

Video quality assessment of HDR content (and beyond)



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Quality of Experience vs Video Quality?

Definition of Quality of Experience

Qualinet White Paper on Definitions of Quality of Experience (2012)

Available at <http://www.qualinet.eu>

⇒ A collective effort of more than 40 authors/contributors (COST Action IC 1003)
European Network on Quality of Experience in Multimedia Systems and Services



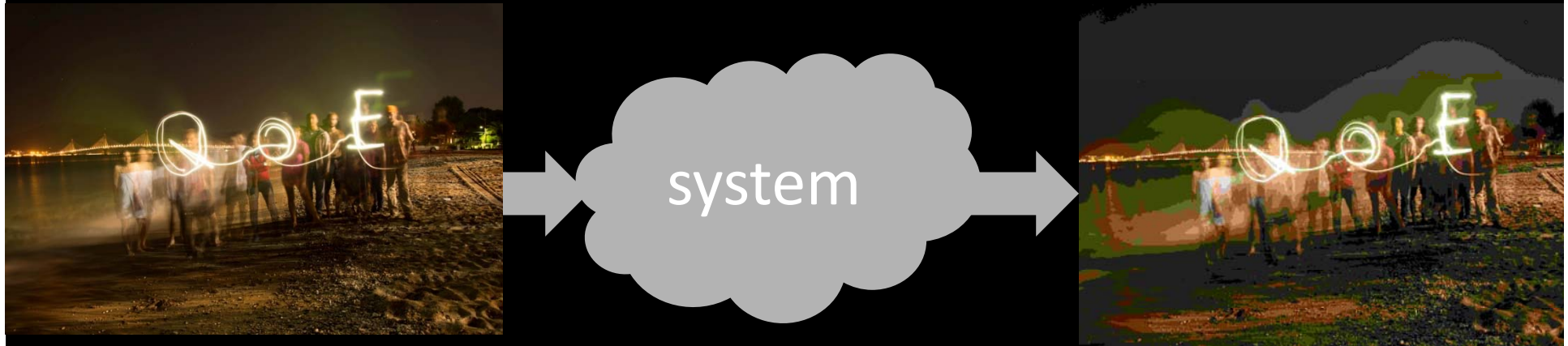
Quality of Experience (QoE) is the degree of **delight or annoyance of the user of an application or service.**

It results from the **fulfillment of his or her expectations** with respect to the utility and / or enjoyment of the application or service in the light of the user's personality and current state.

QoE or not QoE?

common over restriction

Image/Video quality assessment

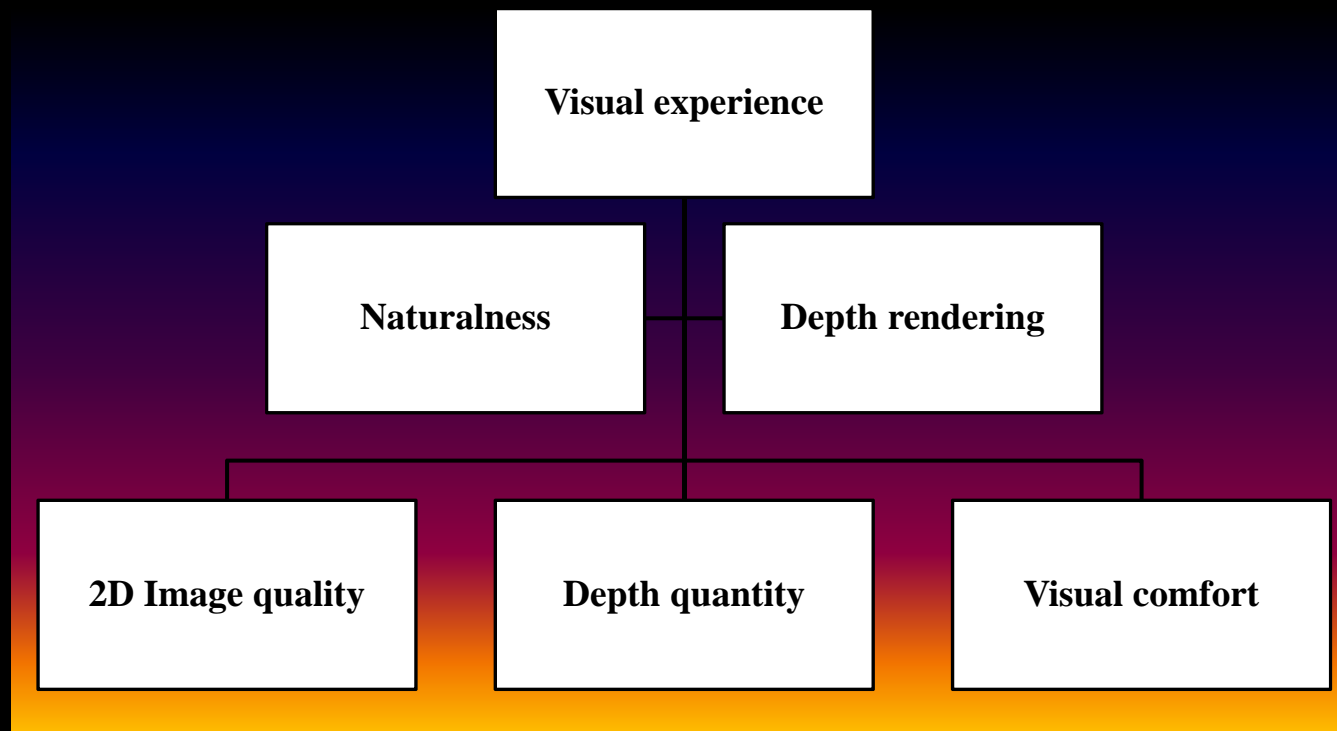


Perceived (or perceptual) image quality

QoE or not QoE?

a model of 3D QoE

3D visual experience: Multiple perceptual dimensions

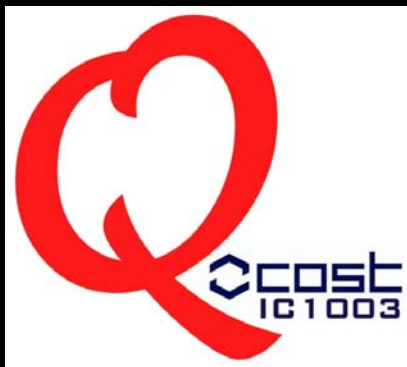


[Chen, W., Fournier, J., Barkowsky, M., & Le Callet, P. (2012). *Exploration of Quality of Experience of Stereoscopic Images: Binocular Depth. VPQM*]

... QoE should also include:
Cost, Expectations, Context...

Video Quality Assessment: a constant quest

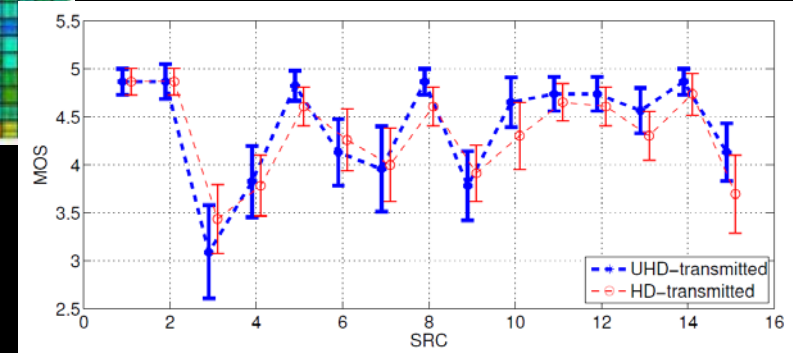
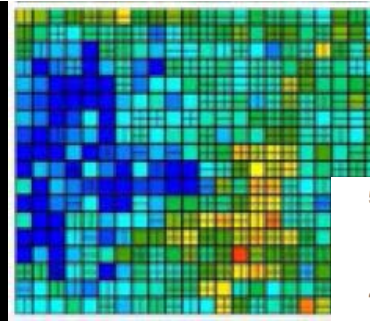
...why do we need to revisit?



VQEG

Optimize
a system

Local
Vs
Global



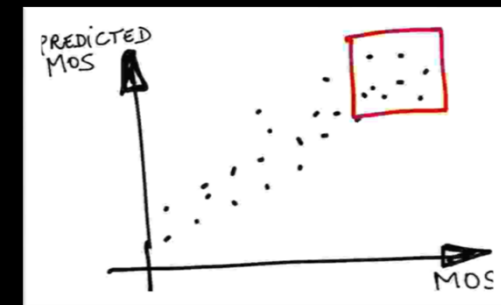
Video Quality Assessment?
...a matter of use case

Quality Range

Benchmark
Systems

« codec A vs codec B »

