Assignment 2

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Time spent:
22:31:44
(hrs:min:sec)

Question 1: 3D Reconstruction using Underwater Stereo Vision (50%)

Introduction

Stereo vision is the process of gathering data from two cameras, matching the points and then calculating the 3D points of the image, as shown in Figure 1:

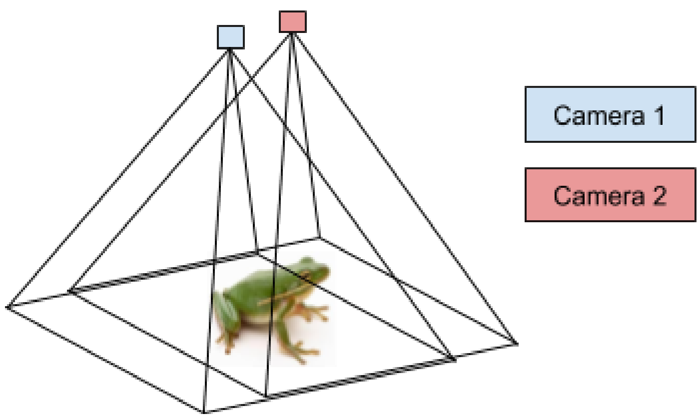

Figure 1: Stereo Vision

Camera 1 and Camera 2 have different perspectives of the same object, in the example, the frog. Matching points are calculated and then, by triangulating the position, 3D points are calculated, as shown in Figure 2.

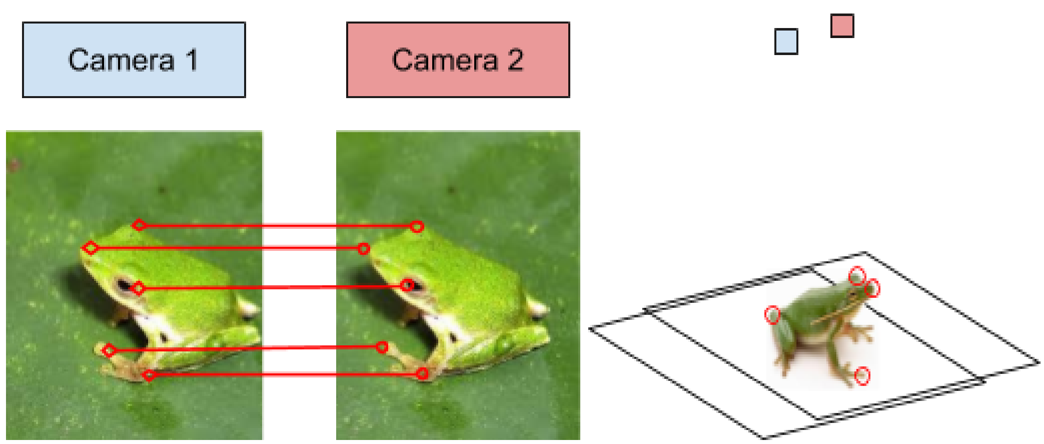

Figure 2: Matching and triangulating points

SURF and Harris are some common algorithms to extract features.

Applications of this technique vary. For instance, this method can be used to calculate the depth of an object.
Let's assume that we have a system that can locate an apple in a 2D space. We want a robot to pick up that apple, but we are missing the Z component. By using two cameras, the apple can be located in both cameras and we can triangulate the position.

Methodology

Similar to the frog procedure, the steps followed for the development of question 1 are listed in Figure 3.

