

Characterising and Correcting Image Distortions

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Abstract

The rapid reduction in cost and size of image sensors has meant that they are now being sold in high quantities, for example in inexpensive web cameras, integrated within cellular phones, or used as security devices. The reduction in size has also meant that the focal length of associated lenses has also reduced, with low cost, often single element lenses being used to keep the size, weight and cost down. Such short focal length, wide angle lenses are prone to radial lens distortion, giving the image a fish-eye appearance.

When using an imaging system to make measurements, it is important to calibrate and correct for any such lens distortions. Calibration requires developing a mathematical model of the imaging process. Conventional algorithms capture an image of a known target and iteratively optimise the model parameters in order to minimise the errors between the captured image and the modelled image of the known target.

This presentation will describe two new techniques that we have developed for characterising and correcting the distortions with image data.

The first algorithm provides a direct solution to the parametric calibration problem. For correcting radial lens distortion, it makes use of the fact that a straight line in the real world should appear as a straight line in the image. Therefore any deviation from linearity must result from lens distortion. An image of a rectangular grid is captured, and parabolas are fitted to each of the gridlines. The curvature of the parabolas is used to directly estimate the radial distortion component. If necessary, the image can also be corrected for perspective distortion after removing the lens distortion. The algorithm presented is relatively simple, and yet directly provides an accurate first approximation to characterising both lens and perspective distortions.

Several examples or case studies will be presented, demonstrating the effectiveness of this technique even in the presence of severe distortions. The first example uses a fixed calibration grid to calibrate a camera used in waste water treatment pond modelling. The second example uses a virtual grid in a robotics application. The robot arm is moved in a grid pattern, and a composite grid image constructed from the individual images. The third example uses the existing structure within a robot soccer environment to perform the calibration.

The second algorithm is a non-parametric method. Instead of representing the distortion with a model with a few parameters, a complete distortion map is obtained. This is useful in applications where there are local distortions that cannot be adequately modelled by parametric methods. This method is applied in a single camera stereo system suitable for mobile robots.

Biography

Donald G Bailey received the B.E. (Hons) degree in Electrical Engineering in 1982, and the PhD degree in Electrical and Electronic Engineering from the University of Canterbury, New Zealand in 1985. From 1985 to 1987, he applied image analysis to the wool and paper industries within New Zealand. From 1987 to 1989 he was a Visiting Research Engineer at University of California at Santa Barbara. Dr Bailey joined Massey University in Palmerston North, New Zealand as Director of the Image Analysis Unit at the end of 1989. He is currently an Associate Professor in the School of Engineering and Advanced Technology, and leader of the Image and Signal Processing Research Group. His primary research interests include applications of image analysis, machine vision, and robot vision. One area of particular interest is the application of FPGAs to implementing image processing algorithms.