Use case: how the
the media is
exploited



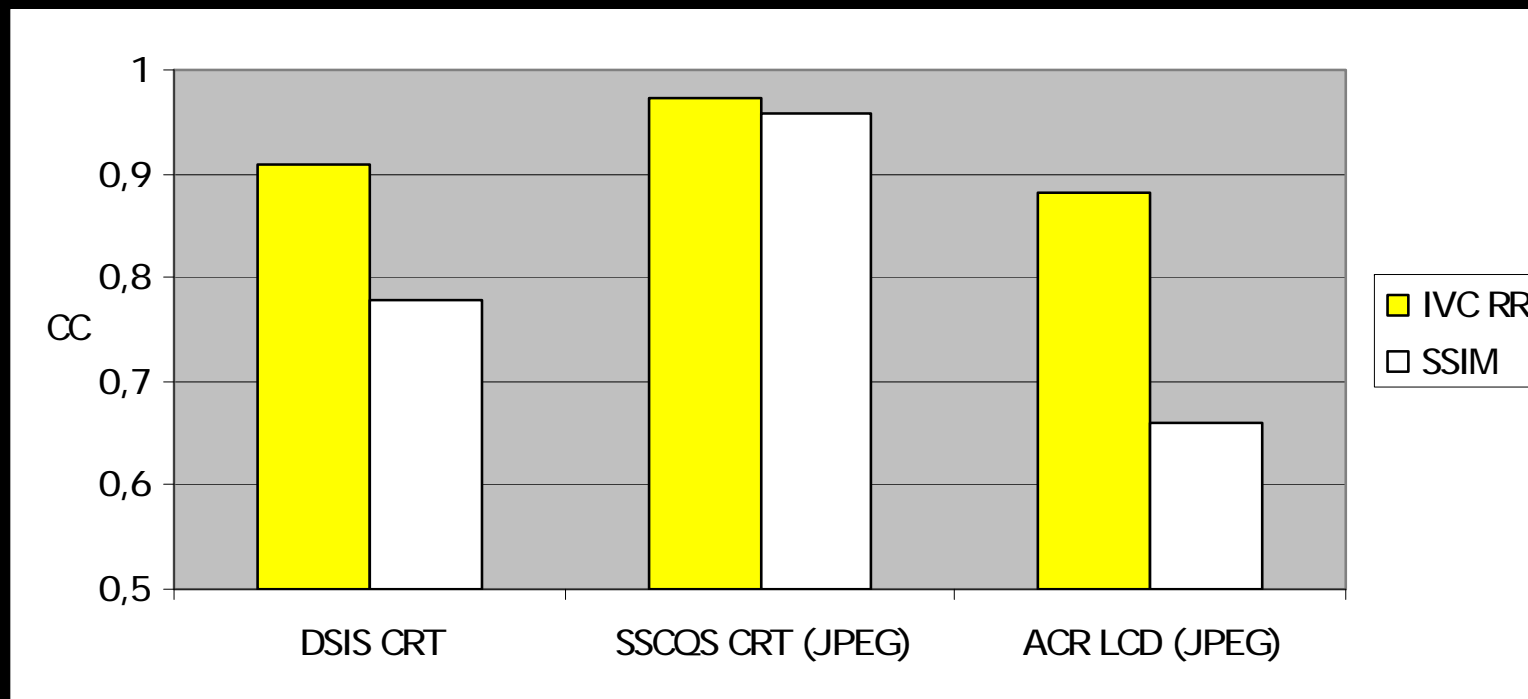
Display
proc. 1

Display
proc. 2

The importance of viewing conditions

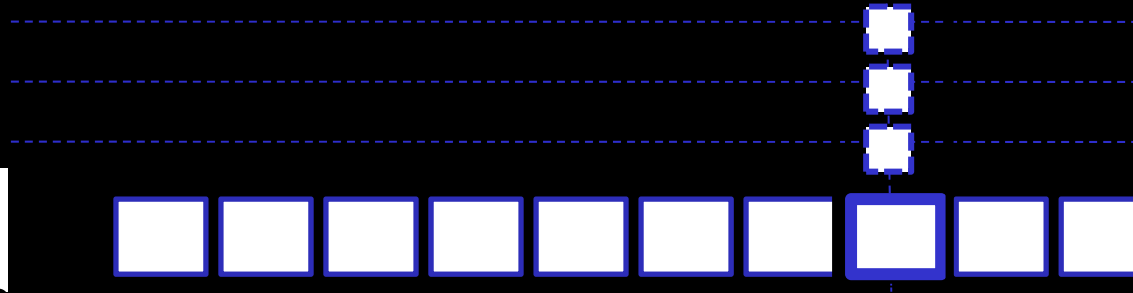
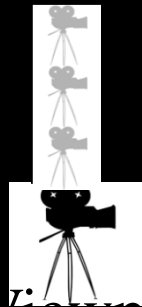
B. Watson: “Viewing distance should be an input parameter of the metric”

& importance of display (before HDR!)



Objective quality assessment of color images based on a generic perceptual reduced reference, M Carnec, P Le Callet and D Barba, Signal Processing: Image Communication, 2006

Define proper use case for testing: FTV (free View Point TV) example



"Crumbling"
artifact



Shifting
artifact

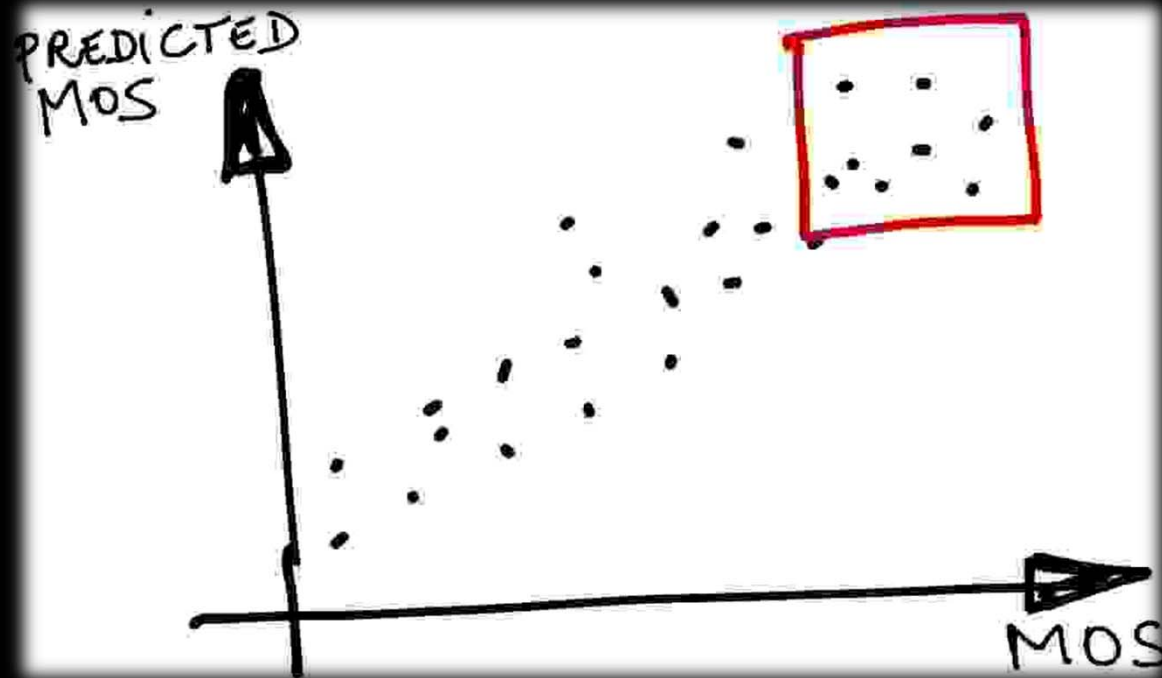
PSNR, SSIM ...**are correlated** with
MOS **ONLY** when looking at the
coded-decoded view !

Metric	All conten PCC
PSNR	0.2671
SSIM	0.0000*
MS-SSIM	0.0105
VIF	0.0584
VIFP	0.0798
UQI	0.0000*
IFC	0.1289

P. Hanhart, E. Bosc, P. Le Callet, et T. Ebrahimi, « Free-viewpoint video sequences: A new challenge for objective quality metrics », in 2014 IEEE 16th International Workshop on Multimedia Signal Processing (MMSP), 2014

Quality Range: beyond correlation

ACR vs Pair Comparison



Range Effect

Michel Saad, Patrick Le Callet and Phil Corriveau «Blind Image Quality Assessment: Unanswered Questions and Future Directions in the light of consumers needs », 2nd VQEG eLetter, 2015

A HyperSpace of possibilities

Content type

SI

TI

DI

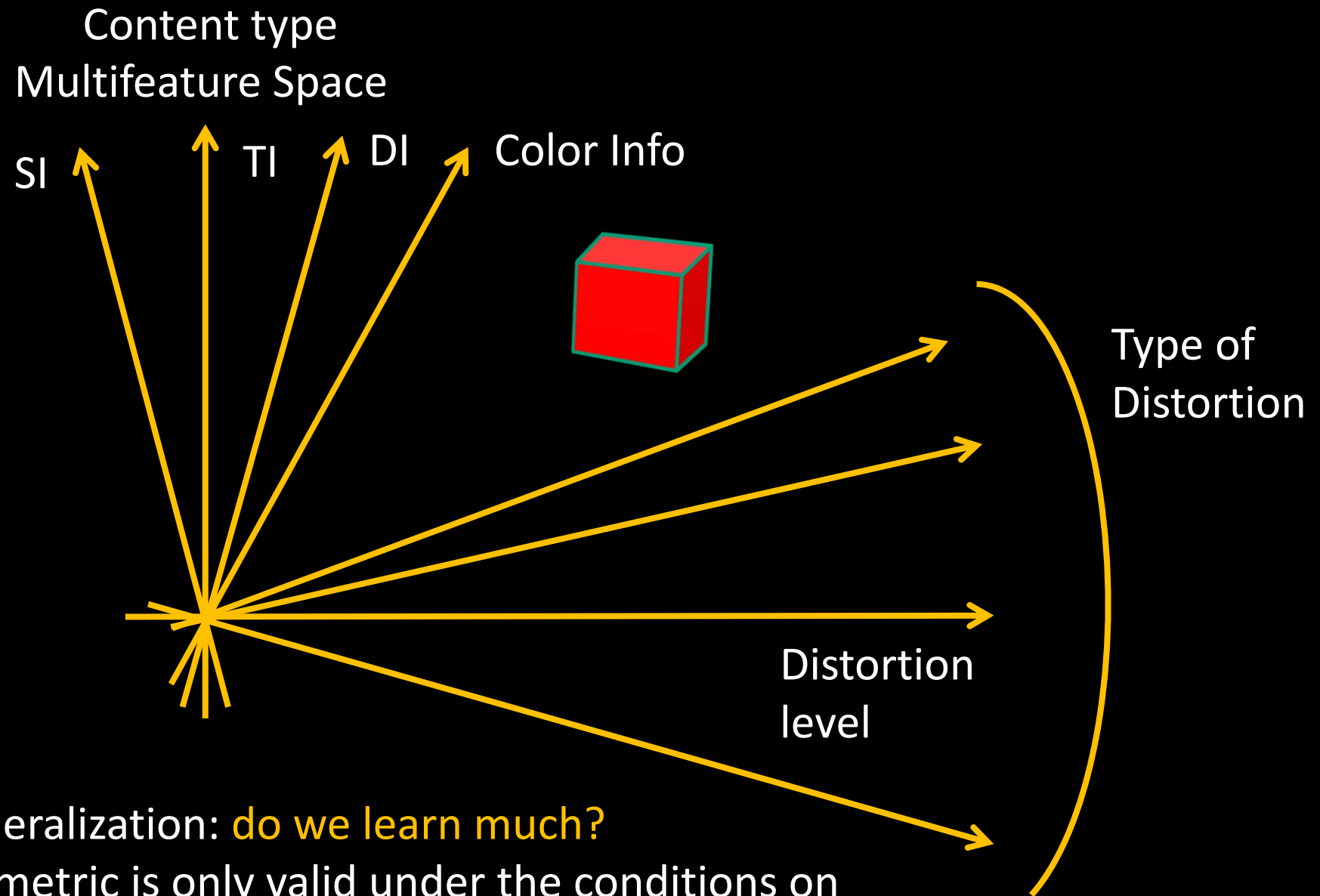
Color Info

Type of
Distortion

Distortion
level

« Selecting scenes for 2D and 3D subjective video quality tests », M. H. Pinson, M. Barkowsky, et P. Le Callet, J Image Video Proc., vol. 2013, no 1, p. 1-12, Dec. 2013.

A HyperSpace of possibilities ...and generalization?

