

EE367 Project Proposal

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Motivation: To improve low-light mobile phone photography by registering multiple burst images and comparing the merged image performance in a contrast enhancement pipeline to the performance of a single image.

Project overview:

Phone cameras are becoming increasingly sophisticated, but they still suffer in conditions of low light. Current solutions include combining flash/no-flash pairs, deblurring, or denoising. None are foolproof, and the last two especially suffer from a lack of information. We propose to combine information from multiple images in low-light situations to enhance denoising and image sharpening. iOS 10 allows the user to save pictures in raw format, which contains more information to test our algorithms. We will take several raw photos in quick succession with low exposure and merge them into a single image for the rest of the enhancement pipeline.

For image registration, we will implement fast algorithms meant for commercial phone usage rather than more accurate but time-consuming methods. We will try the patch-based algorithm used on the Google Pixel phone, a corner-matching algorithm implemented by Nvidia, and a pixel-by-pixel alignment used with lucky image weighting. We will also implement collaborative non-local means, which uses additional information to denoise a reference image but does not actually perform registration. Once we have a single merged image, we will denoise it with NLM and BM3D and compare it to the original reference image.

After we have registered the images, we will implement a processing pipeline for enhancing color and contrast. Our pipeline will include algorithms such as LIME (Low-light Image Enhancement, for estimating illumination and re-lighting the image), exposure fusion (approximating HDR fusion with the original low-exposure image and the new brightly lit image), dehazing, and tone mapping. We will see which of these steps work best by testing them on different cases. Finally, we will compare sharpness and image quality at the end of the pipeline and hopefully see that the merged image behaves better than the single image.

Milestones:

- 1) 2/22: Review literature and revise proposal
- 2) 3/1: Implement simple alignment algorithm, CNLM, denoising, and LIME
- 3) 3/8: Implement remaining registration methods and image quality enhancements
- 4) 3/12: Find metrics for comparison and test algorithms on real-life images in different contexts
- 5) 3/15: Poster Presentation

Related work:

- Motion Stills, the iPhone app that stabilizes the Live Photos:
<http://mashable.com/2016/06/07/google-motion-stills-app-live-photos/#FnC3_TmH7aqG>
- Google Pixel camera:
<<http://www.androidpolice.com/2016/10/18/google-explains-software-makes-pixels-camera-impressive/>>

Scientific references:

Registration:

- **CNLM:** “Collaborative non-local means denoising of magnetic resonance images,” Geng Chen, Pei Zhang, Yafeng Wu, Dinggang Shen, and Pew-Thian Yap. IEEE International Symposium on Biomedical Imaging, 2015.
<<http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=7163936>>
- **Pixel-based:** “Seeing Mt. Rainier: Lucky imaging for multi-image denoising, sharpening, and haze removal,” Neel Joshi and Michael Cohen. IEEE International Conference on Computational Photography, 2010.
<<http://ieeexplore.ieee.org.ezproxy.stanford.edu/document/5585096/>>
- **Patch-based:** “Burst photography for high dynamic range and low-light imaging on mobile cameras,” Samuel Hasinoff, Dillon Sharlet, Ryan Geiss, Andrew Adams, Jonathan Barron, Florian Kainz, Jiawen Chen, and Marc Levoy. ACM Transactions on Graphics, 35(6), Nov 2016. <<https://research.google.com/pubs/pub45586.html>>
- **Feature-based:** “Locally Non-rigid Registration for Mobile HDR Photography”, Orazio Gallo, Alejandro Troccoli, Jun Hul, Kari Pulli, and Jan Kautz. IEEE Conference on Computer Vision and Pattern Recognition Workshops, 2015.
<<http://ieeexplore.ieee.org.ezproxy.stanford.edu/document/7301366/>>

Contrast enhancement:

- **LIME:** “Multi-scale retinex for color image enhancement,” Z. Rahman, D.J. Jobson, G.A. Woodell. International Conference on Image Processing Proceedings, 1996.
<<http://ieeexplore.ieee.org.ezproxy.stanford.edu/document/560995/>>
- **Exposure fusion:** “Exposure Fusion,” Tom Mertens, Jan Kautz, and Frank Van Reeth. Pacific Conference on Computer Graphics and Applications, 2007.
<<http://ieeexplore.ieee.org.ezproxy.stanford.edu/document/4392748/>>
- **Dehazing:** “Single-image haze removal using dark channel prior,” Kaiming He, Jian Sun, Xiaoou Tang. IEEE Transactions on Pattern Analysis and Machine Intelligence, 33(12), Dec 2011. <<http://ieeexplore.ieee.org.ezproxy.stanford.edu/document/5567108/>>