A Win-Win Camera: Quality-Enhanced Power-Saving Images on Mobile OLED Displays

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Motivation

• Existing OLED power-saving techniques change users’ visual experience or degrade images’ visual quality in exchange for power reduction, or seek a chance to enhance image quality by employing a compound objective function.
• Quality enhancement has its necessity because users are often lack of photographic expertise or lighting conditions are not always ideal.

OLED Image Display

• OLED power can be reduced by scaling down the brightness levels of pixels.
• Image quality can be enhanced by redistributing pixels’ brightness levels to better use the full intensity range.

A Win-Win Scheme

A Win-Win Camera for OLED Mobile Devices

• A stand-alone Android app on a Samsung Galaxy Tab 7.7.
• Transforming a picture takes 96ms, while each subsequent editing takes 14ms.

Contrast and Power Metrics

Which brightness level to be adjusted?

Power

Contrast is the difference in brightness that makes some pixels distinguishable from the others: \( C(H) = \sum_{i} \text{pdf}(i) \times \delta(i) \).

Power Metric:

• The power required by an image is the sum of the power consumed by all the pixels: \( P(H) = \sum_{i} \text{pdf}(i) \times e(i) \).

Contrast-to-Power Index:

• Which brightness level to be adjusted? CPI(x) = pdf(x) \times edf(x) to assess the preferability of increasing level x’s distance.

Fundamental Algorithms

Input: A histogram \( H \) and a power function \( e \).
Output: The minimum power \( P_{\text{min}} \).

1. Compute pdf(x), edf(x), CI(x), \( \forall x \), based on H
2. Build \( \delta(x) \) based on pdf(x), \( \forall x \), by WTHE
3. \( \delta(x) \leftarrow 0 \) if pdf(x) = 0, and 1 otherwise, \( \forall x \)
4. Build \( \hat{H} \) based on H and \( \delta \)
5. while \( C(\hat{H}) < C(H) \) do
6. \( \delta(x) \leftarrow \max(\{\delta(x) \times 255\}, 1) \) for x with the largest CPI(x)
7. \( \text{CPI}(x) \leftarrow 1 \)
8. Update \( \hat{H} \) based on \( \delta \)
9. return \( P_{\text{min}} \leftarrow P(\hat{H}) \)

Performance Evaluation

A Win-Win Scheme

• Platform
• Samsung Galaxy Tab 7.7

Image Set

• Kodak image database (24 Images covering a variety of themes and lighting conditions)

Performance Metrics

• Quality scored by EME
• OLED power measured

Compared Algorithms

• HMA: Pure image enhancement approach [TIP’09]
• CURA: Pure power reduction approach [DAC’14]
• CPI: Our win-win approach

Numerical Results

• HMA and CPI increase EME scores by 3.9 and 3.4 times
• CURA and CPI reduce OLED power by 37% and 27%

Conclusion

• Rationale behind our win-win camera
• Contrast is much more central than the absolute brightness to the image quality perceived by the human visual system.
• Experiment results on Samsung Galaxy Tab 7.7
• 88% of the image quality enhanced by HMA [TIP’09], a pure image enhancement approach.
• 73% of the OLED power reduced by CURA [DAC’14], a pure power reduction approach.