Adaptive 3D-DCT based compression algorithms for Integral Images

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Abstract— **This paper proposes a novel mean adaptive 3D-DCT algorithm for 3D content to achieve the optimal result by trading of quality and compression of 3D image. The proposed method enables users to adjust the compression rate according to application areas by applying small blocks to the more detailing area (non -stationary regions) and larger blocks to the background or less details area (homogenous regions) [1]. This proposed method "Mean Adaptive 3D-DCT" is applied on Holoscopic 3D images also known as Integral Images. In addition, the experiment results prove the method is applicable to any 3D content.**

Index Terms— **Holoscopic, Integral image, 3D-DCT, Compression, Blocking artifacts, Ringing artifacts, Adaptive algorithm.**

I. Introduction

THIS compression standards aim to reduce the bitrates in order to store or transmit files. Widely known compression standards such as JPEG and MPEG uses DCT due to its ability to compact energy however DCT's major drawbacks that it has blocking artifacts. In addition there is another issue related to the Blocking technique, which is the lack of inter-block correlation, which means each block is isolated from the other blocks. Therefore each block is treated separately by applying the microcosm technique. Intensive research has been carried on 2D images to avoid or alleviate the blocking artifacts and the attempt is made to find a solution for the miss correlation between the blocks [1].

There are two types of transform method that have been applied to resolve the errors that are Global Transform technique (non-Local) e.g. DWT, Lapping Transform and Local technique based on Blocking but in an adaptive manor.

As stated, using the Global technique e.g. DWT which is applied in JPEG2000 works efficiently in reducing the blocking artifacts, however it is still facing a ringing artifact, which is due to the long basis. In particular, the areas have lots of edges. In addition, the method fails to exploit the local correlations in the areas with low frequency in the background of the image, which leads to improper compression ratio [2].

So, briefly there is a trade between the ringing artifacts and the blocking artifacts, either to have a ghost affect that will appear on the edge of the image or it will appear as a pre-echo in the case of audio or to have a visual discontinuity effect [3].

II. Integral IMages

The three dimensions Display technologies can be categorized to two main categories, the stereoscopic display and auto-stereoscopic display [4] [5].

The main idea of the stereoscopic display based on combining two simultaneous images to be received by the two eyes and combined in the human brain to give the effect of the three-dimension effect. This technology can be achieved by using anaglyphs, which is Color-based filtering, or Polarization or Shutter-based filtering. The stereoscopic Display Technology suffers from causing headache and sickness because it depends on the brain to gather both images together which results of visual fatigue.

On the other hand, in auto-stereoscopic display Technology there is no need to wear any glasses, and the technology doesn't depend on the receiver eye or the brain to combine any images. The auto-stereoscopic display technology contains the holographic three- dimensional display techniques, Integral Photography and Lenticular Sheet 3D Images [4].

3D Holoscopic methodology imaging also referred to, as Integral Images [6] was first proposed by Lippman in 1908 [7].

During the last few decades the Integral images developed by various researches. A glass or a plastic sheet consisting of

marvellous number of small convex lenses is used by Lippman to construct a fly's eye lens sheet [8] as shown in Fig (1).

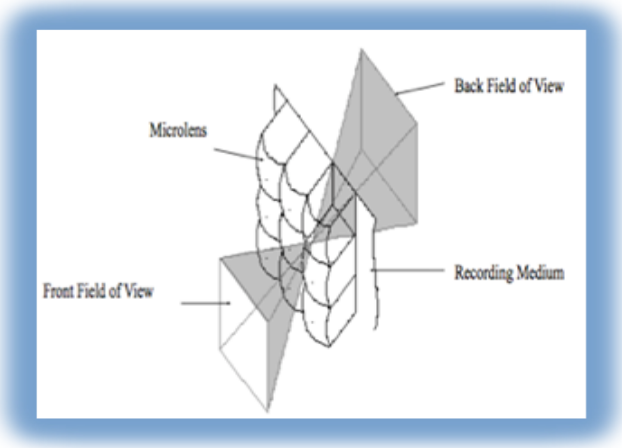


Fig.1. Fly's eye, the micro lens array

One of the main drawbacks of Lippmann proposed scheme is that the reconstructed image is Pseudoscopic. In order to overcome this drawback a two-step method is applied as shown in Fig. (2) [9] [10] [2].

