An ANFIS-based Hybrid Quality Prediction Model for H.264 Video over UMTS Networks

Asiya Khan, Lingfen Sun, Jose-Oscar Fajardo, Fidel Liberal & Emmanuel Ifeachor
8th June 2010

University of Plymouth, United Kingdom
{asiya.khan; l.sun; e.ifeachor} @plymouth.ac.uk

University of Basque Country, Spain
{joseoscar.fajardo; f.liberal}@ehu.es
Presentation Outline

- Background
  - Video quality over UMTS networks
  - Current status and motivations
  - Aims of the project
- Main Contributions
  - Classification of video content from previously defined classification function.
  - Prediction model based on ANFIS over UMTS network from a combination of parameters in the physical and application layer
- Conclusions and Future Work
Background – Video Quality over UMTS Networks

Why do we need to predict video quality?

- Multimedia services are increasingly accessed with wireless/UMTS components
- Streaming video quality is dependent on the intrinsic attribute of the content.
- QoS of multimedia is affected by both the Application and Physical layer parameters
- For Quality of Service (QoS) control for multimedia applications

Video Quality Measurement

- Subjective method (Mean Opinion Score -- MOS)
- Objective methods
  - Intrusive methods (e.g. PSNR, SSIM)
  - Non-intrusive methods (e.g. ANN-based models)
Video quality: end-user perceived quality (MOS), an important metric.

- Affected by application and physical layer and other impairments.

\[
MOS = f(loss, delay, jitter, codec, SBR, FR, \ldots)
\]
Lack of efficient non-intrusive video quality measurement methods

Current video quality prediction methods mainly based on application or network level parameters

It is an open challenge to satisfy user’s Quality of Experience (QoE) requirements and adapt service performance to variable network conditions as the ones occurring in UMTS

Neural network based models have been used for video quality prediction.
Why use ANFIS-based Artificial Neural Networks (ANN)?

- Video quality is affected by many parameters and their relationship is thought to be non-linear.
- ANN can learn this non-linear relationship.
- Fuzzy systems are similar to human reasoning (not just 0 or 1).
- Compared to fuzzy logic systems, ANFIS has an automated identification algorithm and easier design.
- Compared to neural networks it has less number of parameters and faster adaptation.
- ANFIS (Adaptive Neural-Fuzzy Inference System) combines the advantages of neural networks and fuzzy systems.
Hence the motivation of our work –

**to predict video quality using a combination of both application and physical layer parameters for all content types.**
Aims of the project

- Novel non-intrusive video quality prediction model for H.264 video over UMTS network based on ANFIS in terms of MOS
Classification of video contents (1)

Temporal Features:
Measured by the movement in a clip and is given by the SAD (Sum of Absolute Difference) value.

Spatial Features:
Blockiness, blurriness, brightness between the current and previous frames.

Content type estimation:
Hierarchical and K-means cluster analysis.
Classification of video contents (2)

- Data split at 38%
- Cophenetic Coefficient C ~ 86.21%
- Classified into 3 groups as a clear structure is formed
Simulation Set-up (1)

- Error simulated in the Physical layer is employed to generate losses at the link layer.
- The losses are modelled with 2-state Markov model with variable Mean Burst Lengths.

- All experiments conducted in the OPNET® Modeler simulation platform
- 2-state Markov error model
- No packet loss in the wired segment
H.264 encoder used
Packet size is set to 1024 bytes
The MOS value is calculated from PSNR to MOS conversion
Simulation Set-up (3)

- Video quality measured by taking average PSNR over all the decoded frames.
- MOS scores calculated from conversion from Evalvid.

<table>
<thead>
<tr>
<th>PSNR(dB)</th>
<th>MOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 37</td>
<td>5</td>
</tr>
<tr>
<td>31 – 36.9</td>
<td>4</td>
</tr>
<tr>
<td>25 – 30.9</td>
<td>3</td>
</tr>
<tr>
<td>20 – 24.9</td>
<td>2</td>
</tr>
<tr>
<td>&lt; 19.9</td>
<td>1</td>
</tr>
</tbody>
</table>
Test Sequences

Snapshots of video sequences

Akiyo, Foreman and Stefan – training the model
Suzie, Carphone and Football – validation of the model
List of Variable Test Parameters

- **Application Layer Parameters:**
  - Frame Rate **FR** (7.5, 10, 15fps)
  - Spatial resolution QCIF (176x144)
  - Send Bitrate **SBR** (48, 88, 128kbps for video sequences of Akiyo and Foreman, 90, 120kbps for Suzie and Carphone, 88, 130 and 256kbps for Setan and 130, 200kbps for Football)

- **Physical Layer Parameters:**
  - Block Error Rate **BLER** (0.01, 0.05, 0.1, 0.15, 0.2, 0.3, 0.4)
  - Mean Burst Length **MBL** – 1, 1.75, 2.5
A total of 600 samples were generated based on OPNET and Evalvid for testing and 250 samples as the validation dataset.
Proposed Model

FR (Frame Rate), SBR (Sender BitRate), CT (Content Type), BLER (Block Error Rate), MBL (Mean Burst Length)
The error correlation properties of the link layer model does not have an impact on the quality of the streamed video as long as the IP packet error probability remains unchanged.
Conclusions

- Extended our classification function to UMTS networks
- Proposed a reference free model for video quality prediction.
- Model based on a combination of Application (CT, FR, SBR) and Physical Layer parameters (MBL, BLER).
- Obtained good prediction accuracy (around 87%).
Future Work

- Use subjective data for evaluation.
- Currently limited to simulation only.
- Extend to test bed based on IMS.
- Mechanisms for QoS control and adaptation.
Contact details

- **http://www.tech.plymouth.ac.uk/spmc**
- Asiya Khan, asiya.khan@plymouth.ac.uk
- Dr Lingfen Sun, l.sun@plymouth.ac.uk
- Oscar-Jose Fajardo, oscarjose.fajardo@ehu.es
- Dr Fidel Liberal, fidel.liberal@ehu.es
- Prof Emmanuel Ifeachor, e.ifeachor@plymouth.ac.uk
- **http://www.ict-adamantium.eu/**

- Any questions?

Thank you!