



# ICME Grand Challenge on Light Field Image Compression

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- Grand Challenge on Light Field image compression
  - **Collect** new **compression** solutions for LF images
  - **Evaluate** proposed compression schemes w.r.t. **anchor**
    - **Objective** and **subjective** evaluations

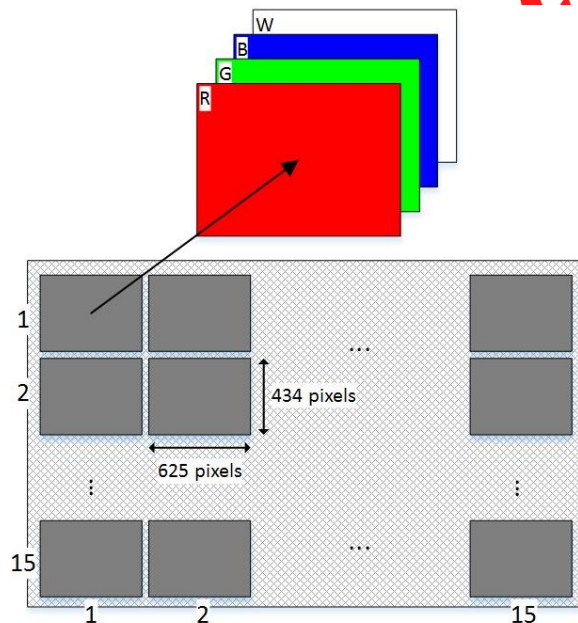
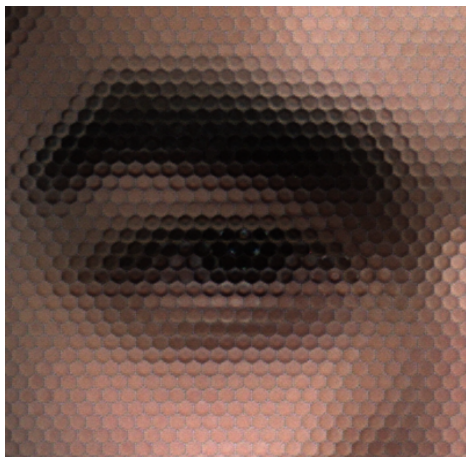
# Light Field photography



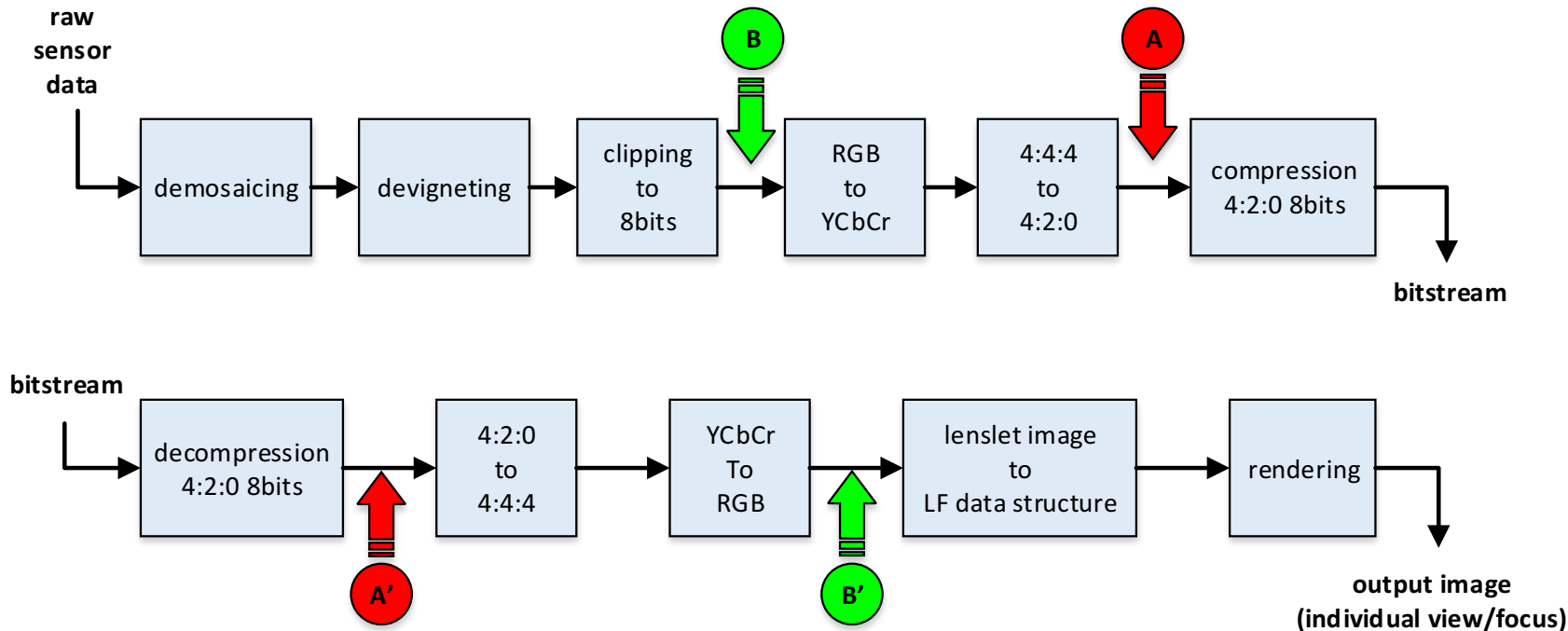
- Captures **plenoptic** information
- Allows **change** of **perspective** and **refocus** in **post-processing**



