Bridging the gap between image quality and aesthetics

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Image Quality

“the perceived ‘goodness’ (value) of an image, viewed by an observer, under a given environment and context”

Adapted from Fry, E., Triantaphillidou, S., et. al 2019
Image quality evaluation

Subjective
• Visual psychophysics
• Large number of observers
• Range of scene contents
Image quality evaluation

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Objective – Image Quality Models/Metrics
• computational
  extract information / model natural scene images
  model visual system
  not concerned with modelling imaging system

• engineering (mechanistic)
  extract information from test image / model imaging system
  model visual system (+ visual data calibration)
  not concerned with individual image contents
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  - IQM scene content dependent
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IQM system-dependent but scene content independent
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Imaging system performance measurement
Visual system measurement
Engineering image quality metrics / models

IQM
system-dependent
scene content independent
Engineering image quality modeling

**IQM**
- System-dependent
- Scene content independent

**IEEE 1864 CPIQ**
- Acutance, visual noise
- Texture blur, chroma level

**IEEE P2020 Automotive IQ**
- Acutance, visual noise
- Texture blur, flare

**CIE**
- DE94, CIEDE2000

**Others**
- ISO 12233 acutance
- SQF
- NEQ
- ...
Linear vs non-linear content aware systems

Linear vs non-linear content aware systems

Measuring camera sharpness/resolution - MTF

Fry, E., PhD Thesis, 2020
Scene dependent *noise* variations

Input

Output noise
(after denoising)
Scene dependent *sharpness* variations

Input

Output image (after denoising)
Scene dependent tone variations

Mobile Computational Photography: A Tour
Delbracio et al., CVPR, 2021
Scene-and-process dependent IQ models

Use imaging performance measures:

- Conform to current (industry) standards
- Account for non-linear, content aware imaging system performance
Scene dependent image quality modeling

Use imaging performance measures:

• Conform to current (industry) standards
• Account for non-linear, content aware imaging system performance

Use scene dependent visual system models:

• Such as the spatial CSF
• While accounting for scene content parameters
MTF/SFR camera performance

Input Test Chart

Measured MTF
MTF/SFR camera performance

Input Test Chart  →  Output Test Image
MTF/SFR camera performance

Input Test Chart ➔ Camera ➔ Output Test Image

Edge Selection
MTF/SFR camera performance

Input Test Chart → Camera → Output Test Image

Measured MTF

ISO 12233 e-SFR calculation

Edge Selection
MTF/SFR camera performance from natural scenes
MTF/SFR camera performance from natural scenes

Input Natural Scene → Edge Image → Natural scene MTF (NS-SFR) → ISO 12233 e-SFR calculation → Edge Selection, Isolation and Verification
MTF/SFR camera performance from natural scenes

This is a concept demo. The processing was not implemented live.
by Oliver vanZwanenberg
MTF/SFR camera performance from natural scenes
MTF/SFR camera performance from natural scenes

2 x DSLR camera systems (near-linear)
MTF/SFR camera performance from natural scenes

2 x DSLR camera systems (near-linear)

iPhone camera system (highly non-linear)

Scene dependent visual measures

Contrast Sensitivity Function (CSF) → Threshold contrast sensitivity
Scene dependent visual measures

Contrast Sensitivity Function (CSF) → Threshold contrast sensitivity

Spatial frequency cycles/degree

Contrast sensitivity
Scene dependent visual measures

Isolated Contrast Sensitivity Function (iCSF)

Threshold contrast sensitivity
Scene dependent visual measures

1. **Isolated** Contrast Sensitivity Function (iCSF)

Threshold contrast sensitivity
Scene dependent visual measures

2. **Contextual** Contrast Sensitivity Function (cCSF)
Scene dependent visual measures

Isolated **Contrast Sensitivity** Function (iCSF)
Contextual **Contrast Sensitivity** Function (cCSF)

Threshold contrast sensitivity

*Models account for scene contrast spectra*

Scene dependent visual measures

Isolated **Contrast Sensitivity** Function (iCSF)