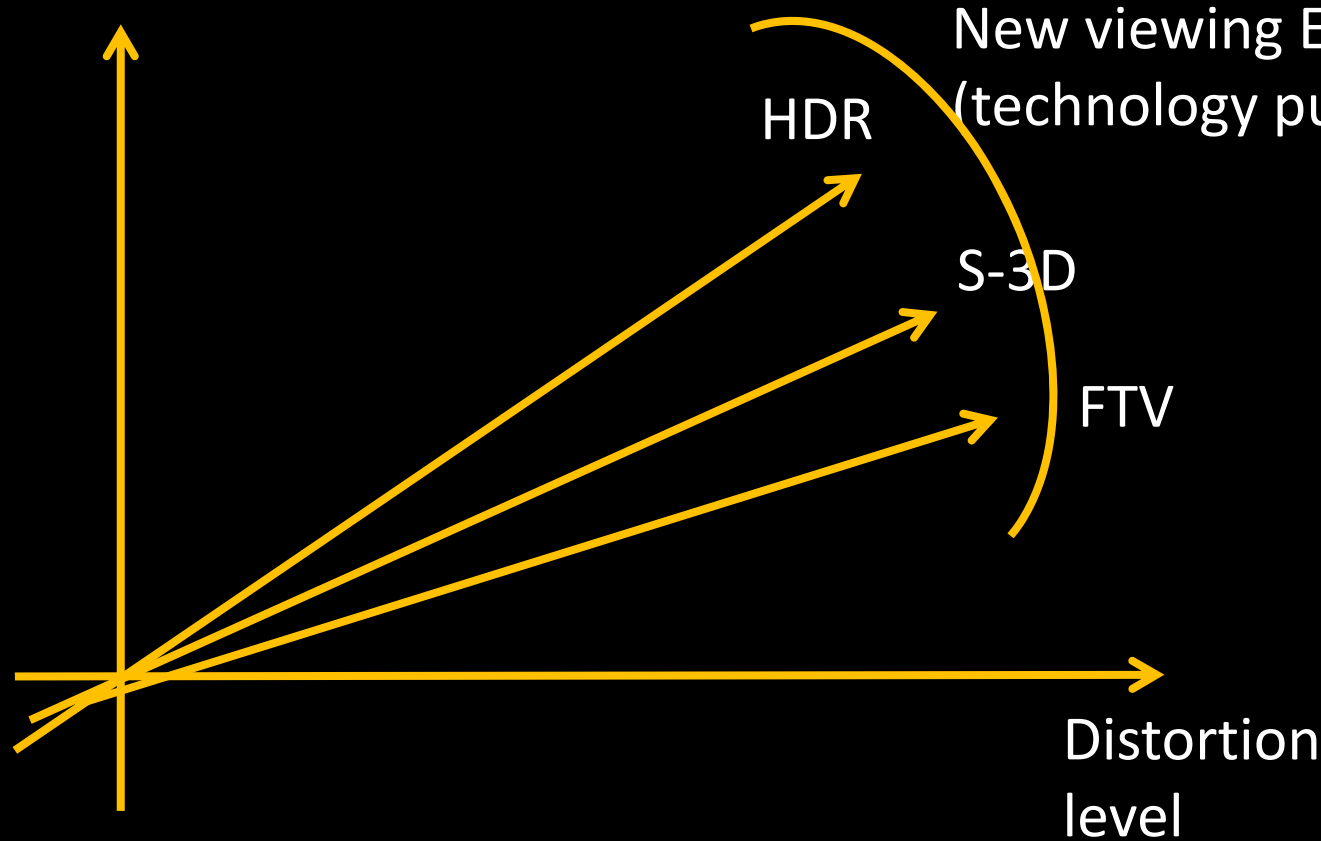


Generalization: **do we learn much?**

« a metric is only valid under the conditions on which it has been tested » Phil Corriveau

A HyperSpace of possibilities: extension of the hyperspace a third meta dimension

Content type



why do we need to revisit?

The example of HDR video quality assessment

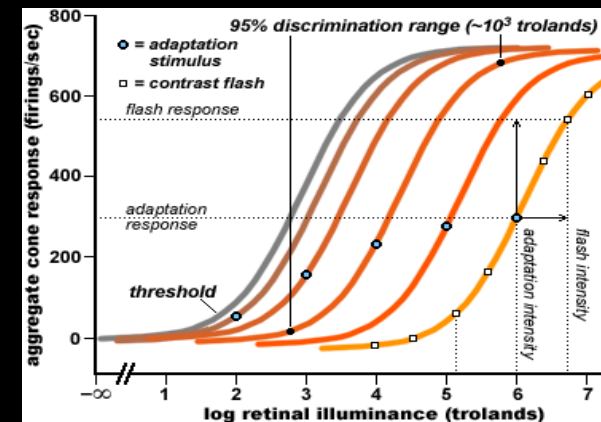
HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions



Adaptation
luminance



BT500-xx suitable for LDR displays
=> 15% of peak brightness

Peak Luminance	Env. Luminance
100 nits	15 nits
500 nits	75 nits
4000 nits	600 nits

HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions



Env. Luminance **too high**: loss of HDR effect

Env. Luminance **too low**: risk of flashing effect and trigger visual annoyance

Content dependent => dynamic range of the content

=> Needs for trade off

BT500-xx suitable for LDR displays
=> 15% of peak brightness

Peak Luminance	Env. Luminance
100 nits	15 nits
500 nits	75 nits
4000 nits	600 nits

HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions
- HDR display

there is **no transparent** HDR display

Needs for clear understanding of the display processing



dual modulation algorithm

temporal coherency preservation

HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions
- HDR display

there is « no true HDR » display => always a TMO in the viewing loop

Understand how it affects the quality
...and the QoE

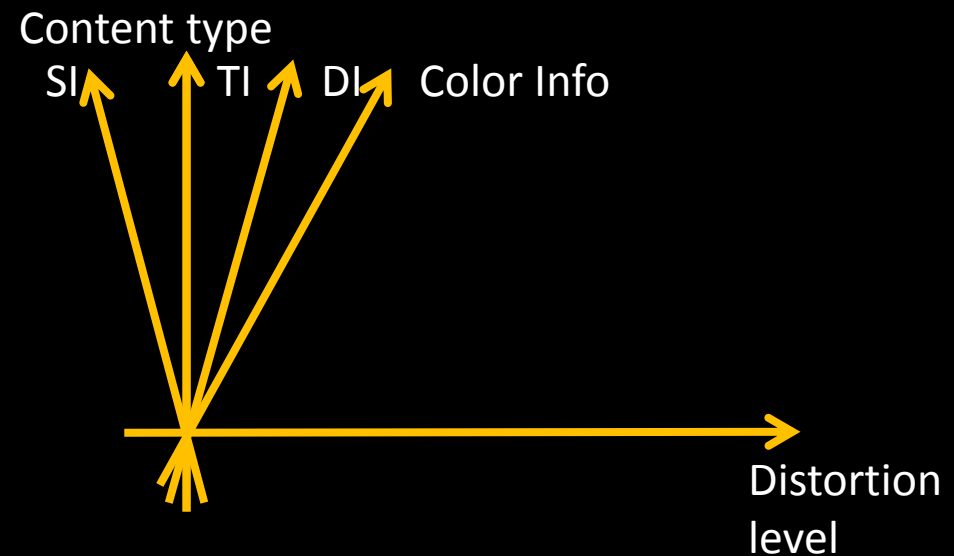


42 TMOs on the grill ...

HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions
- HDR display
- Content Selection



M. Narwaria, C. Mantel, M. Perreira Da Silva, P. Le Callet, and S. Forchhammer, "An objective method for high dynamic range source content selection," in Sixth International Workshop on Quality of Multimedia Experience (QoMEX), pp. 13-18, Sept 2014.

HDR and subjective quality assessment ?

To be revisited:

- Viewing conditions
- HDR display
- Content Selection
- Methodology and use cases

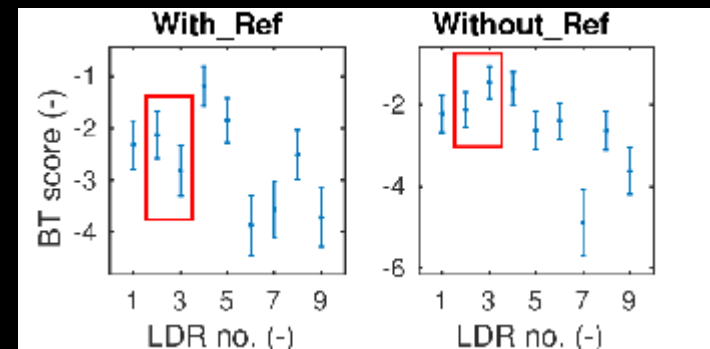
M. Narwaria, C. Mantel, M. Perreira Da Silva, P. Le Callet, and S. Forchhammer, "An objective method for high dynamic range source content selection," in Sixth International Workshop on Quality of Multimedia Experience (QoMEX), pp. 13-18, Sept 2014.

Methodology cares



LDR HDR LDR

↓ ↓ ↓



L. Krasula, M. Narwaria, K Fliegel and P. Le Callet, "Influence of HDR Reference on Observers Preference in Tone Mapped Images Evaluation," in Seventh International Workshop on Quality of Multimedia Experience (QoMEX), May 2015.

HDR and subjective quality assessment ?

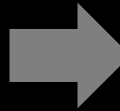
To be revisited:

- Viewing conditions
- HDR display
- Content Selection
- Methodology and use cases
- New QoE Model?

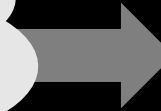
M. Narwaria, C. Mantel, M. Perreira Da Silva, P. Le Callet, and S. Forchhammer, "An objective method for high dynamic range source content selection," in Sixth International Workshop on Quality of Multimedia Experience (QoMEX), pp. 13-18, Sept 2014.

QoE: an artistic intention?

Artist/
Content
Creator



**Transparent
delivery chain?**



Spectator

An emotion
to be triggered

An emotion to be conveyed



QoE &
Artistic intention

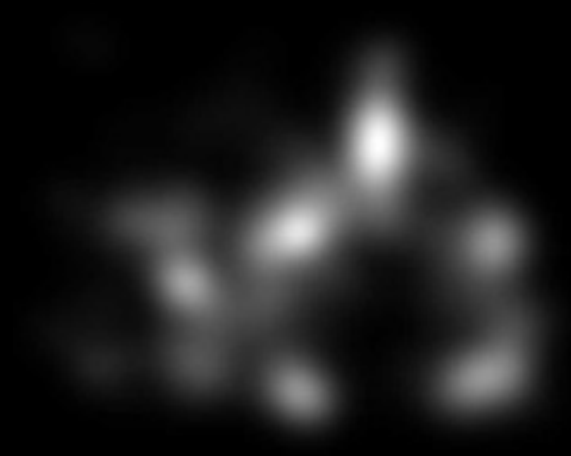
Non transparent
technology

Visual contents can be seen in various conditions



...that can even **change the original artistic intention**
(emotions, image reading ...)

