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Computational Imaging Project Proposal
HDR Techniques with Dynamic Scenes for Mobile Imaging

Motivation:

Cell phone cameras have lower dynamic ranges than most stand alone cameras. This leads to extremely poor mobile performance when high dynamic range scenes are captured. Resultantly, approaches such as capturing different exposures that contain the large dynamic range of the scene and performing tone mapping on said set of exposures to represent the high dynamic range image in an 8-bit format have been explored. One issue with capturing multiple exposures is user motion between exposures. Frame alignment techniques have been developed to rectify the frame misalignments. A second issue is that many HDR algorithms suffer with dynamic scenes again as multiple exposures are needed, leading to effects such ghosting and tearing in the fused HDR images.

We will be investigating and adapting the "Deep High Dynamic Range Imaging of Dynamic Scenes" [Nima 17] SIGGRAPH 2017 publication by Nima et al. pipeline on sets of three exposed LDR images of dynamic scenes with slight user movements on the iPhone 8/Google Pixel 2. Nima et al. proposes a learning-based approach to address the issues that arise with dynamic scenes suggesting three different architectures. The training set, test set, and source code are all publicly available which we plan to leverage. The source code is all written in MATLAB so we may rewrite the CNN portion of the pipeline in Python to improve the pipeline's performance on mobile phone images. We will be implementing their least end-to-end convolutional neural network approach as we will most likely have to caputure training and test data of the mobile phone's distribution which will be of a small number of scenes due to time constraints. We also hope to reduce the inference time as ideally the pathway will be running completely on a mobile device so the least end-to-end approach will let us condense the netowork further.

We will use transfer learning to bridge the differences between the Canon EOS-5D Mark III camera dataset of 78 dynamic scenes used to train the network and the iPhone 8/Google Pixel 2 camera outputs. We will also need to capture a training set with the iPhone 8/Google Pixel 2 utilizing the same data augmentation techniques as the publication. Knowing that ideally the HDR image fusing would be running on a mobile device, network compression techniques such as reducing the number of parameters, pruning, and quantization will be explored for the network.

Similar goals have been accomplished with the Google HDR+ system for mobile, which operates using 3 exposures of the same length and combines them in the RAW form in order to denoise dark images and improve dynamic range [Hasinoff 17]. This allows for high-reliability frame alignment. However, this work requires that HDR+ mode can be used as the camera's main photo mode, which we will not consider as a requirement for this project. This will allow us to relax reliability standards, allowing us to take advantage of different exposures in order to ensure the highest possible dynamic range minimize noise.

The Nokia research center has likewise attempted high dynamic range imaging for mobile [Bilcu 08] but were limited by memory availability on mobile platforms at that time. The technology improvements since 2008 (1 year after the release of the first iPhone) will allow us to store 3 images in parallel and combine all 3 at once, rather than the stacking approach utilized by the Nokia system. They also have an exposure determination system that requires the camera to be still as it captures many incremental exposures of the scene in order to determine which ones are required to cover the desired dynamic range. We can implement and improve upon this system in order to improve imaging of dynamic scenes.

The overall motivation of the project is to leverage elements of the "Deep High Dynamic Range Imaging of Dynamic Scenes" publication, which produces better results than many state-of-the-art HDR algorithms, for mobile imaging on dynamic, high dynamic range scenes in a computationally efficient manner.

TIMELINE/MILESTONES

1. Collect training dataset (base dataset, iPhone 8 data): Feb. 17
2. Pre-network processing (frame alignment): Feb. 20
3. Construct base neural net: Feb. 27
4. Post network processing (alpha blending): Mar. 6
5. Reduce network (prune, quantize): Mar. 10
6. Poster and Report: Mar. 13

[Nima 17] Nima Khademi Kalantari and Ravi Ramamoorthi. 2017. Deep high dynamic range imaging of dynamic scenes. ACM Trans. Graph. 36, 4, Article 144 (July 2017), 12 pages. DOI: https://doi.org/10.1145/3072959.3073609

[Hasinoff 17] Samuel W. Hasinoff, Dillon Sharlet, Ryan Geiss, et.al. 2017. Burst photography for high dynamic range and low-light imaging on mobile cameras. http://static.googleusercontent.com/media/hdrplusdata.org/en//hdrplus.pdf

[Bilcu 08] Radu Ciprian Bilcu, Adrian Burian, Aleksi Knuutila and Markku Vehvilainen. 2008. High Dynamic Range Imaging on Mobile Devices. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4675101