Super Metric for Immersive Video

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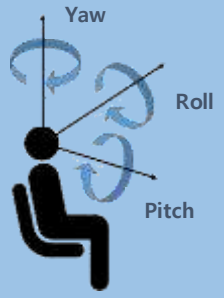
Virtual Reality in MPEG-I

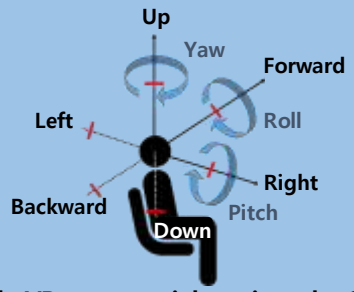
- Three phases of ISO/IEC MPEG-Immersive VR standardization
  - To support the entire movement in VR, 6DoF is required
  - 6DoF media support will be completed by 2022
  - 3DoF+ standard will be established by 2020 to support the limited 6DoF

Step 1



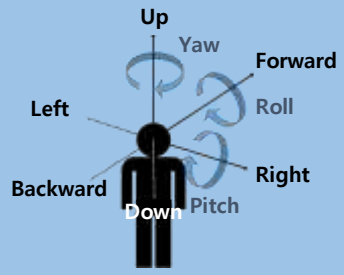
- Complete 3DoF standard by 2017
- Rotate head in a fixed state
- 360 video full streaming by default
- Tiled streaming if possible

Step 2



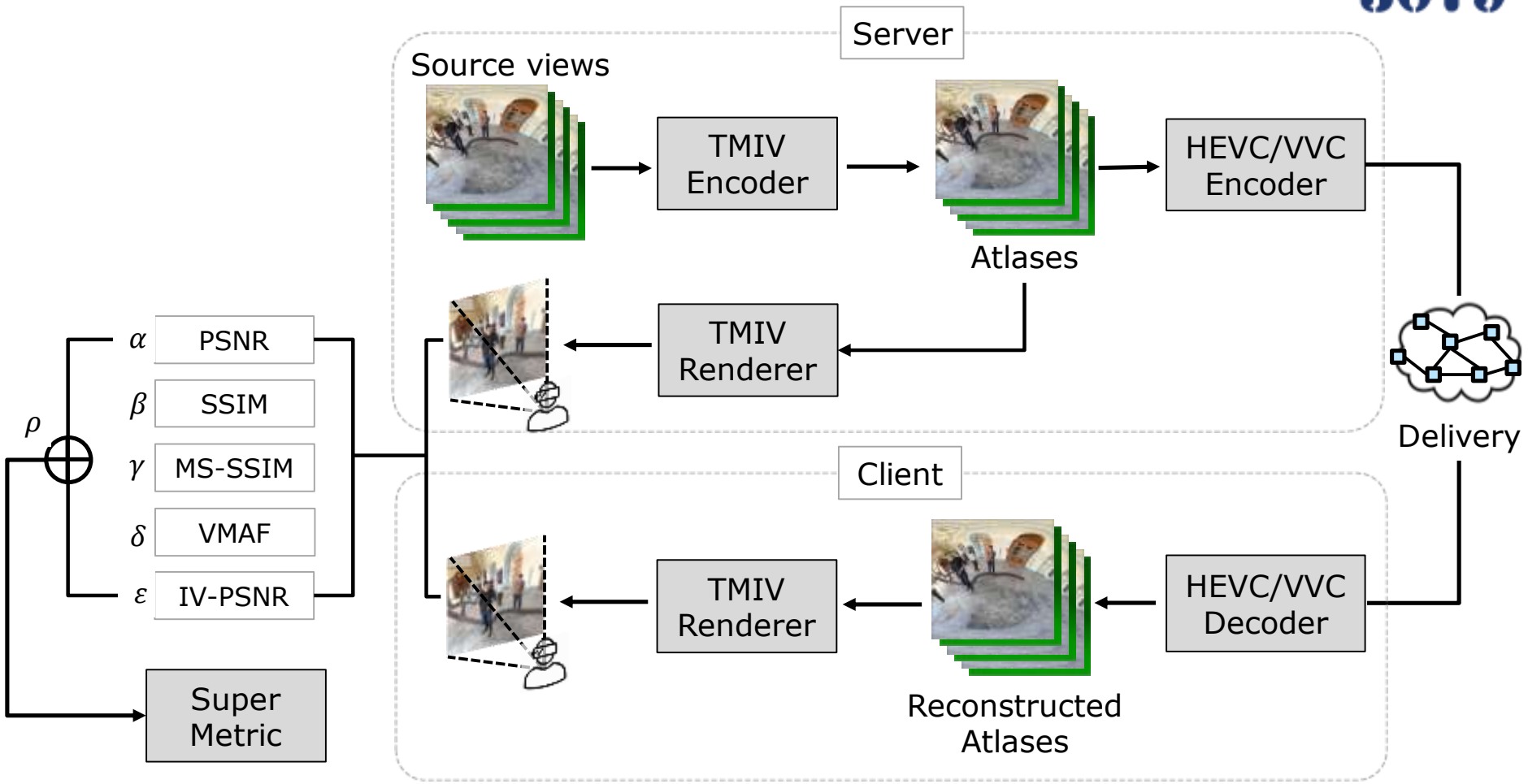
- Enable VR commercial servicers by 2020
- Allow head rotation and movement within a restricted area
- User-to-user conversations and projection optimization

