Automatic Multi-Camera Extrinsic Calibration

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1. Introduction

Camera Calibration

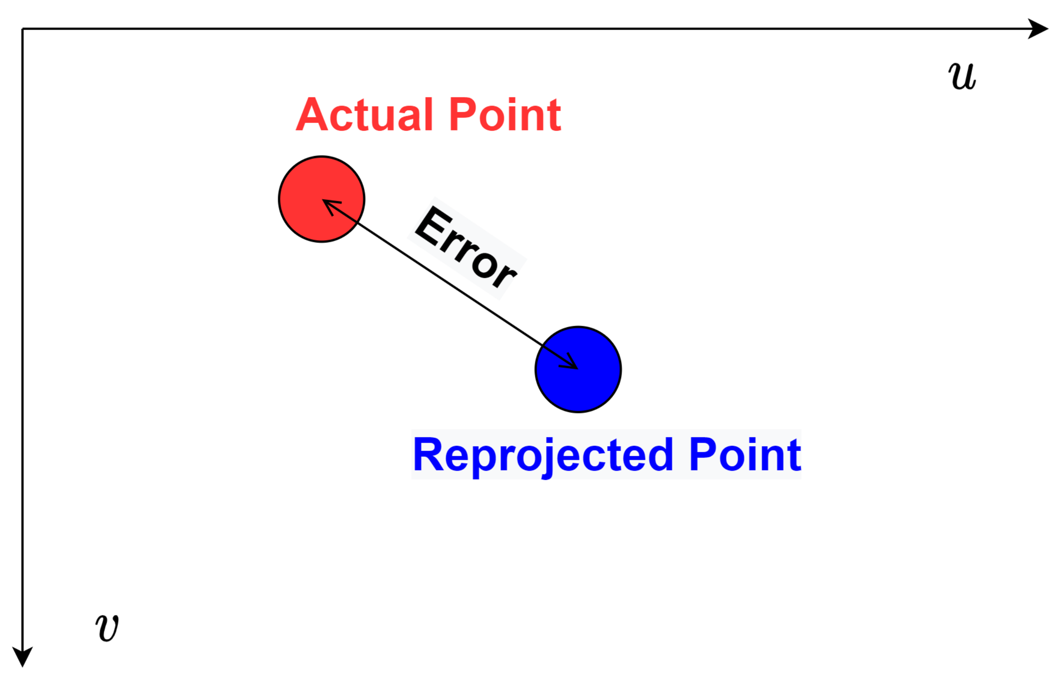
Calibration refers to determining the **intrinsic** and ***extrinsic*** parameters of a camera. Once known, metric information can be recovered from video footage for a number of applications, such as: robot navigation or reconstructed 3D simulation. It typically follows a two stage process, finding the initial estimates and a subsequent optimization of the parameters.

Trajectory Optimization

Trajectory optimization was employed to optimize the calibration parameters as it provides a means to constrain the system and can reduce the effect of outliers.

It was intended to minimize reprojection error by adjusting the following for all the cameras:

- The extrinsic parameters and,
- 3D estimate points.

