Graphical Abstract

Volumentric Calibration and Compenstation of Video Measurement System by Multiple Plane Projection

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Highlights

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- Research highlight 1
- Research highlight 2

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Abstract

Video measurement system is a kind of non-contact measurement method, which has been widely used in the field of industrial measurement. However, the video measurement system is easily affected by the moving stage error. The calibration and compensation for the video measurement system is of great significance. Instead of using laser interferometer for 3D compensation for the moving stage, which is expensive and reluctent to implement real volumetric calibration, we propose a noval and efficient method for precise calibration and compensation of moving stage with only one checkerboard pattern under several positions/poses. We also proofed, with sufficient number of images/poses, the proposed method can achieve a very high accuracy of 3D compensation steadily.

Keywords:

1. Introduction

Video measurement system (VMS), which use a camera and stages for dimension measurement, has been widely used in the field of industrial measurement. Most of the VMS are equipped with telecentric lens for precise in-field measurement and a moving stage for inter-field measurement for large object. Ideally, the coordiante position of the key element can be obtained by combining the pixel coordinates in the image and the corresponding position of the moving stage.

However, the stage error is inevitable in the real measurement, especially for the large scale measurement. Typicallly, a VMS system is of 1 50 μm microns of error in a A4 paper sized measurement range, before anycompensations. Without any compensations, the stage error is one of the major sources of measurement error.

There has been a lot of research on the calibration and compensation of the VMS, e.g. []. Previous works, e.g. [], decompose the 3D mapping as three 1D mapping from the skewed axis the Cartesian axis one by one to, whitout considering the other two directions during each mapping, and assemble them directly. the stage calibration is typically compensated by the laser interferometer, which uses the principle of laser interference to measure the length of moving. The laser interferometer can measure length to very high precision, far better than sub-micron (0.1 μm), thererefor is widely used for linear calibration. However, the laser interferometer is **not** the direct and theroetical ideally method for 3D compensation, since it only measures one direction of the stage, at most with pitch, yaw and etc. errors along this direction but not the 3D position. Such methods are simple yet not suffcient. A prominant phenomemon is that the measurement error is big in 2D, let alone the 3D measurement. There has been patent [], works on the 2D mapping from the skewed 2D space to the Cartesian plane, whitout considering the other one direction. On the other hand, there has been a lot of research on the calibration and compensation of the VMS, whit Glass Lines, for one direction compenstation. Unfortunately, this kind of method is not directly applicable to volumetric calibration, since the difficulty of fabricating the glass dots on 3D, whithout interference with the imageing quality and precision, to our best knowledge.

We propose a novel and efficient method for precise calibration with only one planar checkerboard pattern under several positions/poses. Specificlly, we place the checkerboard pattern on the moving stage, and then move the stage to several positions/poses, and then each time we capture a set of corners of the checkerboard pattern. We then extract the skewed 3D coordinates of the checkerboard pattern from the images and linear scale. The corners in the checkboard pattern is predefined in the checkerboard coordiantes, but not the ideal coordinates, and then fit the 3D coordinates to a plane. After suffcient poses/positions, we can get the 3D mapping from the skewed 3D coordinates to the ideal 3D coordinates. We prooved that, with sufficient number of images/poses, the proposed method can achieve a very high accuracy of 3D compensation steadily.

2. Method

2.1. Algorithm

2.2.

2.2. Example Subsection

Subsection text.

2.2.1. Mathematics

This is an example for the symbol α tagged as inline mathematics.

$$f(x) = (x+a)(x+b) \tag{1}$$

$$f(x) = (x+a)(x+b)$$

$$\begin{aligned} f(x) &= (x+a)(x+b) \qquad (2) \\ &= x^2 + (a+b)x + ab \qquad (3) \end{aligned}$$

$$\begin{aligned} f(x) &= (x+a)(x+b) \\ &= x^2 + (a+b)x + ab \qquad (4) \end{aligned}$$

$$\begin{aligned} f(x) &= (x+a)(x+b) \\ &= x^2 + (a+b)x + ab \end{aligned}$$

$$\begin{aligned} f(x) &= (x+a)(x+b) \\ &= x^2 + (a+b)x + ab \end{aligned}$$

Appendix A. Example Appendix Section

Appendix text.
Example citation, See [1].

References

[1] Leslie Lamport, *LaTeX: a document preparation system*, Addison Wesley, Massachusetts, 2nd edition, 1994.

1	2	3
4	5	6
7	8	9

Table 1: Table Caption

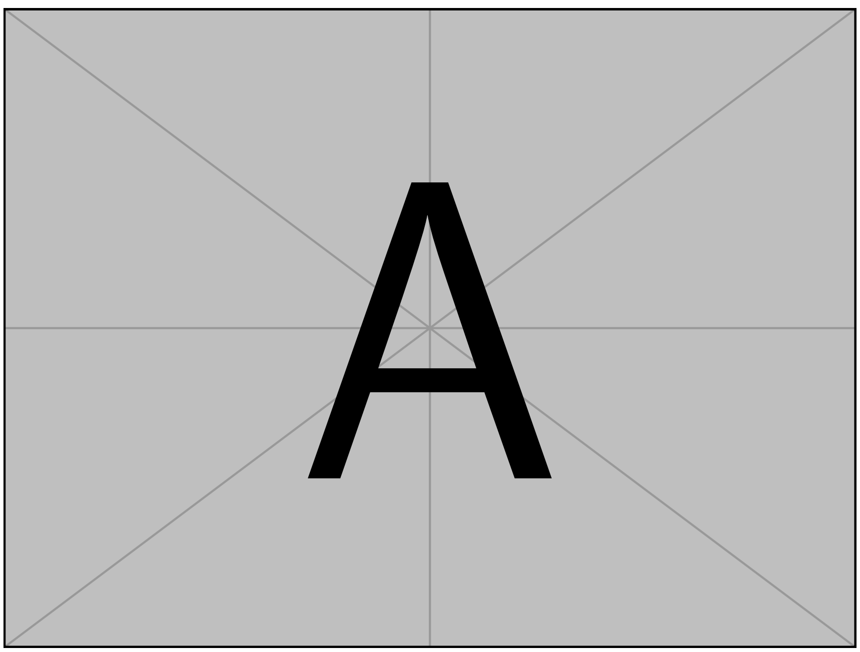

Figure 1: Figure Caption