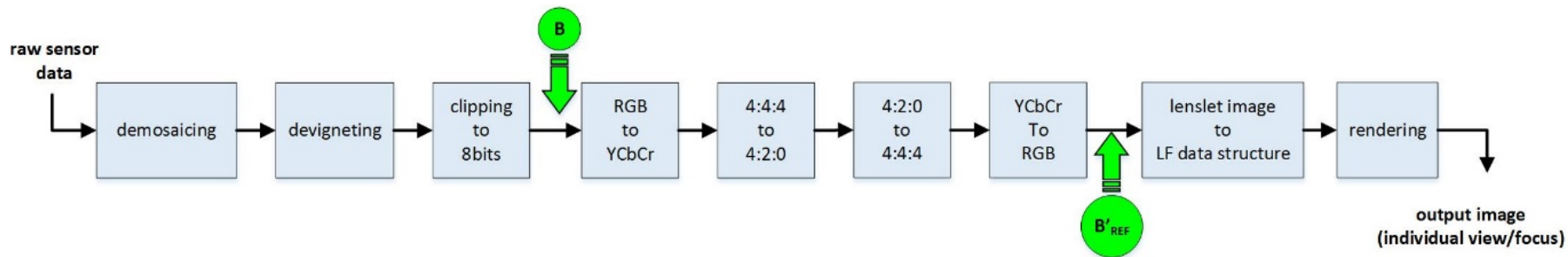
# Lenslet based LF



- **Huge** amount of information
- Need for **coding** techniques to **compress** the LF structure



# Reference and anchor processing chain



- **Reference** image generated following the same steps
- **Anchor** generated using legacy **JPEG**



# Coding Conditions



- **Twelve contents** taken from LF dataset (EPFL)
- **Four fixed compression ratios**
  - 10:1, 20:1, 40:1, 100:1
  - From 1bpp to 0.1bpp

# Light field content

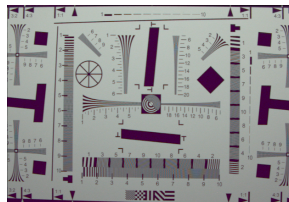
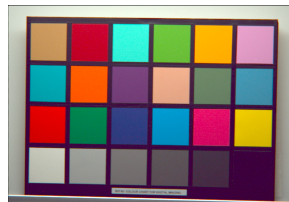
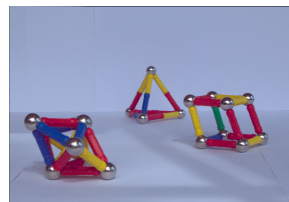




