Low-cost Computational Astrophotography

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Introduction

- Astrophotography is a popular hobby that can be quite expensive due to the equipment involved
- Long exposure is needed to capture celestial bodies
- Earth's rotation causes objects to "move" during exposure which results in star streaks
- Goal: use computational techniques to remove need for rotating mounts and instead post-process images

Related Work

- Most astrophotographers compensate for the rotation of the earth by physically moving the camera
- Remap star streak to polar coordinates, so all stars will have the same "point-spread function" [4]
- Post-processing techniques as Richardson-Lucy deblurring [2] and maximally sparse optimization [1]

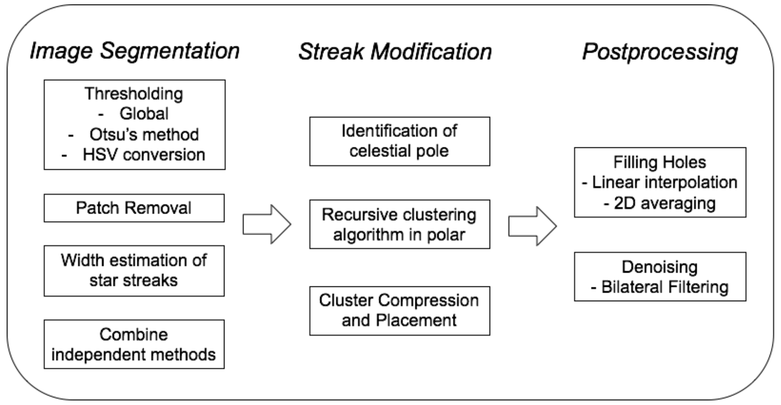
Dataset

- 35 photos of star streaks from Google Images
- All images included celestial pole in photographs
- Performed image preprocessing by removing watermarks and other irrelevant borders
- Varied parameters such as foreground/background elements, # of star streaks, illumination, and noise

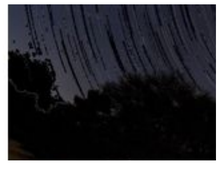
Image 1: original

Image 2: original

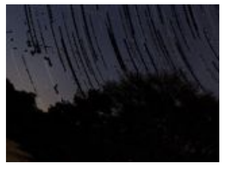
Methods



Results/Discussion



Without patch removal



With patch removal

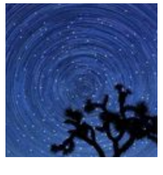
Width estimation

Combined thresholding

Hole filling

Polar Transform

Compressed Polar



Combined Image

Results/Discussion

Qualitative

- Stars are localized at center of original star streaks
- Sky is filled-in smoothly, even with color gradients
- Some issues with segmenting and star shaping remain

Quantitative

- Avg. variance decreases from 2.68e-3 to 1.04e-3
- T = 20 s for medium size images (500k pixels)
- T = 80 s for large images (3 million pixels)

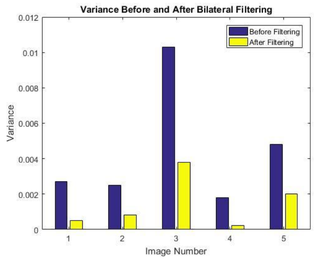


Image 1: processed

Image 2: processed

Conclusion and Future Work

- Algorithm successfully replaces majority of star streaks with appropriately colored point stars
- Images aesthetically pleasing after hole filling, denoising
- Obtain self-taken photos to test algorithm
- Potentially use machine learning to segment streaks
- Investigate other clustering/hole filling techniques

References

[1] B. D. Jeffs and M. Gunsay. Restoration of blurred star field images by maximally sparse optimization. IEEE Transactions on Image Processing, 2(2):202–211, April 1993.
[2] L. W. H. W. Y. H. Laili Su, Xiaopeng Shao. Richardson-lucy deblurring for the star scene under athinning motion path. 9501, 2015.
[3] N. Otsu. A threshold selection method from gray-level histograms. IEEE Transactions on Systems, Man, andCybernetics, 9(1):62–66, Jan 1979.
[4] B. Sease and B. Flewelling. Polar and spherical image transformations for star localization and rso discrimination. 01 2015.