GAMIVAL: VIDEO QUALITY PREDICTION ON MOBILE CLOUD GAMING CONTENT
Background and Motivation

Fig. 2. Sample frames of landscape gaming videos in the LIVE-Meta Mobile Cloud Gaming Database.
**LIVE-Meta Mobile Cloud Gaming dataset**

<table>
<thead>
<tr>
<th>Database</th>
<th># Videos</th>
<th># Source Sequences</th>
<th>Pristine Source Sequences</th>
<th># Ratings per Video</th>
<th>Public</th>
<th>Resolution</th>
<th>Distortion Type</th>
<th>Duration</th>
<th>Display Device</th>
<th>Display Orientation</th>
<th>Study Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>GamingVideoSET</td>
<td>90</td>
<td>6</td>
<td>Yes</td>
<td>25</td>
<td>Yes</td>
<td>480p, 720p, 1080p</td>
<td>H.264</td>
<td>30 sec</td>
<td>24&quot; Monitor</td>
<td>Landscape</td>
<td>Laboratory</td>
</tr>
<tr>
<td>KUGVD</td>
<td>90</td>
<td>6</td>
<td>Yes</td>
<td>17</td>
<td>Yes</td>
<td>480p, 720p, 1080p</td>
<td>H.264</td>
<td>30 sec</td>
<td>55&quot; Monitor</td>
<td>Landscape</td>
<td>Laboratory</td>
</tr>
<tr>
<td>CGVDS</td>
<td>360 + anchor stimuli</td>
<td>15</td>
<td>Yes</td>
<td>Unavailable</td>
<td>Yes</td>
<td>480p, 720p, 1080p</td>
<td>H.264 NVENC</td>
<td>30 sec</td>
<td>24&quot; Monitor</td>
<td>Landscape</td>
<td>Laboratory</td>
</tr>
<tr>
<td>TGV</td>
<td>1293</td>
<td>150</td>
<td>No</td>
<td>Unavailable</td>
<td>No</td>
<td>480p, 720p, 1080p</td>
<td>H.264, H.265, Tencent codec</td>
<td>5 sec</td>
<td>Unknown Mobile Device</td>
<td>Landscape</td>
<td>Laboratory</td>
</tr>
<tr>
<td>LIVE-YT Gaming</td>
<td>600</td>
<td>600</td>
<td>No</td>
<td>30</td>
<td>Yes</td>
<td>360p, 480p, 720p, 1080p</td>
<td>UGC distortions</td>
<td>8-9 sec</td>
<td>Multiple Devices</td>
<td>Landscape</td>
<td>Online</td>
</tr>
<tr>
<td>LIVE-Meta Mobile Cloud Gaming</td>
<td>600</td>
<td>30</td>
<td>Yes</td>
<td>24</td>
<td>Yes</td>
<td>360p, 480p, 540p, 720p</td>
<td>H.264 NVENC</td>
<td>20 sec</td>
<td>Google Pixel 5</td>
<td>Landscape, Portrait</td>
<td>Laboratory</td>
</tr>
</tbody>
</table>
Gaming Video Quality Evaluator (GAMIVAL) model

Adding Additive White Gaussian Noise (AWGN)

Temporal Band Pass Filtering

Spatial Feature Extraction

Mean Subtraction Contrast Normalization (MSCN)

Variance Statistics

GDD Parameters

AGDD Parameters

GDD Parameters

Four-Orientation Pair Productions

Seven-Orientation Pair Log-Derivatives

Temporal pooling

SVR

Overall Quality Score

Extract Patches

CNN Feature Extractor

Pre-training phase

MOS

Training images

VMAF

MOS-fitting phase

Quality

Training images

VMAF

Temporal

pooling

High-level features

VMAF

prox

Training images

Quality

label

label

label

Training images

label

label

Training images

label
Components of the GAMIVAL model

- Adding Additive White Gaussian Noise (AWGN)
- Spatial Feature Extraction
- Temporal Band Pass Filtering
- Extract Patches
- Mean Subtraction Contrast Normalization (MSCN)
- Variance Statistics
- GDD Parameters
- AGDD Parameters
- GDD Parameters
- Four-Orientation Pair Productions
- Seven-Orientation Pair Log-Derivatives
- NSS Feature Extractor
- SVR
- CNN Feature Extractor
- Overall Quality Score
- Temporal pooling
- Pre-training phase
- MOS
- Training images
- VMAF
- Quality
- High-level features
- MOS-fitting phase
- Training images
- VMAF
- label
- label
Components of the GAMIVAL model

A. Spatial Domain Features + Neural Noise

\[ \hat{I} = \frac{I(i, j) - \mu(i, j)}{\sigma(i, j) + C} \]

- \( I(i, j) \) - the input image (or feature map)
- \((i, j)\) - spatial indices
- \(C\) - saturation constant that prevents instabilities
- \(\mu, \sigma\) - weighted local means, standard deviations

\[ \tilde{I}(i, j) = I(i, j) + W_s \]  \hspace{1cm} (2)

- \(W_s \sim N(0, \sigma^2_{W_s})\) = white Gaussian noise
Components of the GAMIVAL model