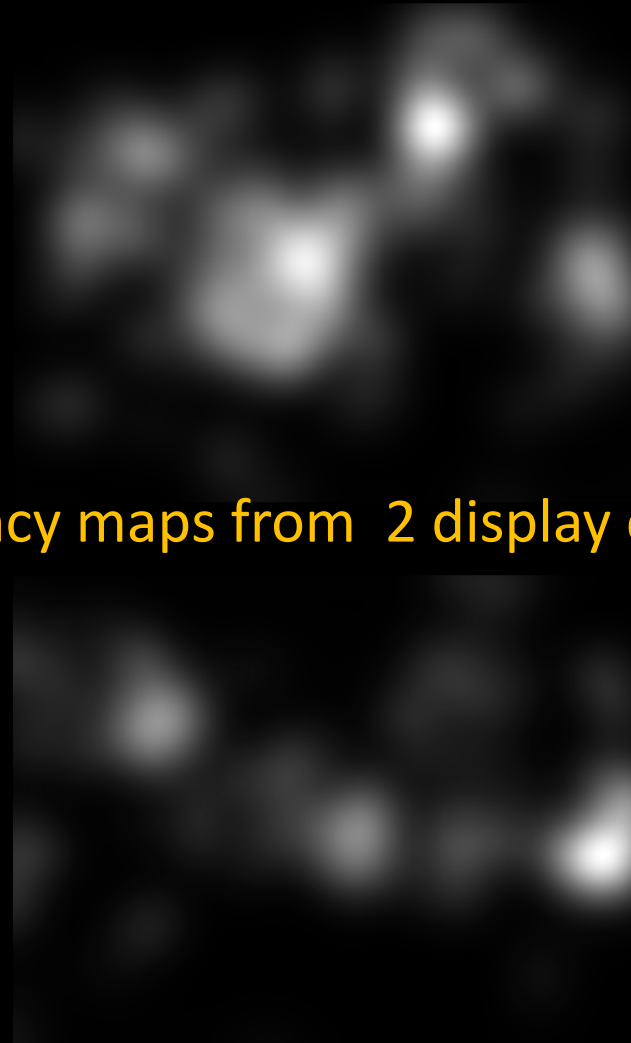
Effects on Visual Attention deployment



Effects of TMO on Visual Attention deployment

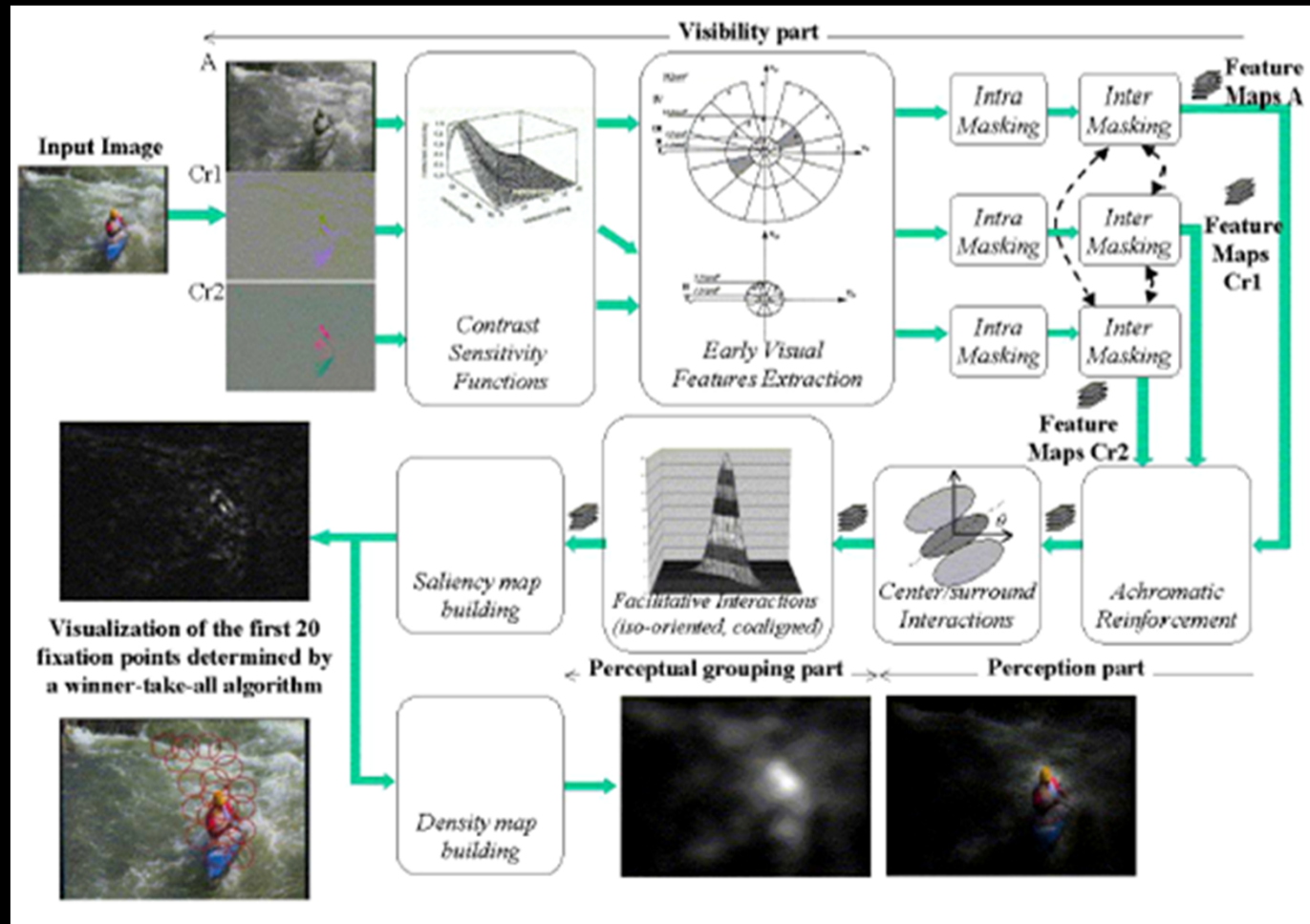


Saliency maps from 2 display conditions



M. Narwaria, M. Silva, P. Callet and R. Pepion “Tone mapping Based High Dynamic Range Compression: Does it Affect Visual Experience?”, Signal Processing: Image Communication (Special Issue on Recent Advances in High Dynamic Range Video Research), 2013

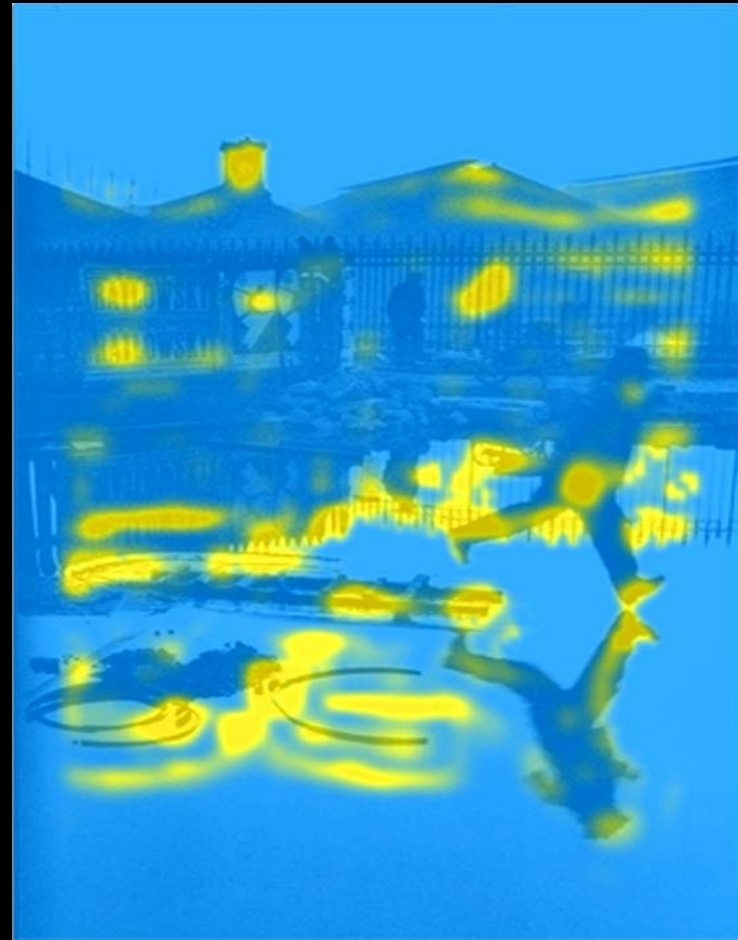
Artist intention: can visual attention models be helpful?



A coherent computational Approach to model the bottom-up visual attention

O. Le Meur, P. Le Callet and D. Barba, IEEE transactions on Pattern Analysis and Machine Intelligence (PAMI), Vol. 28, Issue 5, Pages:802-817 , May 2006

Artist intention: visual attention models can help!



On the role of artistic intent of image quality, Scott J. Daly, Electronic Imaging 2008

