Simulated annealing-based fitting of CAD models to point clouds of mechanical parts' assemblies

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Abstract

This paper introduces a new fitting approach to allow an efficient part-by-part reconstruction or update of editable CAD models fitting the point cloud of a digitized mechanical parts assembly. The idea is to make use of parameterized CAD models whose dimensional parameters are to be optimized to match the acquired point cloud. Parameters may also be related to assembly constraints, e.g. the distance between two parts. The optimization kernel relies on a simulated annealing algorithm to find out the best values of the parameters so as to minimize the deviations between the point cloud and the CAD models to be fitted. Both global and local fitting are possible. During the optimization process, the orientation and positioning of the CAD parts are driven by an ICP algorithm. The modifications are ensured by the batch calls to a CAD modeler which updates the models as the fitting process goes on. The modeler also handles the assembly constraints. Both single and multiple parts can be fitted, either sequentially or simultaneously. The evaluation of the proposed approach is performed using both real scanned point clouds and as-scanned virtually generated point clouds which incorporate several artifacts that could appear with a real scanner. Results cover several Industry 4.0 related application scenarios, ranging from the global fitting of a single part to the update of a complete Digital Mock-Up embedding assembly constraints. The proposed approach demonstrates good capacities to help maintaining the coherence between a product/system and its digital twin.

Keywords: CAD assembly models · Digital twin · Constrained fitting · Registration · Simulated annealing · ICP ·As-scanned point clouds