Computer Aided Inspection procedures to support Smart Manufacturing of injection moulded components

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Abstract

This work presents Reverse Engineering and Computer Aided technologies to improve the inspection of injection moulded electro-mechanical parts. Through a strong integration and automation of these methods, tolerance analysis, acquisition tool-path optimization and data management are performed. The core of the procedure concerns the automation of the data measure originally developed through voxel-based segmentation. This paper discusses the overall framework and its integration made according to Smart Manufacturing requirements.

The experimental set-up, now in operative conditions at ABB SACE, is composed of a laser scanner installed on a CMM machine able to measure components with lengths in the range of 5÷250 mm, (b) a tool path optimization procedure and (c) a data management both developed as CAD-based applications.

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1. Introduction

Nowadays, Reverse Engineering (RE), Computer Aided Tolerancing & Inspection (CAT&I) procedures and Product Data Management (PDM) systems can help “Smart (or Intelligent) Manufacturing”, with the planning,
automation and post processing of component inspection. The benefits of their adoption are enhanced predictions of manufacturing problems and improvements in the product-process final quality.

Quality inspection by means of RE and automation of acquisition paths via CAD-CAM implementation are well known issues. Many commercial solutions are already available and provided as “smart” solutions (see for example Nikon or other acquisition system developers). Nevertheless, changes of a Company quality assessment must always pass through a strict evaluation of pros and cons, with consequences extending outside the metrology lab. For this reason, the introduction of CAT&I smart solutions must be customised according to an integrated product-process point of view, or, in other words, to the integration between product and process engineering. The requirements of CAT&I smart solutions related to the acquisition device (precision, accuracy and measure) affect product engineering. The requirements of CAT&I smart solutions related to the system integration, including part positioning, automation, and data management (measurement protocol, report and feedback) affect the industrial process and organization. In the case of injection moulded parts, RE and CAT&I may play a relevant role not only in quality inspection but also in die set-up [1]. For Companies with high volume of assemblies, it becomes extremely useful to evaluate supplies and manage a large number of suppliers per component, thanks to robust protocols and procedures that reduce repetitive and tedious actions and efficiently process large amounts of data.

In our previous works [2, 3, 4], we discussed the integration of RE in CAT&I applied to electromechanical components made by injection moulding, reporting algorithms and results that were focused upon automatic procedures for feature recognition and measure from a point cloud. In this research, we want to focus on the data treatment before and after the automatic measuring operation that Section 2 summarises briefly, since we aim to highlight requirements for the overall system set-up.

To obtain a reliable and effective measurement campaign, orientation of the pieces and their layout on the reference table must be optimised, not only in respect of the acquisition parameters but also considering that a large number of single, very small size components, must be evaluated per acquisition (typical scanned pieces have characteristic dimensions from 5 mm to 250 mm). In addition, algorithms for the laser scanner paths must also be defined according to the target of speed optimization, keeping in mind pieces orientation and obstacles presented by pieces in terms of visibility and scanner safety. Scanning without path planning may affect completeness and accuracy of the data [5]. Passing from the CAD model to its convex hull (through a STL model), the developed algorithm searches all possible balance positions for the part, and chooses the best three according to criteria such as stability and visibility. Then, for each chosen position, the view perspective is reproduced, evaluating how many points are visible. We take into account the amplitude of the measurement range, occlusion and obstacles represented by the pieces themselves and the angle between the local surface normal and the scanner (paying attention to the differences between camera and laser). In the recent years, the problems of path planning and shape digitizing, in inspection made with Reverse Engineering (RE), was solved through the use of a voxel structure starting from the CAD model [6, 7], or through the study of its surface mesh [8], due to the necessity of acquiring complex free-form shapes. We decided to use a STL based algorithm (conceptually similar to what is reported in [9]) looking for the definition of scan path on components which are obtained mainly by feature based surfaces (planes, cylinders, spheres, pockets) not free-form. All these concepts and procedures, applied before the measurement campaign, represent the macro-area named Computer-Aided Path Definition (CAPD), described in Section 3.

Subsequently, we analyze and discuss the automatic treatment of data after the automatic measure. These concepts are described in Section 4, named Product Inspection Data Management (PIDM). Generally speaking, PDM (and PIDM as a part of it) is now a commercial issue because its structure and use are stabilised. In particular, it is considered as a base for the Product Lifecycle Management (PLM) philosophies, which cover the whole life of the product [10]. All these concepts and methods allow product design to gain connection among value chain activities, according to Concurrent Engineering. The industry goal is to avoid waste time that, usually, is the major portion of the entire time to market in a business, and it can be attributed to the absence of an efficient knowledge management system [11].

In the article, CAPD and PIDM procedures and algorithms are described and some results and examples from case studies are provided in order to evaluate the proposed automation in comparison with the usual procedure (which involves intense work for the technician, often boring and thus not error-proof). To conclude the paper, we present future developments and targets according to a “Smart Manufacturing” implementation.
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