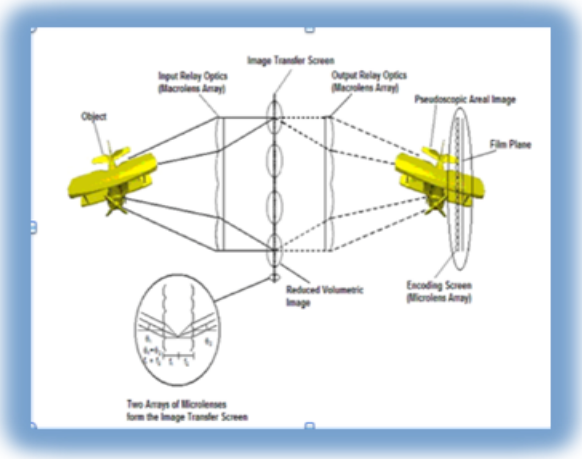


Fig. 2 3D Holoscopic Imaging Camera

The microlense Sheet contains number of horizontal Microlenses in Unidirectional Integral Images. Each microlenses has a very small resolution capturing 2D Planar density which different than the traditional perspective capturing images, which is illustrated in Fig. (3)

The small images resulting from the each micro-lens called Elemental Images or Sub-Images but another term is going to be used which is Viewpoint Images.

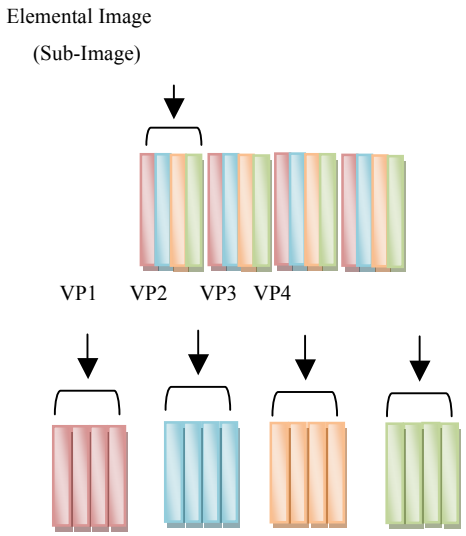


Fig. 3 Extracting Viewpoint

The Viewpoint Images is integrated from the pixels in different micro-lenses but got the same position. The Viewpoint Image contains all the data needed from one certain view direction [11] [12]. Fig. (4) Shows the original unidirectional Horseman image. Fig. (5) Show the Viewpoints for the Image horse.

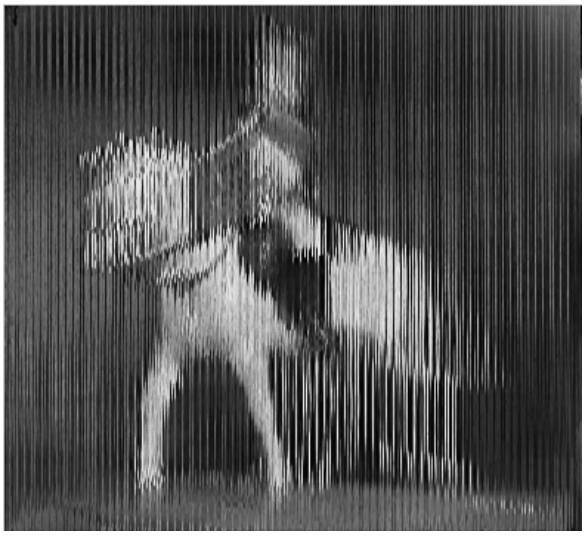


Fig. 4 Horseman Unidirectional Integral Image.

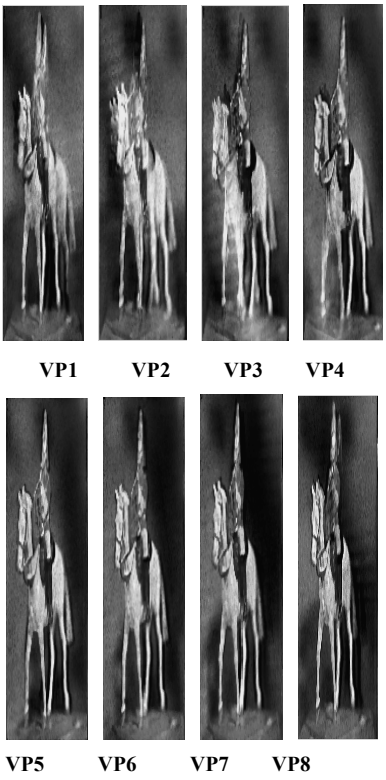


Fig. 5 Horseman Viewpoint

III. Proposed Algorithm

In the mean adaptive 3D-DCT algorithms, the viewpoints are extracted from the raw original Image, and then each viewpoint split into 16x16 Block. For the first viewpoint the mean value is calculated, then for each 16x16 block of all Viewpoints, the mean value is calculated separately. Following this the condition should be applied in order to take a decision if another split is going to occur or not. The condition is a comparison between the local mean value of the block and the mean value for the entire Viewpoint, so this non-local mean value is act as the threshold that is the splitting scheme depends on it.