- Adding Additive White Gaussian Noise (AWGN)
- Spatial Feature Extraction
- Temporal Band Pass Filtering
- Extract Patches
- Mean Substraction Contrast Normalization (MSCN)
- Variance Statistics
- GDD Parameters
- Four-Orientation Pair Productions
- AGDD Parameters
- Seven-Orientation Pair Log-Derivatives
- GDD Parameters
- NSS Feature Extractor
- CNN Feature Extractor
- SVR
- Overall Quality Score
- Temporal pooling
- Pre-training phase
- MOS
- VMAF
- Training images
- Quality
- High-level features
- MOS-fitting phase
- VMAF
- Training images
- Quality
- High-level features
- Pre-training phase
Components of the GAMIVAL model

B. Temporal Domain Features + Neural Noise

\[ \tilde{Y}_k(x, t) = Y_k(x, t) + W_t \]  

\( Y_k(x, t) \) - temporal bandpass coefficients  
\( k = 1, \ldots, 7 \) denotes subband indices  
\( x = (x, y) \) and \( t \) are spatial and temporal coordinates  
\( W_t \sim N(0, \sigma^2_{W_t}) \) - the noise added to the model
Components of the GAMIVAL model

1. Adding Additive White Gaussian Noise (AWGN)
2. Temporal Band Pass Filtering
3. Spatial Feature Extraction
4. Mean Substraction Contrast Normalization (MSCN)
5. Variance Statistics
6. GDD Parameters
7. AGDD Parameters
8. Four-Orientation Pair Productions
9. Seven-Orientation Pair Log-Derivatives
10. NSS Feature Extractor
11. Extract Patches
12. CNN Feature Extractor
13. SVR
14. Overall Quality Score

Temporal pooling

Pre-training phase

MOS-fitting phase
Components of the GAMIVAL model

C. CNN-based Features We used NDNetGaming model as a useful quality indicator by training a shallow regressor on top of the simple feature vector of an fully connected layer.
**Performance comparison**

<table>
<thead>
<tr>
<th>DATASET</th>
<th>LIVE-Meta-Mobile Gaming (600 videos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL</td>
<td>SRCC↑</td>
</tr>
<tr>
<td>NIQE</td>
<td>-0.3900</td>
</tr>
<tr>
<td>BRISQUE</td>
<td>0.7319</td>
</tr>
<tr>
<td>TLVQM</td>
<td>0.6553</td>
</tr>
<tr>
<td>VIDEVAL</td>
<td>0.7621</td>
</tr>
<tr>
<td>RAPIQUE</td>
<td>0.8740</td>
</tr>
<tr>
<td>GAME-VQP</td>
<td>0.8709</td>
</tr>
<tr>
<td>VSFA</td>
<td>0.9143</td>
</tr>
<tr>
<td>Proposed Model</td>
<td>0.9441</td>
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</tbody>
</table>

**Fig.** Box plots of PLCC, SRCC, and KRCC of evaluated BVQA algorithms on the LIVE-Meta-Mobile Gaming dataset over 100 splits. For each box, median is the central box, and the edges of the box represent 25th and 75th percentiles, while outliers are red circles.
## Computation complexity

<table>
<thead>
<tr>
<th>Model</th>
<th>Platform</th>
<th>Time (seconds)</th>
<th>FLOPS ($\times 10^9$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIQE</td>
<td>MATLAB</td>
<td>728</td>
<td>1965</td>
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<td>BRISQUE</td>
<td>MATLAB</td>
<td>205</td>
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<td>TLVQM</td>
<td>MATLAB</td>
<td>588</td>
<td>283</td>
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<td>VIDEVAL</td>
<td>MATLAB</td>
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<td>2334</td>
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<tr>
<td>RAPIQUE</td>
<td>MATLAB</td>
<td>103</td>
<td>322</td>
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<tr>
<td>GAME-VQP</td>
<td>MATLAB</td>
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<tr>
<td>NDNet-Gaming</td>
<td>Python, Tensorflow</td>
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<td>126704</td>
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<tr>
<td>VSFA</td>
<td>Python, Pytorch</td>
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<tr>
<td>GAMIVAL</td>
<td>Python, Tensorflow, MATLAB</td>
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<td>8683</td>
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</table>
## Appendix

<table>
<thead>
<tr>
<th>$\sigma_{W_i}$, $\sigma_{W_f}$</th>
<th>SRCC(↑)</th>
<th>KRCC(↑)</th>
<th>PLCC(↑)</th>
<th>RMSE(↓)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0.8949</td>
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<td>7.5875</td>
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<td>0.9387</td>
<td>0.7893</td>
<td>0.9494</td>
<td>5.7856</td>
</tr>
</tbody>
</table>

![Graph showing performance metrics](image)

(a) MOS=73.96, RAPIQUE=67.14, GAMIVAL=77.08
(b) MOS=73.14, RAPIQUE=66.38, GAMIVAL=74.05
(c) MOS=51.57, RAPIQUE=59.55, GAMIVAL=54.69
(d) MOS=40.10, RAPIQUE=56.78, GAMIVAL=48.39