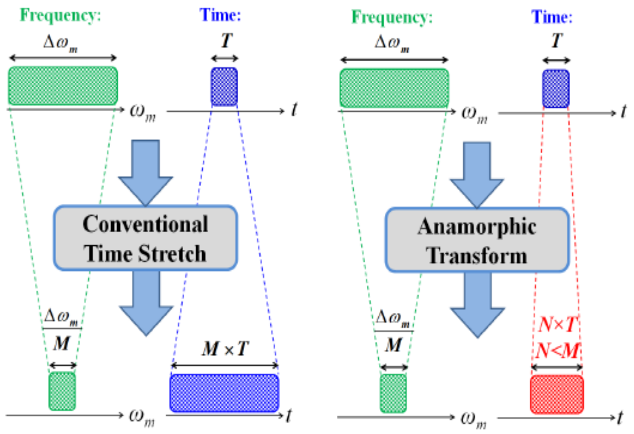

Fig.1. Comparisons of the conventional time-stretch transform (left) and proposed anamorphic transform (right).

From the figure 1, we are observing both are performed prior to sampling and they boost the ADCs sampling rate. However, for a given bandwidth compression factor M, the anamorphic transform leads to a shorter record length with fewer samples.

III. OPERATING PRINCIPLE

Figure 2 show how to implement the discrete anamorphic stretch transform for image compression of given application and includes different stages to compress the image.
1st Stage: Before transforming, using two dimensional discrete spatial variables the original image has to be represented example A $[i, j]$ where i, j represent two dimensional discrete spatial variable. Using DAST to compress the image, the image must be passed through the discrete anamorphic transform.

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2nd Stage: After DAST, the image is down sampled means re-sampling uniformly at a rate below the Nyquist rate of given original image.

3rd Stage: After transmitting the compressed image or from the data storage, the original image is recovered from the compressed and applies inverse re-sampling means up sampled.

4th Stage: After inverse re-sampling, then apply inverse discrete anamorphic stretch transform (DAST) to the recovered original image.

DAST is actually warps the image such that without proportional increases the spatial [9] size of the image, just its reduce the intensity bandwidth. Therefore, only the spatial coherence is increases and finally reducing the amount of data needed to represent the image.

Mathematically, DAST is defined as follows:

$$\bar{A}[i,j] = \left| \sum_{k_1,k_2=-\infty}^{\infty} k[i-k_1, j-k_2] \cdot A[k_1,k_2] \right|^n \qquad (1)$$

The symbol | | is nonlinear absolute operator which extracts the brightness out of the complex amplitude. Where $\bar{A}\,|i,j|$ is the transformed image, $A\,|i,j|$ is the original image intensity (brightness), and i and j represent the two dimensional discrete spatial variables. The transform convolves with the Kernel of DAST *exp* (j. Φ [i, j]) where Φ [i, j] is a nonlinear phase operation it leads to increase the spatial coherence for enabling the image compression. After the DAST transformation, the reshaped image is uniformly re-sampled at a rate below the Nyquist rate of original image. Such that it

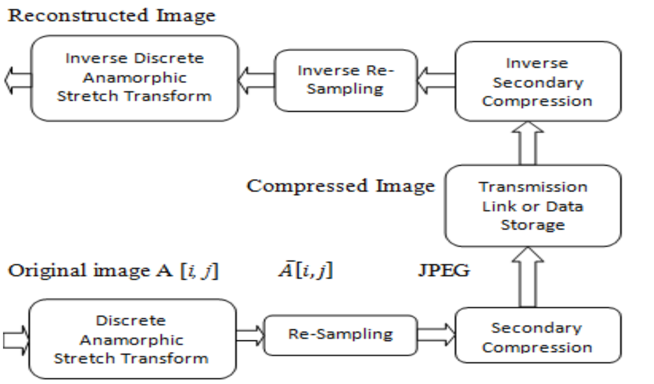

Fig. 2 Discrete Anamorphic Stretch Transform (DAST) is operated on the original image and re sampled followed by secondary compression such as standard image compression algorithms like JPEG. To recover the original image, the inverse operation is performed on the compressed image.