Contextual **Contrast Sensitivity** Function (cCSF)

Threshold contrast sensitivity
*Models account for scene contrast spectra*

Isolated **Contrast Discrimination** Function

Contextual **Contrast Discrimination** Functions

Supra-threshold sensitivity
*Models account for cCSF & scene contrast spectra*

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Image Quality modeling

- Imaging system performance
- Scene
- Visual system performance
- Preference toward IQ attributes & artefacts
- Aesthetics

Most objective → Quality consciousness → Most subjective
Preference and Aesthetics

• Context dependent
• Culture dependent
• Industry/manufacturer dependent
• Personal
• Change with time
  - Fashion trends
  - Imaging system evolution

Quality consciousness

Preference toward IQ attributes & artefacts

Aesthetics

Most subjective
Computational aesthetics

“aim to identify or evaluate visual aesthetic expressions in images using algorithms”

• Composition
  - Rule of thirds
  - Golden ratio
  - Focus, focal length, depth of field

• Features
  - Colour
  - Exposure/luminance
  - Edges/textures/sharpness/contrast

• Contents
Evolution of photographic aesthetics

- Analysis of contemporary photographic collections to track preference & aesthetics
- Large collections
- Commercial photographic agencies (providing images worldwide)
- 40-50 years period
- Curated image collections (aesthetic value)
- Compare findings with literature (art & science)
Evolution of photographic aesthetics

A. Nature
   1. Wildlife
   2. Seasonal Landscapes
   3. Underwater Seascapes
   4. Night Sky
   5. Aerial Landscapes
   6. Close-ups

B. People
   1. Portraits (close ups)
   2. Groups of people

C. Satellite

D. Abstracts
   1. Microscopic
   2. Macroscopic
   3. Textures/detail
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Evolution of photographic aesthetics

Examine color computational aesthetic features

- Colorfulness (CFL) - linear combination of chromaticity variance and chroma magnitude
- Color harmony (CH) - based on the frequency of appearance of color patterns
- Opposing or opponent color (OC)
- Complementary colors (CC)
- Dominant colour palettes (PCP) – based on clustering, and subsequent analysis
Evolution of photographic aesthetics

Discover

• How “portrait” skin tone rendering varied with time & variation between photo agencies
  - Decade trends
  - Culture trends
  - Effect of medium

• Colour trends in “abstracts” category – are they identified, any discoveries?

• Balance
• Rhythm/pattern
• Variety
• Contrast
• Movement
• Surprise
Evolution of photographic aesthetics

Discover

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Evolution of photographic aesthetics

Further work will examine

• Most (all) categories

• Attributes
  - image complexity
  - rule of thirds
  - golden ratio
  - diagonal and leading lines
  - focus and depth of field

• Hand crafted features and potential AI tools

• Compare computational findings with literature findings on photo aesthetics
Summary

- Image quality involves scene contents, imaging chain, human vision and cognition
- Image quality modelling, viewed from a mechanistic viewpoint, requires investigation of all abovementioned elements and their interrelationships
- Developed scene-and-system-dependent performance measures (spatial -> MTF and NPS)
- Developed scene-dependent (spatial) visual models
- Initial testing on benefit of such models in IQMs modeling is very positive
- Moving from scene-dependent imaging performance modelling to modelling preference and aesthetics bridges a gap
- Track aesthetics in contemporary photography using computational means and photo collections with known aesthetic values
Colleagues

Dr Aleka Psarrou, Reader, UoW
Dr John Jarvis, visiting Professor, UoW
Dr Robin Jenkin, visiting Professor, UoW (Nvidia, CA)

Dr Oliver vanZwanenbegr, PhD graduate (now @ Onsemi, UK)
Dr Edward Fry, PhD graduate (now @ Apple, CA)
Adela Shah, PhD student
Thank you!

- van Zwanenberg, O., Triantaphillidou, S. and Jenkin, R. (2023), A tool for deriving camera spatial frequency response from natural scenes (NS-SFR), IS&T Electronic Imaging Symposium: Image Quality & System Performance conference XX, San Francisco, California, USA.