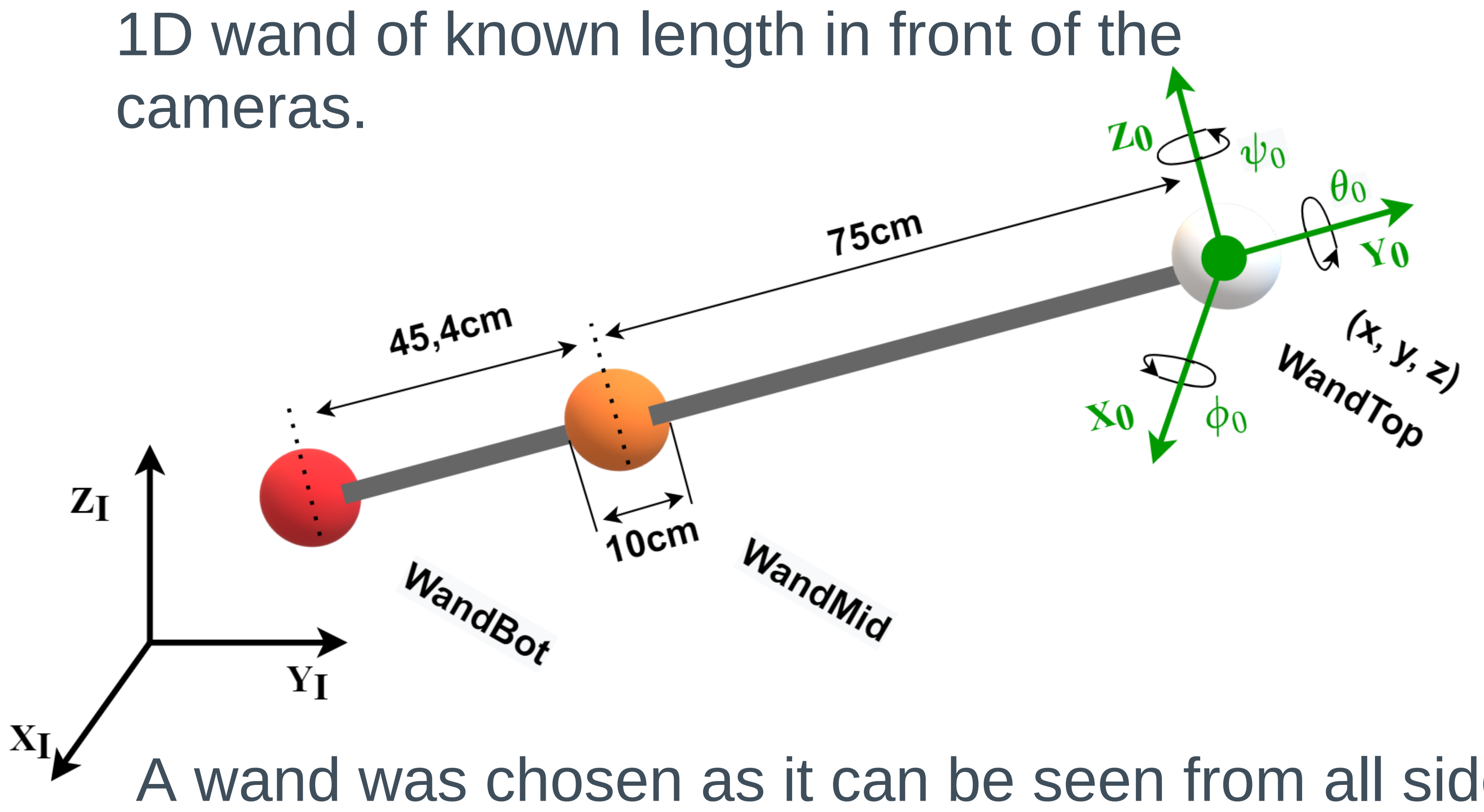


Reprojection error illustration

2. Design

Calibration Object

Calibration was performed by moving a 1D wand of known length in front of the cameras.



A wand was chosen as it can be seen from all sides and is easy to manipulate in large volumes.

Automatic Marker Detection

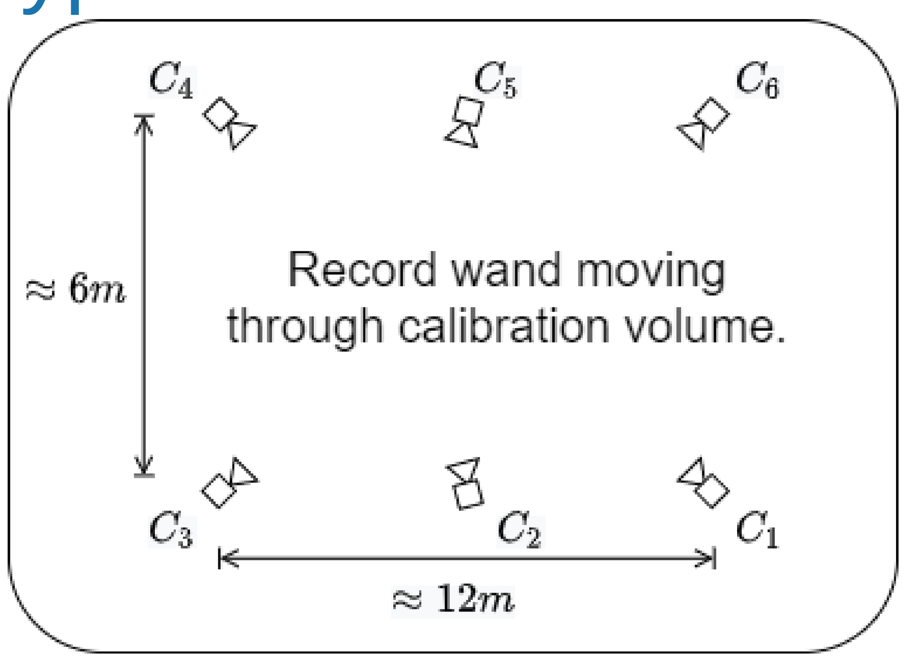
A convolution neural network, a subsection of machine learning from the DeepLabCut toolbox, was trained to track and identify the three distinct markers on the wand. The output was the pixel locations.

