QUALITY OF EXPERIENCE PREDICTION
FOR STREAMING VIDEO

Zhengfang Duanmu

Joint work with Abdul Rehman, Kai Zeng, and Zhou Wang

July 13, 2016
Outline

1. Video Streaming and Quality of Experience
   - Video Streaming
   - Quality of Experience
   - Objective QoE Prediction

2. Streaming Quality Index (SQI)
   - Objective QoE Prediction Model
   - Experimental Results

3. Conclusions
Outline

1. Video Streaming and Quality of Experience
   - Video Streaming
   - Quality of Experience
   - Objective QoE Prediction

2. Streaming Quality Index (SQI)
   - Objective QoE Prediction Model
   - Experimental Results

3. Conclusions
The Age of Streaming
The Age of Streaming

Factors of Picking Streaming Service

- Quality of Experience;
- Content;
- Price;
- Advertisement.
Quality of Experience

Definition

The degree of delight or annoyance of the user of an application or service. [Callet, 2013]
Quality of Experience

Influencing Factors

- Playback smoothness
Quality of Experience

Influencing Factors

- Duration of initial buffering
Quality of Experience

Influencing Factors

- Video presentation quality
Interaction between Presentation Quality and Stalling Experience

Figure: SRCC = 0.79
Subjective QoE Prediction

Enormous video space

Subjective test

Unaffordable

Adaptive HTTP Streaming
Existing QoE models: Quality of Service-based

**Philosophy**

- There exists a causal relationship between generic QoS problems and generic QoE problems.

**Factors**

- Throughput -> Delivered video quality
- Stalling duration -> Waiting experience

**Existing Models**

- Linear mapping [Mok, 2011];
- Exponential mapping [Hoßfeld, 2012];
- Logarithmic mapping [Rodriguez, 2012];
**Existing QoE models: Signal Fidelity-based**

**Philosophy**
- QoE can be measured by the distance from test video to the pristine video in the video space.

**Existing Models**
- PSNR;
- SSIM [Wang, 2004];
- MS-SSIM [Wang, 2003];
- VQM [Pinson, 2004];
- SSIMplus [Rehman, 2015];
Our method: Hybrid

Motivation

- QoS-based: not directly related to human perception;
- Signal fidelity-based: only work for static videos;
- No modeling on the interaction between video presentation quality and stalling.
Outline

1. Video Streaming and Quality of Experience
   - Video Streaming
   - Quality of Experience
   - Objective QoE Prediction

2. Streaming Quality Index (SQI)
   - Objective QoE Prediction Model
   - Experimental Results

3. Conclusions
Presentation Quality

Source

TRANSCODING

Bitrate 1

Bitrate 2

Bitrate 3

TRANSCODING

VQA

SEGMENTER

Seg1

Seg2

Seg3

Seg1

Seg2

Seg3

Seg1

Seg2

Seg3

Seg1

Seg2

Seg3

Seg1

Seg2

Seg3
Presentation Quality

- Static video quality
  - Frame # vs Static video quality
  - Frame # with stallings

- Streaming video quality (P)
  - Frame # vs Streaming video quality (P)

- Stalling position
- Recovery position
Stalling Experience Quantification

\[
S^k(t) = \begin{cases} 
P_{i_k-1} \left( -1 + \exp \left\{ - \left( \frac{tf - i_k}{T_0} \right) \right\} \right) & \frac{i_k}{f} \leq t \leq \frac{i_k + l_k}{f} \\
P_{i_k-1} \left( -1 + \exp \left\{ - \left( \frac{l_k}{T_0} \right) \right\} \right) & t > \frac{i_k + l_k}{f} \\
0 & \text{otherwise}
\end{cases}
\]
Stalling Experience Quantification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>rate of dissatisfaction in stalling event</td>
</tr>
<tr>
<td>$T_1$</td>
<td>strength of memory in stalling event</td>
</tr>
<tr>
<td>$T_{init}^0$</td>
<td>rate of dissatisfaction in initial buffering event</td>
</tr>
<tr>
<td>$T_{init}^1$</td>
<td>strength of memory in initial buffering event</td>
</tr>
<tr>
<td>$P_0$</td>
<td>expectation on initial quality of the video</td>
</tr>
</tbody>
</table>
Presentation Quality

- Static video quality
- Streaming video quality (P)
- Stalling experience ($S^{1}_n$ and $S^{2}_n$)
- QoE ($Q$)
### Experimental Results

Performance comparison of QoE models on streaming video QoE database.

<table>
<thead>
<tr>
<th>Model</th>
<th>PLCC</th>
<th>MAE</th>
<th>SRCC</th>
<th>KRCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTW [Hoßfeld, 2012]</td>
<td>0.3313</td>
<td>14.9455</td>
<td>0.3154</td>
<td>0.2583</td>
</tr>
<tr>
<td>PSNR</td>
<td>0.6663</td>
<td>10.7254</td>
<td>0.6715</td>
<td>0.4697</td>
</tr>
<tr>
<td>SSIM [Wang, 2004]</td>
<td>0.8432</td>
<td>7.6039</td>
<td>0.8177</td>
<td>0.6070</td>
</tr>
<tr>
<td>SSIMplus [Rehman, 2015]</td>
<td>0.8350</td>
<td>7.6934</td>
<td>0.8024</td>
<td>0.5924</td>
</tr>
<tr>
<td>SQI-PSNR</td>
<td>0.7391</td>
<td>9.8445</td>
<td>0.7492</td>
<td>0.5434</td>
</tr>
<tr>
<td>SQI-SSIM</td>
<td>0.9015</td>
<td>5.8941</td>
<td><strong>0.9009</strong></td>
<td><strong>0.7238</strong></td>
</tr>
<tr>
<td>SQI-SSIMplus</td>
<td><strong>0.9026</strong></td>
<td><strong>5.8330</strong></td>
<td>0.9007</td>
<td>0.7213</td>
</tr>
</tbody>
</table>
Experimental Results
Outline

1. Video Streaming and Quality of Experience
   - Video Streaming
   - Quality of Experience
   - Objective QoE Prediction

2. Streaming Quality Index (SQI)
   - Objective QoE Prediction Model
   - Experimental Results

3. Conclusions
Conclusions

Contribution

- Proposed an objective QoE model for video streaming that considers presentation quality and its interaction with stalling;
- Achieved the best performance in predicting subject opinions.

Future Work

- Construct comprehensive database;
- Investigate other QoE-related factors;
- Improve the QoE model.
References


Thank you