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REVIEW AND ANALYSIS OF 3D IMAGE-BASED MEASUREMENTS

Image-based methods can be used for the analysis of the whole deformation field of a body by tracking a vast number of points distributed on the object. Images contain all the information to derive 3D measurements from multiple 2D image coordinates with limited cost and good accuracies. In fact, image-based techniques have been used in several applications which involve the determination of the shape of a body and its changes, with satisfactory results in terms of completeness, precision and time [1, pp. 599-604; 2, pp. 268-276; 3, pp. 181-189; 4, pp. 441-446]. They are also known as vision metrology applications. Some commercial cameras (or photogrammetric ones), tripods, light sources and synchronization devices are the components needed to obtain high precision of 3D measurements for a large number of points. However, the extraction of 3D information from 2D images is not a simple issue and the algorithms for image processing must be developed in order to obtain an automated elaboration.

The goal of image-based methods in material testing is the estimation of accurate 3D coordinates starting from 2D measurements in the images through a perspective mathematical formulation between the object and its projection into several images. Some commercial software allows the analysis of the dynamic changes of several targets distributed on the object in a fully automatic way, but if markerless images are employed no commercial automatic solutions are available on the market.

Moreover, the procedure becomes a full-field non-contact technique only without targets, when the natural texture of the object is directly used (generally after the preliminary enhancement with filters that modify the local contrast of the image).

Basically, the precision achievable with image-based techniques depends on the size of the investigated elements [5, pp. 39-46]. For experiments in the controlled environment a standard deviation of the object coordinates should not be more than 1:100,000 of the largest object dimension, but during the analysis in the repeatable system configurations (e.g., with fixed cameras) a precision of 1:250,000 has been achieved [6, pp. 145-152; 7, pp. 133-140]. In [8, pp. 205-217] a hyper redundancy network is used for the study of the deformations of a radio telescope, with an accuracy in the range of 1:580,000 to 1:670,000 obtainable through the use of more images than those strictly necessary. In film-based photogrammetric measurements of big antennas this idea has led to an accuracy approaching one part in a million [9, pp. 305-310].

As the technological development of commercial low-cost cameras is rapidly increasing, image-based methods and low-cost software are commonly used in several sectors with good results in terms of precision. However, photogrammetric methods have a limited use. This is mainly due to the lack of automatic processing algorithms and user-friendly software, especially in the case of markerless images.

Some low-cost digital cameras and targets can be a convenient solution for the analysis of the whole surface of an object. The employed targets can be really

inexpensive (a piece of white paper with a black mark is sufficient for many applications), while in the case of more exhaustive experiments they can be printed on metal plates or can be made of retro-reflective materials. The centre of the target can be automatically measured with a high precision (up to ±0.01 pixel) in a fully automated way, improving the precision of the corresponding 3D coordinates.

A group of targets permanently fixed on the object provides a regular mesh for all deformation analyses. These dense points can approximate the deformation field of the whole body. A fundamental advantage of an image-based method is the possibility of analysing more targets than those strictly necessary, without increasing the cost of the test and with a limited worsening of the processing time.

However, in some applications targets cannot be employed and automatic methods based on the natural texture of the body must be developed. This kind of analysis is more complicated, especially in the case of bad surfaces without details. This fact limits the use of image-based methods.

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