HDR video quality assessment
...few questions & studies

Objective Quality measures

Image Quality metrics (or measures): usual flow chart

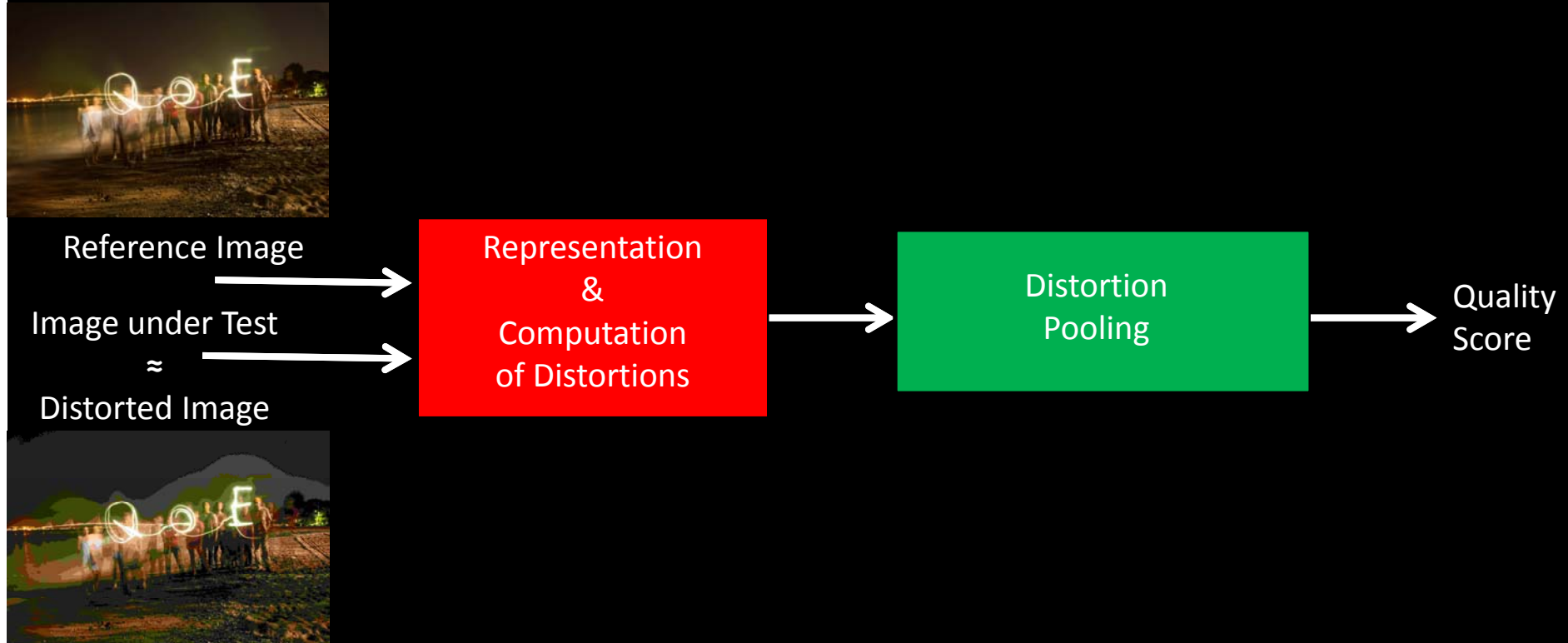


Image Quality metrics: PSNR



Reference Image

Image under Test
 \approx
Distorted Image



Representation &
Computation of
Distortion

+

-

Error
Map



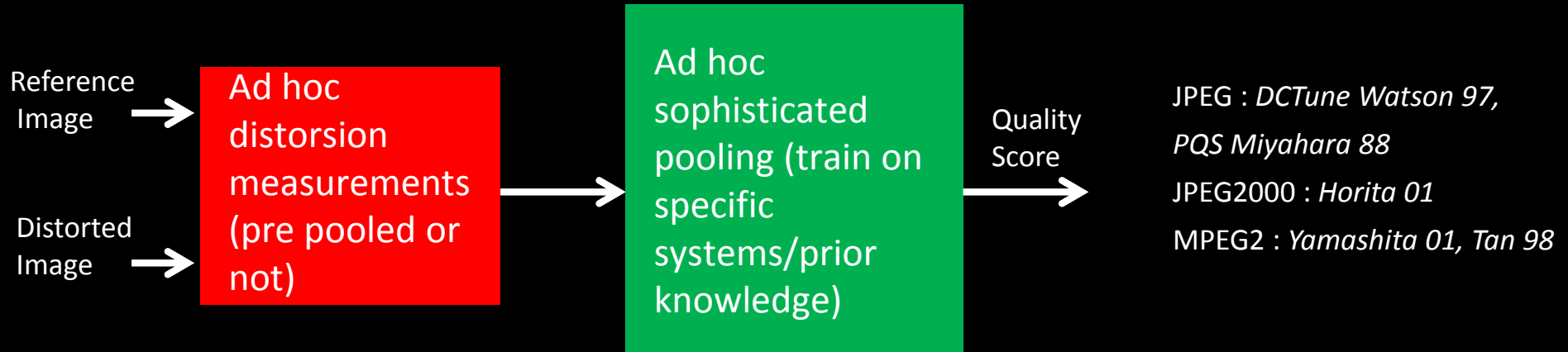
Distortion
Pooling

$$10 \cdot \log \left(\frac{I_{\max}^2}{\frac{1}{N \cdot M} \sum_{i=1}^N \sum_{j=1}^M (\text{error}(i, j))^2} \right)$$

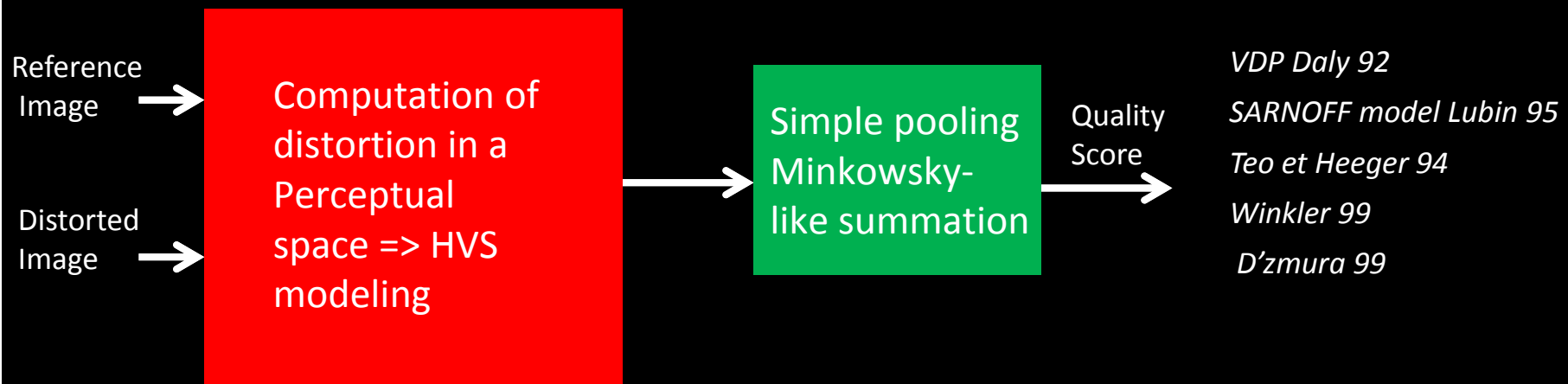
Quality
Score

Image Quality metrics:

« System » based Approach => Artefacts (introduced by know system) driven

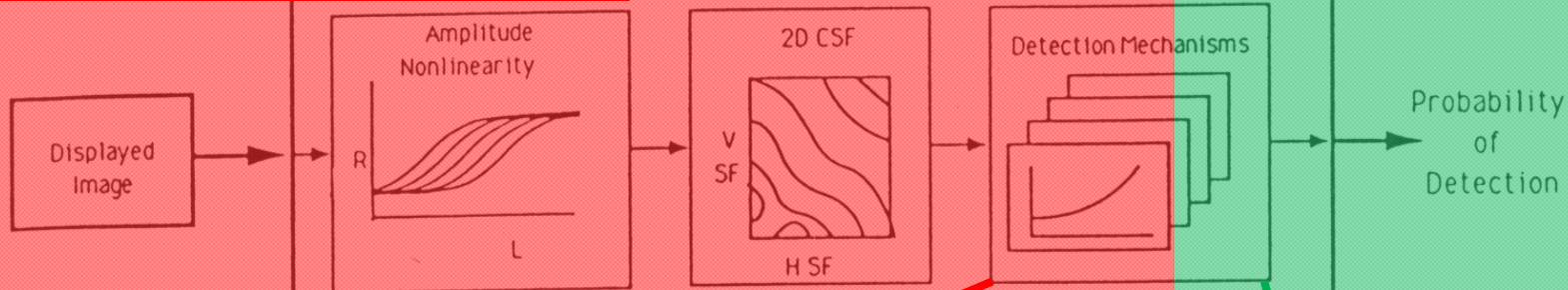


(Full) Perceptual Approach => Bottom-up modeling of Human Visual System



Perceptual based approach: Daly's VDP

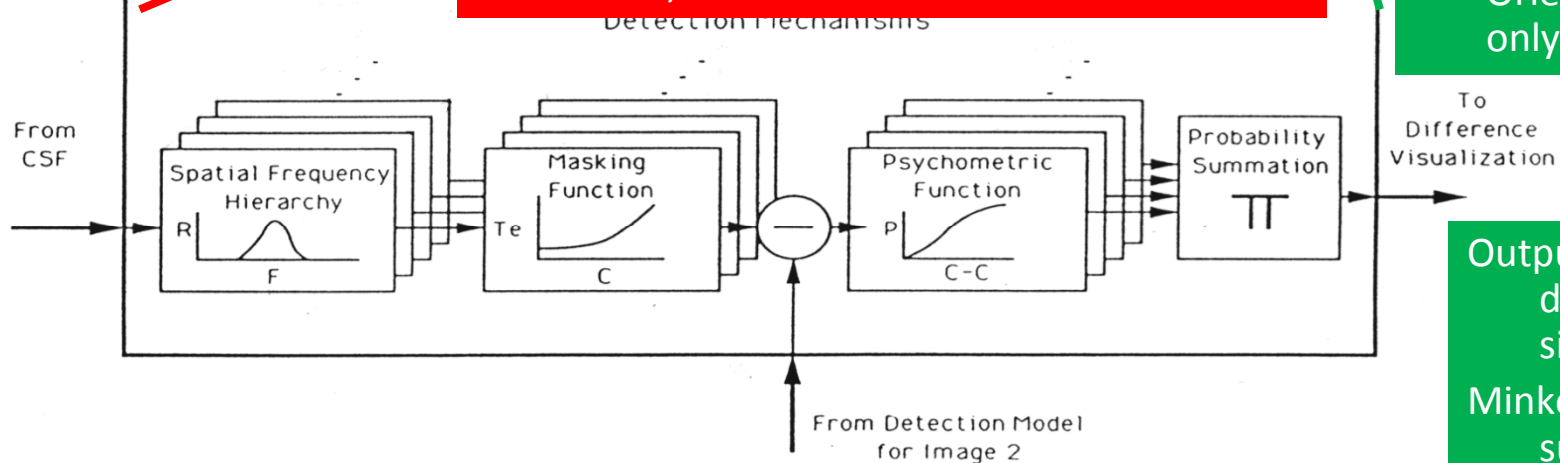
Projection of the Information in a perceptual space



