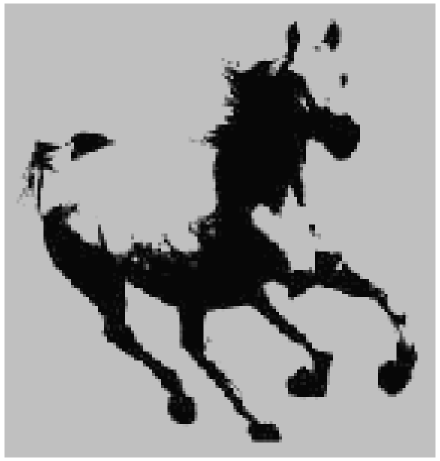
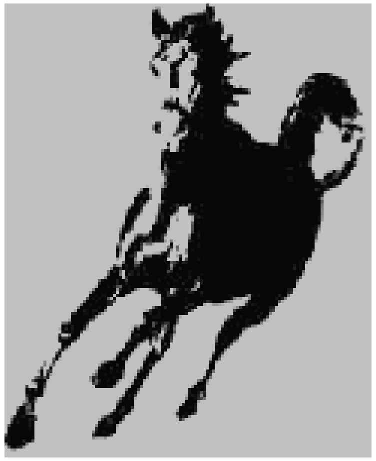
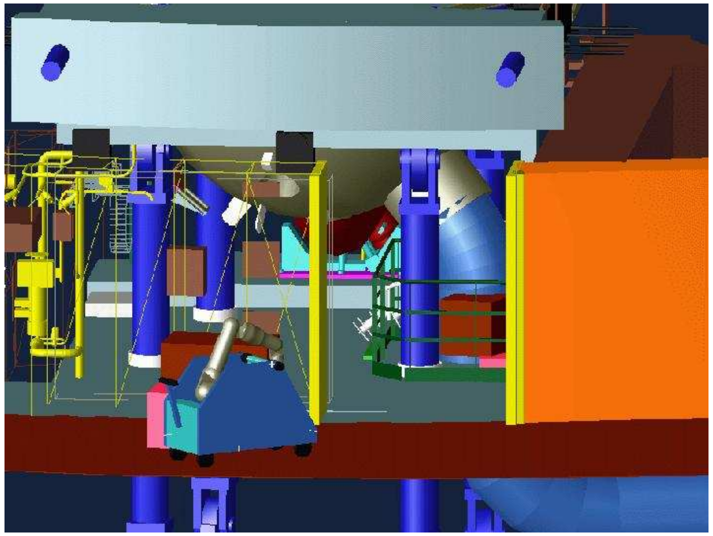
Motion Support for Virtual Prototyping

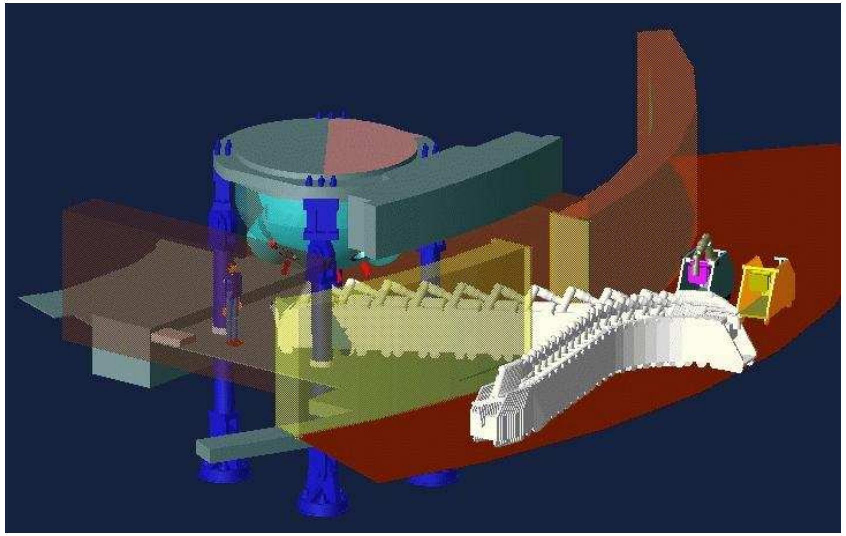




Jean-Claude Latombe
Stanford University

Computer-Aided Design

From electronic drafting tables ... to virtual environments





Exploring how to put a robot arm underneath a steam generator of a nuclear power plant.

Sources: EDF and LAAS-CNRS (MOLOG Project)

Motion support in virtual environments makes it possible to:

- Manipulate, assemble, use, and service mechanical products before they physically exist.
- Plan manufacturing and maintenance operations while products are being designed.
- Design manufacturing and maintenance systems while products are being designed.

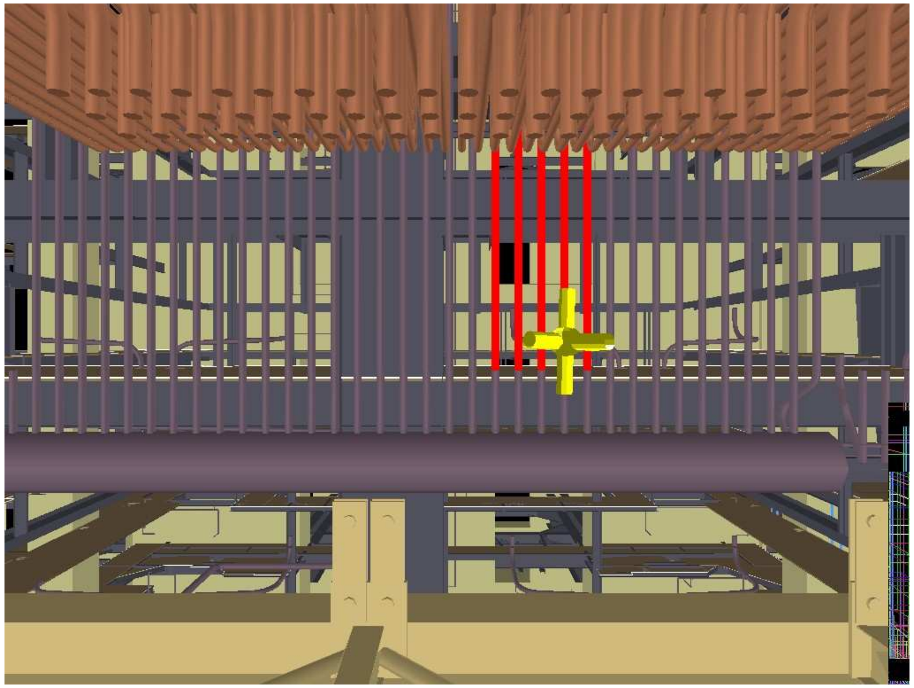
$\Rightarrow$ Better products, reduced costs, shorter time to market, better service, etc...

