Compression of Images using Amplitude Grating

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Abstract- Compression of images is an important application in the field of image processing as it is suitable for optimization of storage space and sharing over internet with optimum bandwidth utilization. This study presentsa novel method for compressing image using amplitude grating. The selected image is first modulated with high frequency amplitude grating in a fixed orientation. Therefore, the image is converted into optical frequency domain from spatial domain. Due to this modulation, three spots (spectrum bands) have been generated. From these three spots, by applying Inverse Fourier Transform in any one band, we can recover the image.Out of these three spots, one is center spectrum spot and other spots are two sidebands. However, to a get a reasonably good output, we have to selectspotcarefully to avoid aliasing effect. Information of the selected image is basically distributed among three spots of the spectrum. Therefore by selecting any one spot from the spectrum, we can retrieve the main image. As we have taken only few coefficients from spectrum, size of the output image is less than the main image. In this way, we have used this technique for image compression. To measure quality of the output images, PSNR value hasbeen calculatedand we have compared this value with PSNR values of previous techniques.
Keywords: Image Compression, Amplitude Grating, Fourier Transform, Image Retrieval

I. INTRODUCTION

Different techniqueshave been used for compression of imagesfor many years.Balakrishnanet. al. [2018] compressed the images based on block truncation coding. In their research paper, they have first convertedRGB image into HSV planes. After that, each H and S planeis encoded using block truncation coding with quad clustering and V plane is encoded with BTC based bi-clustering or tri-clustering, depending on the edge information present in the plane. This method is better than previous BTC methods compared to visual quality of the output image.[1]Sahnoun and Benabadji[2014] used image compression method based on evidence theory and k-Nearest Neighbor (KNN) algorithm. However main drawback of this lossycompression systemwas too muchinformation loss[2] To improve the quality of the output image , Fourier Transform and Huffman Coding was used for modification the previous technique . In both method, visual quality of theoriginal image was poor.[3]Mamun and Hossain [2017] used integer wavelet regression by increasing temporal correlation, which consequently improves the compression gain. [4]Sahnoun and Benabadji[2015] discussed a image compression technique using discrete wavelet transform for noise removal to compress images. [5] Susiloet al[2003] have used only hardware based solutions in this lossless compression technique of X Sat images. [6] Memane and Ruikar [2014] used Discrete Wavelet Transform in their lossy image compression work and performance of different wavelets for image compression have been analyzed.[7] Hacihalilglu and Kartal[2003] have used conventional Discrete Cosine Transform system for lossless image compression. [8]APatra et. al proposed a research paper on satellite image image compression based on sinusoidal grating. [9]

In our proposed method, selected image is first modulated by sinusoidal amplitude grating with high spatial frequency having fixed orientation along x-axis, i.e, $\theta = 0^{\circ}$.Due to modulation along x- axis, three bright spots are generated horizontally on the spectrum plane at different spatial positions. The two extreme spots are actually due to the two side bands. From the spectrum plane, filtering any one spot from the spectrum, the original imageis extracted by regional Inverse Fourier Transform. We have selected the upper side band for filtering purpose.

In this paper, we have explained serially introduction of sinusoidal grating, methodology and result of the system.

II. METHODOLOGY

2.1 Frequency and Orientation Angle selection for grating :

According to rule of sinusoidal amplitude grating, value of the grating frequency (u_0) should be high. Low grating frequency is creates aliasing problem and therefore it would be very difficult to reconstruct the original image. In our research paper we have selected $u_0 =$ 1200 which is sufficient for filtering. In grating, value of the orientation angle (θ) varies from 0 to 3600 . We have worked with 0 orientation angle.

The diffraction gratings used are illustrated in Fig.1

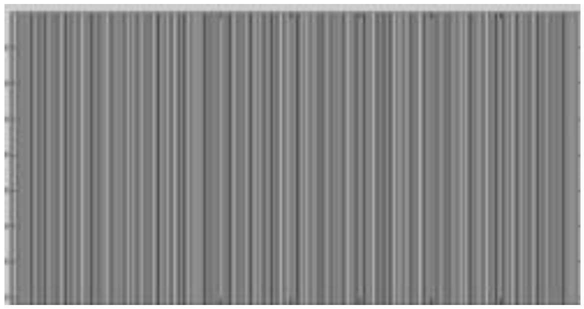

Fig. 1.Grating with orientation θ = 0°

2.2 Spectrum Band Generation :

$f_1(x,y)$ is the original image and u_0 is the spatial frequency for sinusoidal amplitude gratings. The image $f_1(x,y)$ is modulated by the sinusoidal grating $G_1(x)$ with orientation $\theta = 0°$; where $G_1(x) = \frac{1}{2}(1 + cos2\pi u_0 x)$

