Feature-Based Reverse Engineering of Mechanical Parts

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Abstract

Reverse engineering of mechanical parts requires extraction of information about an instance of a particular part sufficient to replicate the part using appropriate manufacturing techniques. This is important in a wide variety of situations, since functional CAD models are often unavailable or unusable for parts which must be duplicated or modified. Computer vision techniques applied to 3–D data acquired using non-contact, three-dimensional position digitizers have the potential for significantly aiding the process. Serious challenges must be overcome, however, if sufficient accuracy is to be obtained and if models produced from sensed data are truly useful for manufacturing operations. This paper describes a prototype of a reverse engineering system which uses manufacturing features as geometric primitives. This approach has two advantages over current practice. The resulting models can be directly imported into feature-based CAD systems without loss of the semantics and topological information inherent in feature-based representations. In addition, the feature-based approach facilitates methods capable of producing highly accurate models, even when the original 3–D sensor data has substantial errors.

Keywords: reverse engineering, surface fitting, feature-based CAD

CAD models are often unavailable or unusable for parts which must be duplicated or modified. This is a particular problem for long life cycle systems for which spare part inventories have been exhausted and original suppliers are unable or unwilling to provide custom manufacturing runs of spare parts at affordable prices and in a timely manner. For many parts, either CAD systems were not used in the original design or the documentation on the original design is otherwise inadequate or unavailable. For a variety of reasons, CAD models, even when they exist, may not be sufficient to support modification or manufacturing using modern methods. Finally, shop floor changes to the original design may mean that the original CAD model no longer accurately reflects the geometry of the part. Reverse engineering techniques can be used to create CAD models of a part based on sensed data acquired using three-dimensional position digitization techniques. Part-to-CAD reverse engineering allows up to date NC fabrication plus easier modification of the design than would otherwise be possible. Successful instances include everything from sporting goods to aircraft parts.

Reverse engineering of solid objects traces its roots back to the pantograph, which uses a mechanical linkage to duplicate arbitrary geometric shapes at any predetermined scale. Copy lathes and mills are more contemporary and automated versions of the pantograph. In a copy lathe, a mechanical stylus is moved along a template specifying a 1–D profile. The position of the cutter is adjusted based on this template, producing a...