Camera-Calibration-using-Open-CV

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***Abstract*—A camera, when utilized as a visual sensor, is a vital piece for a few areas like robotics, surveillance, space exploration, social media, industrial automation, and even the entertainment industry. It is fundamental for us to know the parameters of a camera to utilize it successfully as a visual sensor. The process of estimating the parameters of a camera is called camera calibration. This means we have all the information (parameters or coefficients) about the camera required to determine an accurate relationship between a 3D point in the real world and its corresponding 2D projection (pixel) in the image captured by that calibrated camera. There are many types of camera calibration techniques . The major techniques are - Calibration pattern ,Geometric clues, Deep Learning based .Chessboard images are used for implementation of this project. Checkerboard method is used in these implementation which falls into the category of Calibration pattern , this method is better than others and widely used because of many reasons that we will discuss . For accomplishing this Open CV library in Python and Python Programming Language are used. The camera is calibrated as a result of this implementation . A lot of important parameters of camera are obtained like Intrinsic camera matrix ,Lens distortion coefficients etc. and hence will help us understand lens distortion.**

***Index Terms*—Intrinsic, Calibration, extrinsic , Distortion**

I. Introduction

In the computer vision, the mathematical data of three-dimensional article is acquired from the picture data by cameras. To get the relating connection between the spatial point and the camera picture pixel, the camera calibration is vital. The relationship between the three-dimensional mathematical area of one point and its relating point in the still up in the air by the mathematical model of camera imaging, and these mathematical model boundaries are the camera boundary. In most condition, these boundaries should be acquired through the analysis and the estimation, and this interaction is known as the camera calibration. Albeit the hypothesis on the camera calibration is now extremely developed, and the calibration techniques are additionally some, so far there isn't a strategy to have the option to utilized in an assortment of events, attributable to the camera calibration has the far reaching application prospect and the tremendous monetary productivity in the area of the robot route, the three-dimensional remaking and such, so many researchers and examination foundations.

The applications of camera calibration involves :- Mobile robot navigation, Machine vision, Biomedical, Visual surveillance.

A. Camera calibration

The process of estimating the parameters of a camera is called camera calibration.

This means we have all the information (parameters or coefficients) about the camera required to determine an accurate relationship between a 3D point in the real world and its corresponding 2D projection (pixel) in the image captured by that calibrated camera.

Typically this means recovering two kinds of parameters

Internal parameters of the camera/lens system. E.g. focal length, optical center, and radial distortion coefficients of the lens. External parameters : This refers to the orientation (rotation and translation) of the camera with respect to some world coordinate system.

B. Motivation

Camera calibration is a necessary step in 3D computer vision in order to extract metric information from 2D images.The proposed technique only requires the camera to observe a planar pattern shown at a few (at least two) different orientations. It is essential to know the parameters of a camera to use it effectively as a visual sensor. Distortion effects are introduced by a lens .By the derived distortion coefficients we can obtain the un-distorted image.

We are using checkerboard images and this method is widely used compared to other proposed methodology because of the following reasons. Checkerboard patterns are distinct and easy to detect in an image. Not only that, the corners of squares on the checkerboard are ideal for localizing them because they have sharp gradients in two directions. In addition, these corners are also related by the fact that they are at the intersection of checkerboard lines. All these facts are used to robustly locate the corners of the squares in a checkerboard pattern.

C. Research Contributions

Geometric clues: In these method other geometric clues are there like straight lines and vanishing points which can be used for calibration.

Deep Learning based: In these method we have a single image of the scene, it may still be possible to obtain calibration information of the camera using a Deep Learning based method.

II. Literature Work

In this section we are discussing some major proposed methodology and their adavantages and disadvantages.

A. Hu Zhan-yi, Wu Fu-chao. A review on some active vision based camera calibration techniques [J]. Chinese Journal of Computers, Vol.25, No.11, 1149-1156, 2002.

In this technique, a bunch of transitional boundaries are characterized, and afterward the characteristic furthermore extraneous boundaries of camera model could be tackled by setting up and settling straight conditions without iterative estimations, which is the fascination of the direct direct change technique. Due to this methodology involved not many boundaries and determined effectively, it is somewhat simple to be taken on. Nonetheless, this methodology did not consider the non-direct bending issues during the camera works. To expand precision, the direct straight change strategy can be extended to incorporate these non-straight factors and utilized non-direct means to tackle them.

B. Gozde Unal, Anthony Yezzi, Stefano Soatto.A variational approach to problems in calibration of multiple cameras finder from natural scenes [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol.29, No.8, 1322-1338, 2007.

The benefits and disservices of the contortion alignment technique are proposed dependent on a straightforward and fast alignment technique for the focal point contortion boundaries.This method makes use of the perspective projection of the cross-ratio invariance, in the distortion model is a first-order radial distortion of the cases, only needs the space to a total line of the image coordinates of four points and their cross-ratio, for example, the establishment of a quadratic equation distortion parameters can be calibrated.

C. Yuan Ye,Ou Zong-ying. An adaptive algorithm of camera calibration based on single neuron [J]. Journal of Dalian University of Technology, Vol.45, No.6, 823-826, 2005.