Increases the spatial coherence i.e. it compresses the intensity bandwidth and hence, sub-Nyquist re-sampling does not cause any loss of information. To recover the original image, phase discrimination is used in the decoder side. For better understanding of $\Phi[i, j]$, we introduce a mathematical tool to describe the image intensity bandwidth and image data size after transformation, so, that mathematical tool is called Stretched Modulation (SM) Distribution:

$$S_M[i,j,p,q] = \sum_{k_1,k_2} \bar{B}[i+k_1, j+k_2] \cdot \bar{B} \cdot \bar{K}[i+k_1, j+k_2].\bar{K}^*[k_1,k_2] \qquad (2)$$

Where $\bar{k}\,[p,q]$ is the Fourier transform of the Kernel *exp* (j. Φ [i, j]), and p and q represent the two dimensional discrete frequency variables. Where the symbol * represents complex conjugation. S_M or Anamorphic Distribution provides a tool for image brightness space-bandwidth product through proper choice of Φ [i, j]. For image compression the Kernel's Phase Derivative (PD) function should have a super linear profile such as the tangent function which corresponds to the following Kernel phase profile as

$$\phi[i,j] = \frac{a_1}{b_1} \cdot \ln(\cos(b_1 \cdot i)) + \frac{a_2}{b_2} \cdot \ln(\cos(b_2 \cdot j)) \qquad (3)$$

Where a_1, b_1, a_2 and b_2 are real numbers, ln is natural logarithm, *cos* is Cosine function and $b_1.i$ & $b_2.j < \pi/2$. The parameters a_1/b_1 and a_2/b_2 are normalized to the image size.

We use a 1 Mega pixel [10] raw image as an example shown in left panel of Fig. 4.to study the effect of DAST. In right panel of fig 3 shows the designed DAST Kernel PD profile of 1 Mega pixel raw image showed in left panel of fig 4. The right panel in Fig. 4 shows the image after the transformation, described mathematically with an Equation. Fig 5 shows to understand how the space-bandwidth product is compressed after DAST and compare the intensity bandwidth of the original image with the transformed one. Finally, image coherence is increased means reduces the intensity bandwidth in fig 5, therefore the image spatial size is almost changed which results in image data compression.

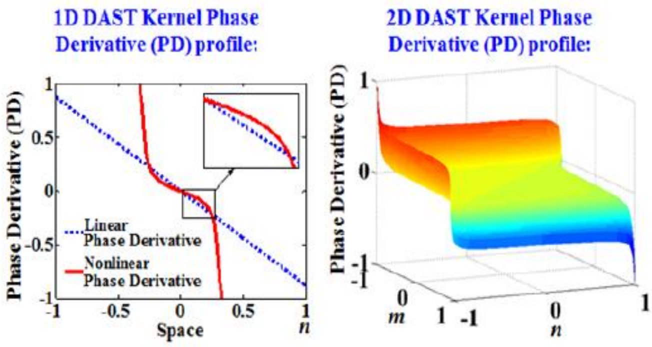

Figure3 Space-bandwidth product compression using Discrete Anamorphic Stretch Transform (DAST). Left: normalized 1D nonlinear DAST Kernel Phase Derivative (PD) profile, right: normalized 2D PD profile of the employed DAST Kernel in Cartesian coordinate system.

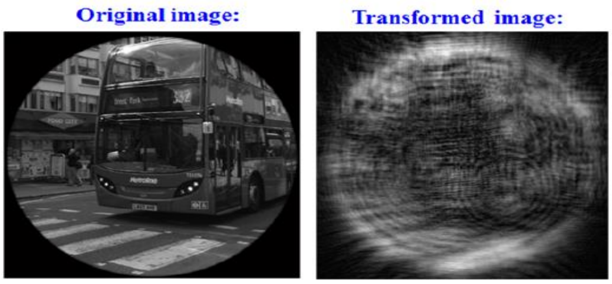

Figure 4 Left: original image, right: transformed image using DAST.

