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微纳技术与精密机械

基于CAD模型引导测量的自由曲面定位及轮廓度误差评定

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摘要： 提出将粒子群优化算法与拟随机序列法相结合对基于CAD模型引导测量的自由曲面进行高精度检测和轮廓度误差评定的方法。为解决用三坐标测量仪检测自由曲面时存在的设计坐标系与测量坐标系不重合问题,提出用拟粒子群优化算法来实现被测曲面与设计曲面精确定位;针对自由曲面特点,采用轮廓峰谷误差和轮廓均方根误差综合评定自由曲面的形状误差。最后,阐述了用拟粒子群优化算法实现曲面匹配时目标函数值的计算方法,确立了用拟粒子群优化算法优化求解参数向量的具体步骤。对仿真实例和大量实测零件自由曲面轮廓度误差的计算表明:采用本文方法能够实现自由曲面精确定位,其轮廓度误差评定精度比由三坐标测量仪内置软件计算的结果高8%～15%,适用于对高精度自由曲面零件形状误差的评定。

关键词： 自由曲面定位 轮廓度误差 CAD模型 拟随机序列 粒子群优化算法

Localization and profile error evaluation of freeform surface based on CAD model-directed measurement

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Abstract: An evaluating method by combination of particle swarm optimization and quasi-random sequence was proposed to detect precisely and evaluate the profile errors of freeform surfaces inspected by Computer Aided Design (CAD) model-directed measuring. In order to solve the un-repetitive problem between design coordinate system and measurement coordinate system when a Coordinate Measurement Machine (CMM) was used to inspect free form surfaces, Quasi Particle Swarm Optimization(QPSO)was proposed to realize the precise localization between measured surface and design surface. Then, according to the features of freeform surface form, the peak-valley error and root mean square error were used to evaluate the freeform surface forms together. The computation method of the objective function was described,in which QPSO is used to match the measured surface and the design surface and the detailed steps were established for solving parameter vectors by using QPSO. Finally, by calculating the surface profile errors of simulation example and many practical measured parts, the results verify that the proposed method can locate precisely freeform surfaces and the evaluation precision of freeform surface profile errors by the proposed method is higher 8%-15% than that by CMM software. The method is suitable for the form error evaluation of high precise freeform surface parts.

Keywords: freeform surface localization profile error CAD model quasi-random sequence particle swarm optimization

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参考文献：

[1] XU Y, JIANG J, LI Z X. Cyclic optimization for localization in freeform surface inspection [J]. *International Journal of Production Research*, 2011,49(2):361-374. [2] LI YD, GU PH. Free-form surface inspection techniques state of the art review [J]. *Computer-Aided Design*, 2004,36(13):1395-1417. [3] 李剑, 王文, 陈子辰. 自由曲面测量若干关键问题的研究[J]. 机械科学与技术,2001,20(5):764-766. LI J, WANG W, CHEN Z CH. Study on some key issues in the measurement of free-form surface[J]. *Mechanical Science and Technology*, 2001,20(5):764-766. (in Chinese) [4] 李大鹏. 三坐标测量机在复杂自由曲面检测中的应用[J]. 工具技术,2007,41(9):85-87. LI D P. Application of coordinate measuring machine in measuring complex freeform surface [J]. *Tool Technology*, 2007,41(9):85-87. (in Chinese) [5] SAHOO K C,MENG CH. Localization of 3-D objects having complex sculptured surfaces using tactile sensing and surface description [J]. *Journal of Engineering for Industry*, 1991, 113(1):85-92. [6] MENG C H, YAU H T, LAI G Y. Automated precision measurement of surface profile in CAD-directed inspection [J]. *IEEE Trans. on Robotics and Automation*, 1992, 8(2):268-278. [7] ZHANG Z. Iterative point matching for registration of freeform curves and surfaces [J]. *International Journal of Computer Vision*, 1994, 13(2): 119-152. [8] LI Y D, GU P H. Automatic localization and comparison for free-form surface inspection [J]. *Journal of Manufacturing Systems*, 2006, 25(4):251-267. [9] 杜建军,高栋,孔令豹,等. 光学自由曲面误差评定中匹配方法的研究[J]. 光学精密工

