Computer Science & the Physical World

Opportunities for further collaboration between

Graphics, Robotics, Vision, Geometry, and Scientific Computing

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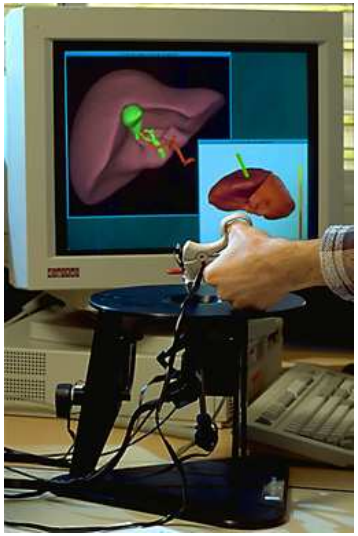
Trends in Physical Computing

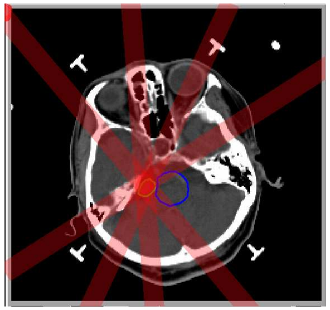
- Many distinct objects
- Motion is ubiquitous
- Interactions among objects
- Different behaviors
- Sense of purpose (e.g., design, control, virtual actors)
- Complex geometry (shape, degrees of freedom, size)
- Sophisticated visualizaton and interaction

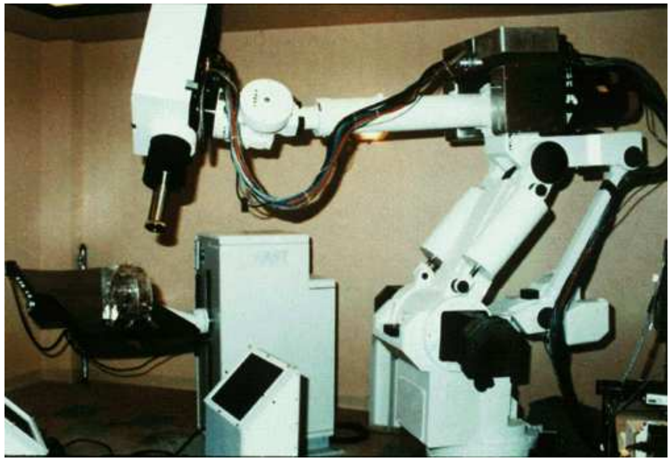
Examples of Application

- Surgical planning and computer-aided surgery
- Digital actors
- Virtual prototyping
- Telepresence
- Drug design
- Service robots