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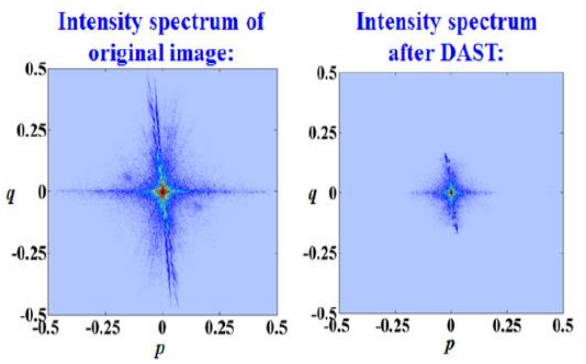


Fig 5 Spatial intensity spectrum before and after DAST operation. We see that the intensity spectrum bandwidth of the image is compressed after passing through DAST which translates to increased coherence; however the image size is not increased proportionally.

IV. RESULTS

With help of images, we examine the proposed image compression method and compare it to JPEG 2000 image compression format. In the first example, we study the performance of DAST for image compression and also show that DAST pre- compression can improve the performance of JPEG2000 for a given image quality. The original image for this example is security and surveillance color image with pixels in TIF format. The left column in Fig. 6 shows the image compressed using JPEG 2000 with PSNR (Peak Signal to Noise Ratio) of 52.1 dB. In this case, the compression factor is 2.3 times. The right column shows the image pre-compressed by DAST followed by JPEG 2000 with the same recovered image PSNR of 52.1 dB. Similarly In the next example, with DAST pre-compression we can improve the performance of JPEG 2000 for a same high compression factor. Results are shown in Fig. 6. The original image for this example is satellite color image with pixels in TIF format.

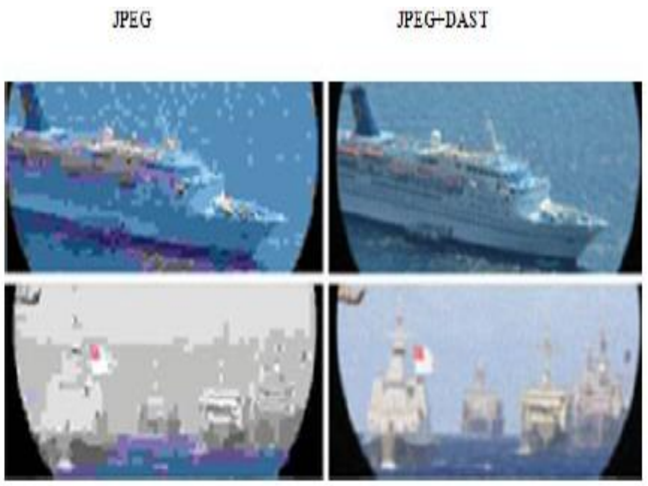
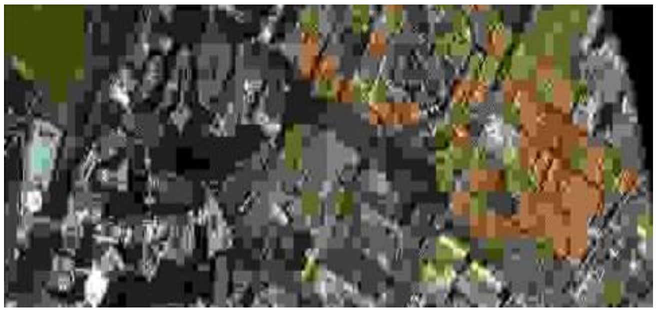


Figure6. Comparison of security and surveillance image using JPEG alone and the case with DAST pre-compression followed by JPEG.

The left column in Fig. 7 shows the image compressed using JPEG 2000 with compression factor of 250. The right column shows the image pre-compressed by DAST followed by JPEG 2000 with same total compression factor of 250. This means that the total compressed data file size in the case with followed by JPEG 2000 plus the metadata) is the same as the case with JPEG 2000 alone. As seen, image pre-compressed with DAST has higher resolution even though the compressed file sizes are the same. In particular, PSNR in the case of JPEG 2000 alone was 23.5 dB versus 26.3 dB for the case of using DAST pre-compression. In both of cases, DAST +JPEG give superior performance.

JPEG



JPEG+DAST

Figure7. . Comparison of performance of JPEG alone for satellite image with improved performance of Discrete Anamorphic Stretch Transform (DAST) pre-compression method.

