SiLVIA – a Simulation Library for Virtual Reality Applications

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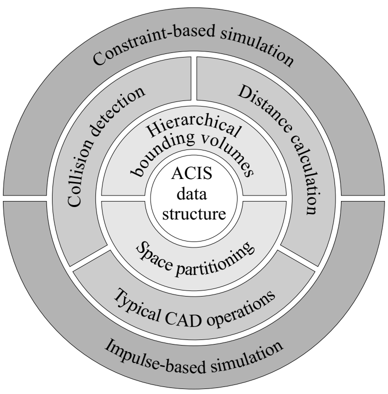
Abstract

The main purpose of SiLVIA is to supply procedures for simulating the dynamics of colliding rigid bodies and the interactive manipulation of these bodies in virtual environments. Detecting collisions between virtual objects and calculating their reaction to these collisions play an important role in VR applications such as ergonomy studies or virtual assembly simulations.

1. Introduction

VR techniques can help to evaluate the virtual prototypes resulting from the design of complex mechanical systems. VR-based assembly planning, e.g. is an effective means to analyse the feasibility of an assembly process. Apart from the pure visualization, the VR software must be able to realistically simulate the behaviour of colliding objects at interactive rates. The simulation library SiLVIA provides ef£cient algorithms to detect collisions and to calculate physically correct responses to collisions.

2. The structure of SiLVIA



The fundamental data structure to represent the geometric shape of an object follows the ACIS® speci£cation which is not restricted to polygonal object representations. This kernel is encapsulated by a module for hierarchical bounding volumes and one for space partitioning. The next level of functionality comprises algorithms for ef£cient collision detection, distance calculation and some typical CAD operations. Detecting collisions and calculating distances between pairs of moving objects are essential for all subsequent mechanical simulations because they provide the necessary geometric information about the admissible spatial positions and orientations of the objects involved. We are able to achieve a realistic object behaviour by using constraint-based (see [1, 3]) and impulse-based simulation techniques (see [2]).

3. Collision detection and response

In order to speed up the interference and distance calculations for a pair of objects, many popular bounding volume hierarchies based on axis-aligned boxes, oriented boxes, £xed directions hulls and spheres have been implemented. By means of these hierarchical approximations the critical zones of overlap and those of small distances can be identi£ed ef£ciently. All interference tests for the bounding volumes as well as for the original surface patches use interpolation methods in order to predict the colliding parts and the corresponding time of collision.

Since all objects are treated as rigid bodies, which are forbidden to penetrate each other, contact forces have to be determined. In our constraint-based approach we tackle this problem by setting up a non-linear complementarity problem which considers inertial, gravitational, frictional and interactively exerted forces.

References

[1] M. Buck and E. Schömer. Interactive rigid body manipulation with obstacle contacts. In 6^{th} *Int. Conf. in Central Europe on Computer Graphics and Visualization*, pages 49–56, 1998.
[2] B. Mirtich. *Impulse-based dynamic simulation of rigid body systems*. PhD thesis, University of California, Berkeley, 1996.
[3] J. Sauer and E. Schömer. A constraint-based approach to rigid body dynamics for virtual reality applications. In *Proc. ACM Symp. on VR Software and Technology*, pages 153–161, 1998.