Image ID	Image name	Compression ratios			
		R1	R2	R3	R4
<b>I01</b>	Bikes	10:1	20:1	40:1	100:1
<b>I02</b>	Danger_de_Mort	10:1	20:1	40:1	100:1
<b>I03</b>	Flowers	10:1	20:1	40:1	100:1
<b>I04</b>	Stone_Pillars_Outside	10:1	20:1	40:1	100:1
<b>I05</b>	Vespa	10:1	20:1	40:1	100:1
<b>I06</b>	Ankylosaurus_&_Diplodocus_1	10:1	20:1	40:1	100:1
<b>I07</b>	Desktop	10:1	20:1	40:1	100:1
<b>I08</b>	Magnets_1	10:1	20:1	40:1	100:1
<b>I09</b>	Fountain_&_Vincent_2	10:1	20:1	40:1	100:1
<b>I10</b>	Friends_1	10:1	20:1	40:1	100:1
<b>I11</b>	Color_Chart_1	10:1	20:1	40:1	100:1
<b>I12</b>	ISO_Chart_12	10:1	20:1	40:1	100:1



# Quality Assessment Methodology



- **Objective** performance evaluation
  - Objective metrics: **PSNR** and **SSIM**
- **Subjective** performance evaluation
  - **DSCQS** methodology
  - Modified QualityCrowd 2 framework



# Objective performance evaluation



- PSNR for Y channel

$$PSNR_Y(k, l) = 10 \log_{10} \frac{255^2}{MSE(k, l)}$$

$$MSE(k, l) = \frac{1}{m n} \sum_{i=1}^m \sum_{j=1}^n [I(i, j) - R(i, j)]^2$$



# Objective performance evaluation



- PSNR for YUV channel

$$PSNR_{YUV}(k, l) =$$

$$\frac{6PSNR_Y(k, l) + PSNR_U(k, l) + PSNR_V(k, l)}{8}$$



# Objective performance evaluation



- Mean PSNR

$$PSNR_{Y_{mean}} = \frac{1}{(K-2)(L-2)} \sum_{k=2}^{K-1} \sum_{l=2}^{L-1} PSNR_Y(k, l)$$

$$PSNR_{YUV_{mean}} = \frac{1}{(K-2)(L-2)} \sum_{k=2}^{K-1} \sum_{l=2}^{L-1} PSNR_{YUV}(k, l)$$



# Objective performance evaluation



- SSIM for Y

$$SSIM_Y(k, l) = \frac{(2\mu_I\mu_R + c_1)(2\sigma_{IR} + c_2)}{(\mu_I^2 + \mu_R^2 + c_1)(\sigma_I^2 + \sigma_R^2 + c_2)}$$

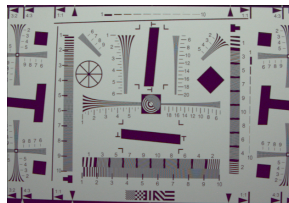
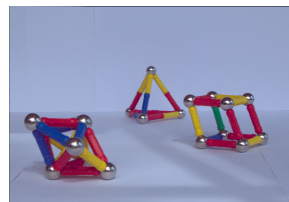


# Subjective Performance Evaluation



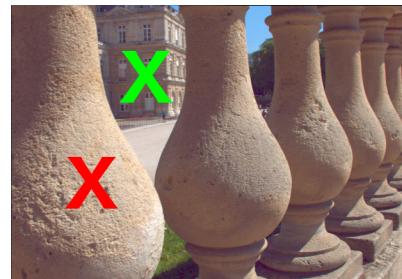
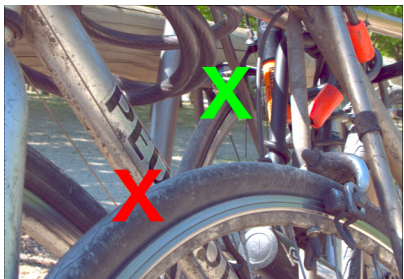
- 3 rendered **perspectives**, 2 **re-focused** points
  - 5 test **stimuli** per content
- Only 6 contents out of 12 from the dataset

# Light field content





# Subjective test





# Subjective performance evaluation



- DSCQS methodology
  - Double stimulus continuous quality scale
  - Rate quality level of **reference** and **decoded** image
  - **Side by side** configuration on a MacBook Pro Retina
  - **5-scale** score from bad to excellent
- Modified QualityCrowd 2 framework