Surgical Planning and Computer-Aided Surgery







Surgery of the liver

Surgery of the brain

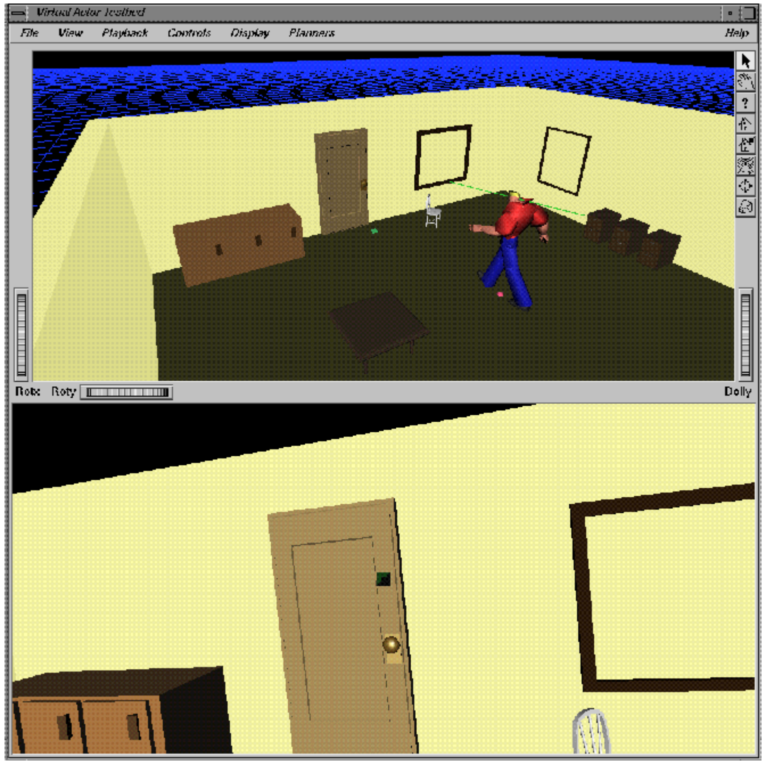
Digital Actors

Motion planning for animating digital actors

Digital Actors

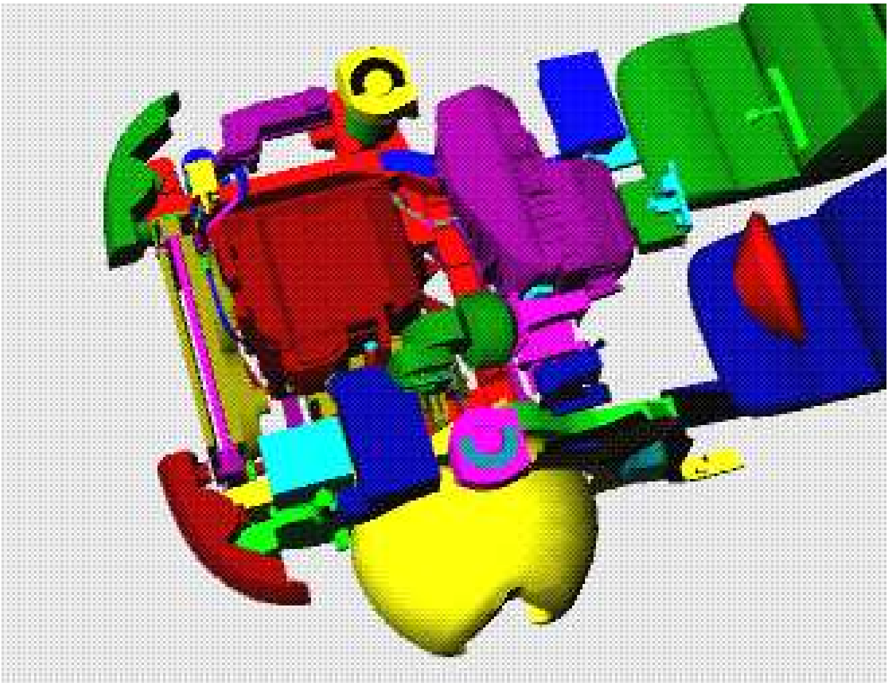
Dynamic simulation for animating digital actors

