CS 184/284A Final Project Milestone Report

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CCS CONCEPTS

• **Computing methodologies** → **Computational photography**.

KEYWORDS

HDR+, HDR, Denoise

1 INTRODUCTION

We implemented a burst (multiple similar shot) photograph HDR pipeline for the final project based on Google's HDR+ paper [1]. The HDR+ paper proposed an image processing pipeline that combines multiple underexposure (to avoid over-saturation) raw images and generates HDR photos. Our project applies a similar HDR+ pipeline to the original dataset of HDR+ paper, with some modification on the alignment and finishing part while maintaining the overall performance.

The HDR+ pipeline can be roughly divided into three parts: Alignment, Merging, and Finishing (including white balance, tone-mapping, etc). A full pipeline, implemented by [1], is shown in Fig. 1.

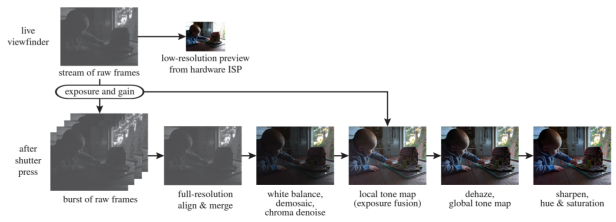

Figure 1: HDR+ pipeline. Align and Merge is represented as one stage. Finishing is represented as multiple stages. Source: [1]

In the alignment part, an image pyramid is first created based on the input data. Tile size is chosen for each pyramid level (8 pixels for the coarsest level, 16 pixels for all other levels). The sharpest image is chosen as a reference image and all other images try to align their tiles to the reference image. The alignment of tiles first starts from the coarsest level using L1/L2 loss. For each following level (of larger size), the previous level (coarser level) alignment is used as the initial guess for alignment. The final result of the alignment part is the tile alignment result on the original image.

In the merging part, aligned tiles from multiple images are merged into the reference image. To achieve that, we first approximate the noise levels and distributions. Then, temporal denoising is applied by comparing each tile to its corresponding reference tile and processing the difference with estimated noise variance; this yields a weighted average of each tile in the frequency domain as the DFTs of the tiles are used. With these tiles, we also implement spatial filtering and blend the overlapping tiles with cosine windows. This creates a final, seamless image with a higher SNR.

After the aligning and merging part, the processed image needs to go through correction, demosaicing and tone-mapping procedures performed by an ISP in order to get the final output. As our project is purely software-based, we implemented all these necessary operations in the finishing part. This is a wrap-up step for the whole project.

Link of our milestone webpage can be found here:
https://ucberkeley-spring2022-cs284a-project.github.io/HDRplus/

2 PROGRESS

2.1 Alignment

Align part can be roughly divided into 2 parts:

(1) Build image pyramid;
(2) Align each pyramid level.

We have finish the first part and is currently working on the second part.

2.2 Merging

Merging is divided into about 4 parts:

(1) Noise level estimation;
(2) Temporal Denoising;
(3) Spatial Denoising;
(4) Overlapping/Blending Tiles.

We have finished the first part and are currently in the process of implementing the second and third stages. We can now estimate parameters related to the shot noise and read noise using the real ISO value and reference noise curve values (with ISO = 100). We also calculate the root mean square of a tile to evaluate the general noise variance.

2.3 Finishing

The finishing part can be mainly divided into the following 9 steps:

(1) Black level subtraction;
(2) White balance;
(3) Demosaicing;
(4) Color correction;
(5) HDR tone mapping;
(6) Contrast enhancement / global tone mapping;

Figure 2: Input image

Figure 3: After process image

(7) Gamma compression;
(8) Sharpening;
(9) JPEG quantization and compression.

We have finished the first 4 steps and Gamma compression. Right now, we are working on step 5 "HDR tone mapping". Fig. 2 shows the input image and Fig. 3 is a visual result of how an input original image looks like after the first 4 steps and gamma compression.

3 FUTURE WORK PLAN

Given the progress we have, we are on track with our proposed timeline. We plan to finish the following steps in the week of April 26 and start testing and tuning in the following week.

In the alignment part, we will implement the align-each-level functionality, which is the core feature of align.

For the merging part, we will continue to work on implementing the following stages: temporal denoising, spatial denoising, and blending overlapping tiles. We will then use sample images to test our implementations.

For the finishing part, we will keep working on the HDR tone mapping, contrast enhancement, global tone mapping and then sharpening.

REFERENCES

[1] 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 Trans. Graph.* 35, 6, Article 192 (nov 2016), 12 pages. https://doi.org/10.1145/2980179.2980254