Laboratory calibration and characterization of video cameras


NASA Langley Research Center, Hampton, Virginia 23665, USA

*Department of Surveying and Land Information
The University of Melbourne, Parkville, Victoria 3052, Australia

ABSTRACT

Some techniques for laboratory calibration and characterization of video cameras used with frame grabber boards are presented. A laser-illuminated displaced reticle technique (with camera lens removed) is used to determine the camera/grabber effective horizontal and vertical pixel spacing as well as the angle of non-perpendicularity of the axes. The principal point of autocollimation and point of symmetry are found by illuminating the camera with an unexpanded laser beam, either aligned with the sensor or lens. Lens distortion and the principal distance are determined from images of a calibration plate suitably aligned with the camera. Calibration and characterization results for several video cameras are presented. Differences between these laboratory techniques and test range and plumb line calibration are noted.

1. INTRODUCTION

The calibration of close-range cameras is usually classified as either laboratory, on-the-job, or self-calibration

Laboratory techniques all suffer the common disadvantage, compared to on-the-job or self-calibration, that the camera calibration is performed at a different time from when the photogrammetric measurement of interest is to be made. However, since on-the-job calibration or self-calibration is often not practical for near real-time video applications, the calibration of video cameras is generally restricted to laboratory methods. Goniometers and multicollimators are usually applied to cameras focused at infinity, whereas test ranges, the plumb line method, and the methods presented in this report have all been used successfully for the laboratory calibration of close-range video cameras.

The laboratory calibration techniques presented here were developed from earlier close-range photogrammetry with video tube cameras in which a reseau was placed on the tube faceplate to correct electronic distortion corrections and in which the plumb line method was used to determine the third order radial lens distortion. This experience with a faceplate reseau led quite naturally to the use of a reticle with an array of dots photographically produced on film for use with solid-state sensors. The reticle (after measurement with a monocomparator) was placed on the protective coverglass of a solid-state sensor and illuminated with a collimated laser beam. The sensor/frame grabber parameters could then be determined from an affine transformation. The principal point of autocollimation and point of symmetry were found by illuminating the camera with an unexpanded laser beam, either aligned with the sensor or lens. The third order radial distortion was found by imaging an aligned target plate. The purpose of this paper is to discuss further these techniques as well as to present a new laboratory technique to determine the principal distance.

2. SENSOR/FRAME GRABBER CALIBRATION

The sensor/frame grabber calibration is accomplished by comparing with an affine transformation a known image (in units of length) to the video image (in units of horizontal and vertical pixels). The photographically produced reticle mentioned above works well for cameras with good access to the sensor protective coverglass. However, some cameras require too much disassembly or the reticle cannot be placed near enough to the sensor surface due to IR blocking filters or external windows (for cooled sensors). In addition, movement of the film reticle to cover different areas of the sensor can be awkward and the vertical setup which is required for the film reticle is not convenient. For these reasons, the film reticle was replaced with a thin brass plate which has a 7 X 9 array of drilled holes 0.35 mm in diameter which slightly underfills the common 2/3 inch format sensor. The locations of the holes in the brass plate reticle were determined with an automatic monocomparator. Measurements of the reticle were made at various orientations on the comparator traversing stage to test for differences in the horizontal and vertical scale and to average out possible small bias errors in the comparator. The uncertainty in the location of the holes is estimated to be ±1 μm. The brass plate reticle can be used in a horizontal arrangement and displaced up to 50 mm from the sensor before the image spread due to diffraction causes interference between adjacent hole images. Such large displacements are not possible with a film reticle due to