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Photogrammetric techniques for aerospace applications

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ABSTRACT

Photogrammetric techniques have been used for measuring the important physical quantities in both ground and flight testing including aeroelastic deformation, attitude, position, shape and dynamics of objects such as wind tunnel models, flight vehicles, rotating blades and large space structures. The distinct advantage of photogrammetric measurement is that it is a non-contact, global measurement technique. Although the general principles of photogrammetry are well known particularly in topographic and aerial survey, photogrammetric techniques require special adaptation for aerospace applications. This review provides a comprehensive and systematic summary of photogrammetric techniques for aerospace applications based on diverse sources. It is useful mainly for aerospace engineers who want to use photogrammetric techniques, but it also gives a general introduction for photogrammetrists and computer vision scientists to new applications.

Contents

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1. Introduction

Photogrammetry is the science of determining the geometrical (or metric) information (position, size and shape) of objects by analyzing images recorded on films or electronic media. The fundamental problem of photogrammetry is to establish the geometrical relationship between the image plane and the three-dimensional (3D) object space at the time of the imaging event. Once this relationship is correctly established, the relevant geometrical information and derived physical quantities about the object can be obtained from its imagery. Photogrammetric methods are particularly useful when the object to be measured is inaccessible or difficult to access, when the object moves and deforms, and when its contour and surface information is required. The earliest roots of photogrammetry can be traced to the Renaissance painters who studied the principles involved via geometrical analysis in the late 1400s. The next significant development was projective geometry that constitutes the mathematical basis of photogrammetry. Interestingly, the advent of the modern aviation after the first power-flight of the Wright brothers in the early 1900s promoted the great expansion of aerial photogrammetry for topographic mapping from photographs taken by cameras installed in a level-flying aircraft. Therefore, as a result of the intensive research focused on this field, the developed methodology, instrument and terminology of photogrammetry are largely influenced by aerial photogrammetry [46,80,102,109].

With the rapid advance of the technology of electro-optical and video cameras and computers in the 1990s, the analytical photogrammetric techniques based on models of cameras have allowed the use of non-metric cameras and the various applications of close-range photogrammetry (or non-topographic photogrammetry) like industry inspection, medical imagery, and architectural documentation. On the other hand, computer scientists have dealt with the perspective projection problem in computer vision or machine vision related to artificial intelligence while they tend to adopt different formulations and more versatile mathematical methods in perspective geometry, differential geometry and image algebra [81,41,34]. Due to the replacement of films by electronic image sensors, expressions other than photogrammetry have been used to denote this extraction of spatial information from images. Part of the impetus for these name-changes is to emphasize the modern nature of these efforts and to emphasize that digital images, rather than film, make up the raw data. These various names, which are largely a matter of personal choice of researchers of a special application, include digital photogrammetry, geomatics, videogrammetry,