Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 11 (2017) 1207 – 1214

Procedia MANUFACTURING

27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

Cost Effective Quality Assessment in Industrial Parts Manufacturing via Optical Acquisition

Francesco Malapelle[a], Diego Dall'Alba[a], Denis Dalla Fontana[b], Ivano Dall'Alba[b], Paolo Fiorini[a], Riccardo Muradore[a]*

[a]*Department of Computer Science, University of Verona, Strada Le Grazie 15, 37134 Verona, Italy*
[b]*Modelleria Pozzan - Via del Progresso 1/20, 36015 Schio VI, Italy*

Abstract

We tackle the problem of dimensional verification via optical acquisition systems in the context of industrial manufacturing processes. Optical methods for quality inspection play a crucial part in the transition process to industry 4.0 and, despite the lack of international standardization, several solutions are available to industries that need to provide dimensional verification to their customers. Unfortunately most of these solutions are still economically unavailable to the majority of small or medium companies. In this paper we present an optical system based on low-cost components and we demonstrate that it provides useful and reliable information in quality inspection procedures.

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Dimensional verification; Quality inspection; Optical acquisition; 3D reconstruction; 3D model acquistition; Smart manufacturing; Industry 4.0;

* Corresponding author.
E-mail address: riccardo.muradore@univr.it

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.07.246

1. Introduction

Dimensional control of mechanical pieces is a key component in today's Industry 4.0. The capability to verify that the designed geometry meets the project requirements in terms of expected dimensional constraints imposed by the specific part functional role is an ongoing challenge during the manufacturing process.

In an effort to verify product form, fit and function, the majority of companies are adopting traditional contact measurement techniques, e.g. using coordinate-measuring machines (CMM). These techniques are highly accurate but provide punctual information, hence they are effective on parts that feature simplistic shapes with easy to measure spots (e.g. circular holes, edges with regular thickness and, in general, regular geometries). Unfortunately product verification becomes a very costly and time consuming process when the parts present complicated characteristics, such as contoured surfaces, heavily featured geometry and product assemblies that render contact techniques impractical. Optical 3D scanning techniques are less accurate than traditional methods [4, 5, 6], but they have proven to be both an accurate and a cost-effective alternative solution to the problem of dimensional information estimation, allowing to create measuring reports that are more meaningful, complete and informative and that can be delivered in a visual fashion (e.g. full color rainbow plots, sectional comparisons), or as traditional CMM-style reports that are compiled automatically. Moreover optical acquisition methods are useful in other time consuming tasks such as reverse engineering of manufactured parts.

Today, many of the industrial sectors have implemented optical 3D scanning technologies to address their inspection and quality assurance requirements, but in many cases highly accurate systems are not affordable for small or medium enterprises (SME). This makes them less competitive in the 4.0 industry evolution. There is a wide gap, in both cost and measuring performance, between high-end systems and affordable solutions available for SME.

Currently there are different optical technologies available for non-contact dimensional verification. Although a complete presentation of the commercially available systems is outside the scope of this work, we can define the following categories, where most systems fall in: photogrammetry, structured light projection, laser scanners, and time of flight (ToF) sensors.

Photogrammetry is only based on the information that can be extracted from images: corresponding points across image pairs are triangulated in order to build a point cloud that is then processed into a mesh. It has the advantage of being a passive technique, i.e. besides capturing images, it does not require any interaction with the scene or object. On the other hand it is much less accurate than active methods such as structured light projection and laser scanners. In structured light systems (see [7] for an excellent in depth survey on this category), known patterns are projected onto the object whereas laser scanning systems project a laser blade. Both type of approaches share the idea of projecting light onto the target of the acquisition. Structured light can also be shed in the form of non-visible light (e.g. infrared). The projection provides aid to the triangulation step which is consequentially much more precise, yielding finer results. At last, ToF sensors measure the time of flight of an emitted light signal between themselves and the target of the acquisition, but they are much less accurate and more suited for the reconstruction of large scenes [8] where less precision is required.

High-end active systems provide high level technical specifications that partially motivate high costs. Therefore, the design and development of a cost-effective and reliable 3D scanning and measurement system suitable for SME is a priority for allowing them to tackle the problem of dimensional control at the same level as bigger stakeholders. Thanks to the technological progress boosted by the mobile phone market, the cost of vision systems has been significantly reduced while precision is constantly improving. It will soon be possible to build a cost effective optical measuring system targeting SME requirements in terms of technical specification and budget. In this work we pursue this idea.