Viewing distance is a parameter!
(unit in the visual space)
Model of the display

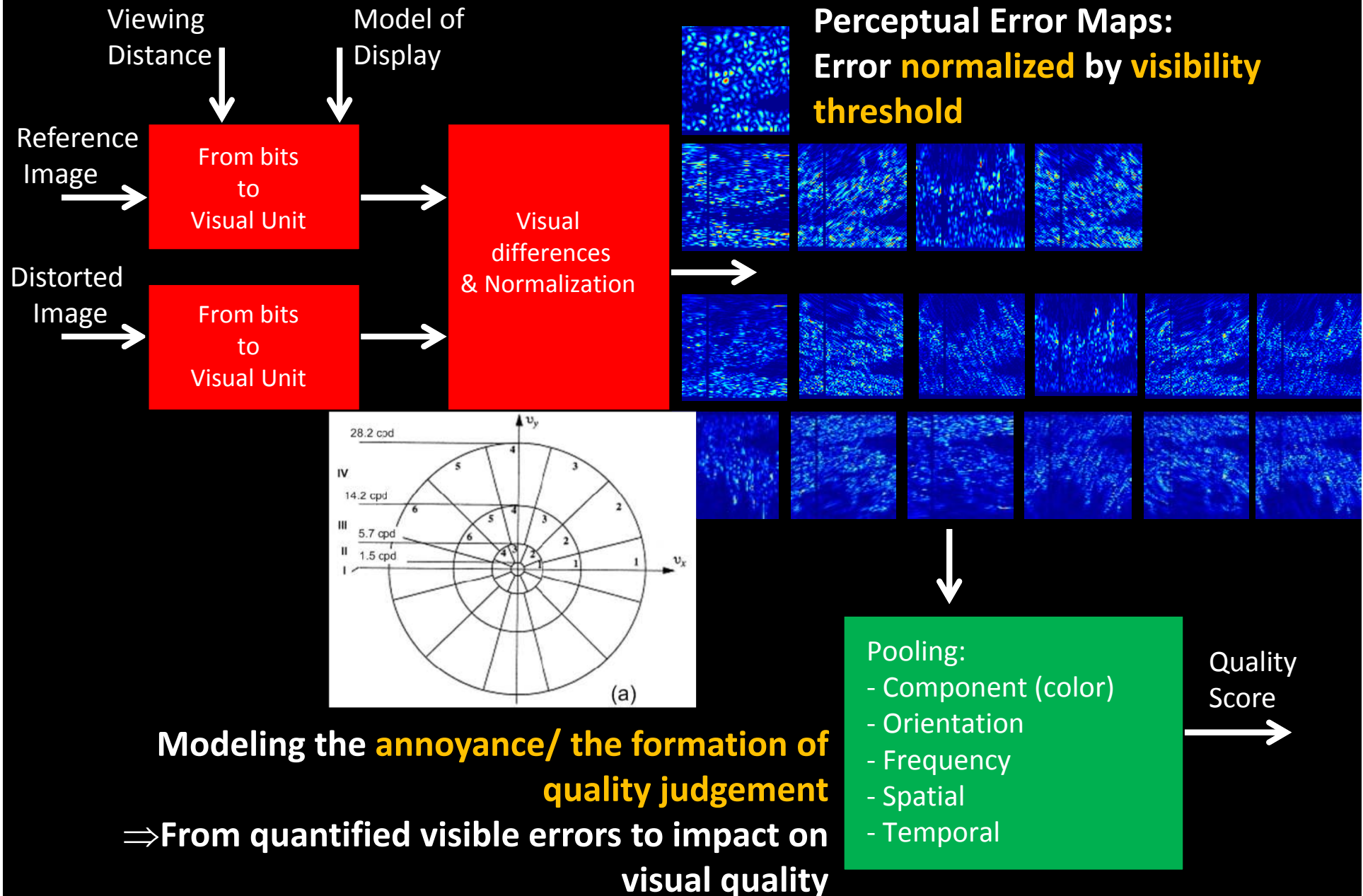
Normalization of errors according to the
Visibility Thresholds (including Masking
effects)

Partial Pooling:
Frequency and
Orientation pooling
only



Output= probability of
detection at each
site
Minkowsky
summation

Perceptual based approach: a closer look



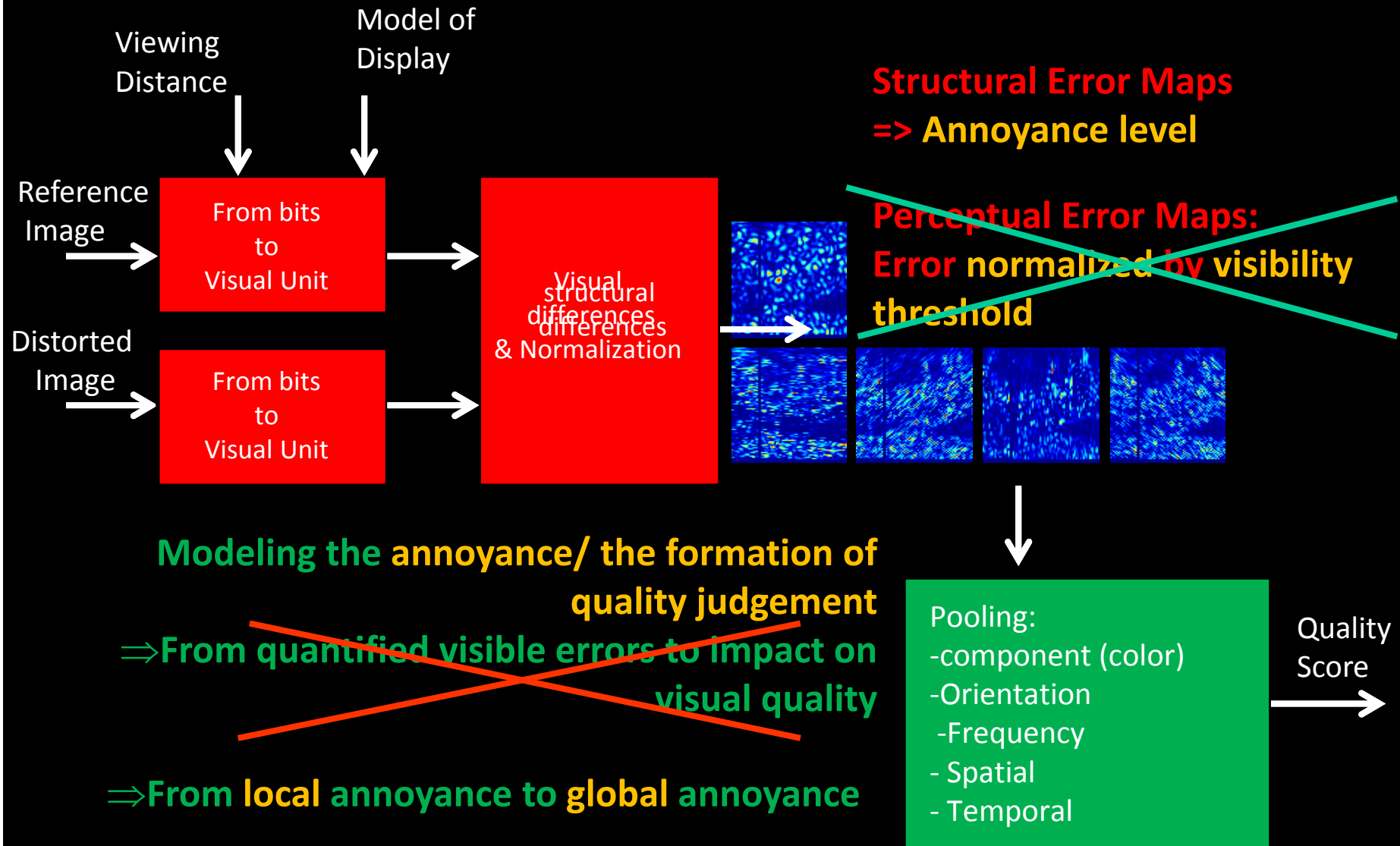
a third path: top down approaches

Perceptual Top Down factors => « agnostic»
structural approach

paradigm shift: local errors take into account **annoyance**
instead of visibility

Define what is what is annoying => Detect it
⇒ SSIM, VQEG Phase 2 (Yonsei's model) ...

Perceptual based approach and top down approach

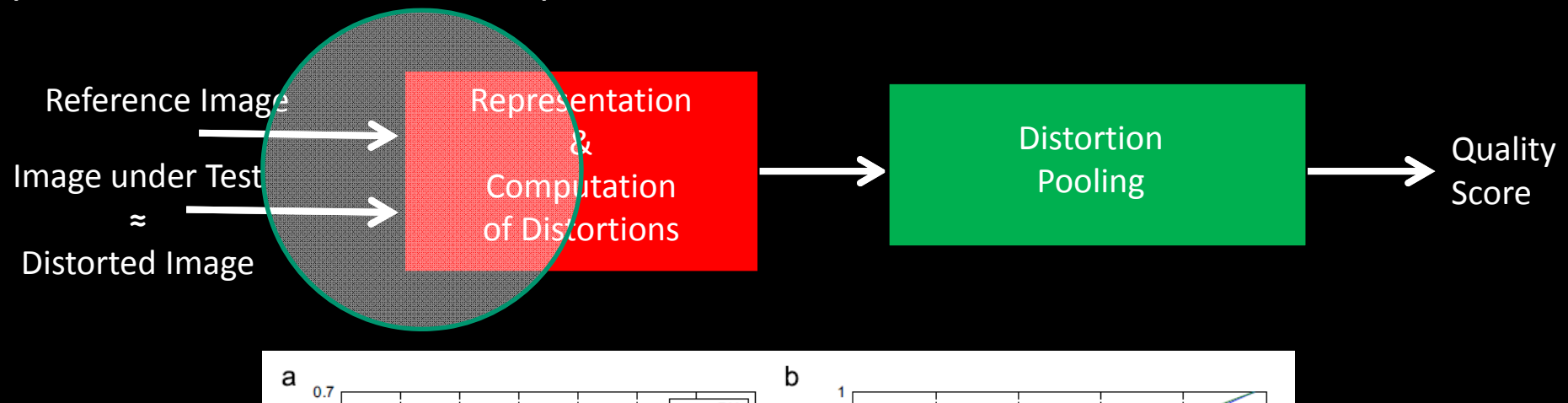


Extending existing objectives measures to cover HDR scenarios

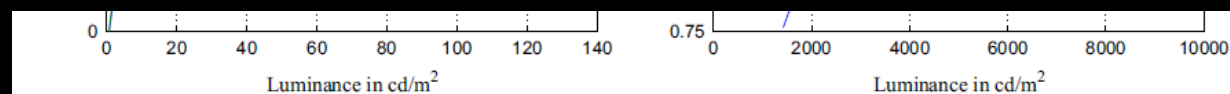
Trivial extension:

