Methods and Algorithms for Constraint-Based Virtual Assembly

ABSTRACT: This paper presents methods and algorithms to achieve constrained motion simulation in a virtual assembly environment by using geometric constraints. The term constraint in this paper refers to the geometrical constraints that are used to reduce the degree of freedom of a part relative to the base part or a sub-assembly. The constraints (axial, planar etc) are extracted from the assembly models in the CAD system. Constraint based motion in virtual assembly allows realistic manipulation and interaction of objects using methods which are not very compute-intensive. These techniques map the movement of the part being manipulated through the use of 3D tracking devices during assembly into corresponding allowable motion based on the constraints that are specified in the assembly model. The main contributions of this paper are : fundamental methods for geometric constraint based motion; an analysis of 'combinations' and 'order of application' of axial and planar constraints; methods and algorithms for checking and applying the constraints in the assembly operation, with a detailed discussion of three special cases that arise when trying to maintain previously applied constraints; constraint encapsulation in object oriented design; and methods, derived from constraints, that guide the assembly operation in a virtual environment. Three test cases are presented to validate the methods and algorithms presented in the paper. Two important aspects of the work presented in this paper that distinguishes it from other similar work are as follows: the constraints are directly obtained from the CAD model of the assembly; and the constraint based assembly operation in the virtual environment directly involves human operators, with a tracking device and a glove to manipulate the part. **KEYWORDS:** Virtual Assembly, Assembly Constraints, Constrained Motion Simulation