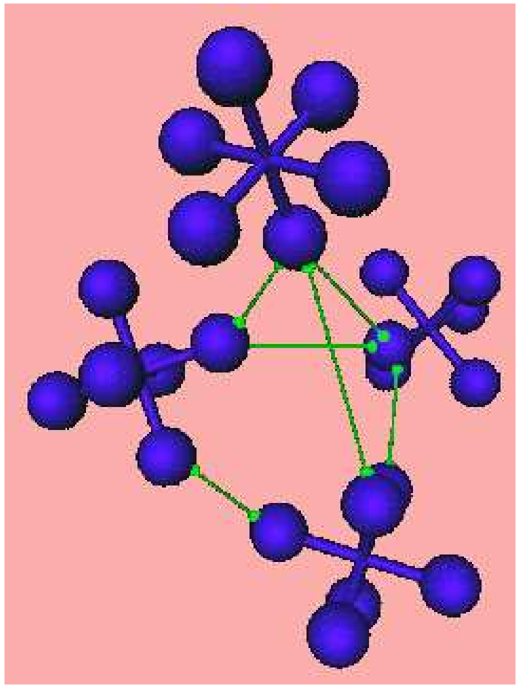
Outline

1. Techniques

2. Applications

Collision Checking and Distance Computation





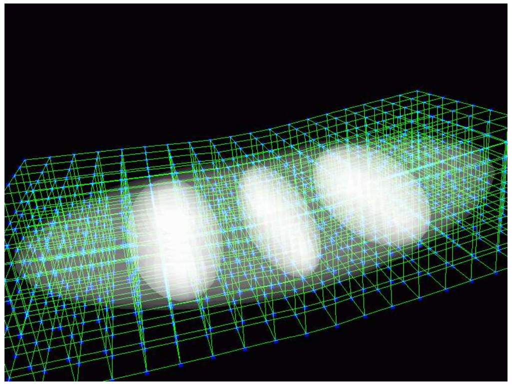
Proximity test in a complex environment (left) and distance computation among multiple moving objects (right).

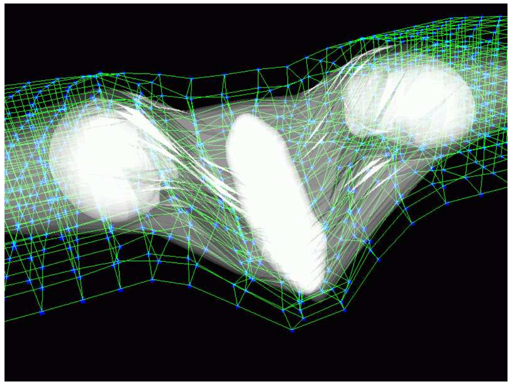
Sources: UNC, Chapel Hill (left) and MERL (right)

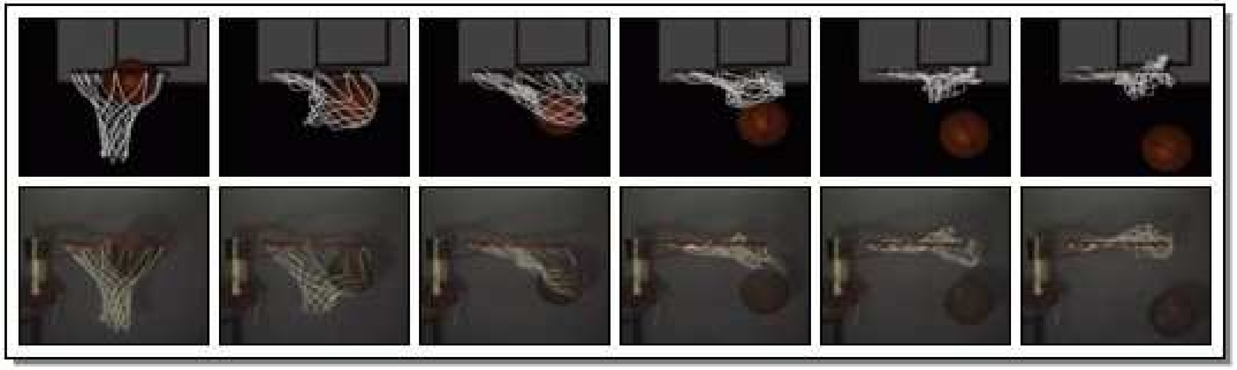
Dynamic Simulation

Sources: MERL (left) and Stanford U. (right)

