Interpreting Plenoptic Images as Multi-View Sequences for Improved Compression

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Simulation Results
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I. ICIP 2017 Grand Challenge: Light field Image Coding

The compression scheme is proposed in response to Grand challenge on plenoptic image compression organized by International Conference on Image Processing (ICIP) 2017 [1]. The results are obtained by following the guidelines set out by the competition. It was required to compress five benchmark plenoptic images on four specified bit rates (R1 = 0.75, R2 = 0.1, R3 =0.02, and R4 = 0.005 bits per pixel). The Table I shows the given input images and their assigned identifiers.

TABLE I: Input images provided in the competition

Image ID	Image name
I01	Bikes
I02	Danger_de_Mort
I04	Stone_Pillars_Outside
I09	Fountain_&_Vincent_2
I10	Friends_1

The Fig. 1, describes the end-to-end processing chain used to compress the images. The reference 10 bit precision sub-aperture images are clipped to 8 bit and chroma components are sub-sampled to YUV 420 representation. The objective evaluation is performed between reference sub-aperture images (point A in Fig. 1) and reconstructed sub-aperture images (point A' in Fig. 1) using the scripts provided by the competition.

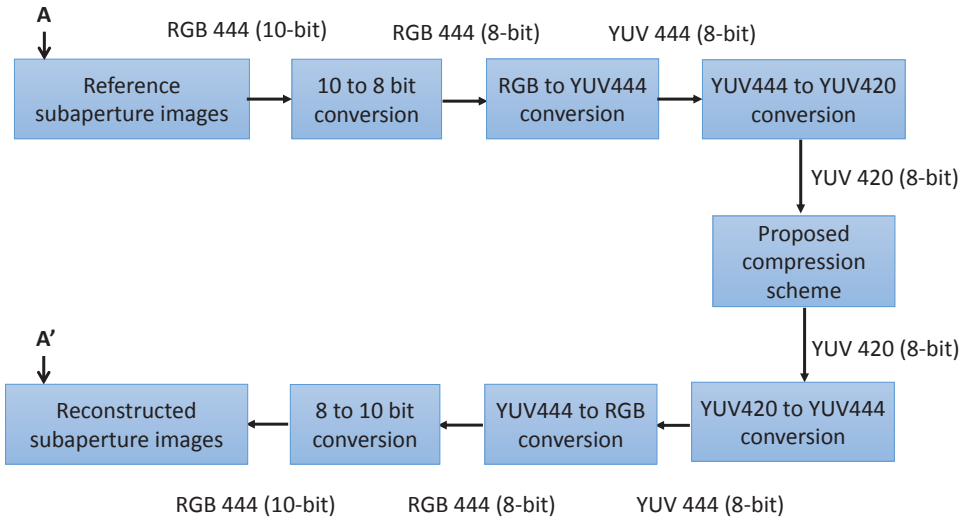

Fig. 1: The complete end-to-end processing chain utilized for proposed compression scheme

In Table II, encoded bit stream size in bytes is reported against each specified bit rate. The required bit rates are computed by taking raw Lytro sensor data (having resolution 5368x7728 with 10-bit per pixel depth) as reference. The approximate encoded bit stream sizes corresponding to specified bit rates are achieved by varying the base quantization parameter in proposed compression scheme.

TABLE II: Encoded bit stream size in bytes corresponding to specified bit rates

Image ID	R1	R2	R3	R4
I01	3955492	478986	107996	25269
I02	3765424	457459	98780	25128
I04	3730930	576117	112134	24860
I09	3786846	561895	107776	23622
I10	3603865	443627	113540	26763

The Table III and IV shows the PSNR YUVmean and PSNR Ymean for the proposed compression scheme.