JPEG JPEG+DAST

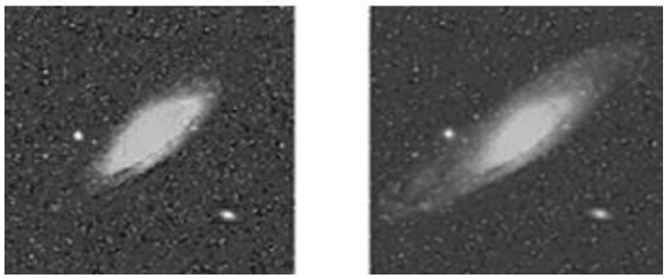


Figure8. Comparison the astronomical image using JPEG alone and the case with DAST pre-compression followed by JPEG. In both cases, DAST +JPEG give superior performance.

Table 1.1 Comparatives of Quantitative Measurements

Method	Image	Compression Ratio	PSNR
JPEG 2000	Standard	2.3	52.1
DAST+JPEG 2000	Standard	5.1	54.5

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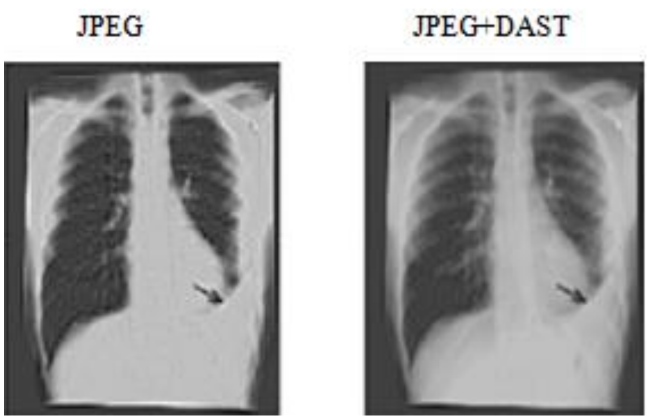
JPEG 2000	Medical	220	17.5
DAST+JPEG 2000	Medical	220	22.2
DAST+JPEG 2000	Astronomy	62	17.1
JPEG 2000	Satellite	250	23.2
DAST+JPEG 2000	Satellite	250	26.56
JPEG 2000	Security and surveillance	2.3	52.1
DAST+JPEG 2000	Security and surveillance	2.3	54.1

V. APPLICATIONS

A. *Medical Image Compression*

This type of technology is applied to different cases for observing the difference between JPEG alone and with the case of DAST + JPEG. From the experimental results, we can easily identify that DAST is best compression technology rather than traditional compression technologies. The observed improvements for different cases are not unique to the specific images used here, but rather describing the general property of the Discrete Anamorphic Stretch Transform. For digital pathology image compression, we compare JPEG compression alone with the case of DAST pre-compression followed by post-compression using JPEG. We compare two methods by the values of PSNR (Peak Signal to Noise Ratio). For the case of JPEG alone, the PSNR value is 17.5 db and for JPEG plus DAST the value is 22.2 db. So finally, the result shows that DAST pre-compression has a higher quality than JPEG alone while two cases having the same total compression factor and hence the same compressed file size.



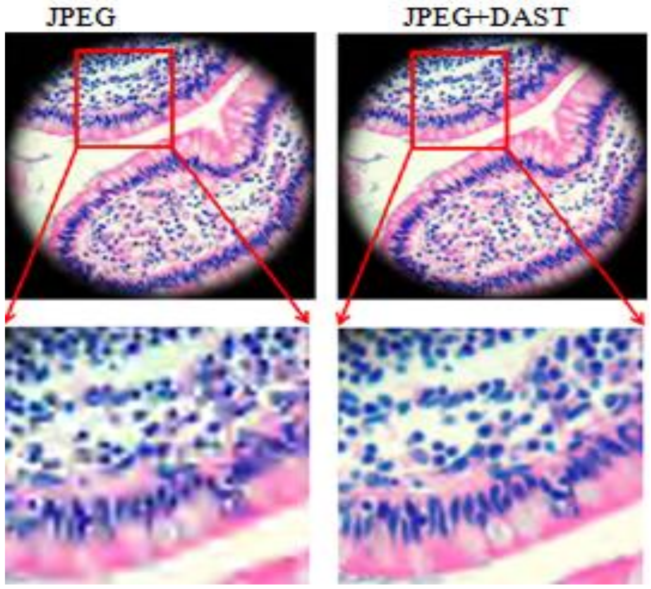


Figure9. Improving the performance of JPEG for satellite image compression using Discrete Anamorphic Stretch Transform (DAST) pre-compression than the case with JPEG only.