# Subjective performance evaluation

## Image quality

A



Please rate the "visual" image quality

- Bad
- Poor
- Fair
- Good
- Excellent

B



Please rate the "visual" image quality

- Bad
- Poor
- Fair
- Good
- Excellent

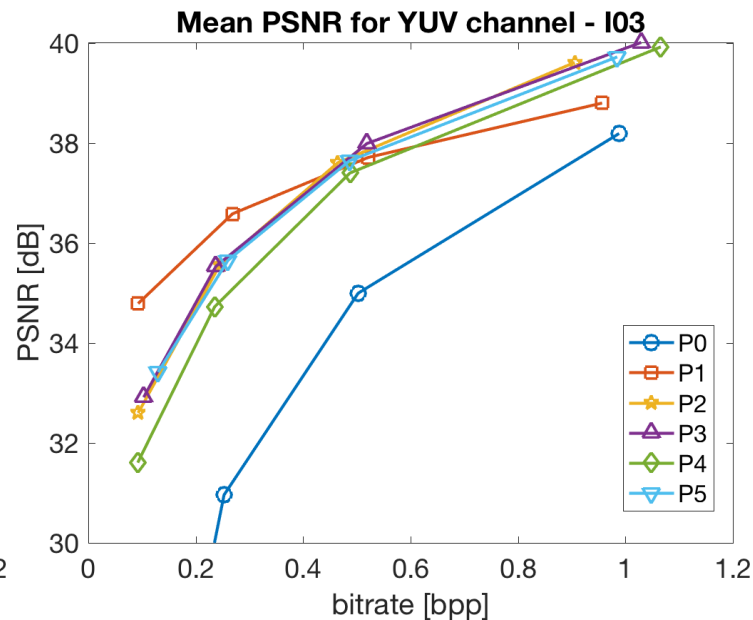
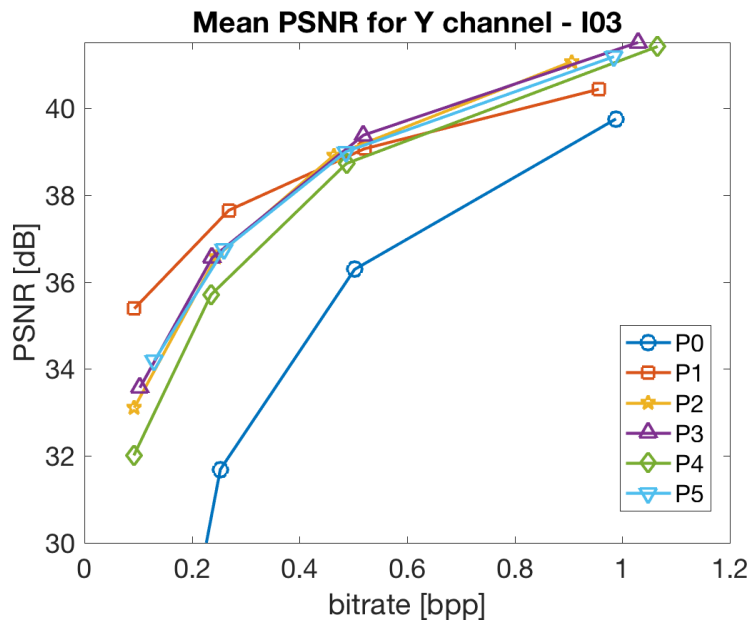


