# Applicability of Existing Objective Metrics of Perceptual Quality for Adaptive Video Streaming

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# Introduction

- Recently video streaming services has grown in popularity
- Nowadays, most services use HTTP based adaptive streaming
- Degradations quite different from other type of distribution
- Slowly varying quality changes on a fairly long timescale (2 sec – 1 min)

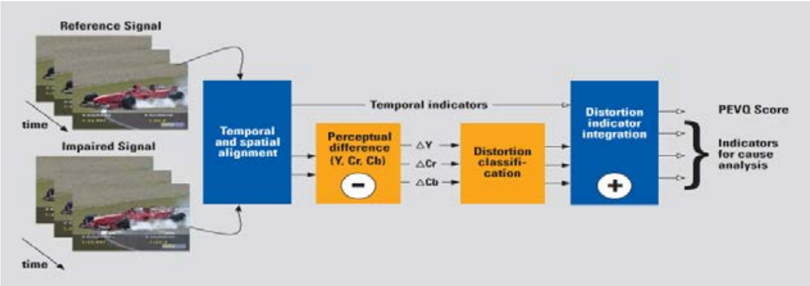
# Introduction

- Many objective video quality methods has been proposed
- Performance results have been published
- Their limitations not always clearly known
- This investigation: evaluated some published methods for adaptive video streaming

# Metrics

Perceptual Evaluation of Video Quality

*PEVQ:*




FR metric and part of ITU-T. Rec J.247 - objective metrics for multimedia

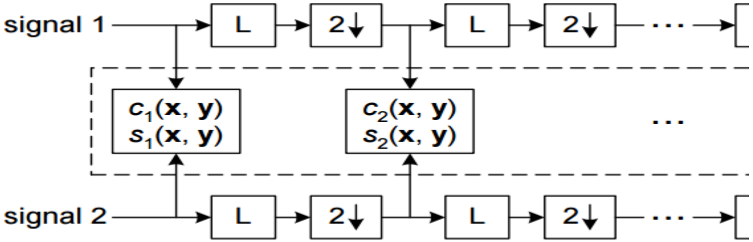
$$PSNR \quad = \quad 10 \cdot \log\left(\frac{MAX^2}{MSE}\right)$$

Luma component used

$$SSIM = \frac{(2\mu_X\mu_Y + c_1)(2\sigma_{XY} + c_2)}{(\mu_X + \mu_Y + c_1)(\sigma_X^2 + \sigma_Y^2 + c_2)}$$

Analyzing structural information. Default parameters used.

*MS-SSIM:*




Multiscale version of SSIM. Default parameters used.

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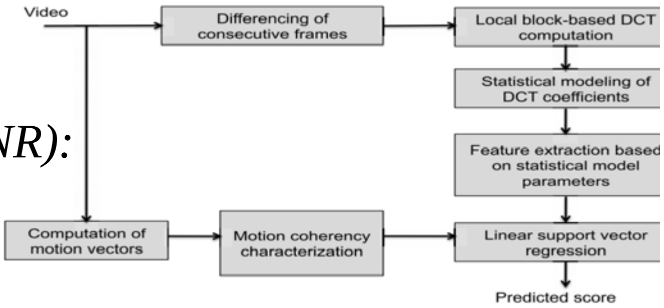
# Metrics

Standardized ITU-T Rec. J.144 RR-metric

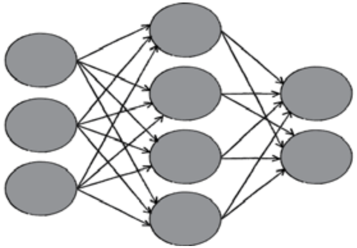
$$
\begin{aligned}
VQM = & -0.21 \cdot si\_loss \\
& +0.60 \cdot hv\_loss \\
& +0.25 \cdot hv\_gain \\
& +0.02 \cdot chroma\_spread \\
& -2.34 \cdot si\_gain \\
& +0.04 \cdot ct\_ati\_gain \\
& +0.01 \cdot chroma\_extreme
\end{aligned}
$$