TABLE III: Objective evaluation based on PSNR YUVmean

Image ID	R1	R2	R3	R4
I01	40.551	37.517	34.641	30.869
I02	39.400	35.619	32.402	29.011
I04	42.097	38.739	36.132	33.082
I09	40.811	37.562	34.60	30.941
I10	39.839	38.408	37.153	34.861

TABLE IV: Objective evaluation based on PSNR Ymean

Image ID	R1	R2	R3	R4
I01	41.499	37.804	34.327	29.710
I02	40.626	35.961	32.051	27.909
I04	43.309	39.091	35.832	32.006
I09	42.266	38.257	34.686	30.094
I10	39.792	38.144	36.680	34.047

Similarly, the analysis is also performed by using the SSIM metric. The Table V and VI shows the SSIM YUVmean and SSIM Ymean for the proposed compression scheme.

TABLE V: Objective evaluation based on SSIM YUVmean

Image ID	R1	R2	R3	R4
I01	0.963	0.939	0.905	0.832
I02	0.954	0.921	0.868	0.770
I04	0.960	0.938	0.909	0.848
I09	0.956	0.936	0.909	0.855
I10	0.974	0.958	0.942	0.907

TABLE VI: Objective evaluation based on SSIM Ymean

Image ID	R1	R2	R3	R4
I01	0.985	0.960	0.921	0.828
I02	0.981	0.949	0.890	0.768
I04	0.983	0.959	0.924	0.844
I09	0.983	0.966	0.939	0.872
I10	0.987	0.969	0.951	0.907

