

Geometric algorithms for planning and simulation tasks in virtual prototyping

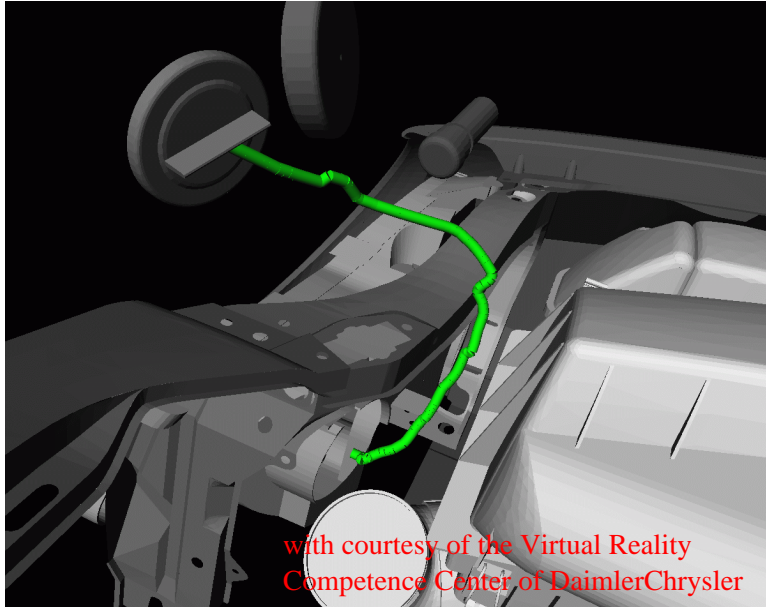
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Motivation



Applications:

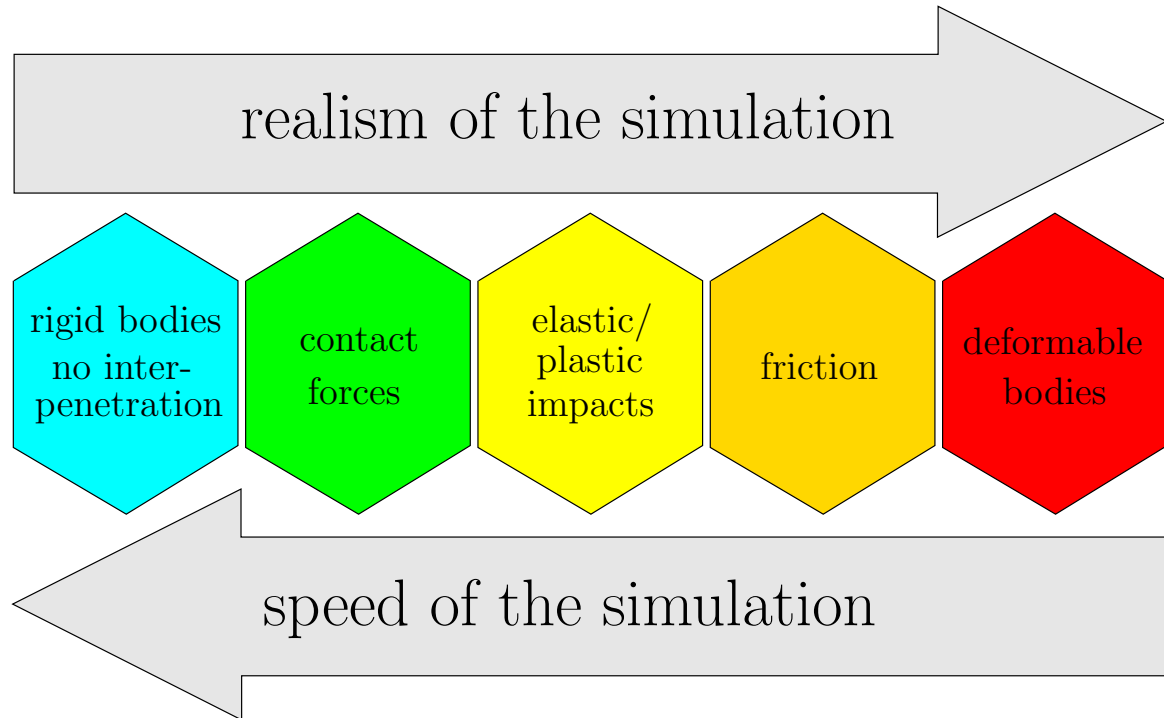
- mounting and demounting operations
- ergonomic studies
- assembly planning

Realization:

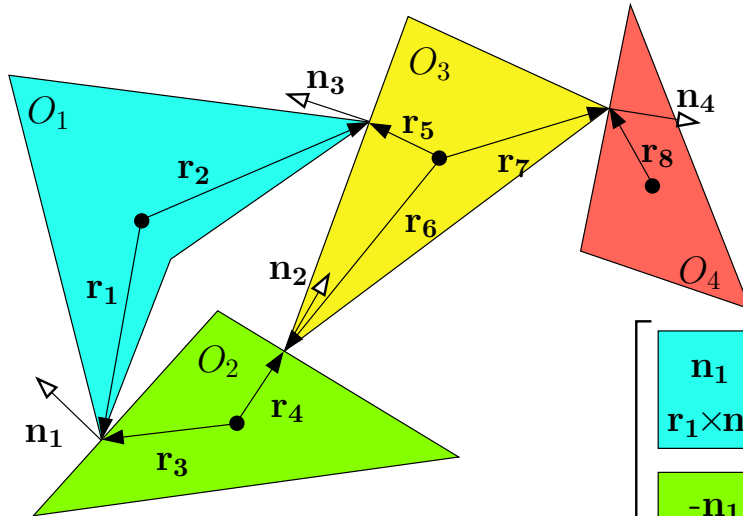
- in a virtual environment
- with the help of virtual prototypes

Economic goals: cut costs, save time, increase quality

Simulation of multibody systems



Rigid bodies with unilateral contacts



$$\dot{\mathbf{s}} = \mathbf{S} \mathbf{u}$$

$$\dot{\mathbf{u}} = \mathbf{M}^{-1}(\mathbf{C}\mathbf{f} + \mathbf{f}_{ext})$$

$\mathbf{C} =$

\mathbf{n}_1 $\mathbf{r}_1 \times \mathbf{n}_1$	0 0	\mathbf{n}_3 $\mathbf{r}_2 \times \mathbf{n}_3$	0 0
$-\mathbf{n}_1$ $-\mathbf{r}_3 \times \mathbf{n}_1$	$-\mathbf{n}_2$ $-\mathbf{r}_4 \times \mathbf{n}_2$	0 0	0 0
0 0	\mathbf{n}_2 $\mathbf{r}_6 \times \mathbf{n}_2$	$-\mathbf{n}_3$ $-\mathbf{r}_5 \times \mathbf{n}_3$	$-\mathbf{n}_4$ $-\mathbf{r}_7 \times \mathbf{n}_4$
0 0	0 0	0 0	\mathbf{n}_4 $\mathbf{r}_8 \times \mathbf{n}_4$

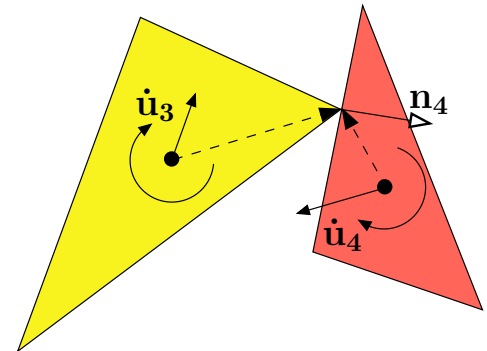
The classical approach

relative contact acceleration in normal direction:

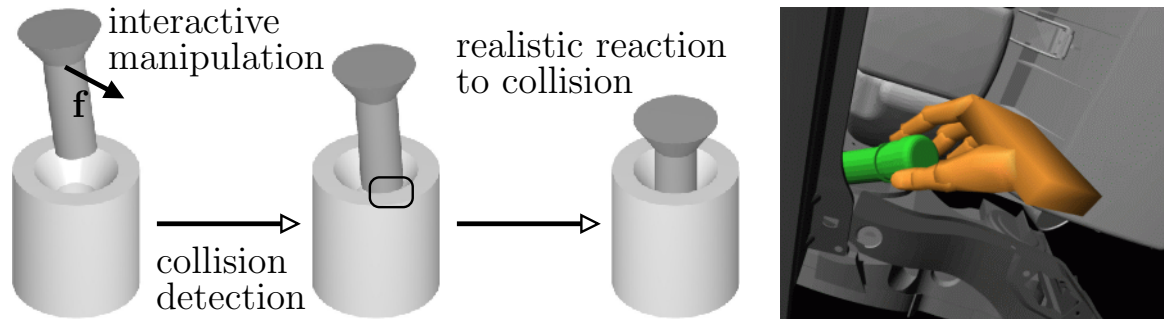
$$\mathbf{a} = \mathbf{C}^T \dot{\mathbf{u}} \geq \mathbf{0} \text{ with } \dot{\mathbf{u}} = \mathbf{M}^{-1}(\mathbf{C} \mathbf{f} + \mathbf{f}_{ext})$$

formulation as a linear complementarity problem:

$$\mathbf{a}_i > 0 \Rightarrow \mathbf{f}_i = 0 \text{ and } \mathbf{f}_i > 0 \Rightarrow \mathbf{a}_i = 0$$