After applying this pre-processing adaptive part, each block, weather it was 4x4, 8x8 or 16x16 block size, is de-correlated using 3D-Discrete Cosine Transform (DCT). The output coefficients are quantized using quantization factor. Finally, the encoding technique applied on the quantized results. All of the process is reversible. The flowchart is represented in Fig. (6).

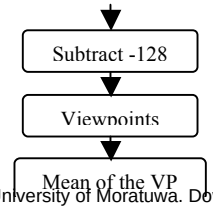


Fig. 6 Mean Adaptive proposed Algorithm

IV. Results

In [10], the author adopted the idea of dividing the Unidirectional Integral to 8x8 blocks; this process is applied to the entire source image without extracting the viewpoints.

Then their proposed algorithm is based on the Mean Adaptive scheme. For each block the mean value calculated and all gathered to form a planar mean image that is results to a low-resolution image, then a split-merge algorithm applied after segmented the image.

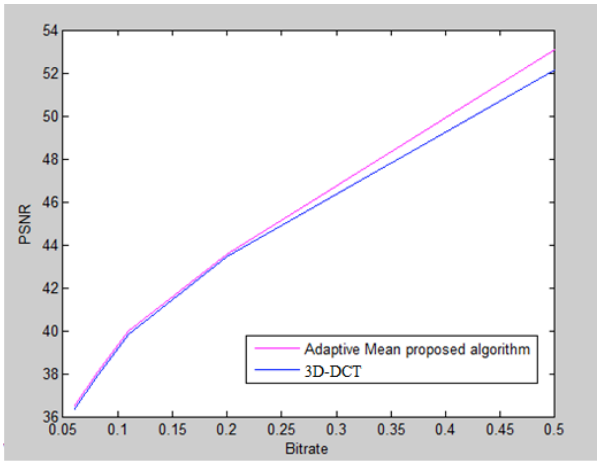


Fig. 7 Average result PSNR vs. Bitrates between 3D-DCT adaptive Mean algorithm and JPEG (8x8) block.

Algorithm proposed in [10]		Our Adaptive Mean Algorithm	
Bitrates	**PSNR**	**Bitrates**	**PSNR**
0.6	39.33	0.55	53.0964
0.4	38.22	0.19	43.57
0.2	34.77	0.06	36.46

Table [1] Comparison between the algorithm in represented [10] and the proposed algorithm

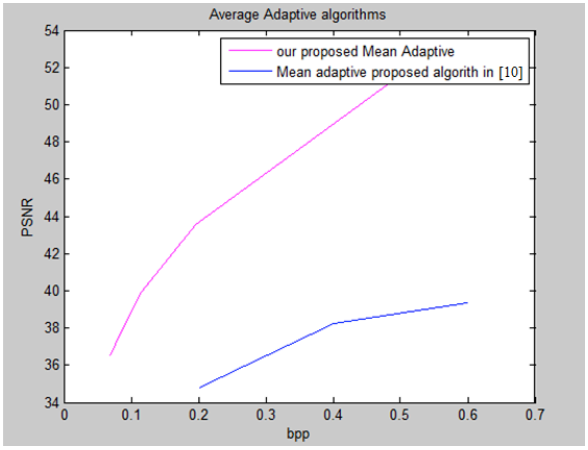
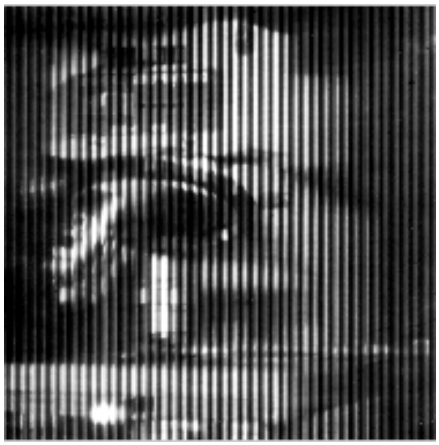
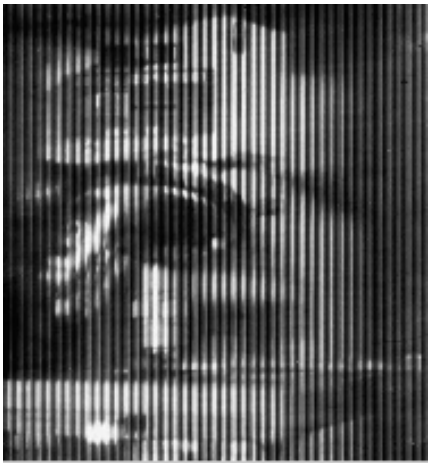