*Video BLIINDS (NR):*




NR machine learning metric natural scene statistics

*VQM_VFD:*



Improved VQM with Variable Frame Delays and FR metric

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# Test video sequences

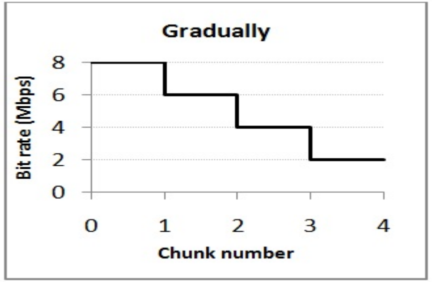


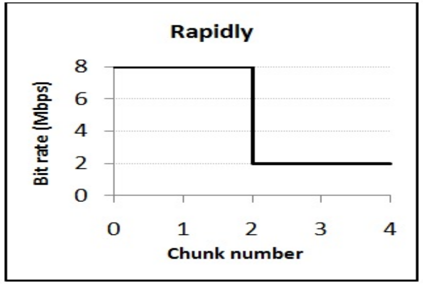



- 7 commercial content: Movie, Documentary, Sport, News, Music
- 6 min; originally 1080p Bluray video, 24/50 fps
- Different spatial and temporal characteristics

# Adaptation study parameters

- Switching behavior
  - Period (chunk length): 2 sec and 10 sec
  - Amplitude (difference between consequtive quality levels)
    gradual vs. rapid switching
  - Decreasing and increasing




- Adaptation dimension
  - Video quality (QP)
  - H.264/AVC
  - 4 streams: 5Mbps, 3Mbps, 1Mbps, 600kbps
  - 1280×720/ 25fps

→ **12 Test conditions in total**
→ **132 individual events (PVS) rated by test subjects**
→ **MOS based on > 60 test subjects**

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# Performance metrics

Standardized ITU-T Rec. P.1401

$$PLCC = \frac{\sum_{i=1}^{N}(MOS_i - \overline{MOS}) \times (MOSp_i - \overline{MOSp})}{\sqrt{\sum_i (MOS_i - \overline{MOS})^2} \times \sqrt{\sum_i (MOSp_i - \overline{MOSp})^2}},$$

$$OR = \frac{n_{\text{outlier}}}{N},$$

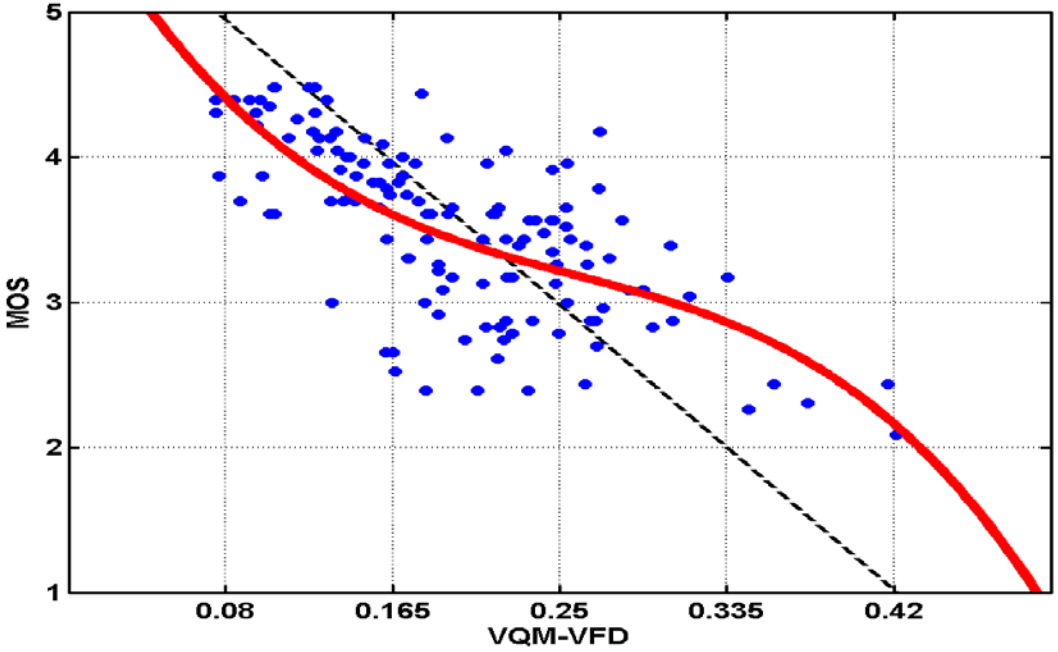
$$SROCC = 1 - \frac{6\sum_{i=1}^{N} d_i^2}{N(N^2-1)},$$

$$RMSE = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} MOS_i - MOSp_i}.$$

*Resolving Power (RP):* Significance of metric differences for sequences with statistically different MOS. Gives 95% confidence of a difference.

