光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林

光学精密工程 2013, 21(2) 522-530 ISSN: 1004-924X CN: 22-1198/TH

信息科学

精密视觉印刷设备的自标定

梁经伦,陈家钊,莫景会,邝泳聪,张宪民

华南理工大学 广东省精密装备与制造技术重点实验室

摘要： 为了提高全自动视觉印刷设备的精度，提出了一种简易、有效标定基于三自由度平面并联调整台的视觉丝网印刷设备的算法。首先，分析和标定了视觉测量系统，并通过激光干涉仪验证了结果的准确性。然后，分析了三自由度平面并联调整台的几何参数误差；基于印刷设备自身的视觉测量系统，分步标定了并联平台的动平台坐标系、传动比误差和仅需的部分几何误差源。提出了一种满足全姿态且适应不同制程的三角形面姿态插值方法和纠偏调整算法，从而避免了较为复杂的几何全参数辨识，降低了对调试人员的技术要求。实验结果表明：在并联调整台工作空间内，标定后的最大位置误差从标定前的161.6 μm下降为12.3 μm，最大姿态误差从标定前的2.232″下降为0.720″，基本满足印刷设备对精度的要求。

关键词： 印刷设备 机器视觉 并联平台 运动学标定 定位精度

Self-alibration of precise vision-based printing equipment

LIANG Jing-lun,CHEN Jia-zhao,MO Jing-hui,KUANG Yong-cong,ZHANG Xian-min

Key Laboratory of Precision Equipment and Manufacturing Technology of Guangdong Province, South China University of Technology

Abstract: To improve the precise of all automatic printing equipment, a simple and effective calibration method was proposed to calibrate the screen printing equipment based on a novel three-degree-of-freedom (3-DOF) planar parallel stage. Firstly, a vision-based measuring system was analyzed and calibrated, and its measurement accuracy was also evaluated by a laser interferometer. Then, the geometric errors of the 3-DOF planar parallel stage was analyzed and the frame of the parallel stage's movable platform, screw lead errors and some geometric errors were identified in steps based on a vision-based measuring system in the equipment. Furthermore, the orientation interpolation and alignment methods using a triangular area to position the alignment point were presented to satisfy the need for different product processes in the whole workspace. For the processing mentioned above, this calibration method can calibrate the equipment itself automatically without complicated identification for all geometric errors and the need for any background in parallel robot calibration. Experimental results after calibration show that the maximum position and orientation errors inside the workspace have been reduced from 161.6 μm and 2.232″ to 12.3 μm and 0.720″, respectively, which satisfies the equipment requirement for high accuracy.

Keywords: printing equipment machine vision parallel stage kinematic calibration position accuracy

收稿日期 2012-11-13 修回日期 2013-01-01 网络版发布日期 2013-02-23

基金项目:

国家863高技术研究发展计划资助项目;粤港关键领域重点突破项目（东莞专项）;国家杰出青年科学基金资助项目

通讯作者: 张宪民

作者简介: 梁经伦(1985-)，男，广东梅州人，博士研究生，2008年于华南理工大学获得学士学位，主要从事并联机构及机器视觉方面的研究。

作者Email: zhangxm@scut.edu.cn

参考文献：

[1]PAN J, STORER R, SALLADE R, et al.. Critical variables of solder paste stencil printing for micro-BGA and fine-pitch QFP [J]. IEEE Trans. on Electron. Pack., 2004,27(2):125-132. [2]JU M, LEE Y, LEE J, et al.. Double screen printed metallization of crystalline silicon solar cells as low as 30 μm metal line width for mass production[J]. Sol. Energ. Mat. Sol. C., 2012, 100: 204-208. [3]YU A, BONEV I, ZSOMBOR-MURRAY P. New XY-Theta positioning table with partially decoupled parallel kinematics[C]. Proceeding of the IEEE Int. Symp. On Ind. Electron., Montreal, QC, Canada: ISIE, 2006:3108-3112. [4]高猛, 李铁民, 唐晓强. 少自由度并联机床标定试验研究[J]. 机械工程学报, 2003, 39(9): 118-122. GAO M, LI T M, TANG X Q. Calibration experiment research of parallel kinematics machine with a few degrees[J]. Chinese J. of Mech. Eng., 2003, 39(9):118-122. (in Chinese) [5]JOUBAIR A, SLAMNI M, BONEV I. A novel XY-Theta precision table and a geometric procedure for its kinematic calibration[J]. Robot. Cim.-Int. Manuf., 2012, 28: 57-65. [6]CHANG P, WANG J S, LI T M, et al.. Step kinematic calibration of a 3-DOF planar parallel kinematic machine tool[J]. Sci. China Ser. E-Tech. Sci., 2008, 51(12): 2155-2167. [7]何小妹, 丁洪生, 付铁, 等. 并联机床运动学标定研究综述[J]. 机床与液压, 2004, 10: 9-11. HE X M DING H SH, FU T, et al.. Review on kinematic calibration of parallel kinematic machine[J]. Mach. Tool & Hydraulics,2004, 10:9-11. (in Chinese) [8]ZOU H, NOTASH L. Discussion on the camera-aided calibration of parallel manipulators[C]. Proceeding of CCToMM Symp. Mech. Mach., and Mechatron., Saint-Hubert, QC, Canada: CD-ROM, 2001:1-2. [9]LIANG J L, KUANG Y C, CHEN J Z, et al.. A novel XY-Theta alignment stage for screen printing and its accuracy analysis[C]. Proceeding of the IEEE Int. Conf. on Mech. and Autom., Chengdu, China: ICMA, 2012:1352-1357. [10]张宪民, 邝泳聪, 卢盛林, 等. 用于锡膏印刷的L型双镜头图像采集装置.中国:ZL20060123893.4[P].2007-05-30. ZHANG X M, KUANG Y C, LU SH L, et al.. A L type double cameras image acquisition device for automatic screen printer. China:ZL20060123893.4[P].2007-05-30. [11]MERLET J-P. Direct kinematic of planar parallel manipulators[C]. Proceeding of the IEEE Int. Conf. on Robot. and Autom., Minneapolis, USA: ICRA, 1994:3744-3749. [12]BRAND P, MOHR R. Accuracy in iamge measure[C].