# Results

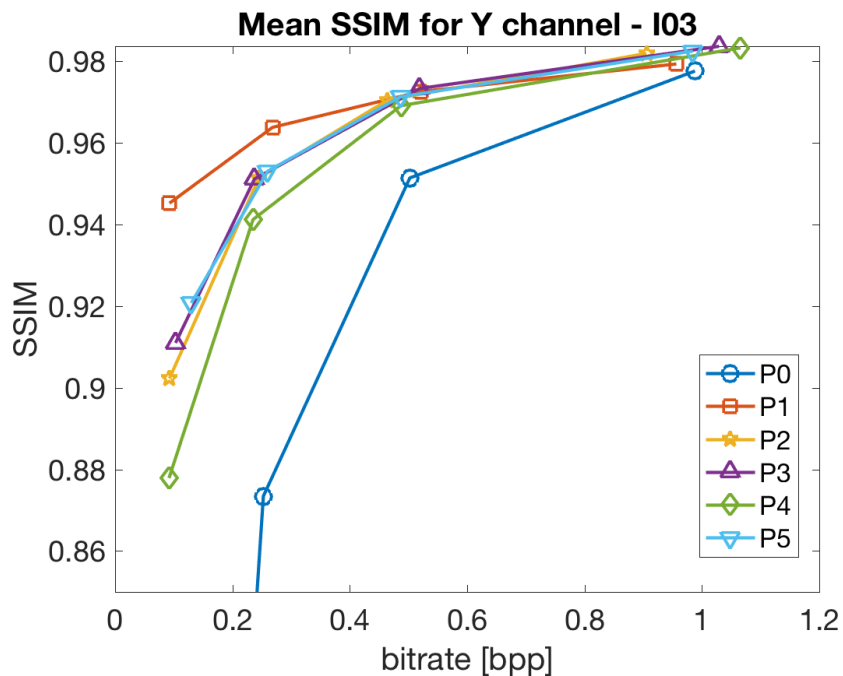


- 7 algorithms were received
  - 5 were accepted
- Anonymized through random labels P1 to P5
  - Anchor P0 is legacy JPEG

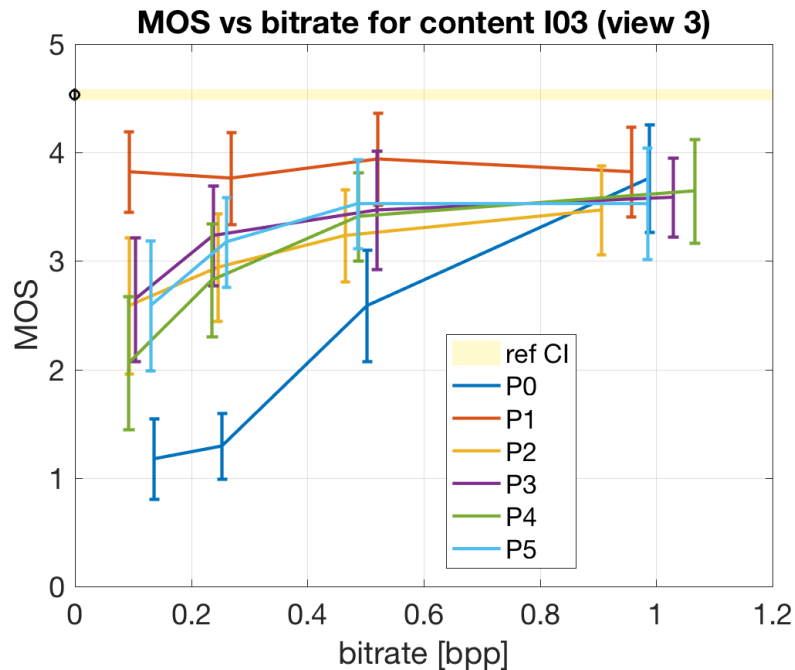
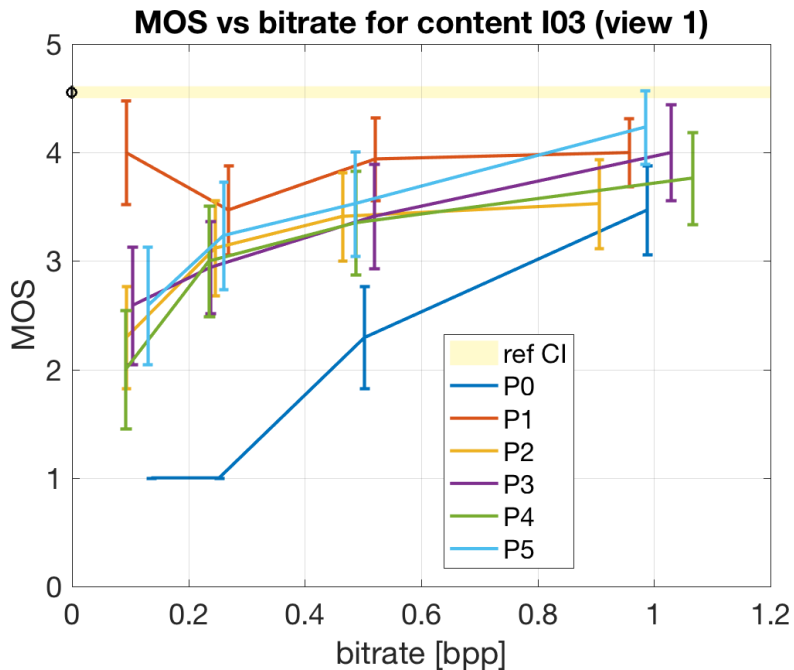
- Objective evaluation



