Identification and Classification of Holds for a Rock Climbing Wall

Sean Csukas

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Abstract

This project was created analyze rock climbing walls in the real world and recreate, modify, and traverse them in the digital world. This is done through a series of steps from image collection, hold detection and classification, route planning, and AI traversal.

1 Introduction

The project is currently a work in progress as of the date of this paper. Current progress includes hold detection and classification by color with few errors on stock images found online. The same method suffers from color and lighting differences on real images taken with a smart phone. Due to the need for depth information from multiple angles. The project has been taken into the 3D space, using point cloud models created using photogrammetry. With this, more information can be collected on each hold, including size, difficultly, angle, etc.

2 2D Space

2.1 Method

Within the 2D Space, images could be classified by color and edges. The image is first filtered manually by color using the image in the HSV color space. A median blur is used to smooth out the color difference across the image before filtering. The resulting binary image is then passed into an openCV blob detector to find the keypoints of the image i.e. the holds on the wall. Each keypoint is then processed, finding the most common color within a rectangle of size proportional to the keypoint. The colors then are sorted into a histogram to group similar colors. The final groupings are drawn back onto the original image.

2.2 Drawbacks

There are some issues seen with the 2D classification method. Shadows can often be misclassified as holds, and holds covered in chalk from climbers can obscure hold from the detector. This method also has no depth information, which means very little information can be gathered about the complexity or difficulty of that hold.

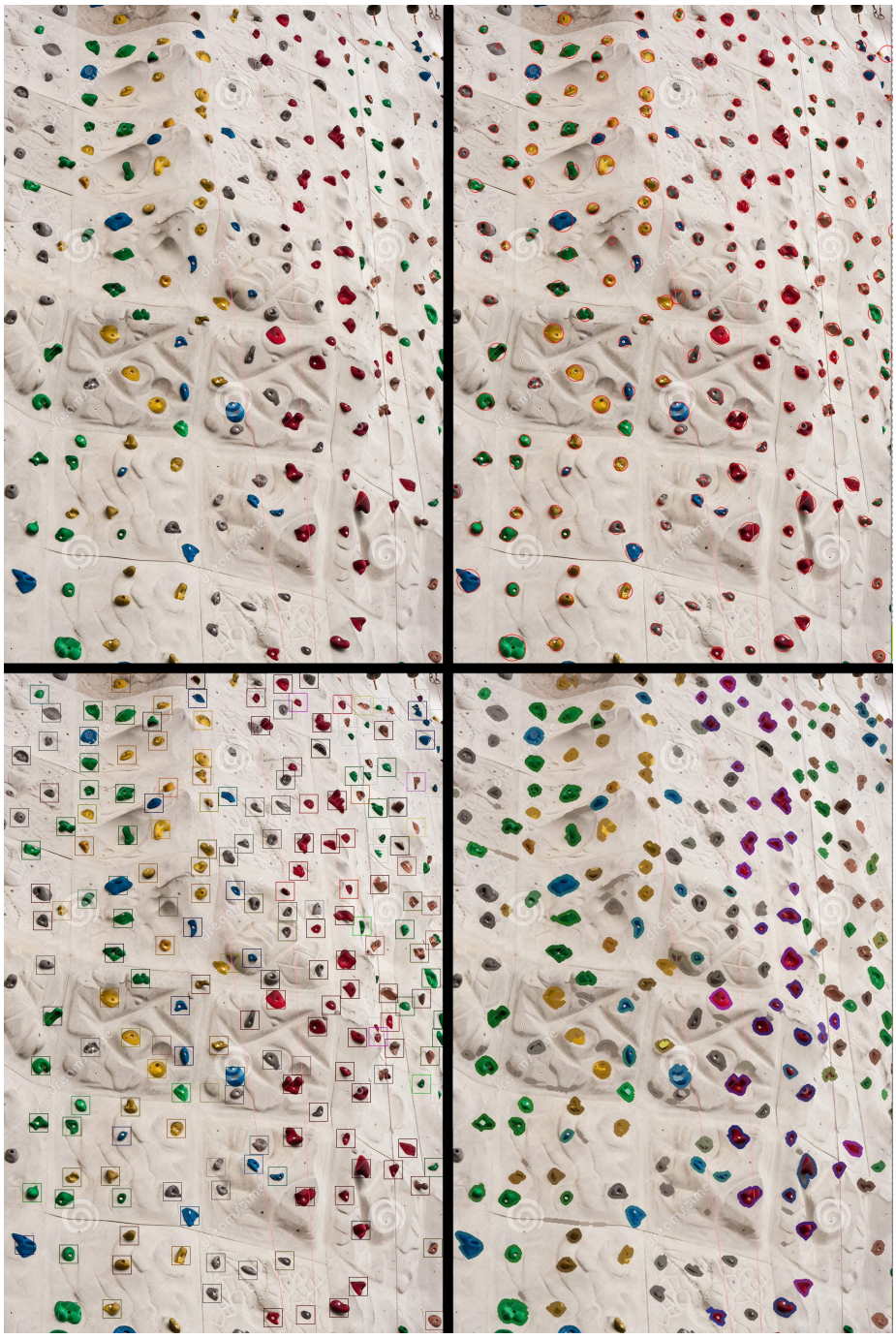

Figure 1: Full process of hold detection and classification.

3 3D Space

Within the 3D space, more information can be gained about the wall, such as the angle of the wall and the complexity of the hold.

3.1 Method

Three dimensional information is gained using photogrammetry. This is a method of creating a 3D model by stitching together 2D images. Autodesk Remake is used to complete this process. The result is a high resolution model that fully recreates the wall. An example portion can be seen in figures 2 and 3. This model gives full view inside and around each hold and preserves the angle of the wall relative to the ground. It is created from 250 images of the wall from several different views.

Figure 2: Right side view of wall model.

Figure 3: Top side view of wall model.

3.2 Drawbacks

With this method, the main drawback is the acquisition method. The current model only spans about 5% of the entire wall but required about 250 pictures. The pictures can be taken relatively quickly, about one minute for the full set, but each set must be processed into a model individually due to the limit set by the student version of Autodesk ReMake. These models then had to be concatenated together to build the full model.

Space complexity is also a consideration. The model shown has a size of roughly 50MB, including the texture. Assuming again the represents 5% of the entire model, we can extrapolate that the full wall structure would take up at least 1 GB. For storage purposes, this is inconsequential, but for processing to segment the holds from the wall, the time complexity will drastically increase. This however can be combated by decimating the model, that is, reducing the number of polygons used to represent the model. This experimentally is able to remove up to 80% of the points used, at the expense of resolution. The decimated model could be used for pre-processing to eliminate large sections of wall that don't need to be searched for holds.