It used a simple structure, strong anti-interference ability of individual neurons adaptive algorithm instead of the usual non-linear optimization algorithm for camera calibration. Experimental results show that the algorithm without calculating the Jacobian matrix, and high precision, simple and feasible. for the complex imaging and distortion models in process of calibration.

D. Liu Yuan-kun, Su Xian2yu, Wu Qing-yang. Multi-camera calibration by FTP technique [J]. Acta Photonica Sinica, Vol.36, No.9, 1734-1737, 2007.

It had proposed a calibration plate using a two-dimensional gray-modulated sinusoidal fringe pattern. According to Fourier fringe analysis the truncated phase distribution of two orthogonal directions can be calculated, and extract the phase feature points as 2D calibration data. We can use the 2D coplanar reference point calibration method to achieve calibration.

III. Methodology

Steps of work :- We are using Calibration pattern . We will

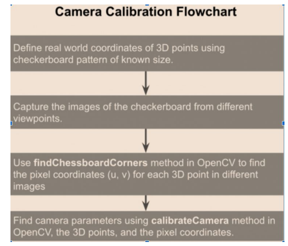

Fig. 1. Work Flow throughout the Implementation

perform calibration by capturing several images of an object or pattern of known dimensions from different view points. We are using images of the chessboard for this purpose.

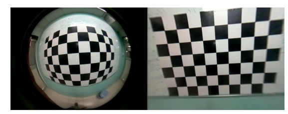

Fig. 2. Effect of geometric correction on distorted image.

1)Define real world coordinates of 3D points using checkerboard pattern of known size.

2)Capture the images of the checkerboard from different viewpoints.

3)Use findChessboardCorners method in OpenCV to find the pixel coordinates (u, v) for each 3D point in different images

4)Find camera parameters using calibrateCamera method in OpenCV, the 3D points, and the pixel coordinates.

Inputs : A collection of images with points whose 2D image coordinates and 3D world coordinates are known. Outputs: The 3×3 camera intrinsic matrix, the rotation and translation of each image.

A. Step 1: Define real world coordinates with checkerboard pattern

Fig. 3. Checkerboard Pattern

Our world coordinates are fixed by this checkerboard pattern that is attached to a wall in the room. Our 3D points are the corners of the squares in the checkerboard. Any corner of the above board can be chosen to the origin of the world coordinate system.

For the 3D points we photograph a checkerboard pattern with known dimensions at many different orientations. The world coordinate is attached to the checkerboard and since all the corner points lie on a plane, we can arbitrarily choose Z for every point to be 0. Since points are equally spaced in the checkerboard, the coordinates of each 3D point are easily defined by taking one point as reference (0, 0) and defining remaining with respect to that reference point.

B. Step 2 : Capture multiple images of the checkerboard from different viewpoints.

Keep the camera constant and photograph the checkerboard pattern at different orientations.

C. Step 3 : Find 2D coordinates of checkerboard

We now have multiple of images of the checkerboard. We also know the 3D location of points on the checkerboard in world coordinates. The last thing we need are the 2D pixel locations of these checkerboard corners in the images.

1) Find checkerboard corners:

2) Refine checkerboard corners:

D. Calibrate Camera

The final step of calibration is to pass the 3D points in world coordinates and their 2D locations in all images to OpenCV's calibrateCamera method.Camera intrinsic parameters are estimated assuming no distortion, and the predicted outer points lie closer to the image center than the detected ones.

IV. Results and Discussion

Fig. 4. Results after drawing the detected checker board corners

We see clearly that the curved pattern in the original images is straightened.e. The estimated distortion parameters allow us to correct the distortion in the original images.

V. Analysis

The recommended calibration procedure is as follows: 1. Print a pattern and attach it to a planar surface; 2. Take a few images of the model plane under different orientations by moving either the plane or the camera 3. Detect the feature points in the images; 4. Estimate the five intrinsic parameters and all the extrinsic parameters using the closed-form solution. 5. Estimate the coefficients of the radial distortion by solving the linear least-squares. 6. Refine all parameters by minimizing

A. Parameters

A vector of vector of 3D points.

- objectPoints The outer vector contains as many elements as the number of the pattern views.
- imagePoints A vector of vectors of the 2D image points.
- imageSize Size of the image
- cameraMatrix Intrinsic camera matrix
- distCoeffs Lens distortion coefficients. These coefficients will be explained in a future post.
- rvecs Rotation specified as a 3×1 vector. The direction of the vector specifies the axis of rotation and the magnitude of the vector specifies the angle of rotation.
- tvecs 3×1 Translation vector.

B. Computational Analysis

Time Complexity :O(N) as we are iterating once for all the images. Space Complexity :O(1) as we are iterating once for all the images.

https://github.com/mahima672000/Camera-Calibration-using-Open-CVCode Link

VI. Conclusion

In this paper, we have developed a flexible new technique to easily calibrate a camera. The technique only requires the camera to observe a planar pattern from a few (at least two) different orientations. We can move either the camera or the planar pattern. The motion does not need to be known. Radial lens distortion is modeled.Compared with classical techniques which use expensive equipment such as two or three orthogonal planes, the proposed technique gains considerable flexibility.This model can be applied to any vision sensors and as for many applications, it is essential to know the parameters of a camera to use it effectively as a visual sensor we discussed the calibration of the values of intrinsic and extrinsic parameters of the camera and hence understanding lens distortion.

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