Modeling the Deformation of Soft Objects



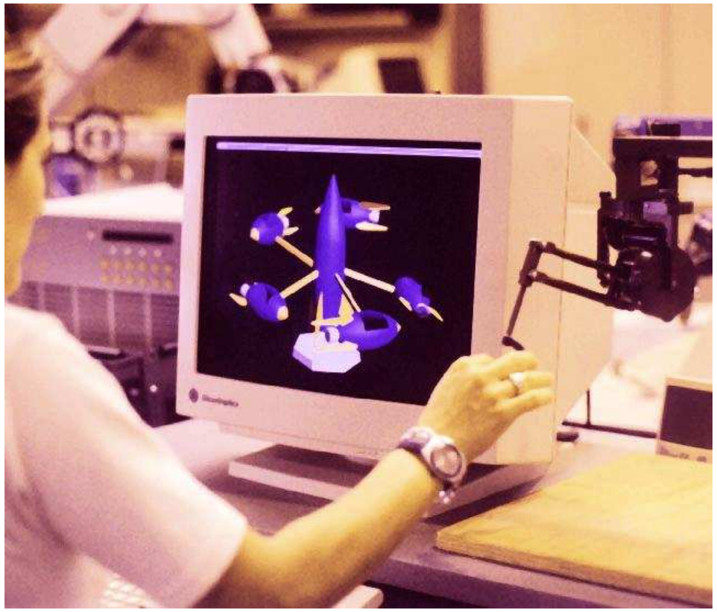


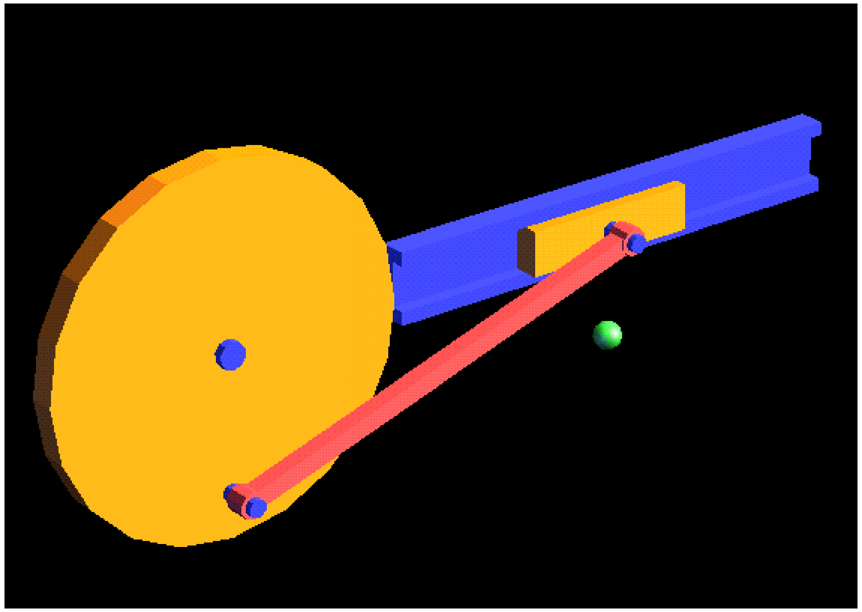


Deformation of soft object with 3 hard "bones" (top) and simulated basket net vs. live footage (bottom).

Source: UNC Chapel Hill (top) and Georgia Tech. (bottom)