Fig. 8 comparison between adaptive proposed algorithm in [10] and proposed algorithm

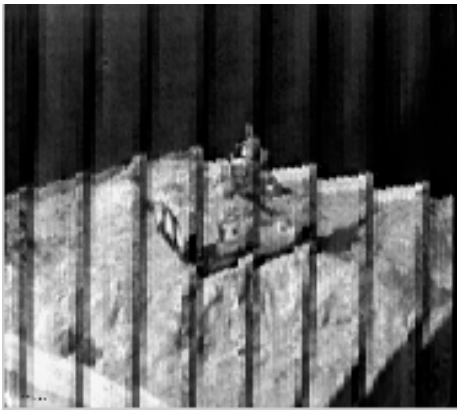


(a)



(b)

Fig. 9 a) The Original Micro Image, b) Reconstructed Image using Proposed Adaptive Mean Algorithm



(a)

(b)

Fig. 10 a) The Original Tank Image, b) Reconstructed Image using Proposed Adaptive Mean Algorithm

V. CONCLUSION

In JPEG a dyadic 8x8 block is used, it has been approved that this size is proper to be used with both level of variations, but because it is periodic, the image is not smooth enough due to the blockalization effect. From another prospective, to end up with a reasonable compression ratio, the regions that contained more details, a small size of block should be applied, otherwise a sever distortion will occur if this details thrown away by applying large block. On the opposite side in the regions with fewer details, a large block is used in order to achieve the desired compression level.

The proposed Adaptive Mean Algorithm shows a higher compression results comparing to the JPEG standard. In addition, it eliminates the blocking artifacts and mitigates the ringing effect.

VI. REFERENCES

[1] Tran, T.D., Liang, J. and Tu, C. (2003) "Lapped transform via time-domain pre-and post-filtering", Signal Processing, IEEE Transactions on, vol. 51, no. 6, pp. 1557-1571.

[2] Dai, W., Liu, L. and Tran, T.D. (2005) "Adaptive block-based image coding with pre-/post-filtering", Data Compression Conference, 2005. Proceedings. DCC 2005 IEEE, pp. 73.

[3] Colbert, M. (2005) "Adaptive Block-based Image Coding with Pre-/post-filtering", university of central Florida.

[4] Okoshi, T. (1980) "Three-dimensional displays", Proceedings of the IEEE, vol. 68, no. 5, pp. 548-564.

[5] Dudnikov,Y.A. (1970) "Autostereoscopy and integral photography", Opt.Tech, vol. 37, no. 7.

[6] Kim, Y. and Hong, K. (2009) "Recent researches based on integral imaging display method", 3D RESEARCH, vol. 1, no. 1, pp. 17-27.

[7] Lippmann, G. (1908) "Epreuves reversibles donnant la sensation du relief", J.Phys.Theor.Appl., vol. 7, no. 1, pp. 821-825.

[8] Eljdid, M., Aggoun, A. and Youssef, O. (2007) "Computer Generated Content for 3D TV", 3DTV Conference, 2007 IEEE, pp. 1.

[9] Milnthorpe, G., McCormick, M., Aggoun, A., Davies, N. and Forman, M. (2002) "Computer generated content for 3D TV displays", International Broadcasting Convention, Amsterdam, Netherlands.

[10] Zaharia, R., Aggoun, A. and McCormick, M. (2002) "Adaptive 3D-DCT compression algorithm for continuous parallax 3D integral imaging", Signal Processing: Image Communication, vol. 17, no. 3, pp. 231-242.

[11] Wu, C., McCormick, M., Aggoun, A. and Kung, S. (2008) "Depth mapping of integral images through viewpoint image extraction with a hybrid disparity analysis algorithm", Journal of display technology, vol. 4, no. 1, pp. 101-108.

[12] Aggoun, A. and Tabit, M. (2007) "Data compression of integral images for 3D TV", 3DTV Conference, 2007 IEEE, pp. 1.