Step 3



- Support 6DoF by 2022
- 6DoF video will reflect user's walking motion
- Support interaction with virtual environments

Super Metric for Immersive Video



Super Metric $= \alpha[PSNR] + \beta[SSIM] + \gamma[MS\ SSIM] + \delta[VMAF] + \varepsilon[IV\ PSNR] + \rho$

Immersive Video PSNR (IV-PSNR)

- Proposed to increase the correlation between: objective and subjective quality
- PSNR is calculated in block units
- Considers pixel movement

Edge artifacts shown in 3DoF+ view synthesis

$$\text{IV-PSNR} = 10 \cdot \log\left(\frac{\text{MAX}^2}{\text{BMSE}}\right)$$

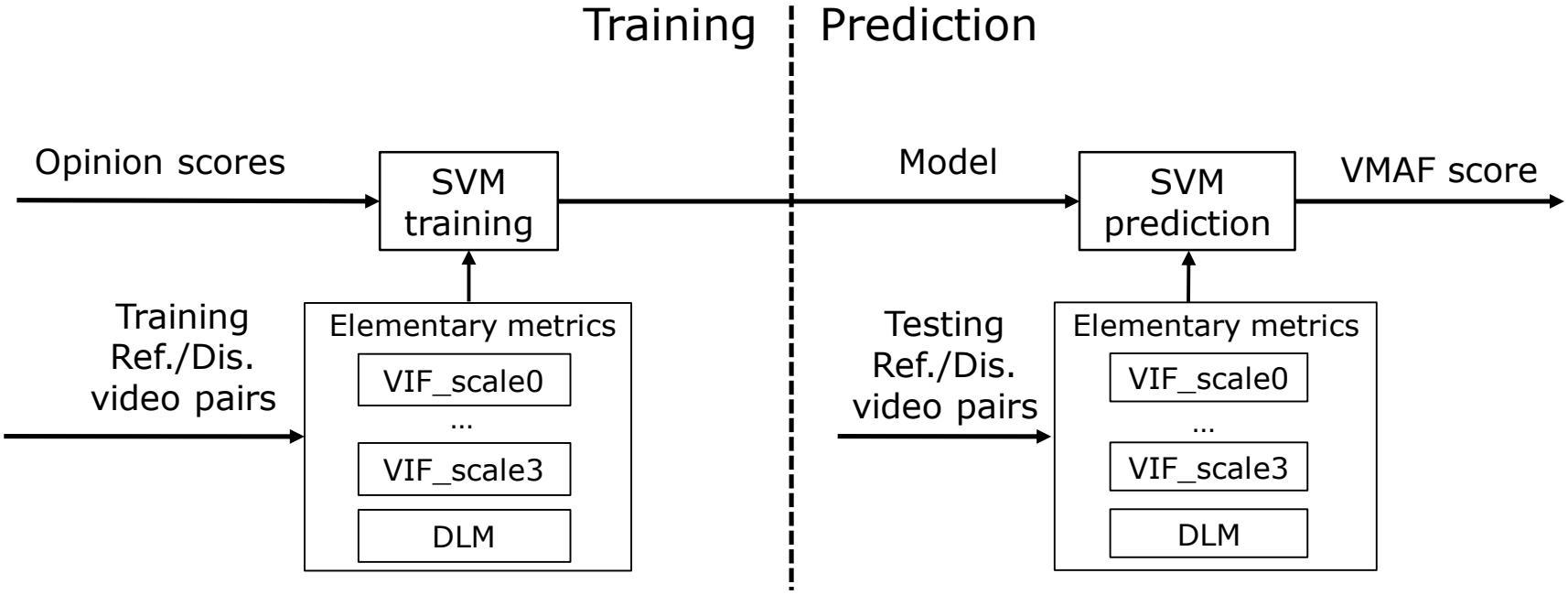
$$\text{BMSE} = \frac{1}{W \cdot H} \sum_{y=0}^{H-1} \sum_{x=0}^{W-1} \min_{\substack{x_R \in \left[x-\frac{B}{2}, x+\frac{B}{2}\right] \\ y_R \in \left[y-\frac{B}{2}, y+\frac{B}{2}\right]}} \left(c_T(x,y) - c_R(x_R, y_R)\right)^2$$

