AUTOMATIC ISP IMAGE QUALITY TUNING USING NON-LINEAR OPTIMIZATION

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Introduction

A typical, modern ISP has multiple processing blocks that include complex image processing algorithms, such as noise reduction (NR), demosaicing and sharpening.

The effort of manual image quality (IQ) tuning is extremely high due to ISP block inter-dependencies, large number of high level tuning parameters and thorough review of the image quality.

Combining non-linear optimization with automatic reference image generation produces highly competitive results in minutes whereas manual tuning by IQ experts takes weeks.

Key contributions

- Prior work: Conducted experiments with IQ KPIs (e.g. SNR and Texture acutance) using MOEA/D. Results indicate that IQ KPIs do not impose enough constraints on image quality artifacts as it is possible to achieve good IQ KPIs even in the presence of unacceptable artifacts.
- Automatic reference image generation method that outputs superior quality in all IQ aspects with respect to the ISPs real-time capabilities.
- Non-linear, gradient-free optimization that can solve non-convex problems: Combination of global and local optimization produces repeatable results that are highly competitive against hand-tuned IQ.

Reference Image Generation

Global optimization: Artificial Bee Colony

Generate and explore new set of tuning points

Local optimization: Subplex, Nelder-Mead simplex

Refine towards optimal solution (gradient approximation)

Experiments

Results of an IQ assessment, conducted as blind experiment: Each participating image quality expert were shown five images of each of the three scenes (Portraits A and D54, and Studio) and were asked to select the best one in terms of IQ. Images were labeled as A, B, C, D and E, where images labeled with ‘B’ were hand-tuned manually and all other images were auto-tuned.

<table>
<thead>
<tr>
<th></th>
<th>Portrait A</th>
<th>Portrait D54</th>
<th>Studio</th>
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</thead>
<tbody>
<tr>
<td>IQ expert 1</td>
<td>A</td>
<td>A</td>
<td>A</td>
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<tr>
<td>IQ expert 2</td>
<td>A</td>
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<td>IQ expert 3</td>
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<td>IQ expert 4</td>
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<td>IQ expert 5</td>
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<td>IQ expert 6</td>
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Difference between reference and each tuning output for each key ISP block: results are shown for not-tuned, hand-tuned and auto-tuned images.

Live demonstration

- Pre-processing:
  - downsampling
  - Bayer demosaicing

- Input: Bayer sensor output

- Output: Auto-tuned image

Basic ISP pipeline

Input: Bayer sensor output

Correction: Bayer NR, Demosaic Color Correction, Gamma, Sharpening

Output: Auto-tuned image

Comments:

- Weeks of tuning

- Minutes of tuning

Comparison between ‘Hand-tuned’ and ‘Auto-tuned’ images on IMX260 and OV16860.

<table>
<thead>
<tr>
<th>Scene</th>
<th>Portraits A</th>
<th>Portrait D54</th>
<th>Studio</th>
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<tbody>
<tr>
<td>Not-tuned</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Hand-tuned</td>
<td>B</td>
<td>C</td>
<td>D</td>
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<tr>
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<td>E</td>
<td>A</td>
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