ITU-T Rec. J.149

# SCATTER PLOT: VQM-VFD




monotonic regression with 3rd order polynomial function

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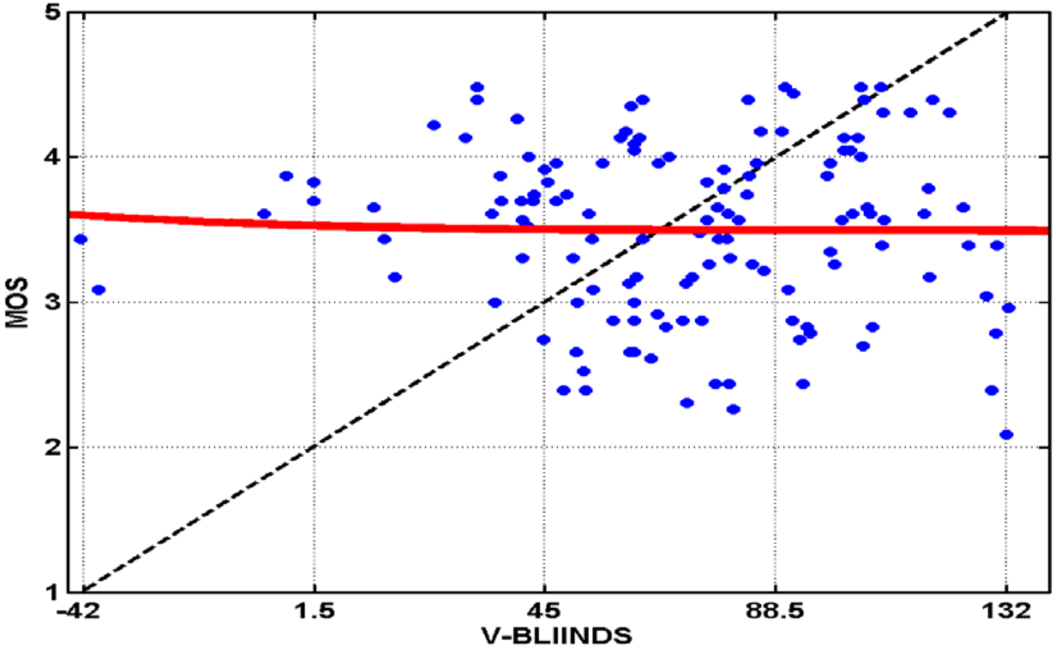
# SCATTER PLOT: VIDEO BLIINDS




monotonic regression with 3rd order polynomial function

# Performance

Table 1: Measures of performance.

| | PLCC | SROCC | OR | RMSE | RP |
|---|---|---|---|---|---|
| **PSNR** | 0.46 | 0.39 | 0.50 | 0.53 | 0.31 |
| **SSIM** | 0.55 | 0.54 | 0.47 | 0.49 | 0.25 |
| **MSSSIM** | 0.64 | 0.64 | 0.39 | 0.45 | 0.28 |
| **VQM** | 0.56 | 0.54 | 0.40 | 0.49 | 0.26 |
| **VQM-VFD** | **0.69** | **0.67** | **0.30** | **0.43** | **0.23** |
| **PEVQ** | 0.33 | 0.19 | 0.51 | 0.56 | **0.23** |
| **V-BLIINDS** | 0.02 | 0.02 | 0.54 | 0.59 | 1.00 |

# Performance

**Table 2: Test of significant differences for SROCC.**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| PSNR (1) | | | | | - | | + |
| SSIM (2) | | | | | | + | + |
| MS-SSIM (3) | | | | | | + | + |
| VQM (4) | | | | | | + | + |
| VQM-VFD (5) | + | | | | | + | + |
| PEVQ (6) | | - | - | - | - | | |
| V-BLIINDS (7) | - | - | - | - | - | | |

Significance test ITU-T Rec P.1401 and
Bonferroni multiple-comparison compensation

