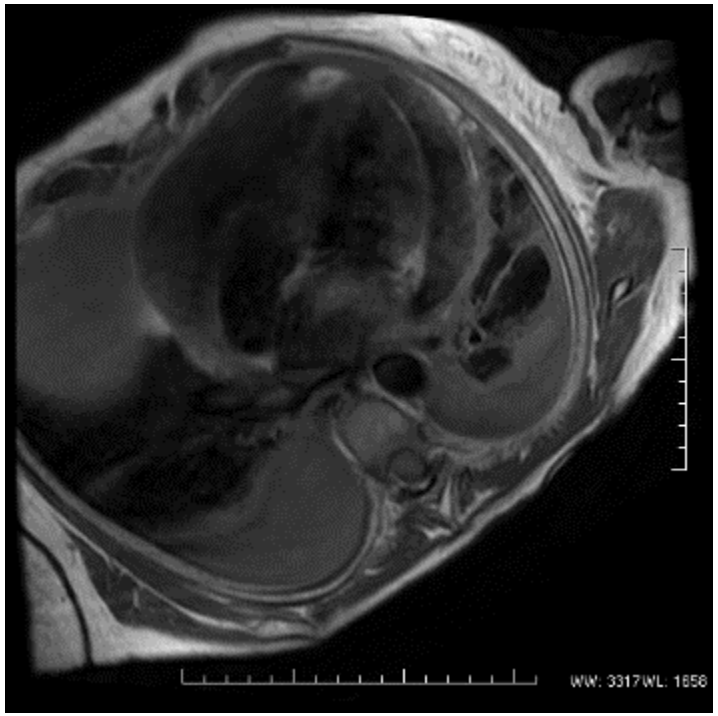
On the suitability of VMAF for quality assessment of medical videos: Medical ultrasound & wireless capsule endoscopy

Arslan Usman and Maria Martini

Presenter:
Prof Maria Martini
Wireless Multimedia and Networking Research Group
Kingston University, London, UK

Medical Image/Video Quality Evaluation

What makes it more challenging?

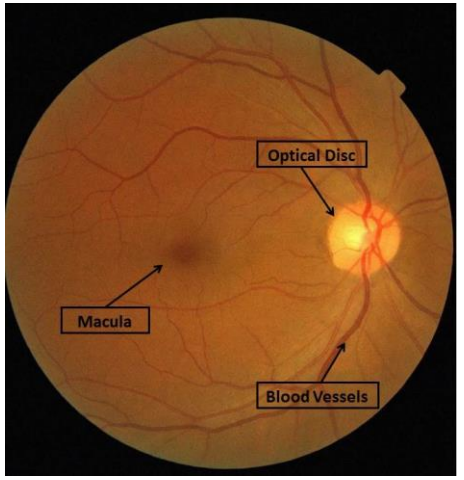


- In medical images **the diagnostic quality** of the image is more important than the perceptual quality
- However, typical objective image quality metrics do not measure the diagnostic quality

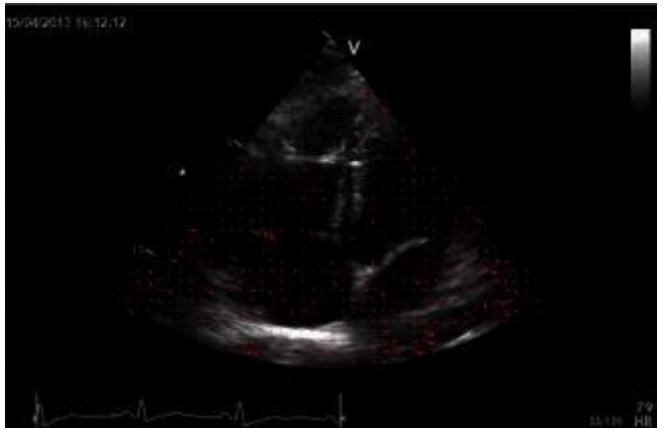
Option 1: develop tailored metrics

Examples:

- A Raj, NA Shah, AK Tiwari, MG Martini, Multivariate Regression-Based Convolutional Neural Network Model for Fundus Image Quality Assessment, *IEEE Access* 8, 2020, 57810-57



- M Razaak and MG Martini, "CUQI: Cardiac Ultrasound Quality Index," *SPIE Journal of Medical Imaging*, 2016.