B. *Astronomy Image Compression*

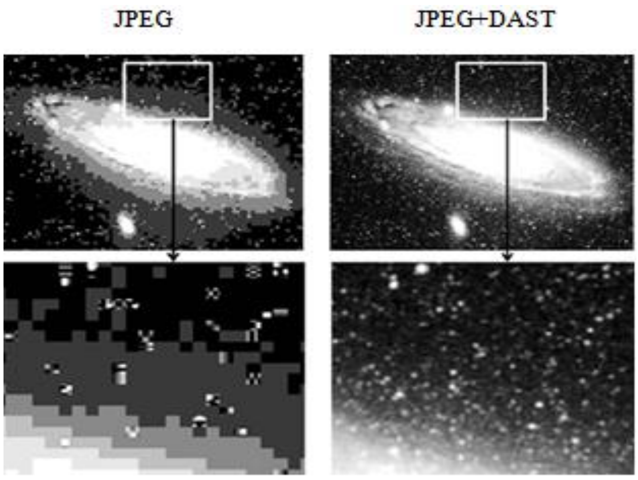


Figure 10 shows that pre-compression with DAST improve the performance of JPEG.

In this application, we are using the image of astronomy kind. So, we compare JPEG compression alone with DAST pre-compression followed by JPEG.From the comparison, resolution is higher in the case with DAST pre-compression shown in below figure but same compression factor in both cases.

C. *Security and Surveillance:*

In security and surveillance applications, we study the performance of JPEG alone with the performance of DAST compression. So, we compare JPEG compression alone with DAST pre-compression followed by JPEG. The figure shows the result of Image compression in both cases. DAST can prove advantageous in security and surveillance applications.

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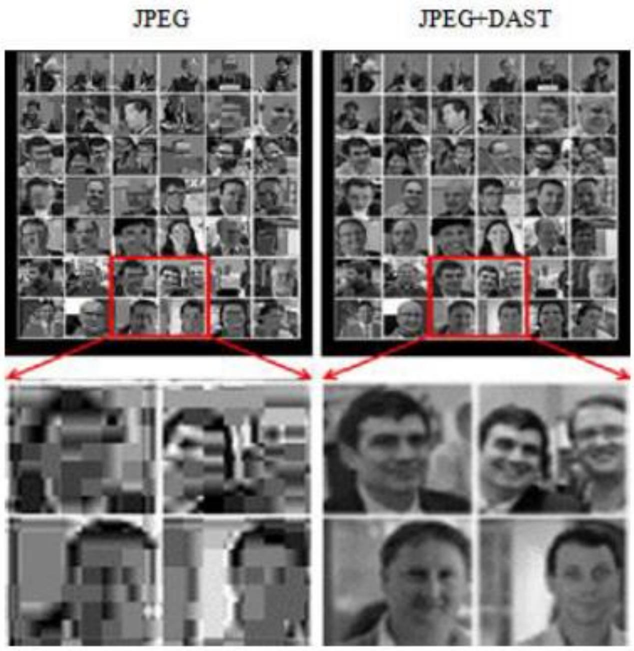

Figure11. Comparison of security and surveillance image using JPEG alone and the case with DAST pre-compression followed by JPEG. In both the cases, DAST +JPEG gives superior performance.

D. Satellite Image Compression

In the experimental results, we compare JPEG compression alone with the case of DAST pre-compression followed by post-compression using JPEG. In this method, clearly shows superior performance when combined with JPEG over JPEG alone while having the same total compression factor. So, we compare JPEG compression alone with DAST pre-compression followed by JPEG. The figure shows the result of Image compression in both cases. DAST can prove advantageous in satellite image applications.