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# Performance

Table 3: Test of significant differences for RMSE.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| PSNR (1) | | | | | | | |
| SSIM (2) | | | | | | | |
| MS-SSIM (3) | | | | | | | + |
| VQM (4) | | | | | | | |
| VQM-VFD (5) | | | | | | + | + |
| PEVQ (6) | | | | | - | | |
| V-BLIINDS (7) | | | - | | - | | |

# Discussion

- No method performs well
- SSIM, MS-SSIM perform slightly better than PSNR – but not significantly
- VQM-VFD performs overall best

# Discussion

- V-BLIINDS are NR models based on machine learning not trained for this case
- PEVQ – dataset definitely out of scope trained on much severe transmission errors
- Videos varying length up to 40 sec – additional challenge for the methods

# Conclusion

- No method performed well
- Caution should be used when using metrics not designed for a particular scope

# More on this topic

- Subjective Analysis and Objective Characterization of Adaptive Bitrate Videos
- HVEI@4.30pm later today

# THANK YOU

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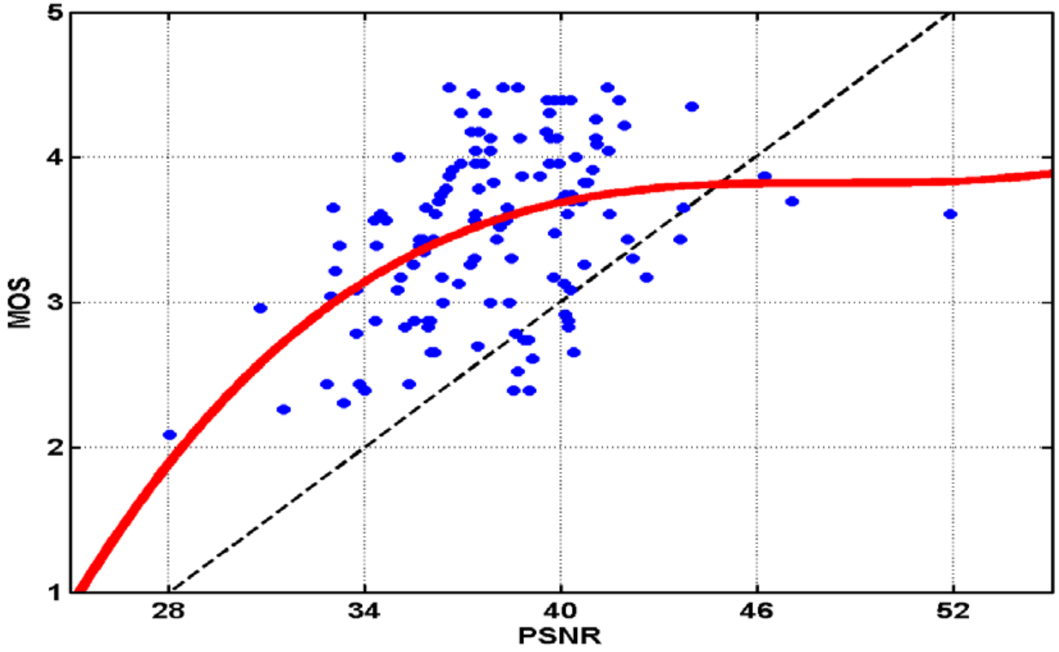
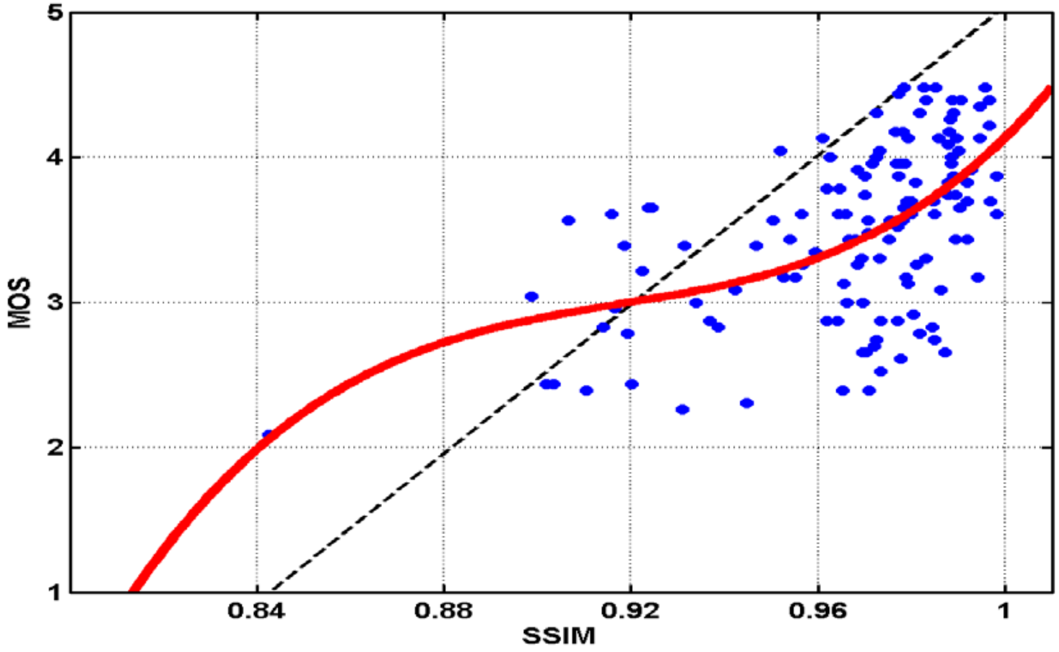
- The support of Multimedia and Sensors lab (MSL) of Center for Signal and Information processing group at Georgia Tech is also gratefully acknowleded.