Model of the display => transformation into emitted luminance

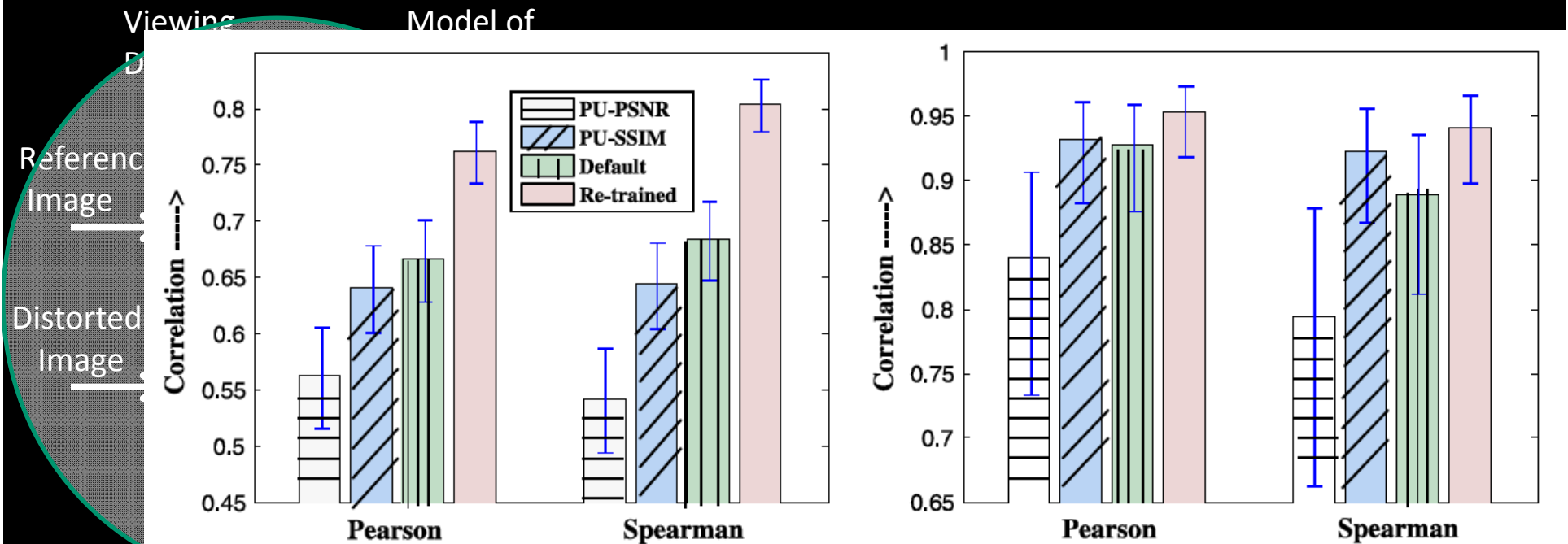
Perceptual Uniform Space => transformation into perceived luminance
(different from LDR case)



Can be done with any of the previous measures (PSNR, SSIM ...)



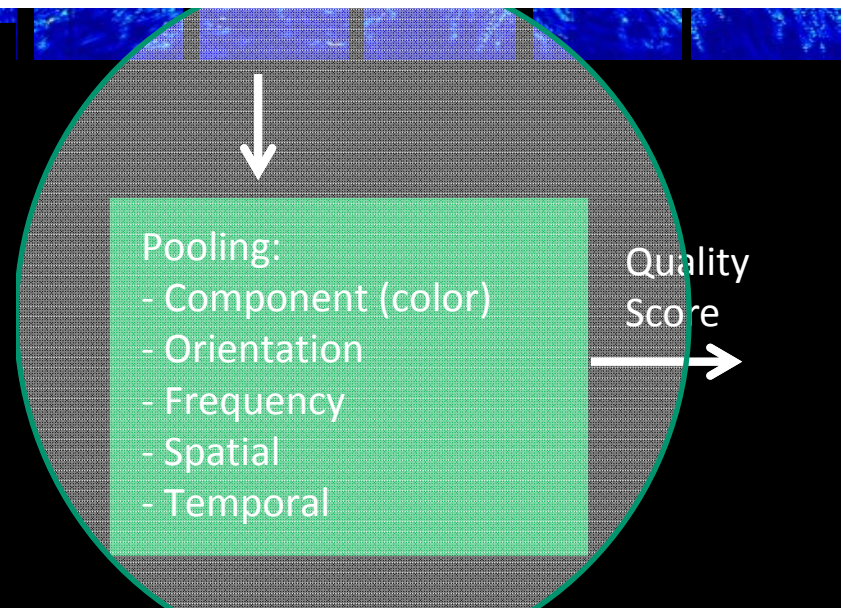
From HDRVDP2.0 to HDRVDP 2.2



HDR-VDP-2.2: trained on **various dynamic range from HDR to LDR conditions**

Narwaria et al. "HDR-VDP-2.2: A calibrated method for objective quality prediction of high dynamic range and standard images", Journal of Electronic Imaging, vol. 24, no. 1, p. 010501, 2015.

Software freely available at: <http://hdrvdp.sf.net/>



HDR VDP 2.x: strenght and limits

HDR-VDP : good at predicting local JND (Just Noticeable Difference) and overall JND with proper pooling ...but:

- not a video quality measure

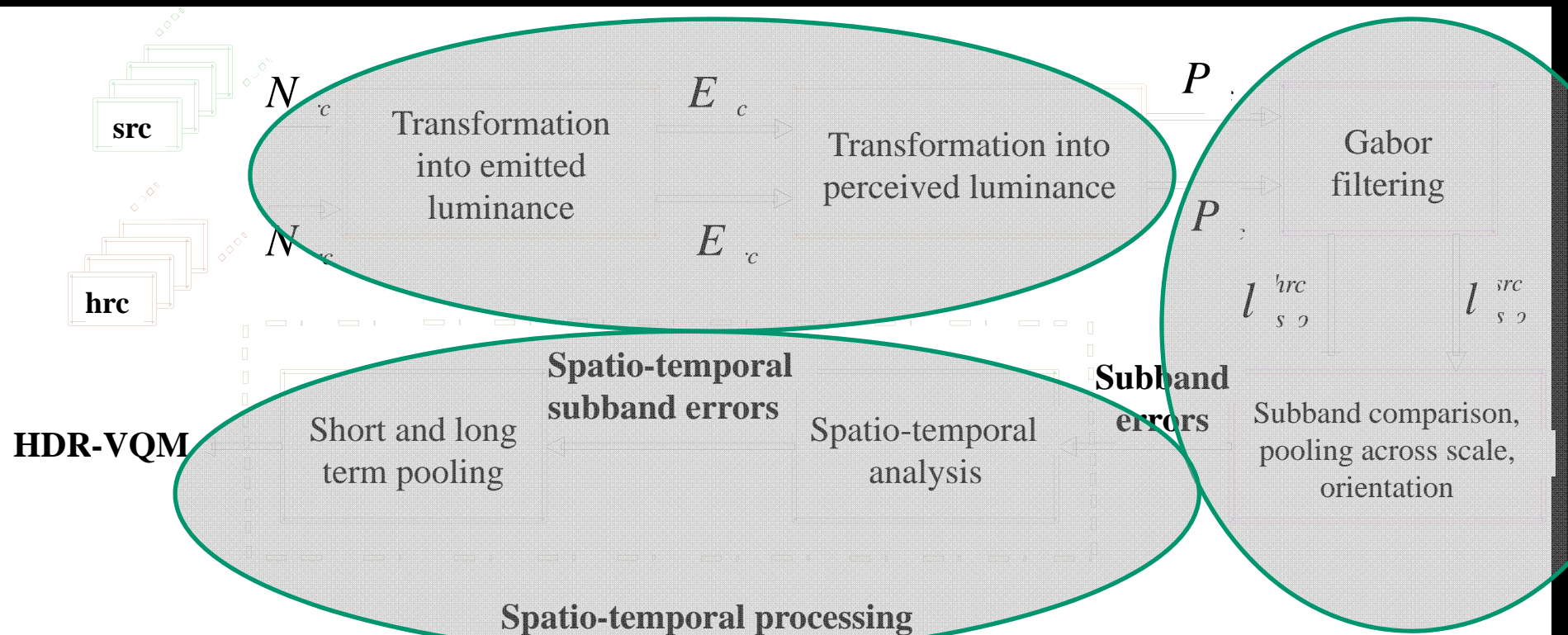
- likely not suitable for wide range of quality (low to high bit rates)

- complexity can be an issue

HDR-VQM (Video Quality Model): a objective quality measure for video

Inter subband
masking @supra

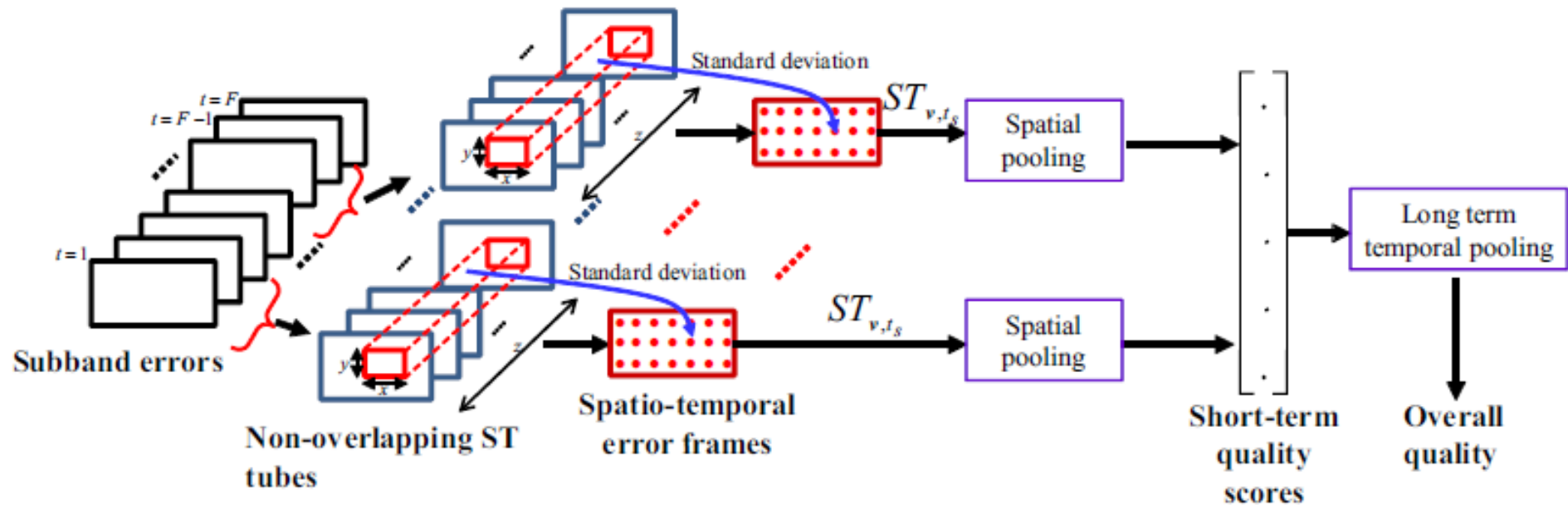
ST Local
analysis



@Scale of Visual fixation

Narwaria et al. "HDR-VQM: An Objective Quality Measure for High Dynamic Range Video", *Signal Processing: Image Communication*, 2015.