Before Colour

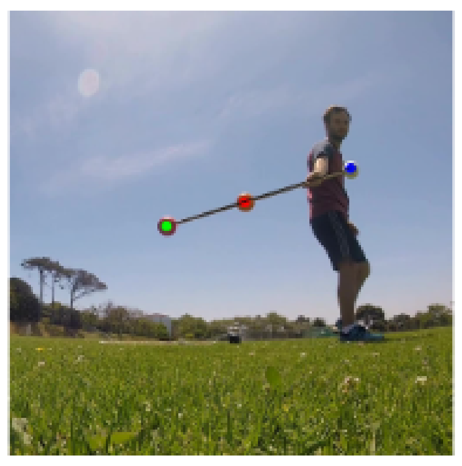
After Colour

Initially, all the markers were white and resulted in poor tracking. Thus, colour was added to the markers to make them more distinct. A video comparison is illustrated with the QR codes on the left.

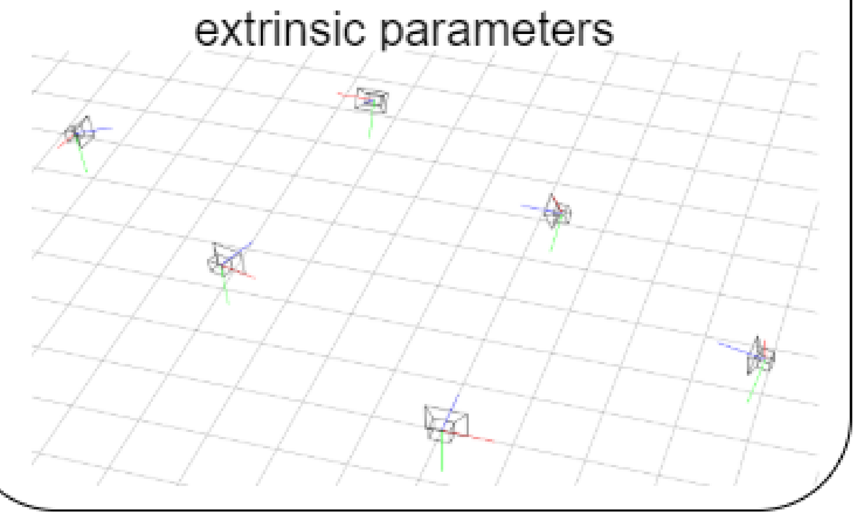
Typical Work Flow



Track wand markers and extract pixel locations from footage



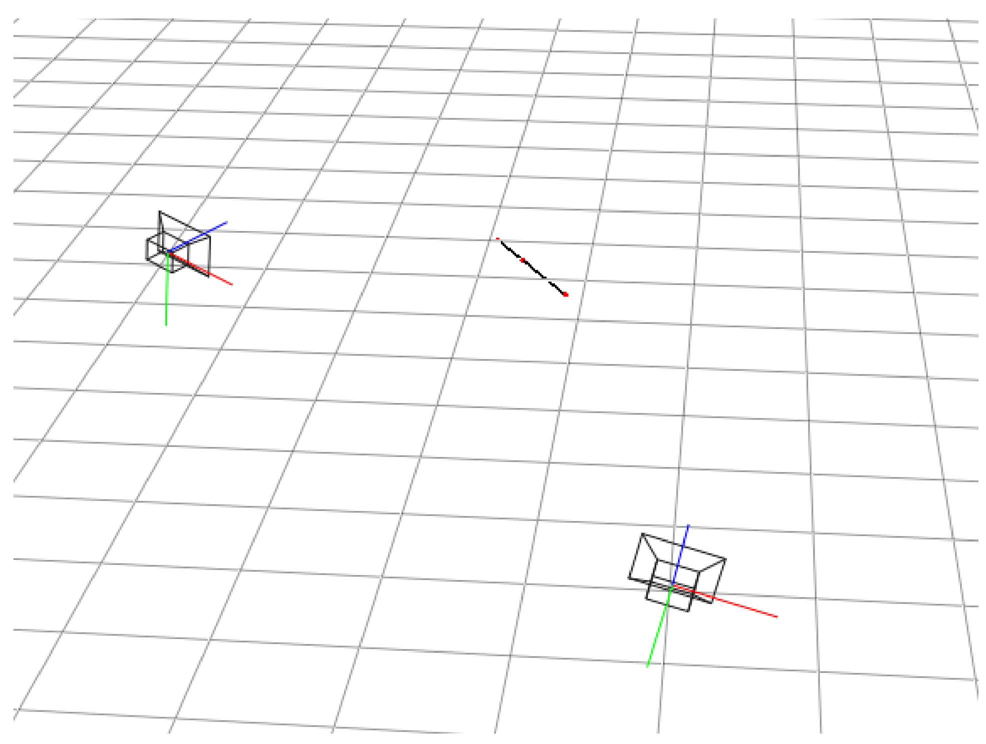
Use Initial calibration estimates and tracked points to optimize extrinsic parameters