Option 2: study which of the existing metrics performs best

PSNR, SSIM, UQI, VQM, NQM, VIF, NIQE, BRISQUE were tested earlier for Ultrasound video, Wireless Capsule Endoscopy, ENT Endoscopic Video, Radiological images

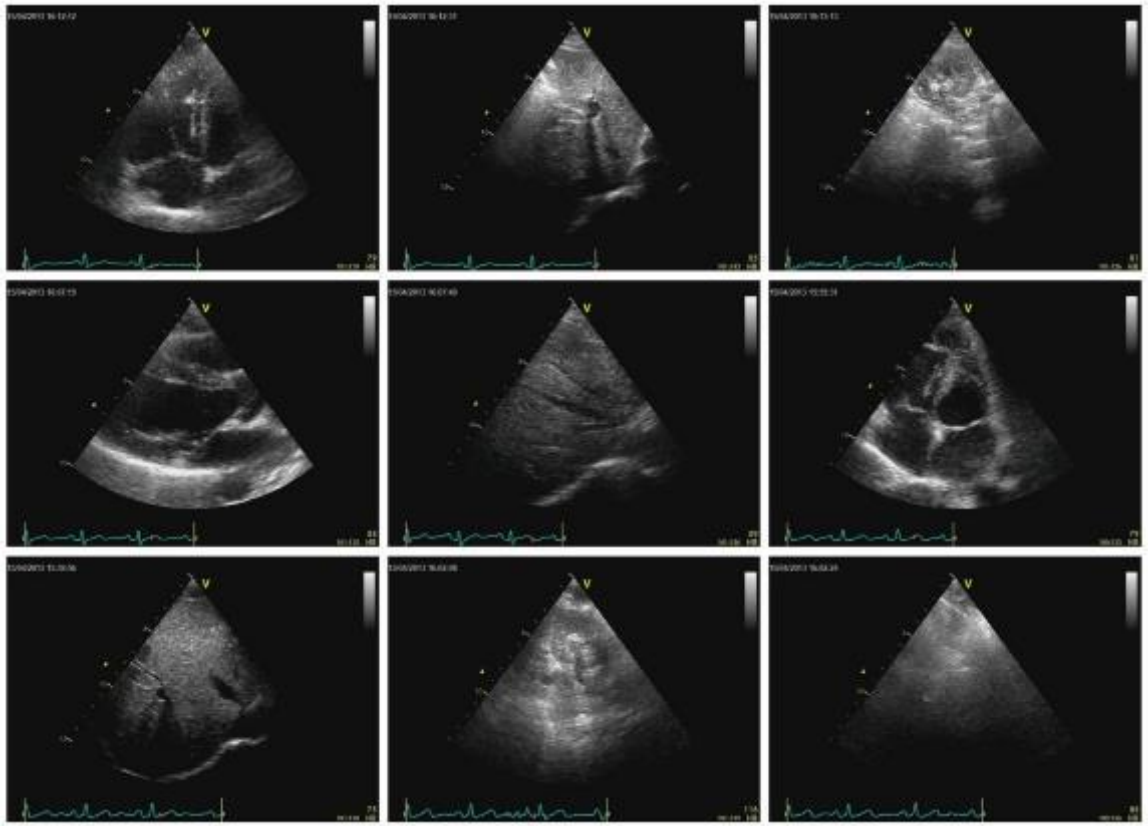
- M. Razaak, M.G. Martini and K. Savino, "A Study on Quality Assessment for Medical Ultrasound Video Compressed via HEVC,"*IEEE Journal of Biomedical and Health Informatics (J-BHI)*, vol. 18, no. 5, pp. 1552-1559, Sep 2014.
- Usman, M. A., Usman, M. R., & Shin, S. Y. (2017). Quality assessment for wireless capsule endoscopy videos compressed via HEVC: From diagnostic quality to visual perception. *Computers in biology and medicine*, *91*, 112-134.
- Chaabouni, A., Gaudeau, Y., Lambert, J., Moureaux, J.M. and Gallet, P., 2014, October. Subjective and objective quality assessment for H264 compressed medical video sequences. In *2014 4th International Conference on Image Processing Theory, Tools and Applications (IPTA)* (pp. 1-5). IEEE.
- Kowalik-Urbaniak, Ilona, Dominique Brunet, Jiheng Wang, David Koff, Nadine Smolarski-Koff, Edward R. Vrscay, Bill Wallace, and Zhou Wang. "The quest for'diagnostically lossless' medical image compression: a comparative study of objective quality metrics for compressed medical images." In *Medical Imaging 2014: Image Perception, Observer Performance, and Technology Assessment*, vol. 9037, p. 903717. International Society for Optics and Photonics, 2014.

