Contrast Aware Multiscale Banding Index (aka CAMBI)

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The curious case of **banding**...

...if you didn’t know about it... **sorry**.
Banding is manifested as false staircase-like edges in otherwise smooth transitions in a picture.

One of the most prominent causes for banding is the quantization step in video encoders.

A relatively small change of the original pixel values can produce an easily noticeable and visually annoying artifacts.
Banding artifacts are notoriously difficult to capture for objective quality metrics.

VMAF = 86
PSNR = 50 dB
MOS = 20
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PSNR = 50 dB
MOS = 20

Artificial colors to highlight bands
Banding artifacts are notoriously difficult to capture for objective quality metrics.

Banding is:

- Imperceptible
- Perceptible, but not annoying
- Slightly annoying
- Annoying
- Very Annoying

86 videos, 23 subjects

<table>
<thead>
<tr>
<th>Metric</th>
<th>VMAF</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SROCC</td>
<td>0.088</td>
<td>-0.202</td>
</tr>
<tr>
<td>PLCC</td>
<td>0.000</td>
<td>-0.271</td>
</tr>
</tbody>
</table>
Existing banding detectors are usually designed for user-generated 8-bit images.

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<tr>
<th></th>
<th>BBAND*</th>
<th>DBI**</th>
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</thead>
<tbody>
<tr>
<td>SROCC</td>
<td>-0.693</td>
<td>0.046</td>
</tr>
<tr>
<td>PLCC</td>
<td>-0.762</td>
<td>0.212</td>
</tr>
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* Z. Tu, J. Lin, Y. Wang, B. Adsumilli and A. C. Bovik, "BBAND INDEX: A NO-REFERENCE BANDING ARTIFACT PREDICTOR," ICASSP 2020

** Akshay Kapoor, Jatin Sapra and Zhou Wang, “CAPTURING BANDING IN IMAGES: DATABASE CONSTRUCTION AND OBJECTIVE ASSESSMENT”, ICASSP 2021
CAMBI:
Contrast-Aware Multiscale Banding Index
CAMBI: Notable features

- Focused on detection of banding in high-quality encodes (VMAF>80)
- Can deal with different resolutions and dithered content
- Validated on subjective data (both 8-bit and 10-bit SDR content)
- Open-sourced as a libvmaf feature [link](#)
- Published: initial version in PCS 2021, Medium [techblog](#)
CAMBI is a white box solution derived from basic principles of human vision with just a few, perceptually-motivated, parameters.

CAMBI significantly outperforms existing metrics and banding detectors on **NETFLIX content** and works for both 8 and 10 bit videos.

<table>
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<tr>
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<th>VMAF</th>
<th>PSNR</th>
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<tbody>
<tr>
<td>SROCC</td>
<td>-0.958</td>
<td>-0.693</td>
<td>0.088</td>
<td>-0.202</td>
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<tr>
<td>PLCC</td>
<td>-0.947</td>
<td>-0.762</td>
<td>0.000</td>
<td>-0.271</td>
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</tr>
</thead>
<tbody>
<tr>
<td>SROCC</td>
<td>-0.762</td>
<td>N/A</td>
<td>-0.294</td>
<td>-0.561</td>
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<tr>
<td>PLCC</td>
<td>-0.928</td>
<td>N/A</td>
<td>-0.385</td>
<td>-0.556</td>
</tr>
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</table>
The beauty of opensourcing...

...is that you get to find corner cases really quickly!
Houston, do we have a problem?!

- The frame is created by converting to 6 bits and back
  - This creates bands with relatively high luma distance
  - Steps are too large for CAMBI’s default setting

- Although our codecs do not seem to produce banding with such large steps, we now allow users to change the CAMBI setting to capture this
  - See `max_log_contrast` on the [CAMBI usage page](#)

- Setting `max_log_contrast = 3` leads to
  - CAMBI $1.75 \rightarrow 13$ for the corner case
  - SROCC $-0.958 \rightarrow -0.955$ for 8 bit dataset
  - SROCC $-0.762 \rightarrow -0.754$ for 10 bit dataset

- Considering larger steps increases false positive rate
  - Full reference variant can help
Future work

● Integration into VMAF as a feature
● Mapping to an interpretable scale
● Full reference variant of CAMBI
● Extension to HDR
Thank you!

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