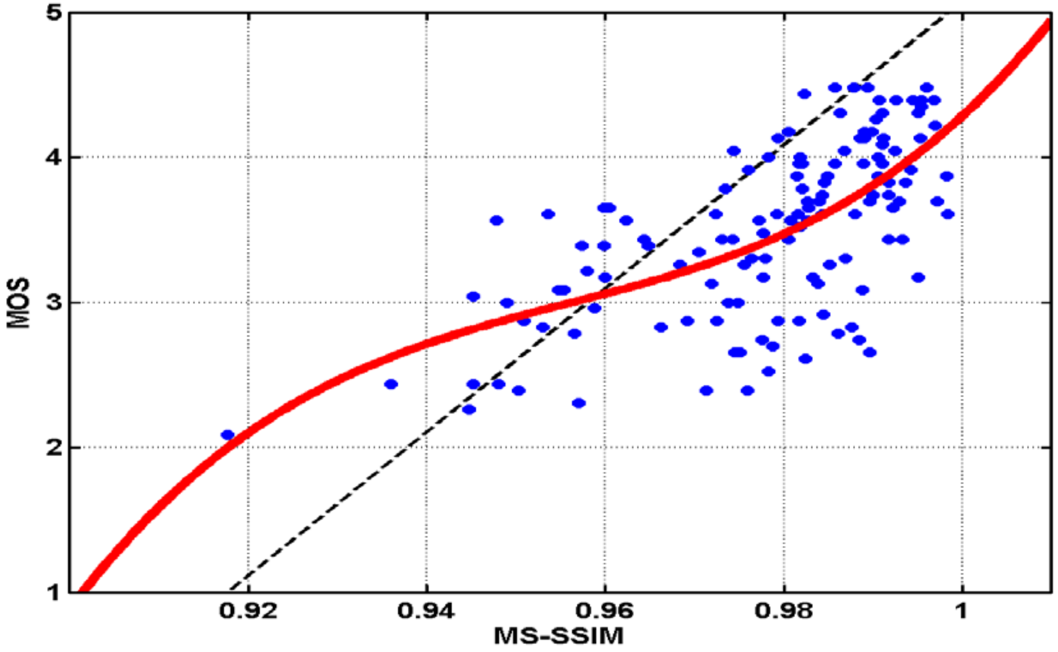
# SCATTER PLOT: PSNR



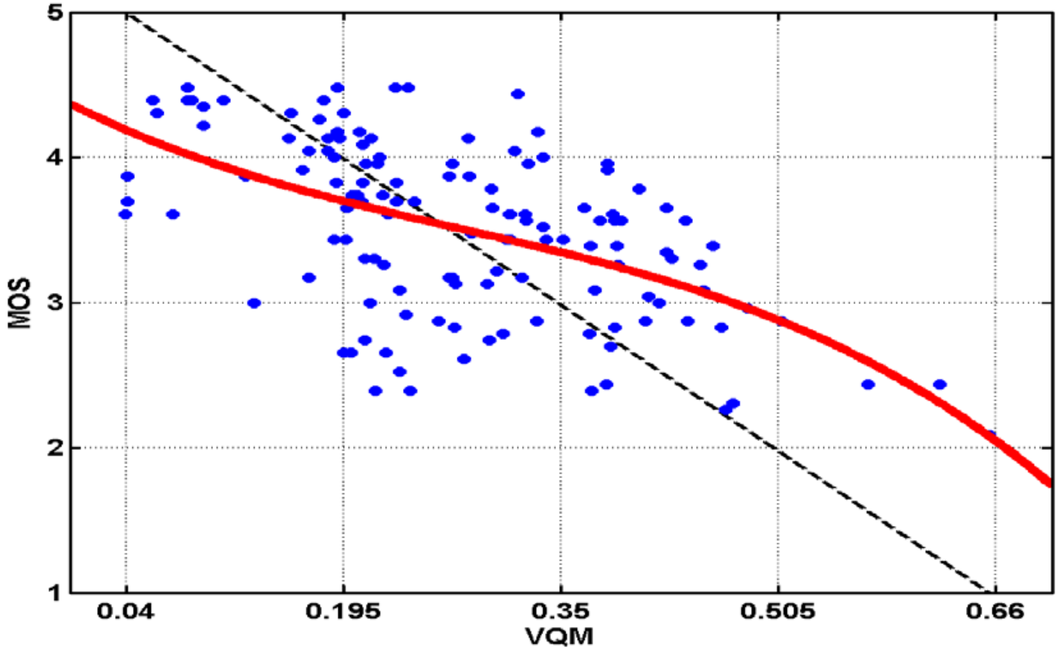
# SCATTER PLOT: SSIM



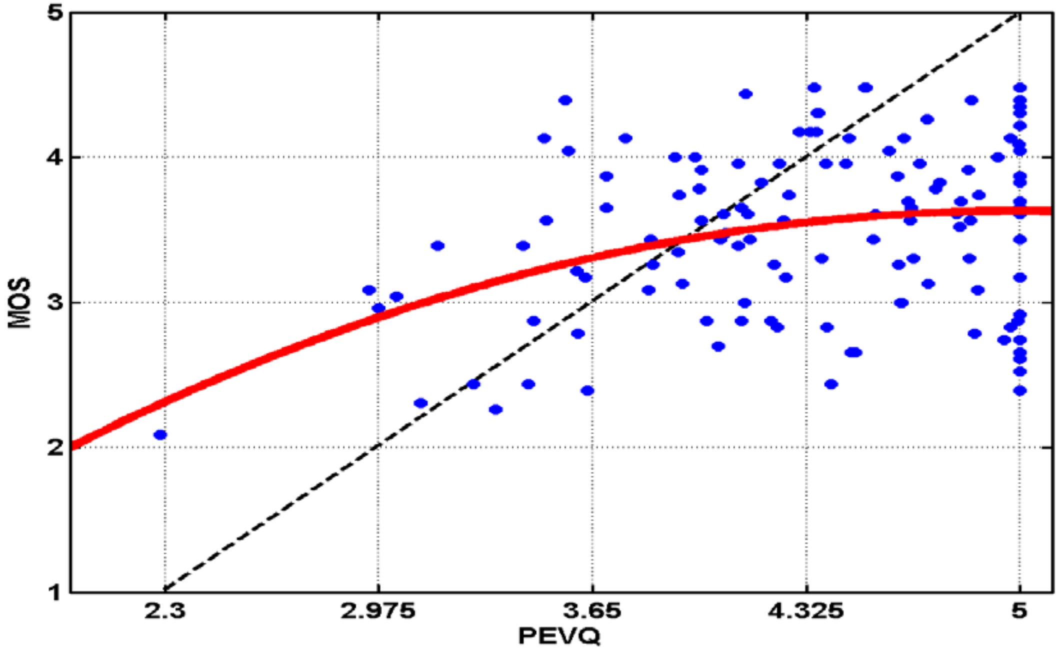
# SCATTER PLOT: MS-SSIM



# SCATTER PLOT: VQM



# SCATTER PLOT: PEVQ



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