Haptics and Motion

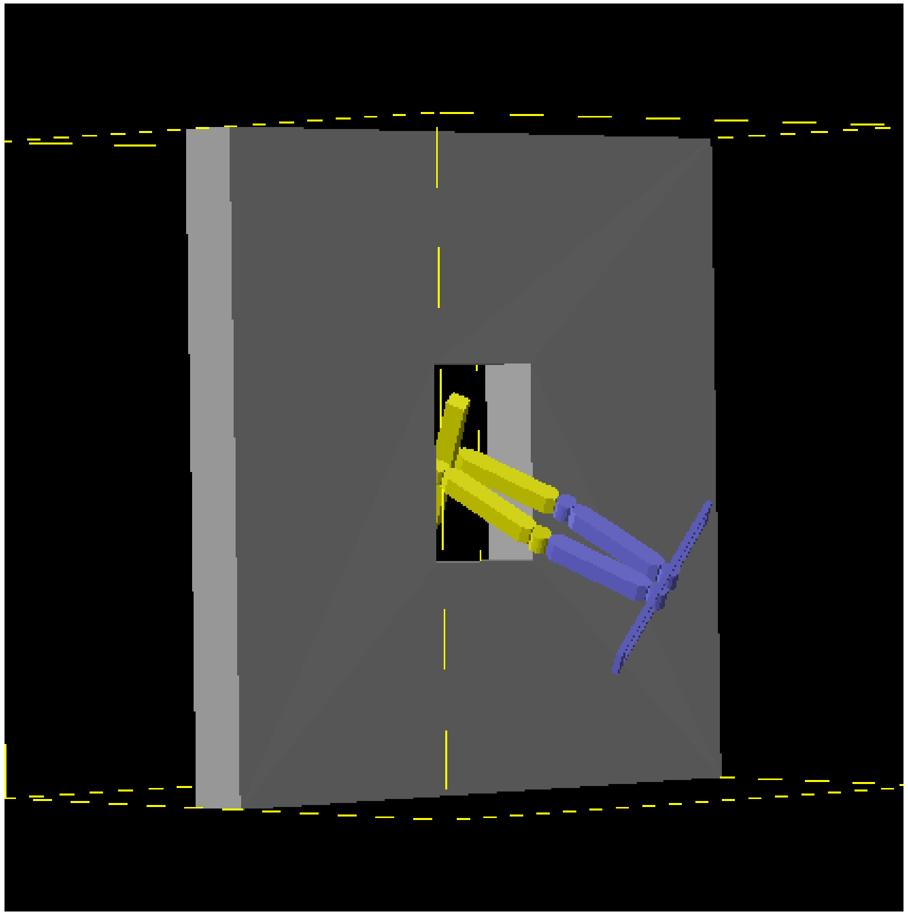


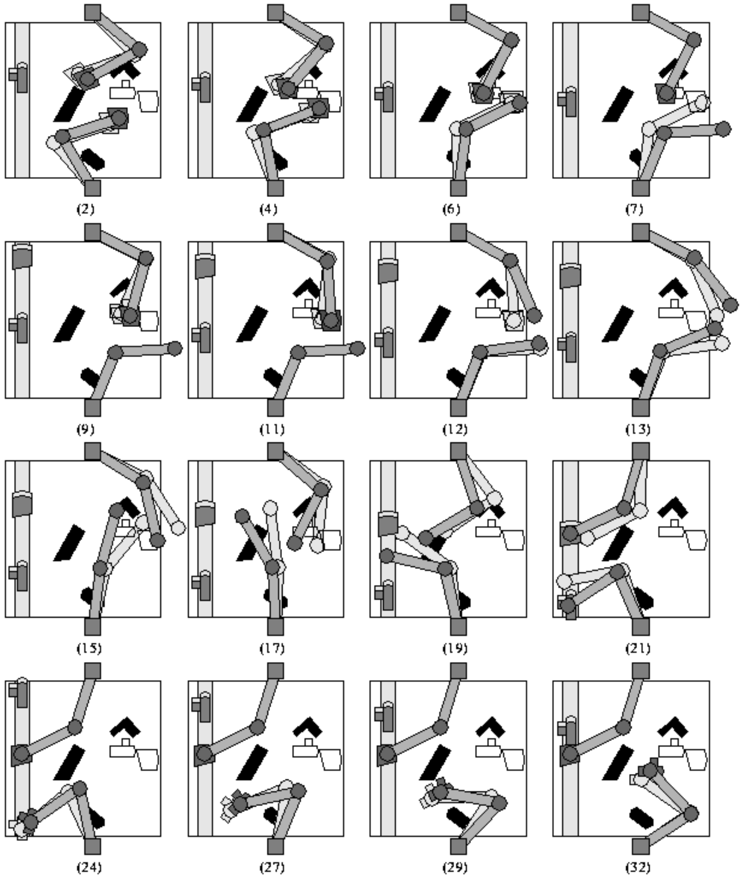


Hactics allows touching virtual objects. It makes it possible to exert forces on them and create motion.

Source: Stanford U.