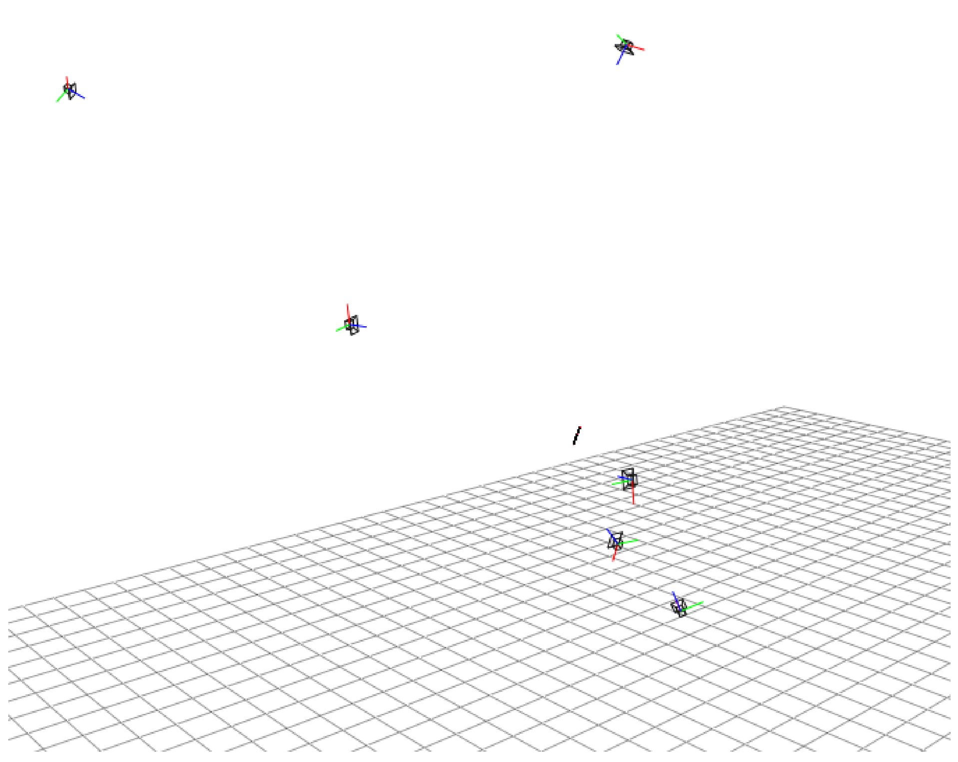
Expected 6 camera extrinsic output

3. Results

The wand calibration method was compared to a common approach of maneuvering a large checkerboard pattern through the field of view of multiple cameras. It was found that the trajectory optimization approach produced comparable results in optimizing the calibration of two cameras. Under the time constraints of the project, the case for 6 cameras was not successfully implemented. The problem was thought to have arisen from the formulation of the trajectroy optimization problem.



Successful 2 camera extrinsic output



Unsuccessful 6 camera extrinsic output

4. Conclusion

Based on the limited results obtained, no thorough comparison could be performed between the wand trajectory based calibration and the common checkerboard approach. However, it was concluded that the wand trajectory calibration could produce comparable results if the trajectory problem is formulated correctly.

It is recommended that marker detection is also improved to consistently identify the centroid of the spheres.