Final Project

Exposure Fusion

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Introduction

A single photo captured by a camera is inadequate in capturing the entire dynamic range of a real-world scene. This is due to the fact that color channels are represented in only 8 bits, giving us a range of 0-255 values to describe an image, where 0 is the darkest value and 255 is the brightest. So how can we go beyond this range and capture a larger range of brightness in a scene? There are 2 ways to do this, which are HDR with tone mapping and exposure fusion. If we want to do HDR however, we need to know the exposure time of an image, and then use tone mapping to put in the range of 0-255 to have it be viewable. This is where exposure fusion is helpful, as it allows us to be able to use multiple images of varying exposure times to get an image that captures the full dynamic range without explicit tone mapping.

Implementation

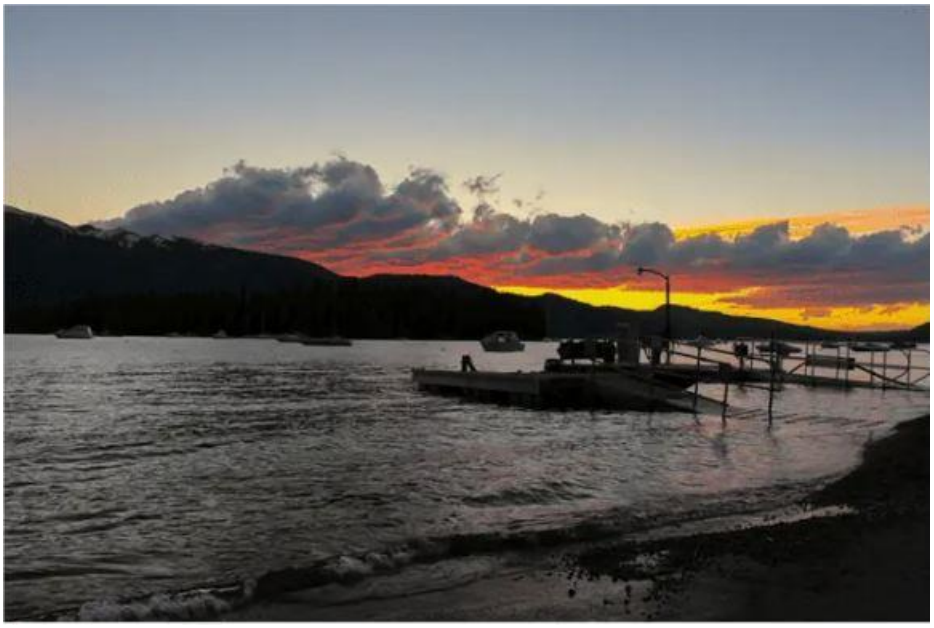
In order to implement exposure fusion, we need to be able to utilize images of scenes that have been underexposed and overexposed. Using these 2 types of images we can take the elements that each type possesses and combine those aspects into a single image for a balanced exposure. To implement this, we first align the images using linear interpolation. Then we merge the images using an algorithm developed by Tom Mertens in his Exposure Fusion paper. We use the OpenCV implementation, which uses this equation under the hood:

$$\hat{W}_{ij,k} = \left[\sum_{k'=1}^{N} W_{ij,k'} \right]^{-1} W_{ij,k}$$

This is used to create a weighted average along each pixel to fuse the input images. We then normalize to make sure the values of the weight maps sum to 1 at each pixel (i, j). We then get the resulting image by a weighted blending of the image using Laplacian pyramids. The resulting image does not require explicit tone mapping and can just be converted to 8-bit by multiplying by 255.

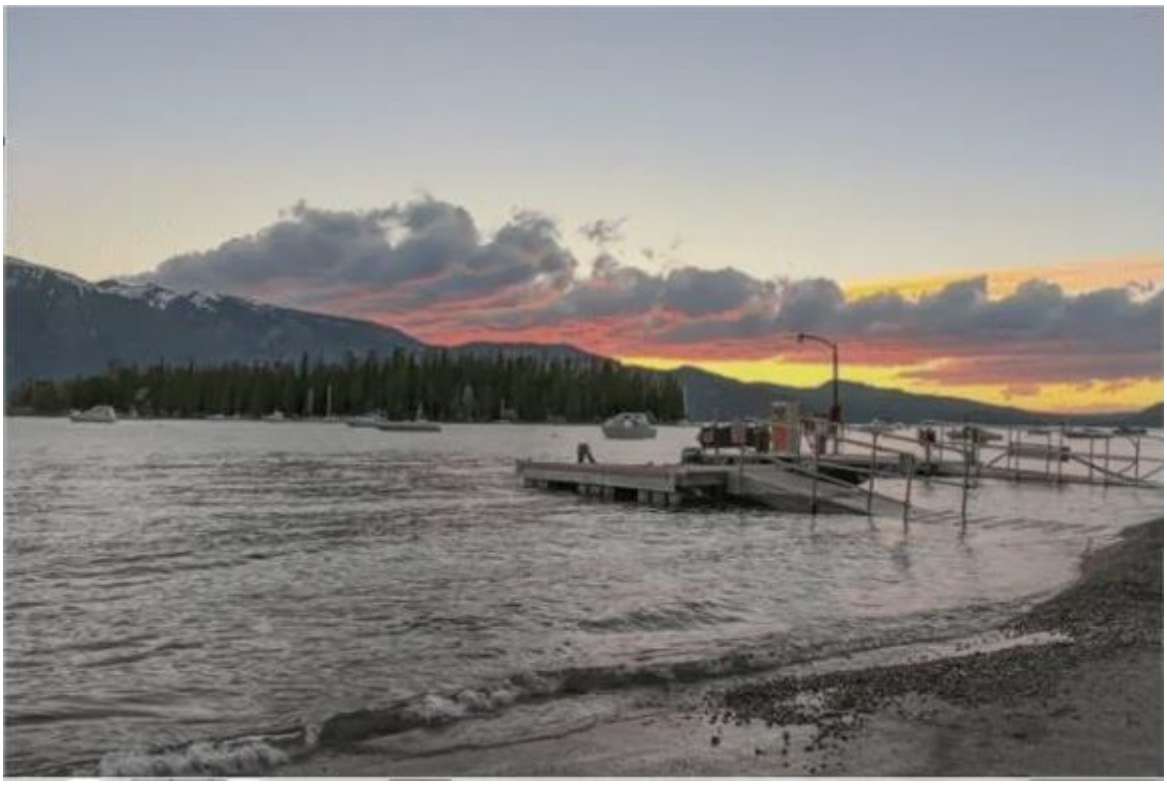
Results

The following are results from conducting this process.



(Figure 1.1) Low Exposure Image

(Figure 1.2) High Exposure Image



(Figure 1.3) Resulting Image

(Figure 2.1) Low Exposure Image

(Figure 2.2) High Exposure Image

(Figure 2.3) Resulting Image

Analysis

As we can see from the results, we have been able to capture a much wider dynamic range. The low and high exposure images allowed us to dynamically build an image that captures information from both types to craft an image with enhanced details in both shadows and highlights.

Looking at Figure 1.3 and 2.3, both the darkest and brightest areas of the image show more detail than the single-exposure images. The sky has a darker hue as borrowed from the low-exposure image in Figure 1.3, as well as brighter water artifacts from the high-exposure image. Figure 2.3 is a fully balanced image. The images have worked together to produce an image that captures the right amount of detail, especially in areas like the barn and the tree’s leaves.