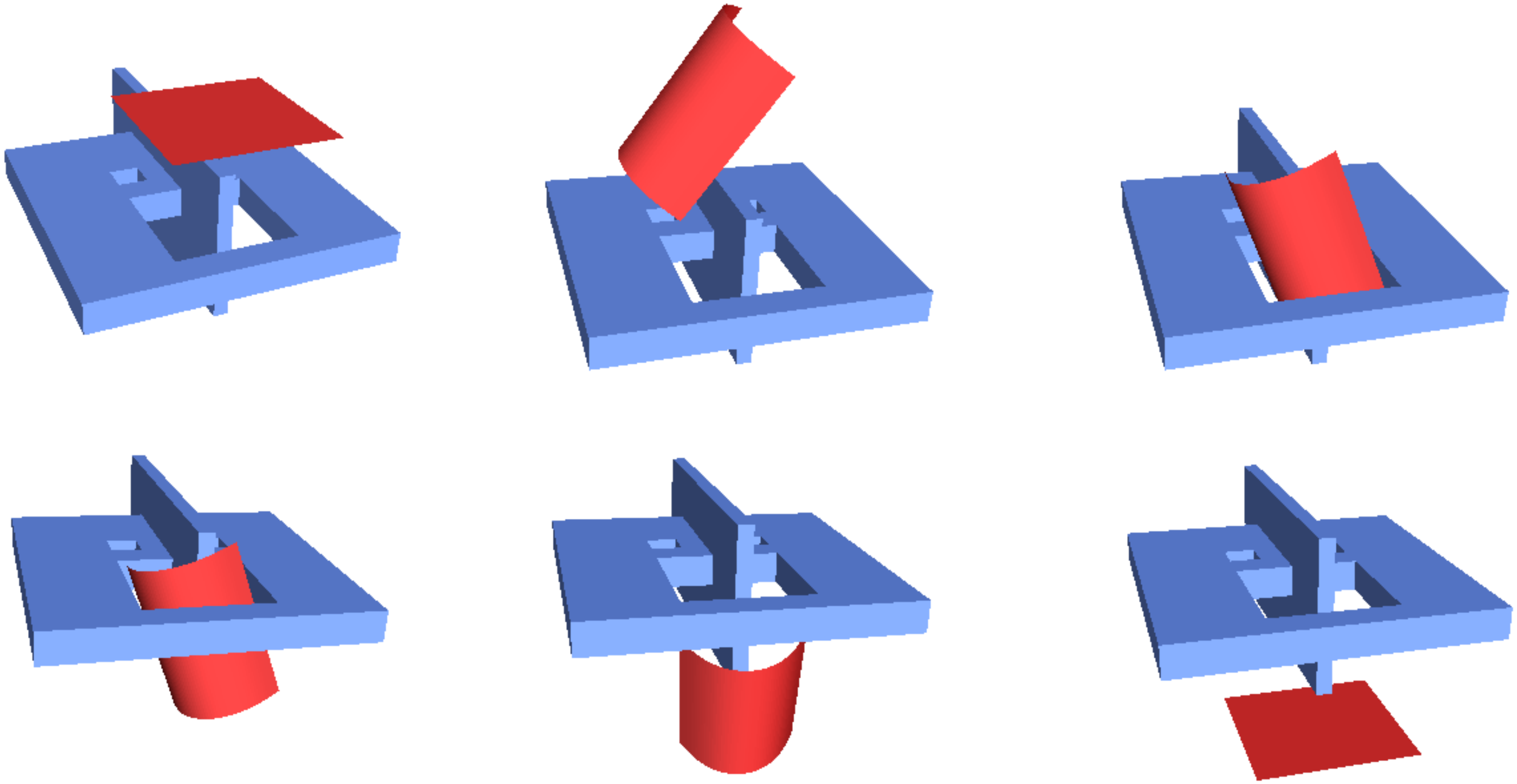
Motion Planning





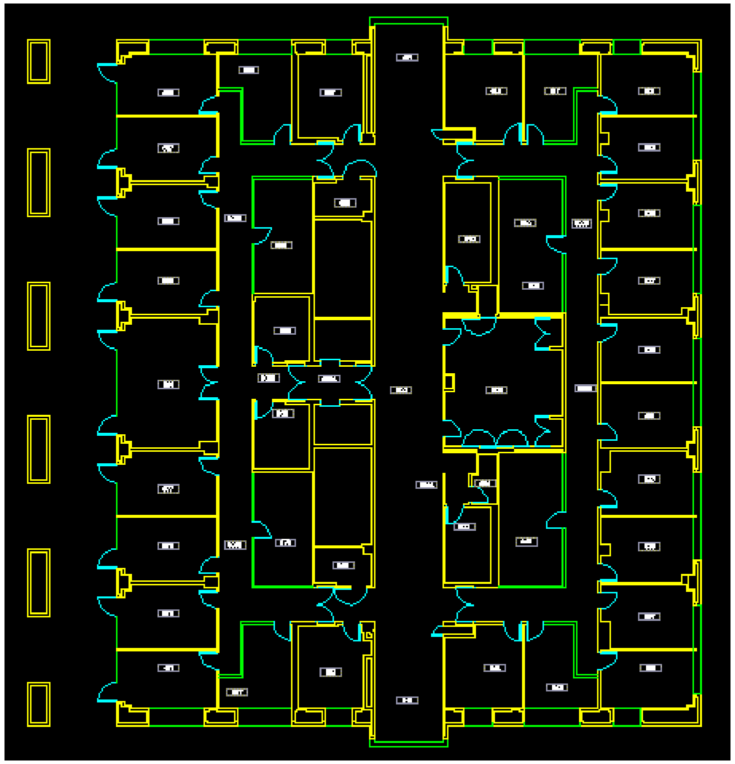
Source: Stanford U.

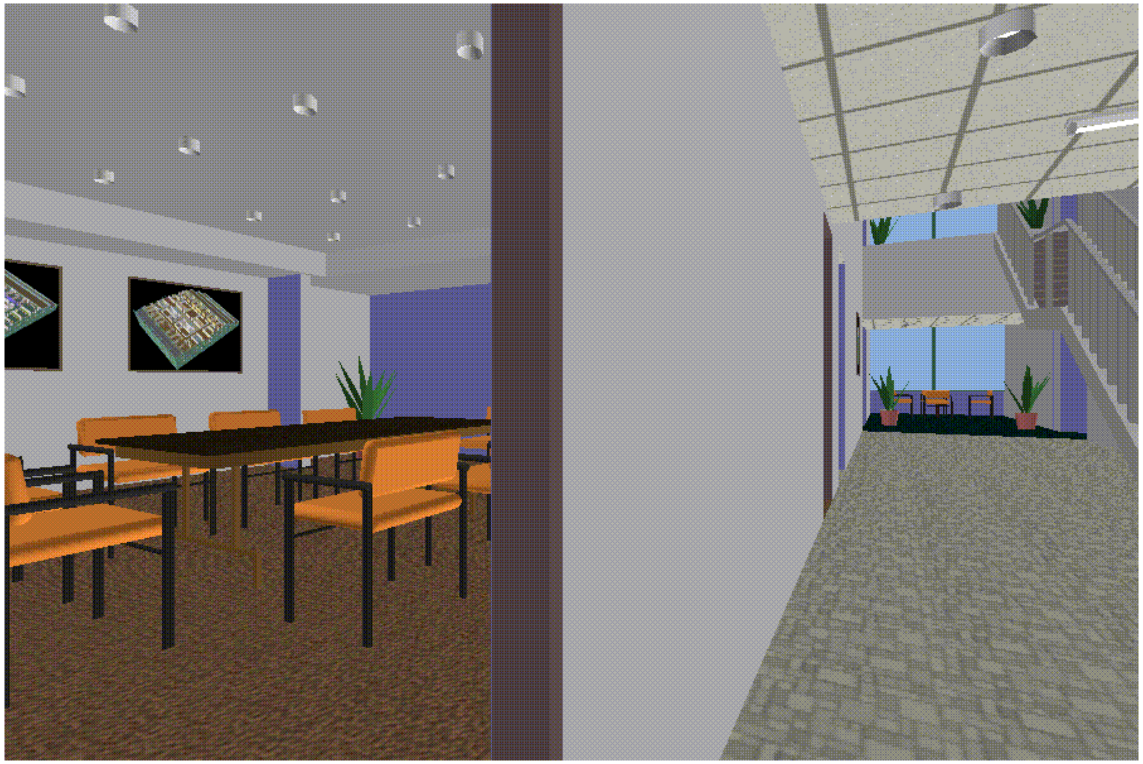
Planning the Motion/Deformation of a Soft Object



Source: Rice U.

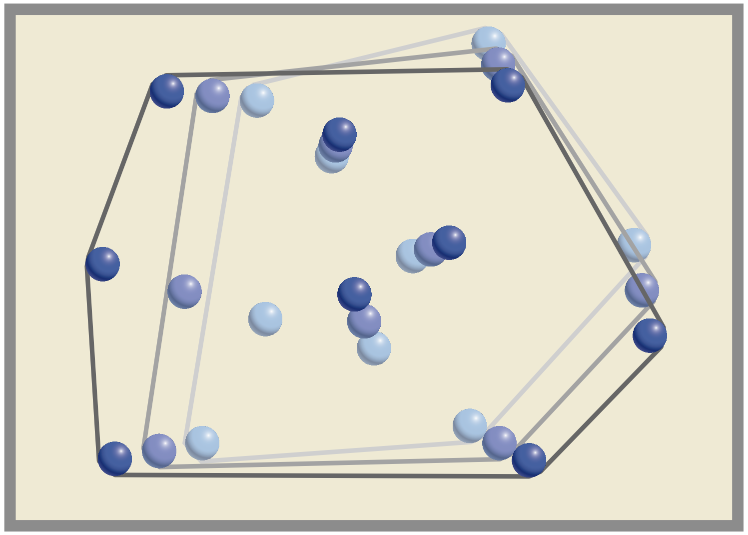
Visibility Computation





Source: U.C. Berkeley

Kinetic Data Structures



As objects move, a Kinetic Data Structure dynamically maintains a set of assertions that guarantee the correctness of an easy computation for an attribute of interest (here the convex hull of moving balls). The events of interest to the KDS are the failures of these assertions.