Equations of IV-PSNR

Source: Adrian Dziembowski. 2019. Software manual of IV-PSNR for Immersive Video. 128th MPEG meeting of ISO/IEC JTC1/SC29/ WG11, MPEG127/n18709.

Video Multimethod Assessment Fusion (VMAF)

- Proposed by Netflix
- Combination of several elementary metrics
  - Visual quality fidelity (VIF) and detail loss measure (DLM): spatial domain
  - Temporal information (TI): temporal domain
  - Considers the subjective quality



Internal process of VMAF

Super Metric for Immersive Video

IEEE 3079

- Background
  - Each quality metric evaluates different factors
  - For evaluation, common test conditions for immersive video defines the enhanced quality metric
- Purpose
  - Evaluate the 3DoF+ system SW (test model for immersive video (TMIV)) to:

    Provide the viewport which satisfies the user's quality of experience (QoE)

Metric name	Document No.	Location	Tag/branch
WS-PSNR	w18069	https://gitlab.com/mpeg-i-visual/wspsnr	v2.0.1
VMAF	-	https://github.com/Netflix/vmaf	v1.3.14
MS-SSIM	-	https://github.com/Netflix/vmaf	v1.3.14
VIF	-	https://github.com/Netflix/vmaf	v1.3.14
IV-PSNR	w18709	https://gitlab.com/mpeg-i-visual/ivpsnr	v1.0