Option 2: study which of the existing metrics performs best, ctd.

VMAF was developed for and trained on non-medical video, but has shown excellent performance for different types of video (e.g. gaming)

Challenge: what if we apply it to medical video?

Ultrasound video dataset



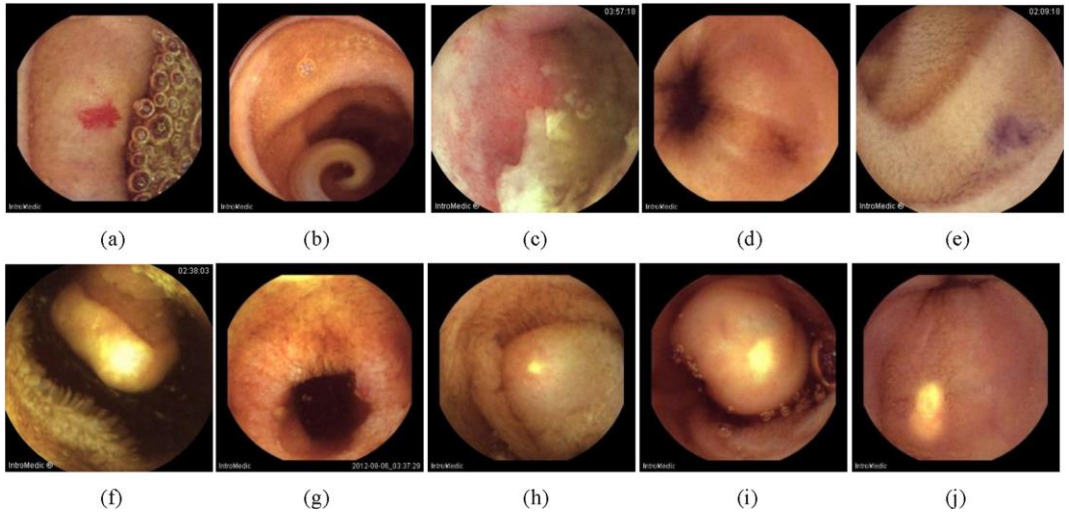
- Nine ultrasound video sequences provided by cardiologist in Perugia Hospital (Heart, Liver, Kidney, Lung), 640 x 416, 100 frames, 25fps
- Compressed with HEVC at eight different compression ratios

9 x 8 = 72 video sequences being evaluated with DSCQS
(144 sequences evaluated by each specialist not including intra-subject controls)

[Razaak, Martini, Savino, IEEE JBHI 2014)]

Extensive subjective tests run with medical doctors in Hospital of Perugia

Wireless Capsule Endoscopy video dataset



Ten source video sequences provided by Intromedic Co. Ltd.,
South Korea, for research purposes.

3 fps (Native)
320 x 320 (Native)
10 s

HEVC compression with QP 27, 29, 31, 33, 35, 37, 39 & 41

Usman, M. A., Usman, M. R., & Shin, S. Y. (2017). Quality assessment for wireless capsule endoscopy videos compressed via HEVC: From diagnostic quality to visual perception. *Computers in biology and medicine*

Medical Image quality evaluation
Other Objective Quality Metrics considered

Existing FR-VQMs considered as benchmark.