After modulation, we have

$$f_1(x,y).G_1(x) = \frac{1}{2}f_1(x,y)(1 + cos2\pi u_0 x) \quad (1)$$

After convolution, we have

$$S(x,y) = f_1(x,y).G_1(x) \quad (2)$$

We can write

$$S(x,y) = \frac{1}{2}f_1(x,y).(1 + cos2\pi u_0 x) \quad (3)$$

If the Fourier transform of $S(x,y)$ is $S(u,v)$, then

$$S(u,v) = \frac{1}{2}[F_1(u,v)] + \frac{1}{4}[F_1(u - u_0,v)] + \frac{1}{4}[F_1(u + u_0,v)] \quad (4)$$

Three spectrum bands are generated due to modulation. Mathematically they are represented as $[F_1(u,v)]$, $[F_1(u - u_0,v)]$ and $[F_1(u + u_0,v)]$

Out of three terms in the above expression, first term contributes to the central bright patch of the Fourier plane, which is shown in each picture of Fig2(a-c).

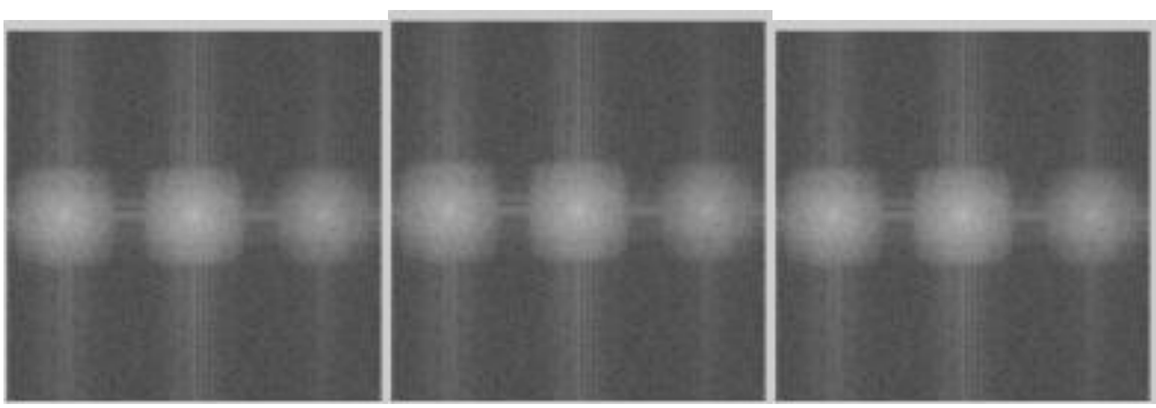

Fig 2(a) Fig 2(b) Fig 2(c)
Fig 2 : Spectrum of Images due to Grating

2.3 Filtering from Spectral Band

As we have maintained a high frequency for optical grating, therefore there are enough gaps between bands i.e. no aliasing effect is there. This is helpful for zonal filtering of image. For filtering purpose, any band from two sidebands can be selected. In our paper, we have selected upper sideband for filtering purpose. Inverse Fourier Transform is applied to upper spectrum band (whose Fourier Transform is represented by $[F_1(u-u_0,v)]$.

2.4 Quality Checking of Filtered Image

To check quality of the output images, we have calculated PSNR value of the filtered images.
PSNR value is calculated by

$$MSE = \frac{1}{mn}\sum_{y=1}^{m}\sum_{x=1}^{n}[f(x,y) - g(x,y)]^2 \quad (5)$$

where MSE = Mean Square Error ;$g(x,y)$ = Extracted image ; m , n denotes dimension of images

$$PSNR = 20log10\frac{255}{\sqrt{MSE}} \quad (6)$$

Same methodology is applied to other images $f_2(x,y)$ and $f_3(x,y)$ respectively.

III. RESULTS AND DISCUSSIONS:

Images which are chosen areshown in Fig 3 (a-c).Dimension of our selected images are 512 x 512.