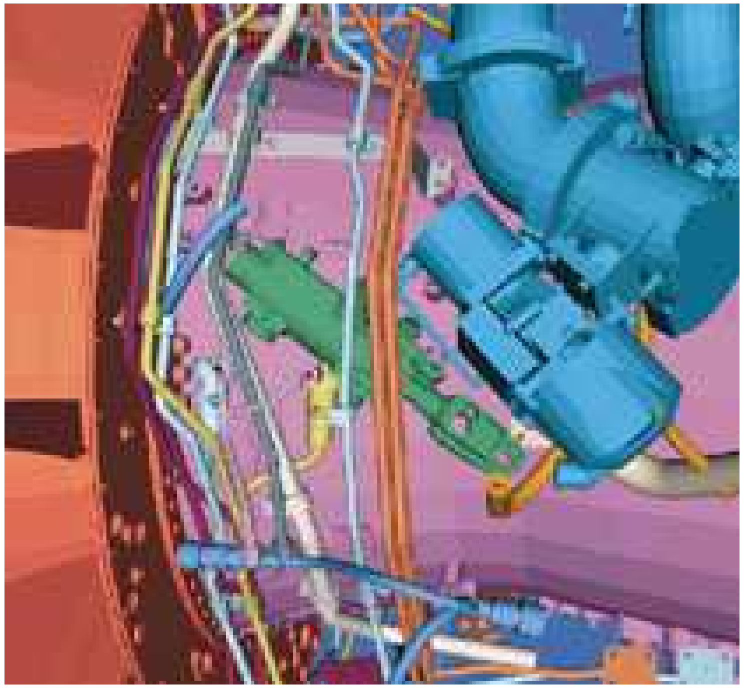
Digital Actors



Visual sensing for digital actors

Virtual Prototyping



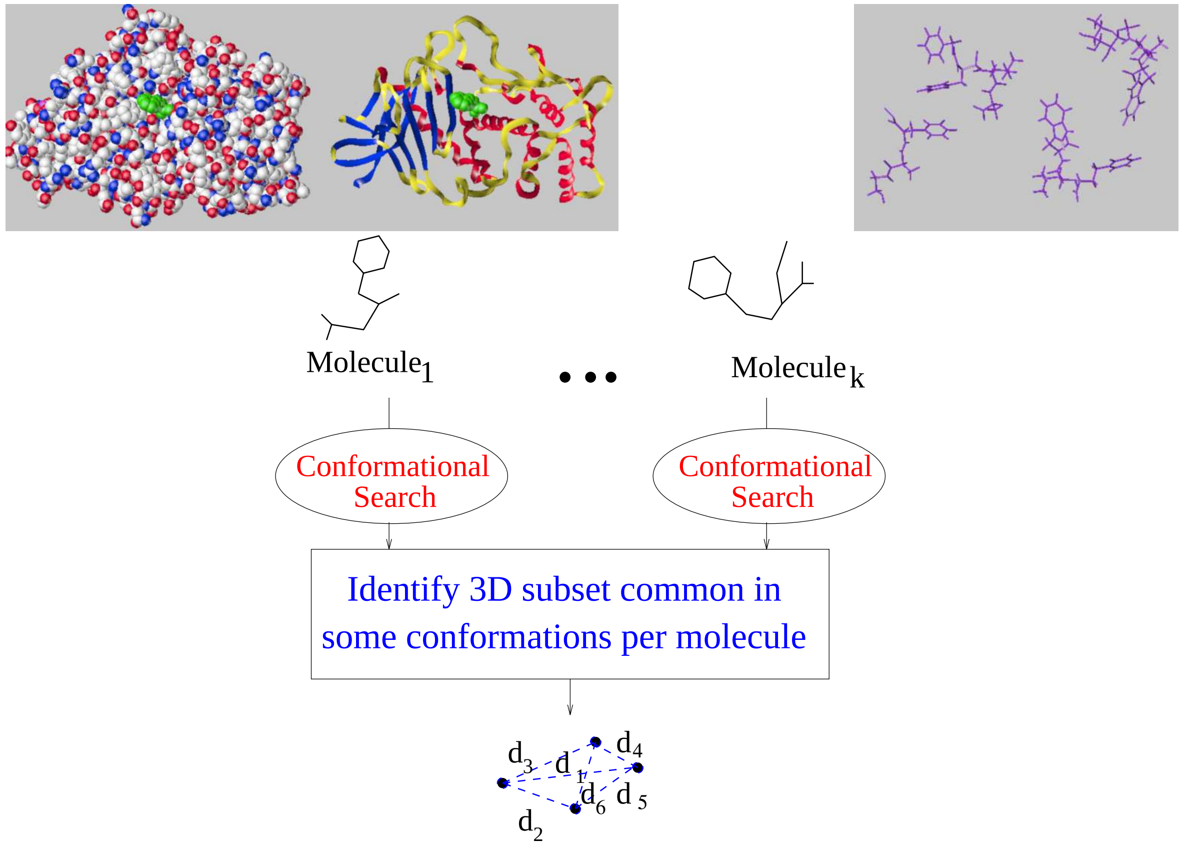


Checking (dis)assemblability of parts

Telepresence

Cooperative work in robotics

Drug Design



Finding 3-D invariants in flexible molecules

Service Robots

Force-controlled cooperative robots

Put the Physical World in the Computer

- e.g., computer-aided design, video games

or **Put the Computer in the Physical World**

- e.g., manufacturing, automobiles

or **Both**

- e.g., surgery, haptic/graphic interaction

The Physical Computing Areas

- Computer Graphics
  - rendering techniques, discrete representations, large data sets, physically-based approximations
  - specialized processors, new interfaces
- Computational Geometry
  - combinatorial complexity, robustness issues
  - arrangements, collision detection, visibility analysis

The Physical Computing Areas, continued

- Computer Vision
  - “inverse” graphics, ill-posed problems, connection to cognitive models
  - 3D model capture, motion capture, image-based rendering

The Physical Computing Areas, continued

- Robotics
  - controllability, observability, uncertainty
  - haptic devices, motion planning, potential-field based behaviors
- Scientific Computing
  - continuous mathematics, error analysis
  - finite element, optimization, signal processing

The Physical Computing Areas: Common Themes

- conceptual, mathematical
  - shape
  - motion
  - physical modeling
  - visibility
- technological, systems
  - effectors, sensors, and displays
  - high-bandwidth architectures, including image/graphics processors and networks

Specific Interactions

- 3-D model capture and graphics
- visual motion capture and graphic animation
- dynamic control and graphic animation
- image-based rendering
- motion planning for computer animation
- scientific computing in robot control and imaging
- geometric arrangements and motion planning
- wavelets and global illumination

What are we doing?

- the physiqual: a qualifying exam in the PhD program
- concentration area in the Masters' program
- CS 528: a joint seminar
- more cohesive course structure
- joint research projects: algorithmics of motion, autonomous observer (telepresence), medical surgery, haptic and graphics
- connections to other domains of CS: HCI, architecture, networking, algorithms, databases, artificial intelligence