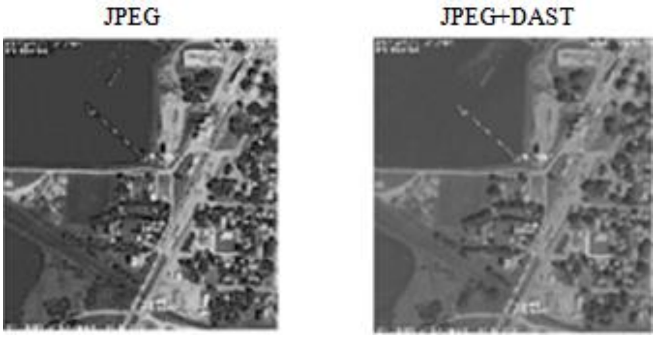

Figure 12. Comparison the satellite image using JPEG alone and the case with DAST pre-compression followed by JPEG. In both cases, DAST +JPEG method gives superior performance.

VI. CONCLUSION AND FUTURE WORK

In this paper, it is shown that how DAST pre-compression can give the better performance than the traditional method means JPEG2000 for any kind of compression factor and PSNR. In future, This DAST method can be extending to digital compression for Big Data. For example, in the case of rare cancer cell detection in blood, to screening millions of cells in a high speed flow stream is required. Such that a new type of camera is needed as a real time instrument. These instruments can provide temporal data approximately 1 Tbit/s. To manage such huge amount of big data loads led to the development of the Anamorphic Stretch Transform For this kind of application, traditional method is not suitable to compress the image.

REFERENCES

1. W. B. Pennebaker and J. L. Mitchell, JPEG still image data compression standard, 3rd ed., Springer, 1993.H. Poor, An Introduction to Signal Detection and Estimation. New York: Springer-Verlag, 1985, ch. 4.
2. Skodras, C. Christopoulos, and T. Ebrahimi, "The JPEG 2000 still image compression standard", IEEE Signal Process. Mag., Vol. 18, pp. 36 -58, 2001.
3. M. Lustig, D. Donoho, J. M. Pauly, "Sparse MRI: The application of compressed sensing for rapid MR imaging," Magn. Reson. Med., Vol. 58, pp. 1182-1195, 2007.
4. K. Goda, A. Ayazi, D. R. Gossett, J. Sadasivam, C. K. Lonappan, E. Sollier, A. M. Fard, S. C. Hur, J. Adam, C. Murray, C. Wang, N. Brackbill, D. Di Carlo, and B. Jalali, "High-throughput single microparticle imaging flow analyzer," Proceedings of the National Academy of Sciences, Vol. 109, p. 11630 2012.
5. Ashok, P. Baheti, and M. A. Neifeld, "Compressive imaging system design using task-specific information," Appl. Opt., vol. 47, pp. 4457–471, 2008.
6. N. I. Cho and S. K. Mitra, "Warped discrete cosine transform and its application in image compression," IEEE Trans. Circuits Syst. Video Technol., vol. 10, pp. 1364–1373, 2000.
7. M. H. Asghari and B. Jalali, "Discrete anamorphic transform for image compression," IEEE Signal Processing Letters, Vol. 21, pp. 829-833, 2014.
8. L.W. Chang, "Signal Processing: Image Communication" EURASIP Vol. 15, pp. 879-890, 2000.
9. Guo and L. Zhang, "A novel multi resolution spatiotemporal saliency detection model and its applications in image and video compression," IEEE Trans. on Image Proc., Vol. 19, pp. 185-198, 2010.
10. http://www.pixera.com/sample-images /professional/
11. E. J. Candes and M. B. Wakin, "An introduction to compressive sampling," IEEE Signal Process. Mag., vol. 25, pp. 21–30, 2008.
12. G. Evangelista and S. Cavaliere, "Discrete frequency warped wavelets: Theory and applications," IEEE Trans. Signal Process., vol. 46, pp. 874–885, 1998.

Hari Hara P Kumar M working as a Assistant professor at Sri Vasavi Engineering College, Tadepalligudem and his research interest areas are Image Processing, Digital Signal Processing and Embedded Systems.

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