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Curvature Based-Methods for Automatic Coarse and Fine Registration in Dimensional Metrology

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Abstract : Multiple measurements by means of various data acquisition systems are generally required to measure the shape of freeform workpieces for accuracy, reliability and holisticity. The obtained data are aligned and fused into a common coordinate system within a registration technique involving coarse and fine registrations. Standardized iterative methods have been established for fine registration such as Iterative Closest Points (ICP) and its variants. For coarse registration, no conventional method has been adopted yet despite a significant number of techniques which have been developed in the literature to supply an automatic rough matching between data sets. Two main issues are addressed in this paper: the coarse registration and the fine registration. For coarse registration, two novel automated methods based on the exploitation of discrete curvatures are presented: an enhanced Hough Transformation (HT) and an improved Ransac Transformation. The use of curvature features in both methods aims to reduce computational cost. For fine registration, a new variant of ICP method is proposed in order to reduce registration error using curvature parameters. A specific distance considering the curvature similarity has been combined with Euclidean distance to define the distance criterion used for correspondences searching. Additionally, the objective function has been improved by combining the point-to-point (P-P) minimization and the point-to-plane (P-Pl) minimization with automatic weights. These ones are determined from the preliminary calculated curvature features at each point of the workpiece surface. The algorithms are applied on simulated and real data performed by a computer tomography (CT) system. The obtained results reveal the benefit of the proposed novel curvature-based registration methods.

Keywords : discrete curvature, RANSAC transformation, hough transformation, coarse registration, ICP variant, point-to-point and point-to-plane minimization combination, computer tomography
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