Objective quality metrics for immersive video

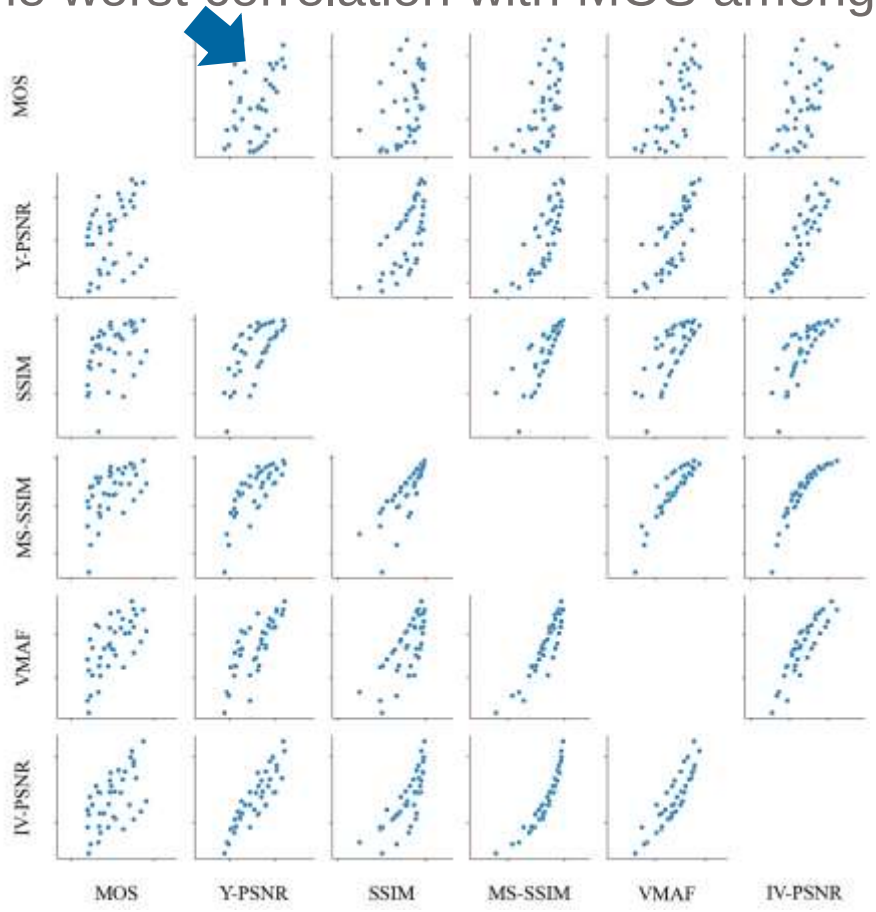
Test Conditions

- Test Materials
  - Followed common test conditions (CTC) of MPEG-I
  - 5 test sequences(class A, B, C, D, E) were encoded
  - For subjective data, used 3DoF+ CfR results including mean opinion score (MOS) [1]
- Environment
  - Versions of softwares meet the requirements of 3DoF+ CfP
  - OpenCV 3.4.2 was used to build reference view synthesizer (RVS) v3.1

[1] document m47979

Experimental Results

- In scatter plot matrix, linear representation with MOS means high correlation
- Y-PSNR showed the worst correlation with MOS among the metrics



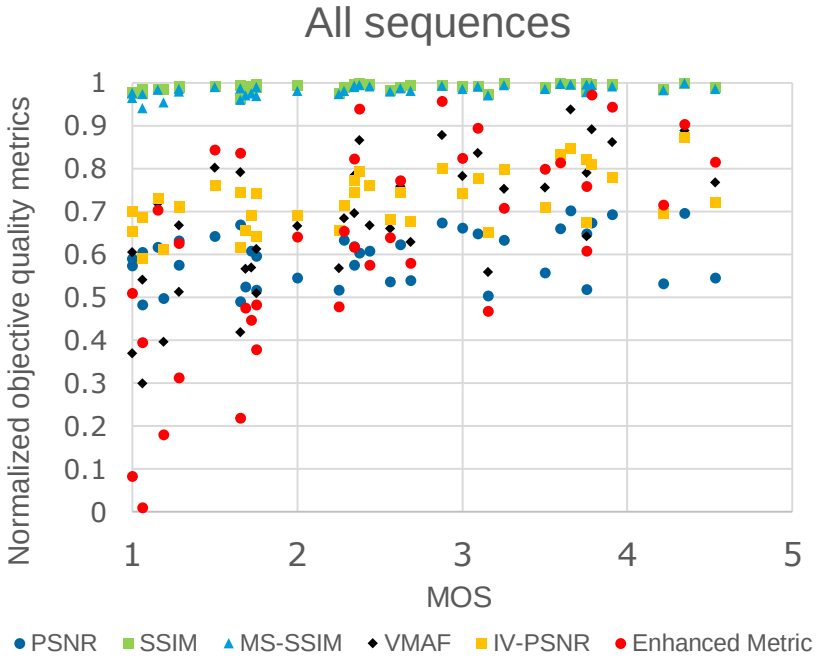
Scatter plot matrix of metrics

Experimental Results

- Super Metric is weighted sum of metrics

$$\alpha = -0.212892 \quad \beta = -0.414345 \quad \gamma = -0.610262 \quad \delta = 0.031026 \quad \epsilon = 0.226949 \quad \rho = -0.66383$$

- Super Metric has higher correlation coefficient with MOS than any other single metric



Correlation between MOS and objective quality metrics

Metric name	Correlation coefficient with MOS
PSNR	0.3012
SSIM	0.3932
MS-SSIM	0.5694
VMAF	0.6601
IV-PSNR	0.5539
Super Metric	**0.7525**

Correlation coefficient between MOS and objective quality metrics

Conclusion

- Problem
  - For state-of-the-art virtual reality system, quality metric is very important
  - Subjective quality and traditional metric (e.g. PSNR) show low correlation with MOS
- Proposed Methods and Insights
  - Weighted sum of traditional metrics can achieve high correlation with MOS
  - A single traditional metric (e.g. PSNR) is not appropriate for 3DoF+
- Future Work
  - Collaboration Prof. Nikil Jayant (Prof. @Georgia Tech & Adj. Prof. @UCSB)
  - Mathematical analysis of each metric and simplify process
  - Combining the metrics according to their characteristics (e.g. IV-PSNR and WS-PSNR)