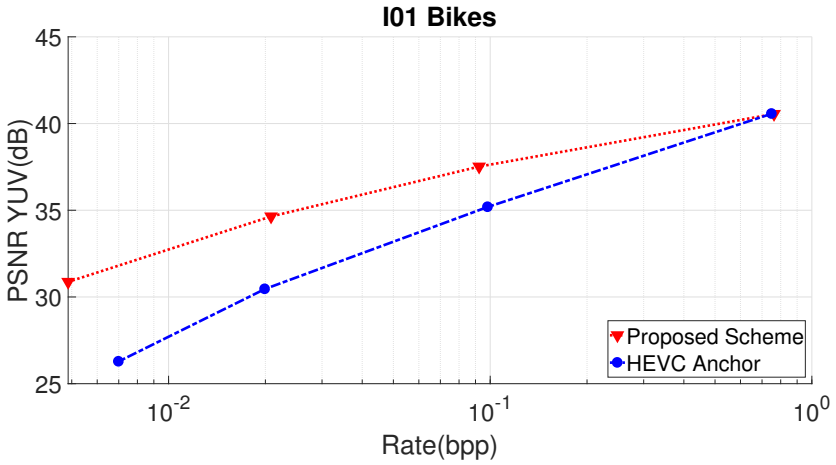

Fig. 2: Rate distortion analysis for Image 01

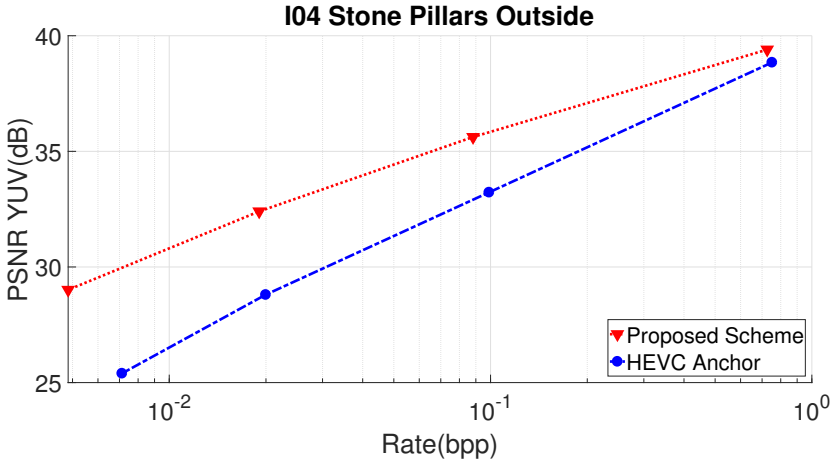

Fig. 3: Rate distortion analysis for Image 04

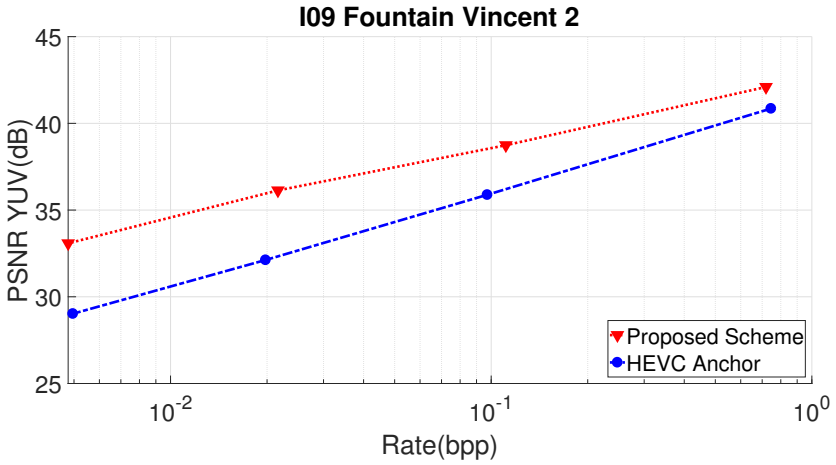

Fig. 4: Rate distortion analysis for Image 09

Rate-Distortion Comparison with Anchors

The proposed compression scheme is compared with provided HEVC anchors using objective metric PSNR YUV. For HEVC anchors generation, the given sub-aperture images are encoded as pseudo video sequence as defined by the compe-

tition. The same PSNR calculation methodology is used for both schemes. The rate distortion comparison is performed on a subset of images and shown in Fig. 2 to 4. The proposed compression scheme outperforms HEVC anchor with an average PSNR gain of 2.5 dB.

II. ICME 2016 Grand Challenge: Light field Image Coding

The proposed scheme is also evaluated on the input image format and compression ratios defined by ICME 2016 Grand challenge on plenoptic image compression [2]. A subset of 6 images from EPFL database, provided in the Grand Challenge are encoded on four specified bit rates corresponding to compression ratios (R1 = 1, R2 = 0.5, R3 = 0.25, and R4 = 0.1 bits per pixel).The Table VII reports the gain in PSNR (mean) with respect to reference JPEG anchors. The base quantization parameter for each image is also explained in the table to obtain desired compression ratio. The proposed scheme shows an average improvements of 7.5 dB over reference JPEG anchors. The gain is minimum for image 4 with PSNR improvement of over 6.5 dB and it is maximum for image 9 with PSNR improvement of 9.3 which reflects the scene dependence on compression scheme.

TABLE VII: Comparison of proposed scheme with reference JPEG anchors

Image ID	**Base QP**				**BD-PSNR (dB)**	
	R1	R2	R3	R4	Y	YUV
1	8	13	17	21	7.9	7.3
2	12	15	19	23	8.0	7.7
3	10	15	18	23	7.2	7.0
4	9	13	16	20	6.4	6.5
9	10	14	18	22	10.6	9.3
10	7	12	15	19	8.1	7.5
Average					**8.0**	**7.5**

The Fig. 5 to 7 shows the Rate Distortion (RD) analysis of proposed compression scheme (PCS) with reference JPEG anchors, Pseudo sequence based encoder (PSE) and Image B-coder (IBC) [3], [4]