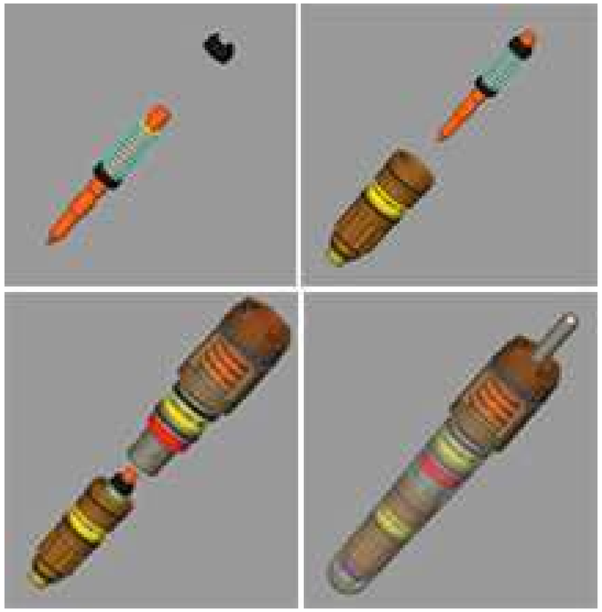
Source: Stanford U.

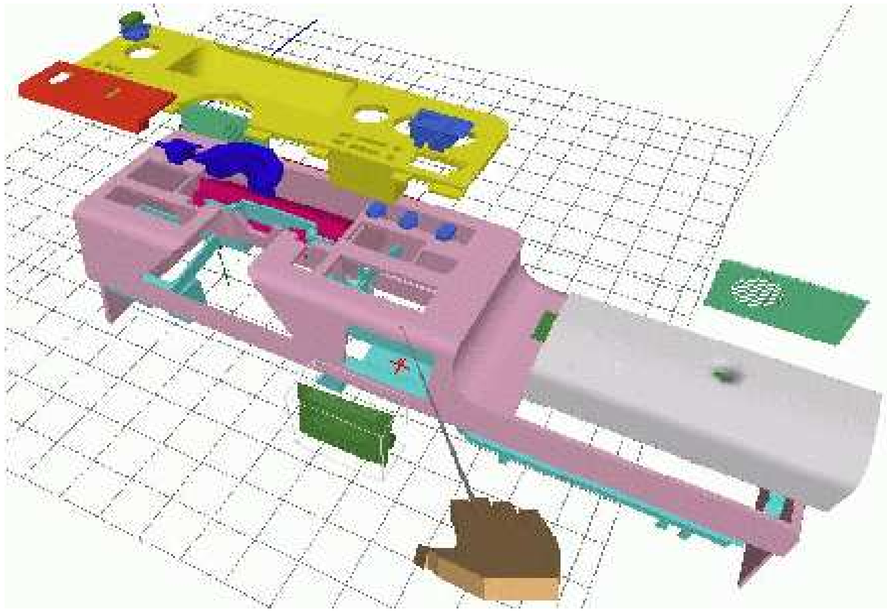
Outline

1. Techniques

2. Applications

Design for Manufacturability

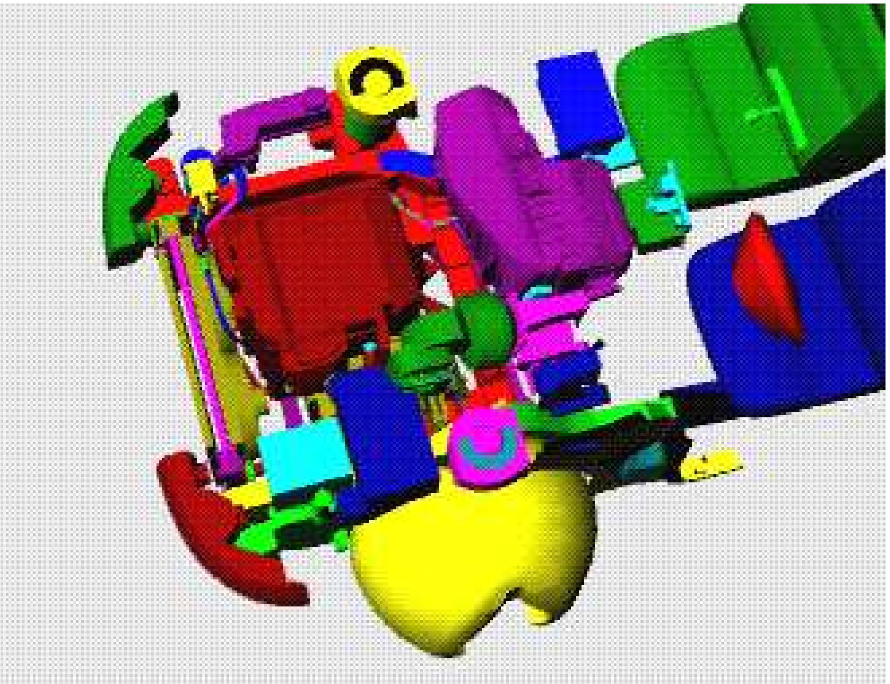


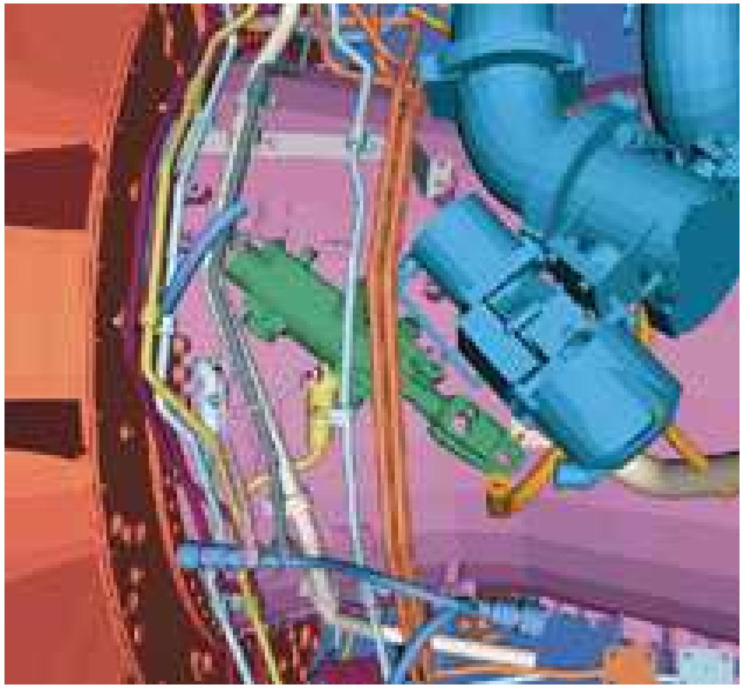


Automatically planning assembly sequences yields complexity measures of the product and its assembly process.

Sources: Sandia Labs (left) and U. of Wisconsin (right)

Design for Serviceability

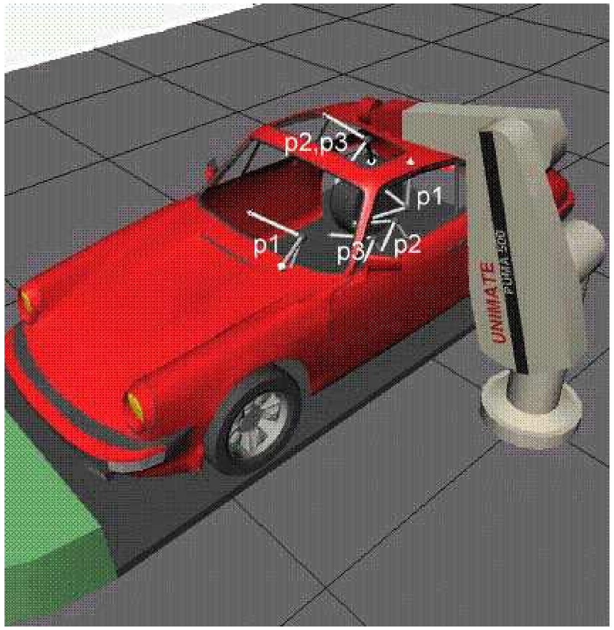


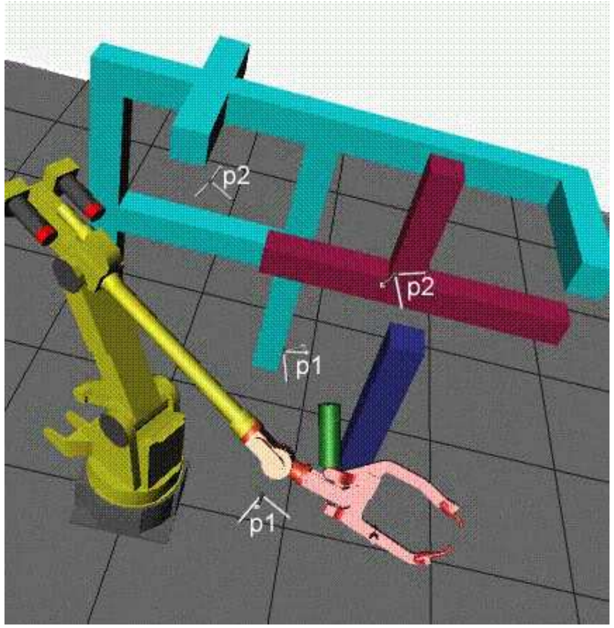


Using a motion planner to automatically check disassemblability of parts yields products that are easier to maintain and service.

Sources: General Motors (left) and General Electric (right)

