Range image accuracy improvement by acquisition planning

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Abstract

The recent requirement for increased speed in the design and manufacturing of new products led to a rapid evolution of the technics for fast production (rapid prototyping, machining at high speed, etc.). But a significant component did not follow this evolution, that is the dimensional and functional checking process, which is most of the time carried out in a traditional way. The use of range sensor allows very significant improvement in acquisition speed but does not equal the accuracy obtained with a coordinate measuring machine. In order to obtain a quality control close to that obtained in metrology, we suggest to improve the accuracy of the depth measurements by following an acquisition strategy. We propose in this paper such a strategy to automatically produce a sensing plan for completely and precisely acquiring the geometry of a surface or of a complete piece whenever possible. The system requires the exact position and orientation of the part and its CAD model in IGES format. There is no limitation regarding the shape of the part to be digitized. A Biris sensor was used, and for this sensor, the precision of the 3D measured points is function of the distance and of the incident angle with which the laser beam reaches the surface. Our strategy guaranties that the viewpoint found meets the best precision conditions in the scanning process.

1 Introduction

The increased production rate of manufactured objects showing complex surfaces, either for functional reasons or by design, and the technological developments in manufacturing tools create a need for automatic inspection of complex parts. This type of control requires a very accurate geometrical definition of the inspected object, a large number of acquisition points with sufficient accuracy, and clearly defined rules for the inspection of these surfaces.

The use of three-dimensional measuring machines and recent progress in laser sensors combining measurement accuracy and fast acquisition speed allow to obtain many 3D measurements. These accurate 3D points form an explicit description of object surfaces. In addition, knowledge of the corresponding CAD model provides an exact and complete description of the geometry of the object under inspection. We develop a method for automatic inspection of parts containing complex surfaces, running from their CAD model (in IGES format) and 3D data output provided by a telemetric sensor fixed to a coordinate measuring machine. The quality of the results depends almost exclusively on the precision of measurements.

At present, it is near to impossible to compare the accuracy obtained with a coordinate measuring machine equipped with a contact sensor (lower than the micron) and those delivered by a measuring machine equipped with a laser range finder (about 25 micron at best). If one wants to take advantage from the speed of acquisition obtained with a contactless sensor to make systematic dimensional check of complex parts, it is necessary to attain the best precision of the depth images obtained with a range finder.

3D sensors, delivering information about the geometry of the object, all operate generally according to a common principle: emission of a laser beam (incidental ray), generally from a laser diode, followed by the analysis of the reflected ray [2, 3]. From this analysis, we obtain the spatial position of each swept point (x, y, z), relative to