Camera calibration method based on phase encoding for out-of-focus condition

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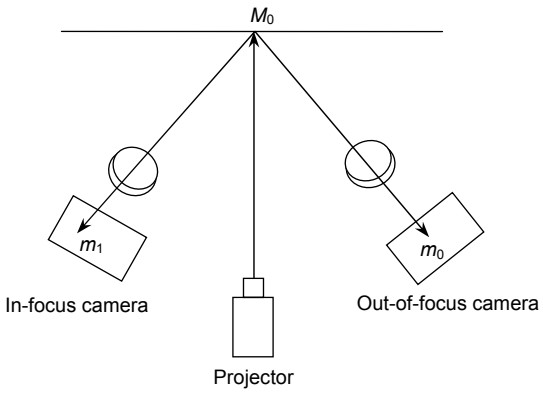

The composition of calibration system

Overview: With development in the past decades, the normal camera calibration method has become more and more mature. Among them, the method proposed by Zhang is a representative one. However, there is still a lack of the calibration method of some cameras and lenses used in special occasions. Recently, there are a few calibration studies for cameras with special imaging ranges, such as macro cameras and telephoto cameras. In 2012, Guo proposed a method for macro camera calibration using a semicircle template instead of a checkerboard in the general method. This method needs to fit the semicircle curve during the actual use. This step is difficult in the use of this method. Wang proposed a calibration pattern that can still be detected when the camera is out of focus, but its rendering method is difficult.

Our works are as follows: The state-of-art camera calibration method requires the user to provide accurate pixel coordinate of calibration plate feature points. For some cameras with special sensing range, general calibration objects' (such as calibration plates with a centimeter-long dimension) using range is outside their clear sensing range. This paper analyzes the influence of the focusing state of the camera imaging system on the optical phase information of a sinusoidal structured light. Using the properties that the sinusoidal structured light's phase information is independent of the focusing state of the camera, this paper proposes a method for encoding a normal calibration object using sinusoidal structured light to make the calibration of the camera in the defocus state make true. This method uses an in-focus camera to get the phase information of the encoded normal calibration object. The out-of-focus camera uses the phase information to calculate the feature points' accurate coordinates by the phase information. Then, the traditional method (e.g. Zhang method) is used to calculate the intrinsic, extrinsic parameters and distortion coefficient of the out-of-focus camera. Based on this method, the camera parameters can be accurately calibrated by using a blurred picture of the coded calibration object. This paper provides a cheap and convenient solution to the calibration of these special cameras. We don't have to manufacture the special calibration objects. The experiment results show that this method can calibrate special camera parameters accurately under different defocus state. After experimental verification, the calibrated focal length deviation from the real value is 0.47%, the average pixel reprojection error is 0.17 pixels.

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