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CHALLENGES IN VIDEO QUALITY ASSESSMENT FOR UNDERWATER WIRELESS SENSOR NETWORKS

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Motivations

- **Ocean scientists** often need not only sensor measures (temperature, salinity…) but also they **need to watch** underwater environments.

- **Images** from oceanic resources are currently **difficult** and **expensive** to obtain.
  - Exploration expeditions with divers or robots submerging with cameras are needed.

- **Video** services **in USNs** would allow to **reduce** these **costs**.

Subjective Video Quality Assessment (VQA)

- Subjective tests are considered the most **reliable** approach to quality.
  - The opinion is gathered **directly** from users.
  - It is a **well known** procedure (ITU BT.500 and P.910).

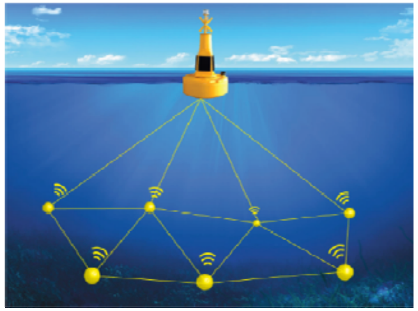
- They also bring important drawbacks.
  - It is a **time-consuming** method.
    - A session for a single user is at least 20 minutes.
  - It requires a fair amount of **human resources**.
    - Viewers should not be experienced in quality assessment.
    - If the same people take part in different experiments, a wide enough time lapse must be used.

Challenges in subjective VQA – Underwater

- Underwater video is currently used for **specific applications**.
  - Ocean scientists, companies managing underwater resources, safety and security specialists…
- It is more difficult to find an **appropriate group** of evaluators.
- In this kind of application, quality is usually related to the tasks the video is used for.
  - Different professionals perform different tasks. The quality can be perceived in a different way.

Challenges in objective VQA – Underwater

- Nodes are virtually **unreachable** once deployed.
  - The original unimpaired video cannot be recovered.



- Nodes must operate as long as possible. **Energy saving** is a priority.
  - Intensive processing tasks that would reduce battery life should be avoided.
- The low bitrate heavily **constrains** the amount of information that can be sent for quality measuring purposes.

Objective Video Quality Assessment

- The quality is estimated with a **mathematical model**.
  - Once the model is built and tested, quality can be assessed without the disadvantages of subjective VQA.
  - Most models compute an approximation to the MOS.

$$MOS = 1 + I_{Ofr} \exp\left(\frac{\left[\ln(Fr) - \ln(Ofr)\right]^2}{2D_{Fr}^2}\right)$$

$$Ofr = v_1 + v_2 Br$$

$$I_{Ofr} = v_3 - \frac{v_3}{1 + \left(\frac{Br}{v_4}\right)^{v_5}}$$

- Models can be classified according to their inputs:
  - *Full Reference*
  - *Reduced Reference*. The **received** signal and some **features from the original** signal are used to compute the quality estimation.
  - *No Reference*. **Only the received** signal required for the quality estimation.

Applicability of VQA methods – Full Reference

- The **received** and the **original** signal are analyzed and compared to compute the quality estimation.
- Extensively used
- Standard Algorithms
  - PEVQ algorithm models human visual system (ITU J.247)
  - SSIM performs better than PEVQ (more recent)
- Drawbacks
  - Original signal is required (UWSNs bitrates are too low)
  - Involve heavy image processing, expensive energy use for underwater nodes

➔ Usefulness only in laboratory tests

Applicability of VQA methods – Reduced Reference

- The **received** signal and some **features from the original** signal are used to compute the quality estimation.
- RR methods in J.249 use 15-256 kbps
  - Data for features should only need a fraction of video bitrate
- Still too large bitrate
- Feature extraction still requires intensive image processing
  - Energy concerns
- New method uses 0.875 kbps (~6% of 15 kbps video flow)

➔ Applicable but requires novel algorithms

Applicability of VQA methods – No Reference

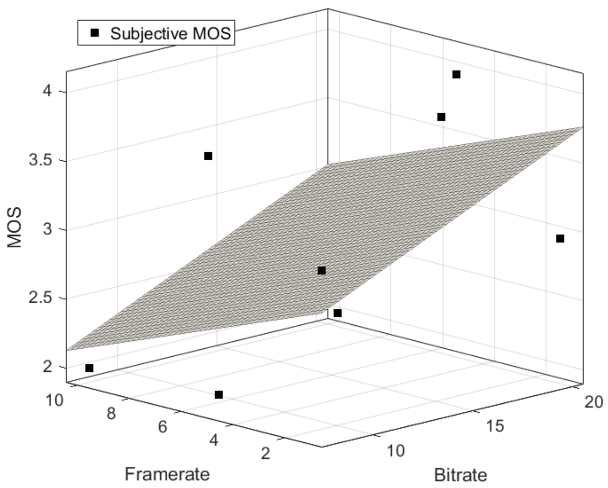
- Advantages:
  - Only needs received signal
    - Pixel-based, bit-stream or network parameter analysis
  - No extra processing in intermediate nodes
- Disadvantage: Good performing methods, but none tested in underwater channels
- Standard parametric method G.1070 was intended for videoconferences
  - Cannot be extended to underwater (previous published study) due to mismatch in quality scores [10]

➔ Proposal: New parametric model for underwater

New parametric model

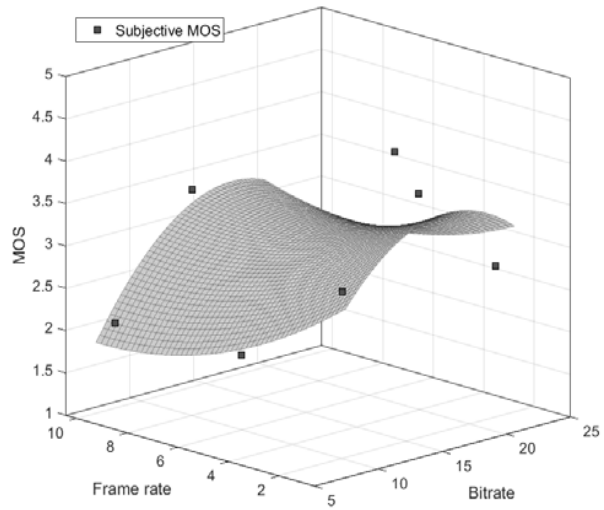
Plane

$$MOS = a_0 + a_1 B_r + a_2 F_r$$



2nd Degree Polynomial

$$MOS = a_0 + a_1 B_r + a_2 F_r + a_3 B_r^2 + a_4 F_r^2 + a_5 B_r F_r$$



Model	GOF Statistics		
	R^2	SSE	RMSE
Plane	0.3781	2.76	0.6789
2nd degree polynomial	0.5419	2.033	0.8232

Conclusion

- Quality assessment is required for development of successful video services (challenges)

- Standard methods:
  - Full, Reduced and No Reference

- For underwater, only RR and NR methods could be suitable but should take into account
  - Processing requirements
  - Bandwidth constraints
  - Application intended

Thanks for your attention

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