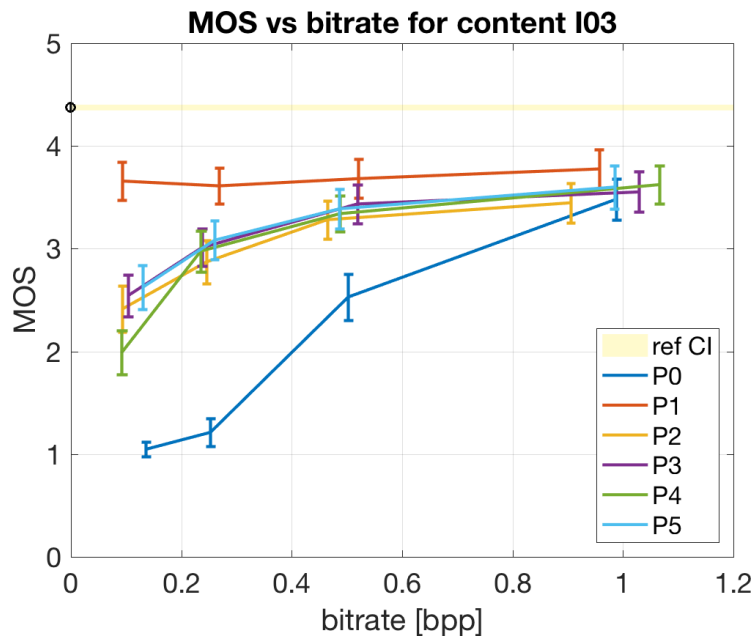
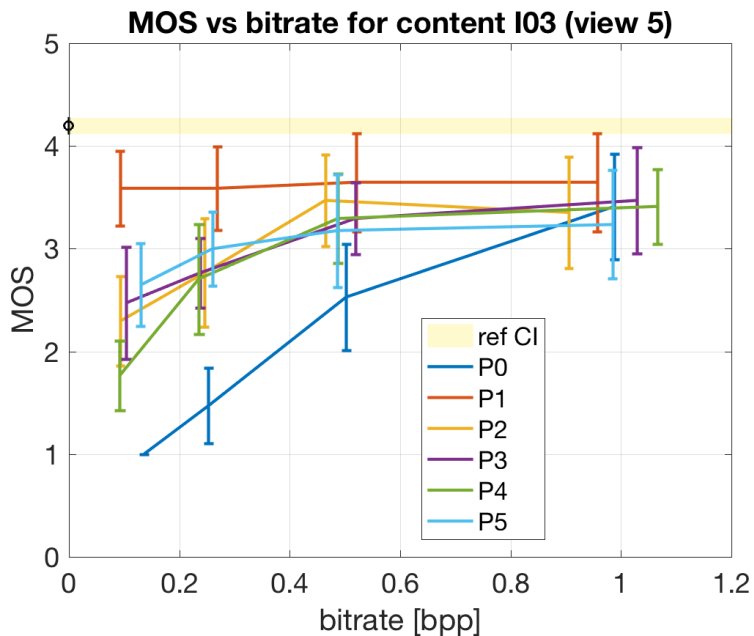
- Objective evaluation