HDR-VQM: perceptual error spatio temporal pooling



ST tube volume:

$$(\tan 2^\circ \times V)^2 \times \frac{R}{D_A} \times T_{fixation}$$

foveal vision

viewing distance

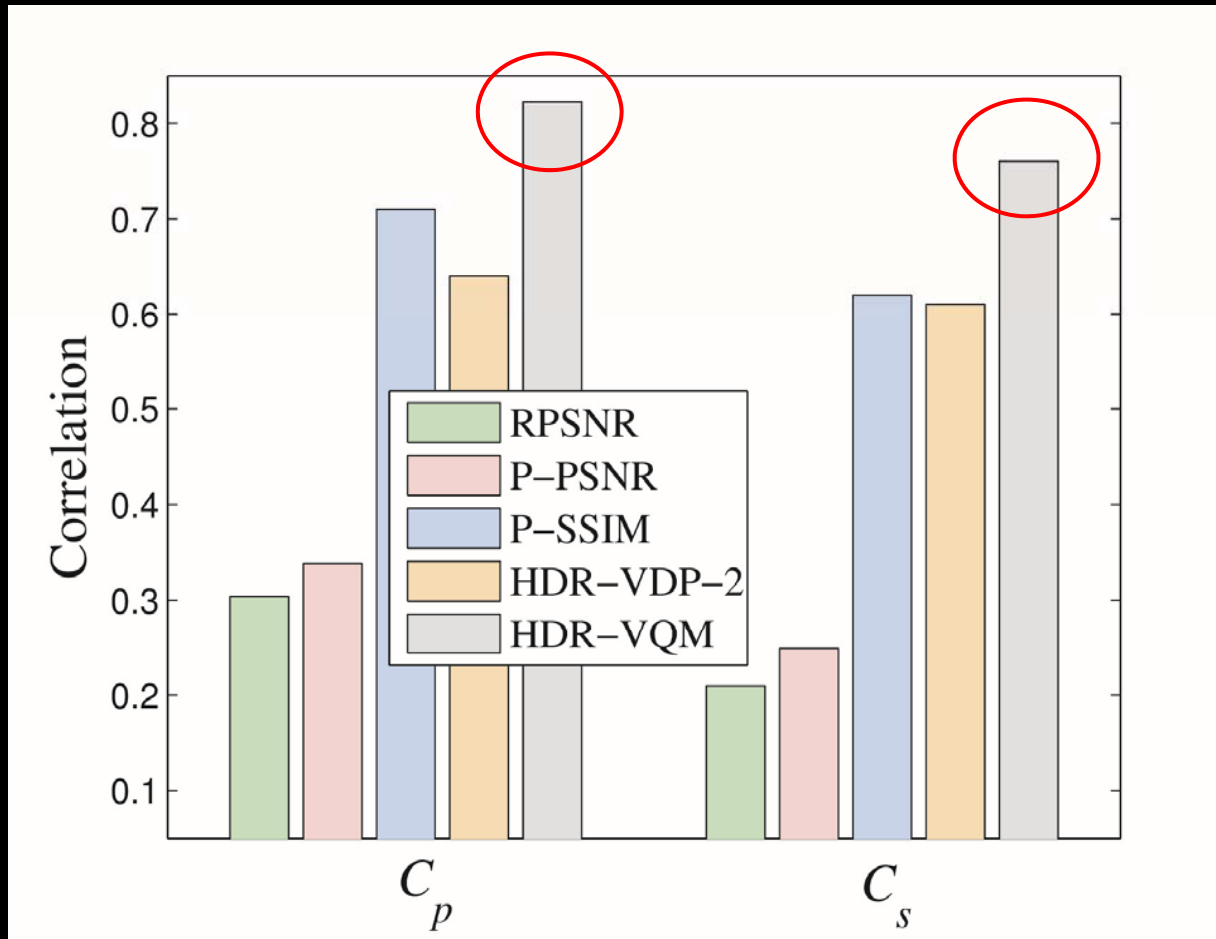
display resolution

fixation duration

area of display

Narwaria et al. "HDR-VQM: An Objective Quality Measure for High Dynamic Range Video", *Signal Processing: Image Communication*, 2015.

HDR-VQM: performance

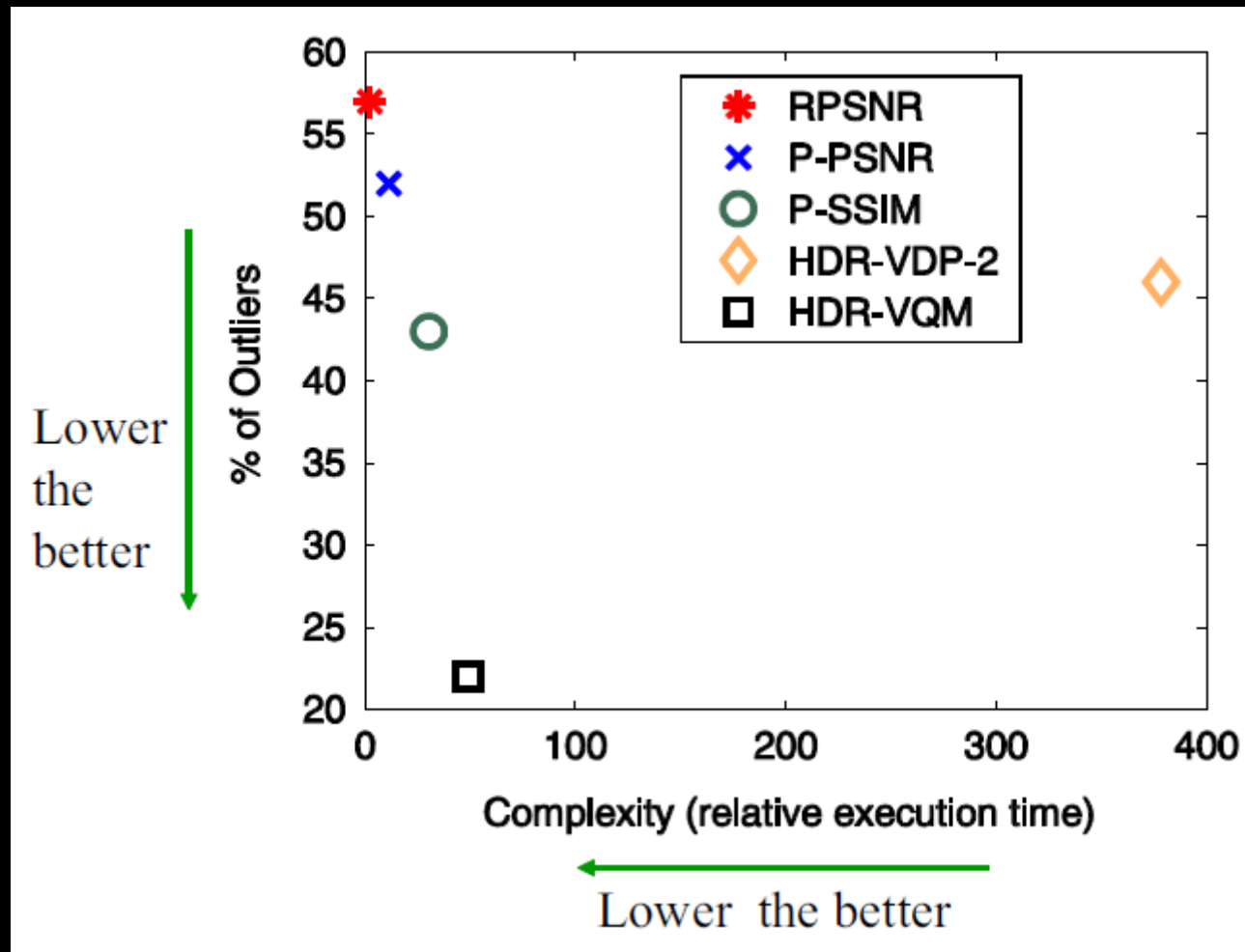


Results on backward-compatible HDR video compression method

A. Koz & F. dufaux « Optimized tone mapping with perceptually uni-form luminance values for backward-compatible high dynamic range video compression

Narwaria et al. “HDR-VQM: An Objective Quality Measure for High Dynamic Range Video”, *Signal Processing: Image Communication*, 2015.

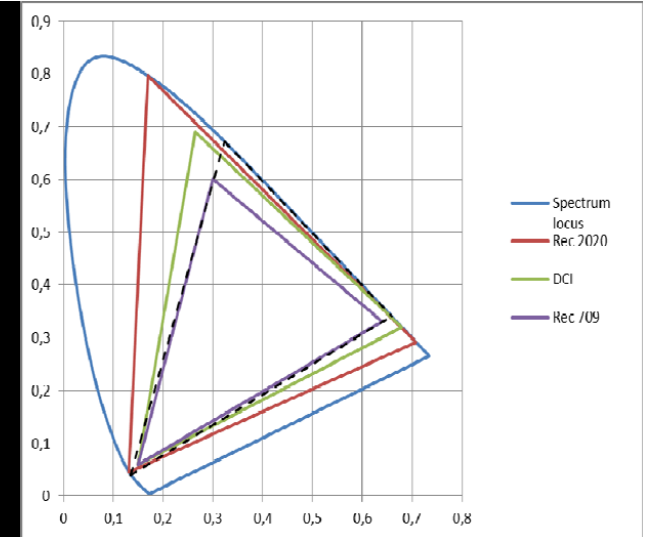
HDR-VQM: performance



Narwaria et al. "HDR-VQM: An Objective Quality Measure for High Dynamic Range Video", *Signal Processing: Image Communication*, 2015.

On going ...

HDR/WCG



Rec. 2020 vs Rec.709: tone and color reproduction

Meta data: mastering Display info, maxFall, max CLL, color Remapping Info

Color volume conversion => New form of processing and
...use case for quality assessment

Color Volume conversion and quality assessment

Can we reconcile image Quality assessment with color vision science (Delta_E, CIECAM, ...)?

small patch vs huge patch

new displays stressing mean observer => observer metamerism

Can we predict image naturalness (QoE formation)?

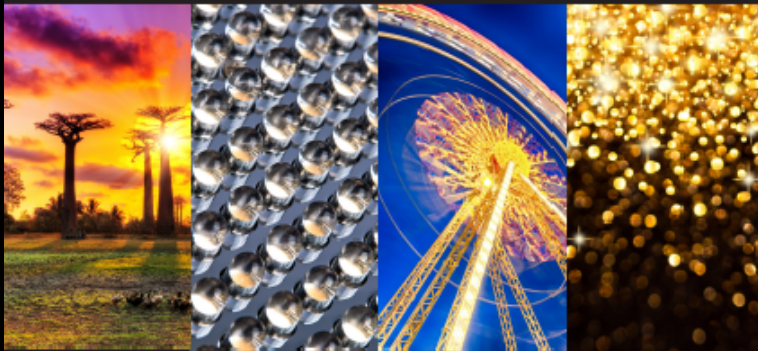
Subjective quality experiment: colorfulness, contrast, naturalness

objective measurement of Naturalness

Video quality assessment of HDR content (and beyond)

High Dynamic Range Video

Acquisition, Display and Applications



Frédéric Dufaux, Patrick Le Callet,
Rafal Mantiuk, Marta Mrak



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