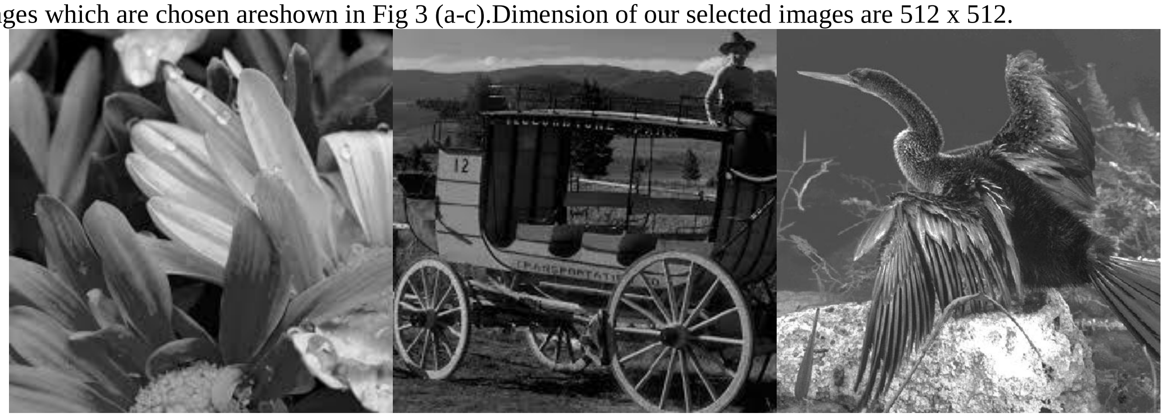

Fig 3(a) Fig 3(b) Fig 3(c)

Fig.3 (a-c)Selected Images

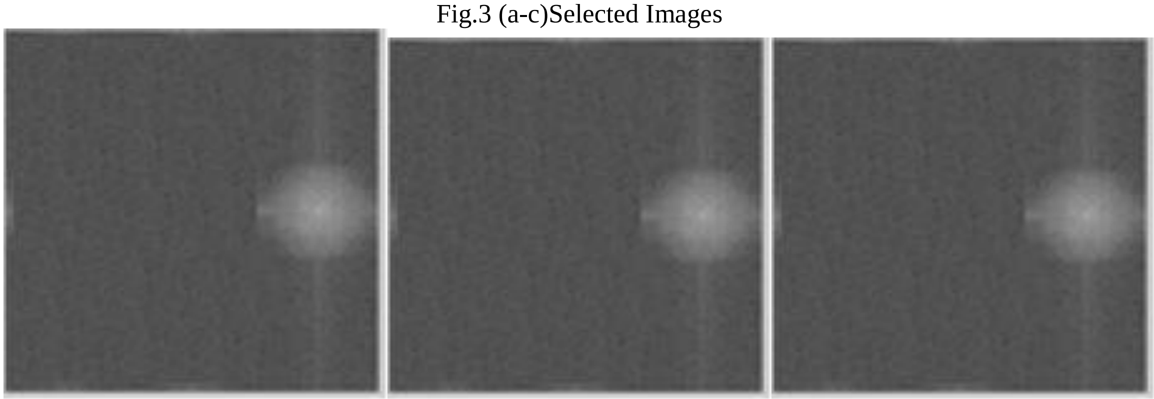

Fig 4(a) Fig 4(b) Fig 4(c)

Fig.4 (a-c) Upper Spectrum of Transformed Images

During zonal filtering operation, image $f_1(x,y) f_2(x,y)$ and $f_3(x,y)$ have been extracted by Regional Inverse Fourier Transform by taking upper spectrum from horizontal direction. Extracted imagesare shown in Fig 5(a-c)

Fig 5(a) Fig 5(b) Fig 5(c)
Fig.5 (a –c)Extracted Images

Table 1

Image	Original ImageSize (kB)	Compression Ratio(Compressed Image/ Original Image)	PSNR
$f_1(x,y)$	218	0.73	33.1
$f_2(x,y)$	231	0.76	32.7
$f_3(x,y)$	240	0.75	32

Table 2

Method	PSNR
DCT and Wavelet Based Image Compression In Images [Reference 8]	26.23 29.44

IV. CONCLUSION:

Sinusoidal amplitude gratinghas been proposed in this study to compress the image in frequency domain. The original object is retrieved by Inverse Fourier Transform from the respective spectrum of the image. As we have taken only few coefficients from the spectrum, size of the output image is less than the main image. To maintain the same dimension with original image and to avoid aliasing effect, spectral area should be carefully selected. Compared with earlier method, visual quality of theselected images are very good.Our proposed technique is simple and moreover this technique has potential to multiplex more imagesby varying the value of spatial frequency which will be discussed in future communication.

V. REFERENCE

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