- Subjective evaluation



- Subjective evaluation







# Statistical Analysis



- Welch's t-test of equal means

$$H_0: MOS_{P_A} = MOS_{P_B}$$

$$H_1: MOS_{P_A} \neq MOS_{P_B}$$

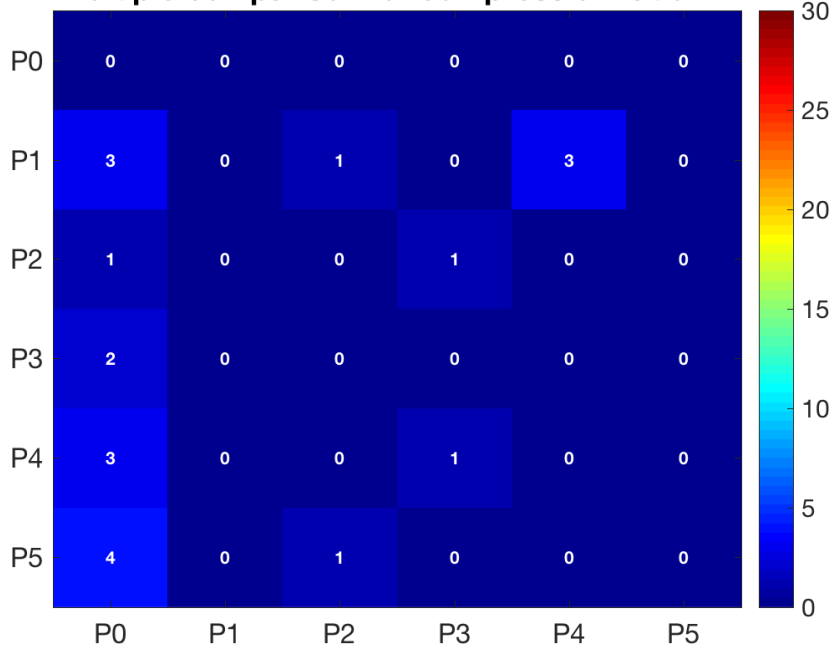


# Statistical Analysis

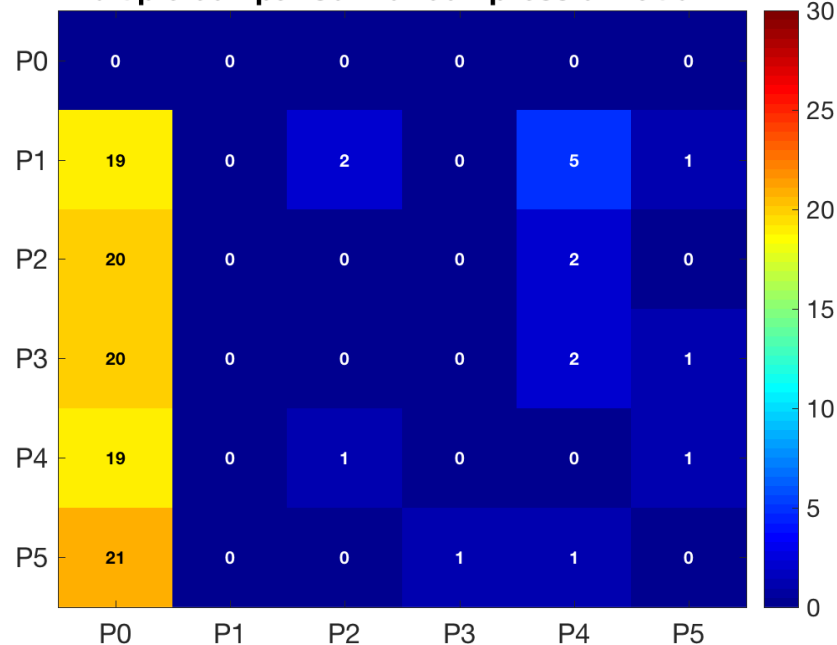


- **Examine if the null hypothesis is rejected or not**
- **For each bitrate, store for how many contents and views one codec performs better than the other**

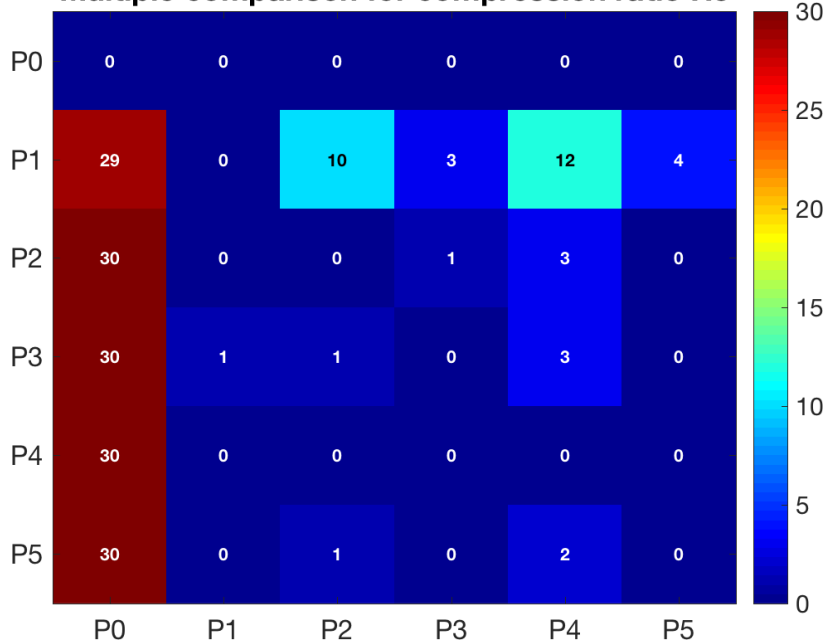
Multiple comparison for compression ratio R1



