A Photogrammetry Algorithm

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Background

What is photogrammetry and what it it currently used for?

- Photogrammetry is the process of creating a 3D model out of a series of photos.
- Photogrammetry has many applications. It's useful in various fields, such as:
  - Mapping (cities, terrain models, ect.)
  - Digital preservation of cultural heritage
  - Robotics
  - Digital art and design
  - Film and entertainment
  - Medicine
- This project in specific is aimed to provide an accessible method for the user to create a small-scaled 3D model for personal use.

Methods

There are 5 components to the algorithm

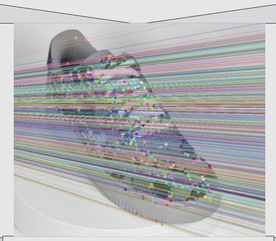
1) **Input:**
   - The photos should encapture all points of the object (save the bottom). Each photo must have intersecting points with the previous image taken.
2) **Image matching:**
   - Feature points are distinct pixels that have strong/distinct features (using the information we get from a histogram) based on Speeded-Up Robust Features (SURF) of line segments.
   - Using the feature points, we find the straight line of intersection of the epipolar plane with the image plane for the purpose of making the algorithm faster and more accurately identifying overlapping feature points.
3) **Camera Calibration:**
   - Estimating the intrinsic and extrinsic camera parameters using correspondences between 3D-2D control points (rotation and translation)
4) **Triangulation:**
   - Constructing a 3D point cloud of the object from a set of tie points in the stereo images that the user inputs
5) **Output:**
   - A 3D model of the object

Architecture Overview

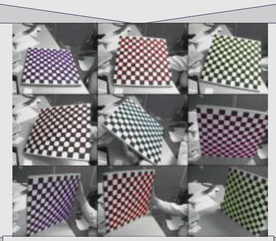
This overview goes through portions of the algorithm with a graphical representation of its return result.

1 The user **inputs** a series of 2D images to the algorithm for the purpose of getting a 3D model of the object.

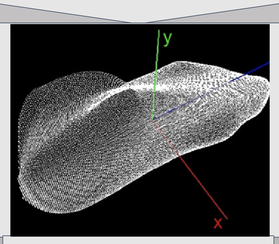
2 Then, the algorithm identifies **image matches** using keypoints. Epipolar lines are then constructed by those keypoints to make the images stereo.



3 To **calibrate the camera**, the user must take a 3 photos of an object of known dimensions. For this algorithm in specific, the user must take a photo of a 6x9 checkerboard.



4 A **point cloud** is constructed using the 3D points that are calculated. Then the points are connected and tied together, creating a 3D image.



5 The **output** is a 3D model of the object, created by the 2D images that were inputted.

Evaluation

How does the algorithm work best?

- The algorithm was test for the purposes of estimating the best distance to take the photos from.
- 5 objects of similar dimensions and differing sizes were used in this experiment. The photos were taken from the same distance from each other. It can be concluded that the further away the object is from the camera (as long as the pixel quality is not compromised), the better the results.

Literature Review

Methods used throughout the algorithm

- The feature point detection uses the speeded up robust features (SURF) offered by OpenCV, which is a patented local feature detector and descriptor.
- This algorithm incorporates Zhang method of camera calibration which was first proposed in 1998. It is considered one of the standard methods of camera calibration which uses know calibration points and self-calibration techniques

Takeaways

What I learned and what I accomplished

- The main purpose of creating this algorithm was to become more familiar with 3D spaces and computer graphics in general.
- Photogrammetry has a wide variety of uses, and new methods/ software is constantly being researched and created, but not implemented. If these new discoveries were to be put to use more efficiently, this useful process would be more accessible, progressing applicable fields.