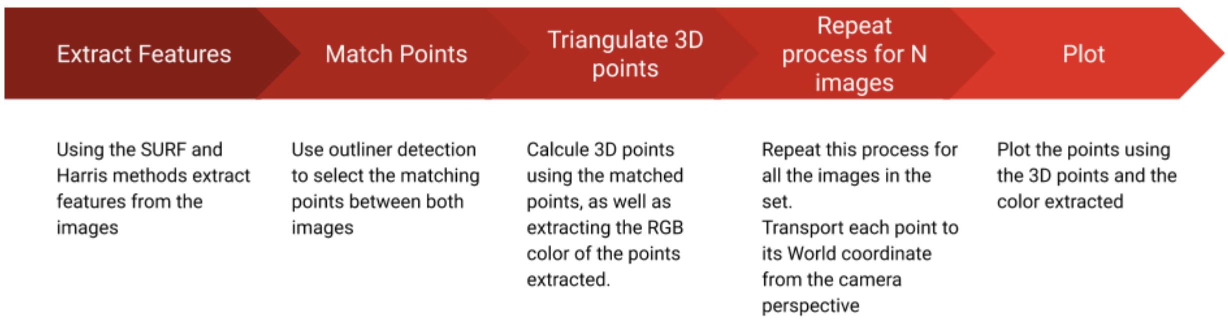

Figure 3: Methodology for stereo vision

One thing to point out is that when the 3D points are calculated the color of those points can also be saved. By doing so we are able to plot the points later on.
What is different from the introduction is that the frame of reference switches between the camera to the world, as shown in Figure 4. The camera is now moving, thus the frame of reference. The key to solving the problem is to change the points to a World reference.

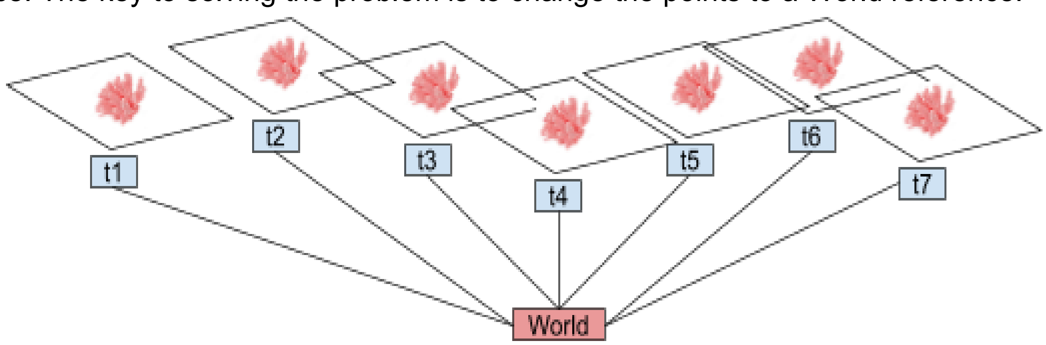

Figure 4: Different takes of images moving through the seabed.

Once the points for each pair of images have the world frame of reference, all points can be plotted using scatter3. The resulting cloud of points is shown in Figure 5.

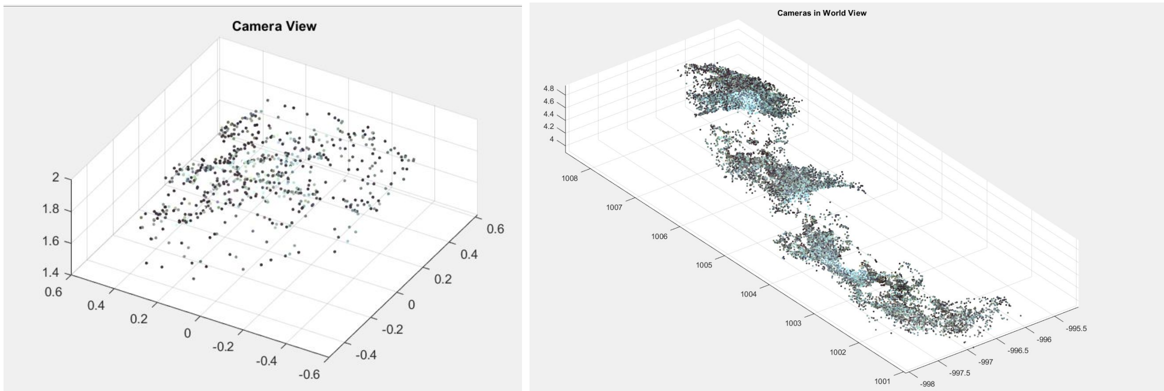

Figure 5: 3D points through the camera's frame of reference, left.
All pairs combined through the world's frame of reference, right.

This outcome matches the values given by the tutor on the assignment 2 pdf.

Results and Discussion

SURF and Harris comparison

Two highly popular extraction algorithms were used during the development, as shown in Figure 6. Both options were timed and analyzed.