程,2006,14(1):133-138. DU J J, GAO D, KONG L B, *et al*..Study of matching methods for error evaluation of optical free-form surface [J]. *Opt. Precision Eng.*,2006,14(1):133-138. (in Chinese) [10] INTERNATIONAL STANDARD ORGANIZATION. ISO/TS 12780-1—2003, Geometrical product specifications (GPS)-Straightness-Part 1: Vocabulary and parameters of straightness[S]. Switzerland: ISO copyright office, 2003. [11] INTERNATIONAL STANDARD ORGANIZATION. ISO/TS 12781-1—2003, Geometrical product specifications (GPS)-Flatness-Part 1: Vocabulary and parameters of Flatness[S]. Switzerland: ISO copyright office, 2003. [12] INTERNATIONAL STANDARD ORGANIZATION. ISO/TS 12181-1—2003, Geometrical product specifications(GPS)-Roundness-Part 1: Vocabulary and parameters of Roundness[S]. Switzerland: ISO copyright office, 2003. [13] INTERNATIONAL STANDARD ORGANIZATION. ISO/TS 12180-1—2003, Geometrical product specifications(GPS)-Cylindricity-Part 1: Vocabulary and parameters of Cylindricity [S]. Switzerland: ISO copyright office,2003. [14] CHEUNG C F, LI H F, KONG L B, *et al*.. Measuring ultra-precision freeform surfaces using a robust form characterization method [J]. *Measurement Science and Technology*, 2006,17(3):488-494. [15] CERARDI A, MENEGHELLO R, CONCHERI G, *et al*.. Form errors estimation in free-form 2D and 3D geometries. *Proceedings of International Conference on Innovative Methods in Product Design, Italy:Venice, June* 15-17, 2011: 550-555. [16] EBERHART R, SHI Y, KENNEDY J. *Swarm Intelligence* [M]. San Mateo, CA: Morgan Kaufmann,2001. [17] SAMANTA B, NATARAJ C. Use of particle swarm optimization for machinery fault detection [J]. *Engineering Applications of Artificial Intelligence*, 2009, 22(2): 308-316. [18] WEN X L, HUANG J C, SHENG D H, *et al*.. Conicity and cylindricity error evaluation using particle swarm optimization[J]. *Precision Engineering*, 2010, 34(2): 338-346. [19] BOHM W, GEYER-SCHULTS A. *Exact Uniform Initialization for Genetic Programming, Foundations of Genetic Algorithms* IV [M]. California: Morgan Kaufmann,1997. [20] MAARANEN H, MIETTINEN K, MAKELA M. Quasi-random initial population for genetic algorithms [J]. *Computers and Mathematics with Applications*, 2004, 47(12): 1885-1895. [21] RAFAJLOWICZA E, SCHWABE R. Halton and hammersley sequences in multivariate nonparametric regression [J]. *Statistics & Probability Letters*, 2006, 76(8): 803-812. [22] LIANGF J J, QIN A K, SUGANTHAN P, *et al*.. Comprehensive learning particle swarm optimizer for global optimization of multimodal functions [J]. *IEEE Trans. On Evolutionary Computation*, 2006, 10(1):281-295.

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2．刘仁浩, 王华.数字磁罗盘的全姿态罗差补偿[J]. 光学精密工程, 2011,19(8): 1867-1873

3．李绍成, 左洪福, 张艳彬.油液在线监测系统中的磨粒识别[J]. 光学精密工程, 2009,17(3): 589-595

4．王仲操晶晶张进.基于图像的轮廓度测量与评定方法研究[J]. 光学精密工程, 2009,17(2): 395-401

5．张进,王仲,贡力,叶声华.基于图像的线轮廓度评价算法研究[J]. 光学精密工程, 2008,16(11): 2281-2285

6．崔长彩;黄富贵;张认成;李 兵.粒子群优化算法及其在圆柱度误差评定中的应用[J]. 光学精密工程, 2006,14(2): 256-260

7．温秀兰.基于CAD模型引导测量的自由曲面定位及轮廓度误差评定[J]. 光学精密工程, ,(): 0-0