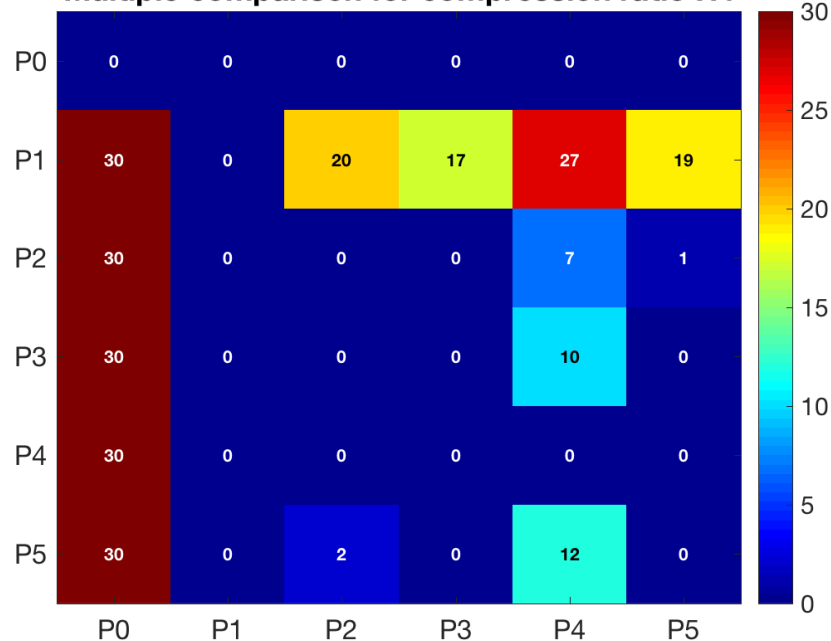
Multiple comparison for compression ratio R2



Multiple comparison for compression ratio R3



Multiple comparison for compression ratio R4





# Statistical Analysis



- Multi-way ANOVA to test interaction among groups
- Inter- and intra-variance among views

Group	R1		R2		R3		R4	
	F	p-value	F	p-value	F	p-value	F	p-value
contents	86.284	0.000	125.982	0.000	80.109	0.000	122.346	0.000
proponents	6.715	0.000	184.978	0.000	630.502	0.000	693.525	0.000
contents*proponents	2.926	0.000	13.710	0.000	3.972	0.000	8.644	0.000
views	47.664	0.000	29.757	0.000	9.462	0.000	7.199	0.000
contents*views	2.388	0.002	1.471	0.109	1.684	0.048	1.153	0.311
proponents*views	1.974	0.015	1.256	0.227	2.385	0.002	1.909	0.019
focus	0.035	0.854	0.082	0.777	2.241	0.147	3.773	0.063
contents*focus	2.465	0.060	1.424	0.250	3.992	0.008	1.684	0.175
proponents*focus	2.697	0.044	0.491	0.780	0.643	0.669	0.927	0.480
perspective	3.287	0.046	1.113	0.337	0.100	0.905	2.668	0.079
contents*perspective	3.066	0.004	0.894	0.545	0.324	0.971	0.974	0.478
proponents*perspective	1.369	0.222	1.249	0.284	2.059	0.046	2.957	0.005



# Expert viewers



- Higher confidence interval
- Results are consistent with naïve viewers



# Conclusions



- At **higher bitrates**, proponents and anchor have **similar subjective performance**
- At **lower bitrates**, **P1** can be identified as performing better for the rendering points that were subjectively assessed,
- However, overall P1 exhibited **lower PSNR** performance at **higher bitrates**
- **Several lessons were learned and ideas to improve the challenge in the future have been identified**





**Thank you!**