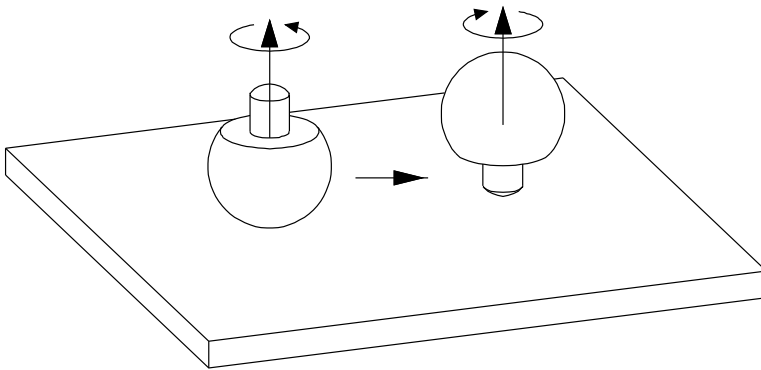
The role of contact forces



Contact forces

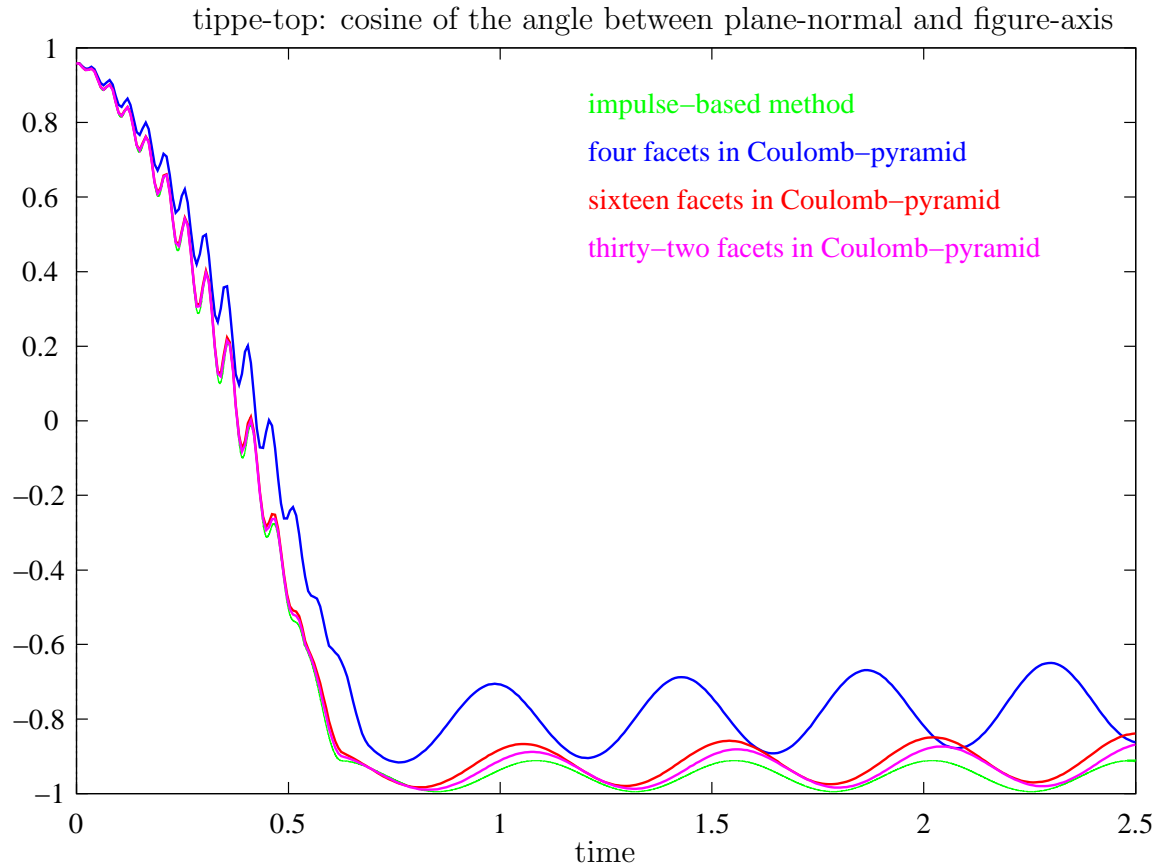
- prevent interpenetration of objects
- facilitate interactive manipulation of objects
- are necessary for haptic feedback

The tippe top



Some experiments

Evaluation of the simulation results



Evaluation of the simulation results