Quality metric	Abbreviation
Peak Signal to Noise Ratio	PSNR
Structural Similarity Index Metric [13]	SSIM
Multi Scale SSIM [14]	MS-SSIM
Visual Signal to Noise Ratio [15]	VSNR
Information Fidelity Criterion [16]	IFC
Visual Information Fidelity [17]	VIF
Pixel-based VIF [17]	VIFP
Universal Quality Index [18]	UQI
Noise Quality Measure [19]	NQM
Weighted Signal to Noise Ratio [19]	WSNR
Video Quality Metric [20]	VQM^{NTIA}
Video Multimethod Assessment Fusion [10]	VMAF

Results - 1

Accuracy comparison

Results for fitting the VMAF measurements to the subjective DMOS.

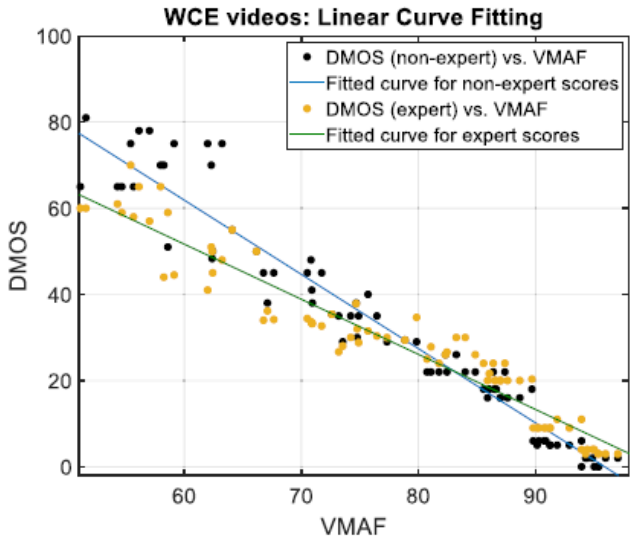
Dataset	Category	Exponential			Linear			Logistic		
		R^2	Adj. R^2	RMSE	R^2	Adj. R^2	RMSE	R^2	Adj. R^2	RMSE
Ultrasound Videos	Expert	0.8032	0.8004	11.1736	0.8620	**0.8601**	**9.3557**	0.8544	0.8502	9.680
	Non-Expert	0.8334	0.8310	8.7630	0.8862	**0.8846**	**7.242**	0.8791	0.8756	7.5199
WCE Videos	Expert	0.9214	0.9204	3.8859	0.9267	**0.9258**	4.9820	0.9268	0.9239	**3.7994**
	Non-Expert	0.9501	**0.9494**	**3.0967**	0.9433	0.9426	5.8556	0.9501	0.9481	3.1370

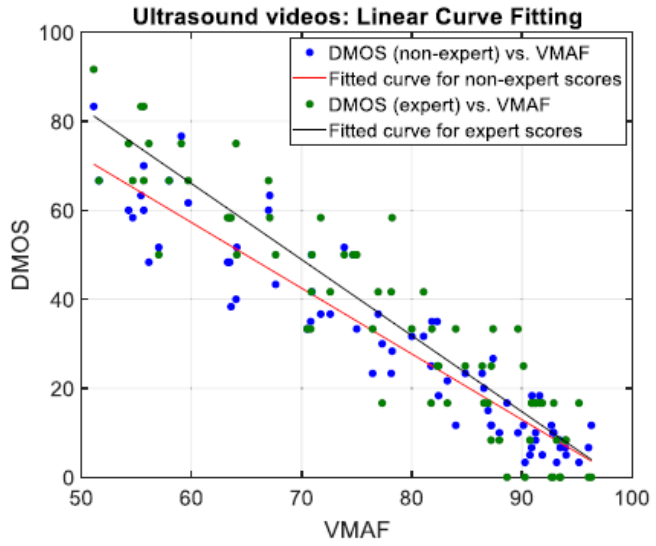
Comparison of VMAF with other FR-VQMs.

