Measuring Perceived Quality of Speech and Video in Multimedia Conferencing Applications

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Outline
• Introduction
• Measuring Perceived Quality
• What is Multimedia Quality?
• UCL Approach to Measuring Quality
• Summary

Motivation
• As power and connectivity of computers has increased → increase in Multimedia networking research
• Recognized that Multimedia has “special” constraints
  – Ex: delay, loss, jitter
  – Enter Network Quality of Service (QoS)
• QoS provides network guarantees on delay, loss, jitter, bandwidth …

Quality of Service
• Some say, QoS will be resolved through:
  – RSVP
  – Bandwidth increase
  – Consumers will want lower quality for low cost
• Need to know how QoS impacts the user to know what QoS to aim for!
  – Optimal conditions
  – Minimum QoS acceptable
    → Ex: one-way delay less than 250ms
    → Ex: need 3 frames per second
  – Maximum QoS beyond which does not make better
    → Ex: one-way delay less than 100ms
    → Ex: 30 frames/second is max

User-Centric Performance
• Network QoS gives you objective measures to shoot for
• But the end-user is the one who finally matters
• Need a subjective assessment of quality → Called Perceptual Quality (PQ)
• Then, can tie an objective measure to PQ
Measuring Perceived Quality

- Typically done by using standards
  - International Telecommunications Union (ITU)
- ITU for Traditional media
  - Speech quality (phone, etc)
  - Images (television, etc)
- ITU not suitable for computer based multimedia network communication
- Next up:
  - ITU recommended measures
  - Criticism

ITU on Measuring Speech Quality

<table>
<thead>
<tr>
<th>Quality of the speech/connection</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>5</td>
</tr>
<tr>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>Fair</td>
<td>3</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
</tr>
<tr>
<td>Bad</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effort required to understand the meaning of sentences</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete relaxation possible; no effort required</td>
<td>5</td>
</tr>
<tr>
<td>Attention necessary; no appreciable effort required</td>
<td>4</td>
</tr>
<tr>
<td>Moderate effort required</td>
<td>3</td>
</tr>
<tr>
<td>Considerable effort required</td>
<td>2</td>
</tr>
<tr>
<td>No meaning understood with any feasible effort</td>
<td>1</td>
</tr>
</tbody>
</table>

- Based on 10 second test
- Quality and Effort
- Listening

ITU on Measuring Speech Quality

Did you or your partner have any difficulty in talking or hearing over the connection?

- Yes 1
- No 0

(c) Conversation difficulty scale

- Conversation

Criticism of ITU Speech Measure

- Vocabulary-based poor
  - "Bad", "Poor" and "Fair" difficult to define
  - Clusters at the low end
- Time-period is too short
  - Network conditions often unpredictable
  - Loss rates may be transient
- Effort scale is too simplistic
  - Again, network conditions change
  - Some effort for some of the talk but not all

ITU on Measuring Image Quality

<table>
<thead>
<tr>
<th>Image quality</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>5</td>
</tr>
<tr>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>Fair</td>
<td>3</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
</tr>
<tr>
<td>Bad</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Image impairment</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperceptible</td>
<td>5</td>
</tr>
<tr>
<td>Perceptible, but not annoying</td>
<td>4</td>
</tr>
<tr>
<td>Slightly annoying</td>
<td>3</td>
</tr>
<tr>
<td>Annoying</td>
<td>2</td>
</tr>
<tr>
<td>Very annoying</td>
<td>1</td>
</tr>
</tbody>
</table>

- Stimulus or Impairment scales

Criticism on ITU for Images

- Vocabulary not suitable
  - Same problems for "fair", "poor" and "bad"
  - "Imperceptible" and "Perceptible" fine for television but not so good for lower-quality multimedia
- Time period too short
  - Same 10 second test not enough
- Artificiality of video test
  - Testing video without audio not good for multimedia
  - Unlikely would be watching video with no audio
International Interval Scale

- For an international measure, labels need to be translated equally
- To compare research across countries

Subjects given line:
- “Worst Imaginable” at the bottom
- “Best Possible” at the top

Place the 5 labels on this line:
- Do we get 5 equal intervals in all languages?

ITU Scale in Different Languages

- In English “Poor” and “Bad” seen as the same
  - Points spaced to a 4 point, 3-interval scale
  - Not 5 points, as indicated
  - Users avoid the end (1 and 5), so 2 points
- In Italian,
  - no mid-point
  - “Ok” is equivalent to “Good”
- In Swedish,
  - “Poor” and “Bad” the same
  - “Fair” above mid-point
- In Dutch, also not equal
- In Japanese, all intervals equal!

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What is Multimedia Quality?

- Not one-dimensional
  - 1995 telecom identified at least 4 dimensions that affect quality
- Speech quality depends upon
  - Intelligibility, loudness, naturalness, listening effort, pleasantness of tone...
- Video quality depends upon
  - Color, brightness, background stability, speed in image reassembling...

What is Multimedia Quality?

- A one-dimensional quality view
  - does not let us figure out where bottleneck is
  - leads to one-dimensional approach to fixing
- “Add more bandwidth to increase quality”
  - Probably many other ways to increase quality without increasing bandwidth

UCL Approach to Measuring Quality

- Identify suitable vocabulary to describe quality
- Identify key quality dimensions
- Employ knowledge in developing measure
Build Suitable Quality Vocabulary

• Don’t supply words
  – Often too technical, may be lacking
  – Ex: “Does the picture have jitter?”
• Let users describe media in own terms
  – Ex: “choppy” or “buzzy” or “static”
• Build database of terms

Identify Dimensions

• Based on frequency of words associated with media quality
• For example, “choppiness” associated with:
  – Cut up
  – Irregular
  – Broken

Investigating New Scales

• Unlabeled scale
  – Subjects did not avoid endpoints
  – Consistent ratings across users
• Longer testing periods
  – But comparison across tests difficult
  – Cumulative affect on quality difficult
    – Instead, get last impression
  – Users get bored, so tests less effective
• Combination of quality
  – Users will “forgive” bad video if followed by good
  – Good followed by bad is often bad
    – Recency effect

Quality Assessment Sliders (QUASS)

• Unlabeled slider
• Records quality taken every second
  – Captures ‘instantaneous’ effects
• (Picture here?)

Summary

• We don’t yet know how to measure MM quality
• Unlabeled scales look promising
• Worry about length of tested sample
  – Not too short, not too long
• Worry about order of samples
  – Avoid recency effect