Proceeding of SPIE Conf. Videometrics III, Vol. 2350, Boston, Ma, USA, 1994: 218-228. [13]王建民, 浦昭邦, 赵辉, 等. 一种新的二维图像测量系统标定方法[J]. 哈尔滨工业大学学报, 2000, 32(3):37-41. WANG J M, PU ZH B, ZHAO H, et al.. A new method for calibrating 2-D image measuring systems[J]. J. of Harbin Institute of Technology, 2000, 32(3):37-41. (in Chinese) [14]张舞杰, 杨义禄, 李迪, 等. 自动影像测量系统关键算法[J]. 光学 精密工程, 2007, 15(2):294-301. ZHANG W J, YANG Y L, LI D, et al.. Key algorithms of automatic image measurement system[J]. Opt. Precision Eng., 2007, 15(2):294-301. (in Chinese) [15]梁经伦, 张宪民, 莫景会. 一种XY-Theta并联平台精度分析及标定[J]. 华南理工大学学报, 2012, 11. LIANG J L, ZHANG X M, MO J H. Accuracy analysis and calibration of a XY-Theta parallel stage[J]. J. of South China University of Technology, 2012,11. (in Chinese) [16]Manipulating industrial robots—performance criteria and related test methods, ISO 9283, 1998.

本刊中的类似文章

1．王耿 官春林 张小军 周虹 饶长辉.应变式微型精密压电驱动器的一体化设计及其PID控制[J]. 光学精密工程, 2013,21(3): 709-716

2．裘祖荣 陈浩玉 胡文川 邹茂虎 杨婷.基于嵌入式的角度视觉检测及误差补偿[J]. 光学精密工程, 2013,21(10): 2480-2487

3．王小鹏 刘志华 陈天宁.透明材料微小器件键合质量检测系统设计[J]. 光学精密工程, 2013,21(1): 69-76

4．胡文川, 裘祖荣, 张国雄.大尺寸空间异面直线夹角的检测[J]. 光学精密工程, 2012,20(7): 1427-1433

5．王俐, 饶长辉, 饶学军.压电陶瓷微动台的复合控制[J]. 光学精密工程, 2012,20(6): 1265-1271

6．徐亮, 赵建科, 薛勋, 刘峰, 胡丹丹.月基望远镜探测能力的地面标定[J]. 光学精密工程, 2012,20(5): 972-978

7．王磊, 郭淑霞, 张凤玲, 冯彬, 张建城.微型铣刀外径视觉测量的不确定度[J]. 光学精密工程, 2012,20(4): 880-887

8．何博侠, 何勇, 卜雄洙, 商飞.机器视觉多视场协同测量方法[J]. 光学精密工程, 2012,20(12): 2821-2829

9．ZHAO Li-ping, LI Xiang, FANG Zhong-ping.塑料眼镜内外缺陷检测的全内反射照明技术[J]. 光学精密工程, 2011,19(9): 2247-2254

10．向守兵, 苏光大, 任小龙, 吉倩倩, 方飞.实时手指交互系统的嵌入式实现[J]. 光学精密工程, 2011,19(8): 1911-1920

11．葛动元, 姚锡凡, 向文江.嵌入正交权值神经网络在摄像机内外参数标定中的应用[J]. 光学精密工程, 2011,19(11): 2782-2790

12．郭宏伟,邓宗全,刘荣强.空间索杆铰接式伸展臂参数设计与精度测量[J]. 光学精密工程, 2010,18(5): 1105-1111

13．耿洁,刘向东,陈振,赖志林.

Preisach迟滞逆模型的神经网络分类排序

[J]. 光学精密工程, 2010,18(4): 855-862

14．李建,赵军,马瑞.管线钢管JCO精确弯曲成形技术[J]. 光学精密工程, 2010,18(3): 638-645

15．魏振忠,赵征,张广军.基于角度约束的圆姿态识别二义性消除方法[J]. 光学精密工程, 2010,18(3): 685-691