Dataset	Scores	CC	PSNR	SSIM	MS-SSIM	VSNR	WSNR	NQM	UQI	VIF	VIFP	IFC	VQM ^{NTIA}	VMAF
Ultra-sound	Experts	PLCC	0.9109	0.9264	0.8570	0.8925	0.9123	0.8961	**0.9292**	0.9258	0.8887	0.8644	0.8080	0.9056
		SROCC	0.9331	0.9375	0.8907	0.9139	0.9251	0.9090	0.9251	**0.9382**	0.8997	0.8926	0.8368	0.8941
	Non-experts	PLCC	0.8896	0.9208	0.8668	0.8888	0.9173	0.9233	**0.9520**	0.9431	0.8796	0.8446	0.8146	0.9220
		SROCC	0.9280	0.9383	0.8899	0.9277	0.9354	0.9464	0.9495	**0.9663**	0.9047	0.8906	0.8606	0.9186
WCE	Experts	PLCC	0.8039	0.6840	0.8366	0.6055	0.8010	0.7158	0.8701	0.9016	0.8955	0.8844	0.7764	**0.9627**
		SROCC	0.8611	0.8063	0.9127	0.6571	0.8709	0.8257	0.8930	0.9424	0.9263	0.9482	0.8426	**0.9763**
	Non-experts	PLCC	0.8257	0.7232	0.8696	0.6204	0.7963	0.7371	0.8909	0.9238	0.9227	0.9020	0.7578	**0.9712**
		SROCC	0.8642	0.8129	0.9247	0.6474	0.8774	0.8311	0.9061	0.9533	0.9408	0.9525	0.8402	**0.9796**

Results - 2

Scatter plots





Observations and proposed future steps

- Limited number of scores from experts in available datasets
- The level of expertise of the “experts” influences the quality scores (not all expert subjects are equal!)
- More datasets with videos assessed by a wide range of experts are required

References

A Raj, NA Shah, AK Tiwari, MG Martini, Multivariate Regression-Based Convolutional Neural Network Model for Fundus Image Quality Assessment, *IEEE Access* 8, 2020, 57810-57

Raj, A K Tiwari, MG Martini, Fundus image quality assessment: survey, challenges, and future scope, *IET Image Processing* 13 (8), 2019. 1211-1224

Usman, M. A., & Martini, M. G. (2019). On the suitability of VMAF for quality assessment of medical videos: Medical ultrasound & wireless capsule endoscopy. *Computers in biology and medicine*, *113*, 103383.

Lévêque, L., Liu, H., Baraković, S., Husić, J. B., Martini, M., Outtas, M., ... & Pinheiro, A. (2018, May). On the subjective assessment of the perceived quality of medical images and videos. In *2018 Tenth International Conference on Quality of Multimedia Experience (QoMEX)* (pp. 1-6). IEEE.

Kara, P. A., Kovacs, P. T., Vagharshakyan, S., Martini, M. G., Imre, S., Barsi, A., ... & Balogh, T. (2017). Perceptual quality of reconstructed medical images on projection-based light field displays. In *eHealth 360°* (pp. 476-483). Springer, Cham.

Usman, M. A., Usman, M. R., & Shin, S. Y. (2017). Quality assessment for wireless capsule endoscopy videos compressed via HEVC: From diagnostic quality to visual perception. *Computers in biology and medicine*, *91*, 112-134.

Nasr, K.M. and Martini, M.G., 2017. A visual quality evaluation method for telemedicine applications. *Signal Processing: Image Communication*, *57*, pp.211-218.

M. Razaak and M.G. Martini, "CUQI: Cardiac Ultrasound Quality Index," *SPIE Journal of Medical Imaging*, 2016.

M. Razaak, M.G. Martini and K. Savino, "A Study on Quality Assessment for Medical Ultrasound Video Compressed via HEVC,"*IEEE Journal of Biomedical and Health Informatics (J-BHI)*, vol. 18, no. 5, pp. 1552-1559, Sep 2014.

Kingston University London

Thank you!

On the suitability of VMAF for quality assessment of medical videos: Medical ultrasound & wireless capsule endoscopy

Arslan Usman and Maria Martini

Presenter:
Prof Maria Martini
Wireless Multimedia and Networking Research Group
Kingston University, London, UK