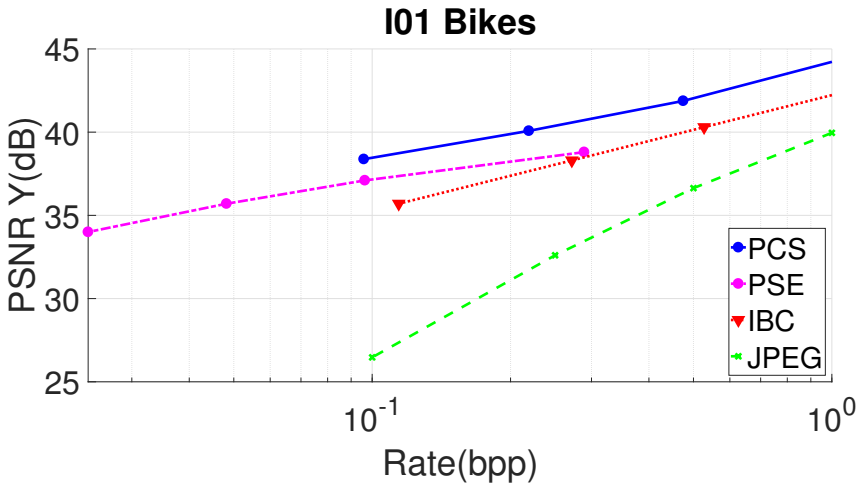

Fig. 5: Rate distortion analysis for Image 01

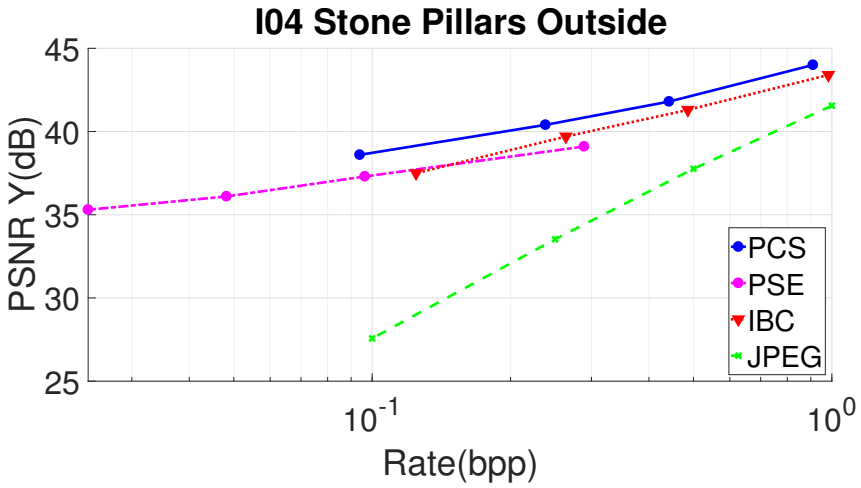

Fig. 6: Rate distortion analysis for Image 04

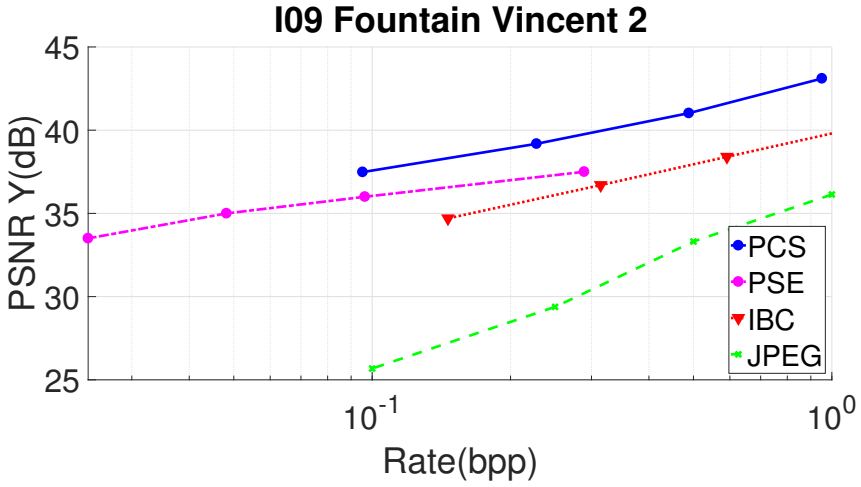

Fig. 7: Rate distortion analysis for Image 09

In all the test cases, the proposed scheme completely outperforms the other schemes in the low, medium and high bit-rate scenarios. The Table 2 reports the gain in PSNR (mean) with respect to reference JPEG anchors. The proposed scheme provide better compression efficiency in comparison to the work presented in ICME 2016, Grand challenge for plenoptic image coding [3]–[7]. .

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