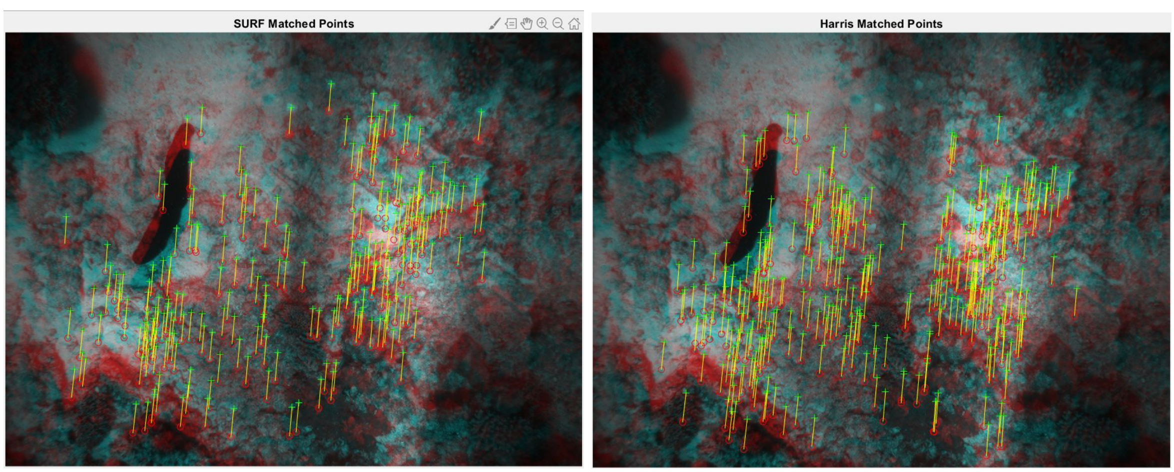

Figure 6: SURF vs Harris, image pair comparison.

For feature detection and points match the **SURF** algorithm took **0.37 seconds.**
The **Harris** algorithm, on the other hand, was twice as slow with **0.82 seconds.**
The matched points using SURF are sufficient, therefore that was the algorithm used.

Run time

Each subroutine was timed to find the most time-consuming algorithms. The slowest part was the undistortion of the points. The function “tic toc” was used to time the algorithms.

```
% undistort 0.768767 s
tic
undistort1 = undistortPoints(matchedPoints1.Location, stereoParams.CameraParameters1);
undistort2 = undistortPoints(matchedPoints2.Location, stereoParams.CameraParameters2);
toc
```

Figure 7: tic toc used to measure the undistortion of the points run time

The elapsed time was 0.768767 seconds for 1 iteration. This means that to be able to undistort all points from all images will take 0.768767 times 49.
This means **37 seconds** lost on undistorting points, making the program really inefficient.

To solve the problem, the calculated inliners were calculated with and without distortion.

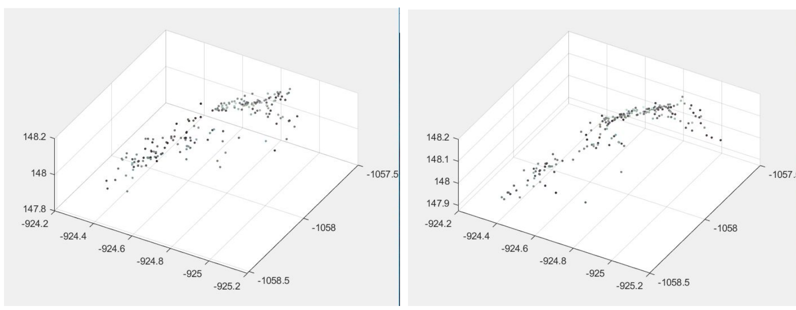

Figure 8: undistorted out-liner detection, left
Distorted out-liner detection, right

The results are really similar. One thing to consider is that the out-liners are calculated using a RANDOM function. Each batch of the same configuration will outcome different points.
For a faster performance (that includes certain errors), the out-liners can be omitted.

Performance

The overall performance of the system was highly similar to the graph provided by the tutors.
The axis is within the range of X,Y,Z provided and the shape matches without any major change