Concurrent Design of Workcell Layouts

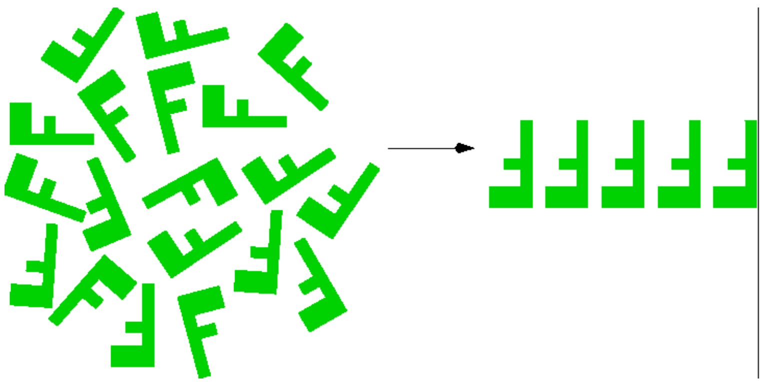


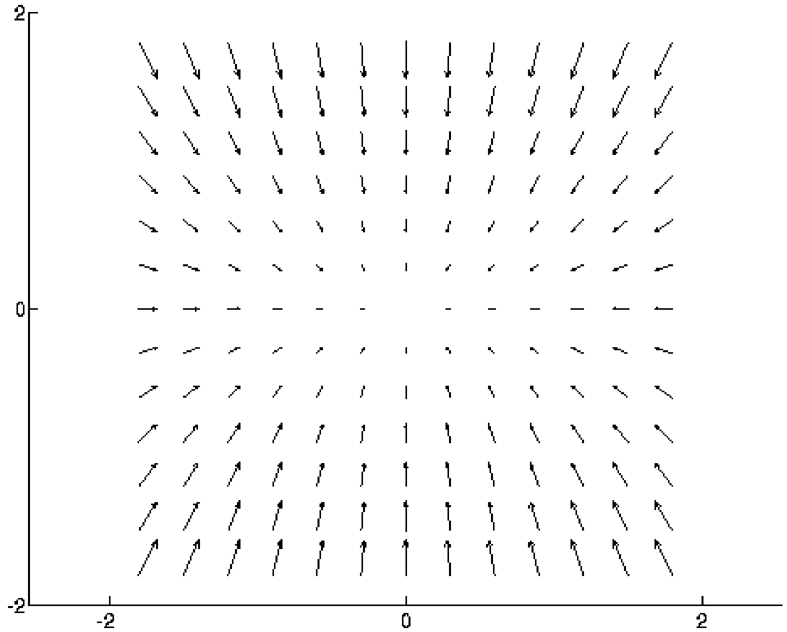


Motion planning and optimization techniques yield optimal placements of robots and other devices on workcells.

Source: Stanford U.

Concurrent Design of Part Feeders

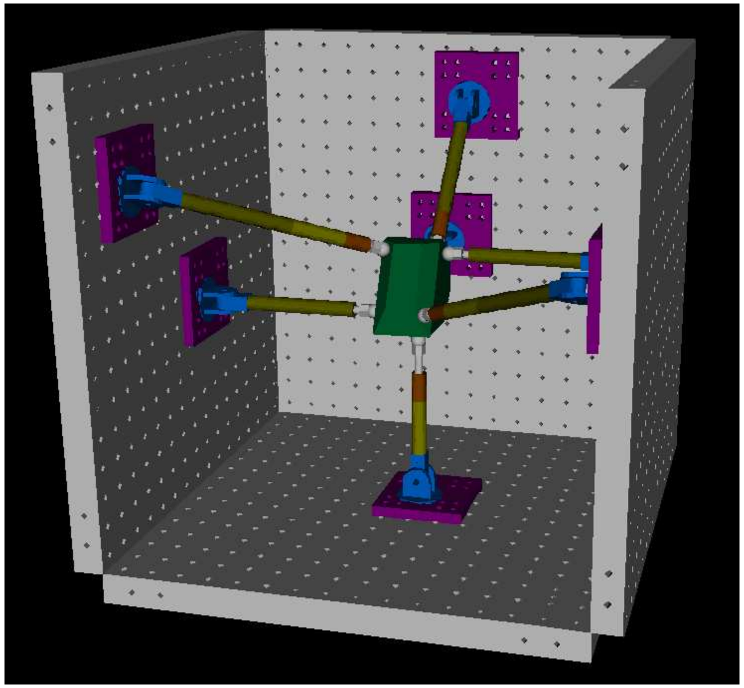




Dynamic simulation yields part feeders design, such as fence-based and trap-based feeders, or feeders based on the generation of a programmable vector fields (such as above).

Sources: Rice U.

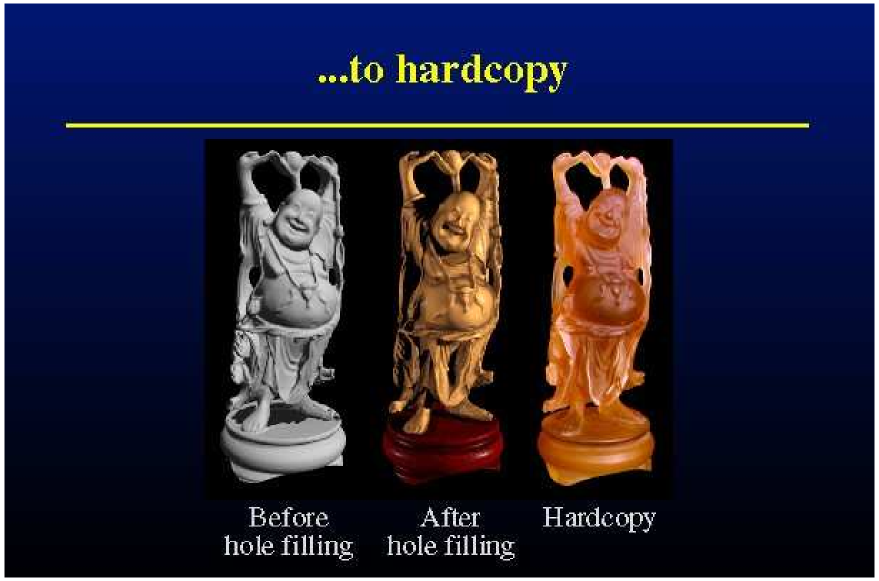
Concurrent Design of Fixtures



Reasoning about ways to restrain motions yields the design of optimal fixtures.

Sources: U.C. Berkeley

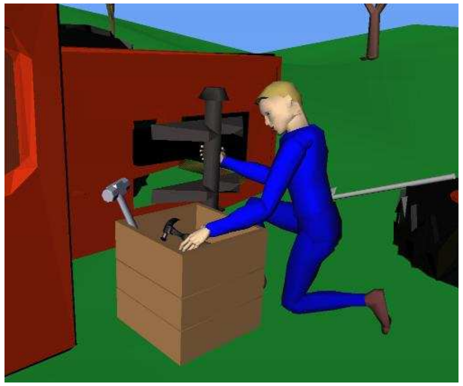
Construction of Computer Models of Physical Objects



Motion planning can also be used to control the motion of a sensor in order to efficiently generate the computer model of an existing object.

Source: Graphics Lab., Stanford U.

Simulation of Human Characters

Human characters can be created that sense their virtual environments and plan/control their motions:

- safety, stress, and comfort analysis
- advanced training
- customized graphic instruction sheets

Source: Pixar (first left), Transom Inc. (second left right), and Stanford U. (rightmost two)