Opt-HDR: A Hyper-Optimized HDR Imaging Pipeline

Project Proposal

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1 Summary

We want to implement a highly optimized version of Google's original HDR+ burst photography system Hasinoff et al. (2016) that receives a bust of raw image frames as input and returns a processed image plane as output. We intend to maintain the broad system architecture but explore more optimal implementations of each stage, drawing insights from recent papers and Halide schedules. Success would be measured by the level of speed-up offered by our optimizations and how closely our final output matches the reference images.

2 Inputs and outputs

The input would be a payload of input burst images, low-resolution floating-point gain maps for the Bayer color channels, 3x3 color transform matrix for RGB color space to output linear sRGB color space transformation, and a timing text file that details the time spent in each stage of the architecture in the original HDR+ paper. The output would be a merged and processed image frame and a text file detailing the time spent at each stage.

3 Task List

Core Tasks:

- Load DNG Files
- Initial alignment implementation
- Initial merge implementation
- Initial finish operations (white balance, demosaic, chroma denoise, sharpen, hue saturation)
- Optimized alignment implementation
- Optimized merge implementation (Implement Wronski et al. (2019))

Nice to haves:

- Optimized finish operations
- A feature (e.g., portrait mode) over HDR that uses fusion to prevent latency increase
- DNN-Infused layers for further optimizations
- On-device Android app to demonstrate the system

4 Expected Deliverables and/or Evaluation

The goal at the end of our exploration is to have:

- An implementation of HDR+ that is visually indistinguishable from the reference final images in our HDR+ dataset. This will be measured with FID, SSIM, and PNSR metrics.
- Performance improvement from a naive implementation that rivals or exceeds that reported in the HDR+ paper. This will be measured with by the latency of our system.

5 What are the Biggest Risks?

There are two major risks involved with this project relative to our goals:

- Not being able to get the initial naive HDR+ pipeline implemented.
- Not getting optimizations to a naive implementation that approaches those reported in the paper and the dataset.

6 What do you need help with?

I need help with the following:

- References to more recent papers with potential improvements for any part of the pipeline, from alignment to merging to demosaicing.
- Help from CA to answer questions when methods discussed in the paper are unclear.
- General advice on streamlining my project goals to something attainable withing the quarter.

References

Samuel W. Hasinoff, Dillon Sharlet, Ryan Geiss, Andrew Adams, Jonathan T. Barron, Florian Kainz, Jiawen Chen, and Marc Levoy. 2016. Burst photography for high dynamic range and low-light imaging on mobile cameras. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia)*, 35(6).

Bartlomiej Wronski, Ignacio Garcia-Dorado, Manfred Ernst, Damien Kelly, Michael Krainin, Chia-Kai Liang, Marc Levoy, and Peyman Milanfar. 2019. Handheld multi-frame super-resolution. *ACM Trans. Graph.*, 38(4).