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摘要: 结合局部曲面拟合和广义二分优化搜索,提出了用于大尺寸自由曲面形貌测量中多视三维散乱点云自动配准的算法。首先,对点云微小局部区域进行标准最小二乘曲面拟合,根据拟合残差提取给定点云的全部非平坦区;借助图论中“邻接”与“可达”的概念以及非平坦区的空间分布统计特征,进行相邻点云非平坦区的区域聚类计算以及区域匹配,进而自动获得配准位姿初值。然后,计算源点云在目标点云中最近点的k邻近,并向k邻近点的局部移动最小二乘拟合曲面做正交投影,以提取对应点。最后,采用广义二分优化搜索进行位姿变换的优化求解。试验结果表明:该方法稳定、可靠,无需人工交互,适用于采样错移情形。在重叠区域内选取150个对应点进行位姿优化时,平均配准缝隙约为0.02 mm,可以满足大尺寸自由曲面形貌测量的多视三维散乱点云配准的要求。

关键词: 形貌测量 三维散乱点云配准 局部曲面拟合 广义二分搜索

Unconstrained registration of 3-D scattered point clouds for free-form shape measurement

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Abstract: In combination of local surface fitting and generalized bisection optimization search, an automatic registration method is proposed for the multi-view 3-D scattered point cloud registration in the shape measurement of a large scale free-form surface. First, the standard least square surface is fitted in a small local area of point clouds. According to the fitting residue, all the non-flat regions for given point clouds are extracted. Based on the definition of “adjacency” and “reachability” of graph theory and the statistical characteristics of spatial distribution of non-flat regions, the non-flat regions for pairwise adjacent point clouds are clustered and matched coarsely. Thereby, the initial transformation is obtained. Then, a point in source point cloud is given and the most closed point and its corresponding k neighboring points in destination point cloud are calculated. Furthermore, the Moving Least Squares (MLS) surface fitting is performed for the k neighboring points. The given point and its orthogonal projection point on the MLS surface are selected as the matching points. Finally, the generalized bisection optimization search is employed to optimize the transformation. Experimental results indicate that the proposed registration method is stable, reliable and without human interaction. It is also suitable for the situation of offset sampling. The average registration seam is about 0.02 mm when 150 matching points in overlapping region are used in optimization calculation. The proposed method meets the requirements of multi-view 3-D scattered point cloud registration in the shape measurement of large scale free-form surfaces.

Keywords: Morphology measurement 3-D scattered point clouds registration Local surface fitting Generalized bisection search

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