Motion Planning: New Challenges
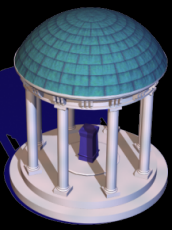
Dinesh Manocha
Department of Computer Science
UNC Chapel Hill
dm@cs.unc.edu
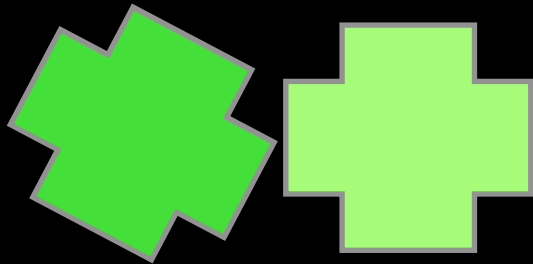
http://gamma.cs.unc.edu
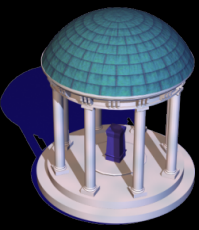
Talk Organization

- Collision Detection/Proximity Queries

- Motion Planning for Physical Robots
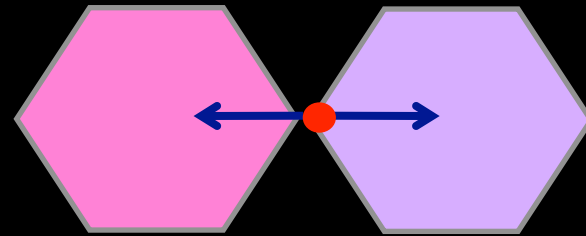
- Human-Like (Dense) Motion Planning

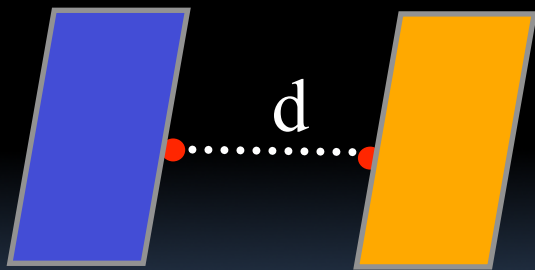# Collision & Proximity Queries

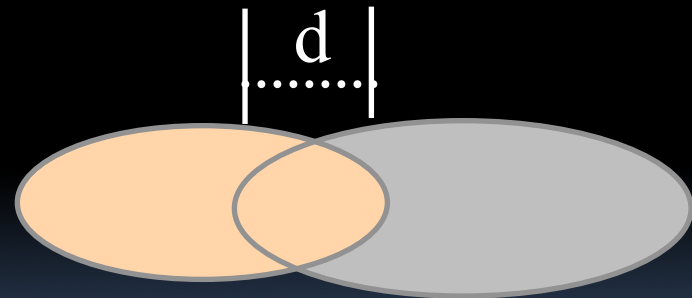*Geometric reasoning of spatial relationships among objects (*in a dynamic environment)
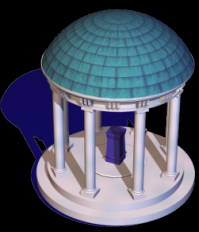
Collision Detection

Contact Points & Normals

Closest Points & Separation Distance

Penetration Depth

Prior work on Proximity Computations

- Fast algorithms for convex polytopes (1991 onwards)

- Bounding volume hierarchies for general polygonal models (1995 onwards)

- Deformable models & self-collisions (2000 onwards)

- Use of GPUs and multi-core hardware (2005 onwards)

- Multi-robot collision avoidance using reciprocal velocity obstacles (2008 onwards)
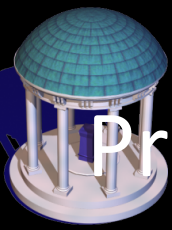
Proximity Computations: Software Systems

- I-Collide, RAPID, PQP, DEEP, SWIFT, SWIFT++, DeformCD, PIVOT, Self-CCD, FCL (ROS), RVO2, HRVO

- http://gamma.cs.unc.edu/software/#collision

- More than 120,000 downloads from 1995 onwards

- Issued more than 55 commercial licenses (Kawasaki, MSC Software, Ford, Sensable, Siemens, BMW, Phillips, Intel, Boeing, etc.)

- Multi-robot (RVO) is widely used in gaming

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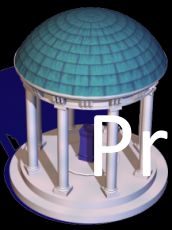
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useful for simulation, graphics, gaming, CAD, VR,.....

Motion Planning for Physical Robots

- Motion Planning has been a success, but OUTSIDE robotics (Laumond 2010)

- What are the challenges in developing planning algorithms for physical robots (IJRR Special Issue 2013)?
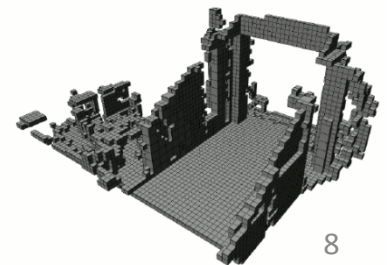
- Forthcoming workshop at IREX'2013

http://www.nikkan.co.jp/eve/irex/english/symposium/3.html
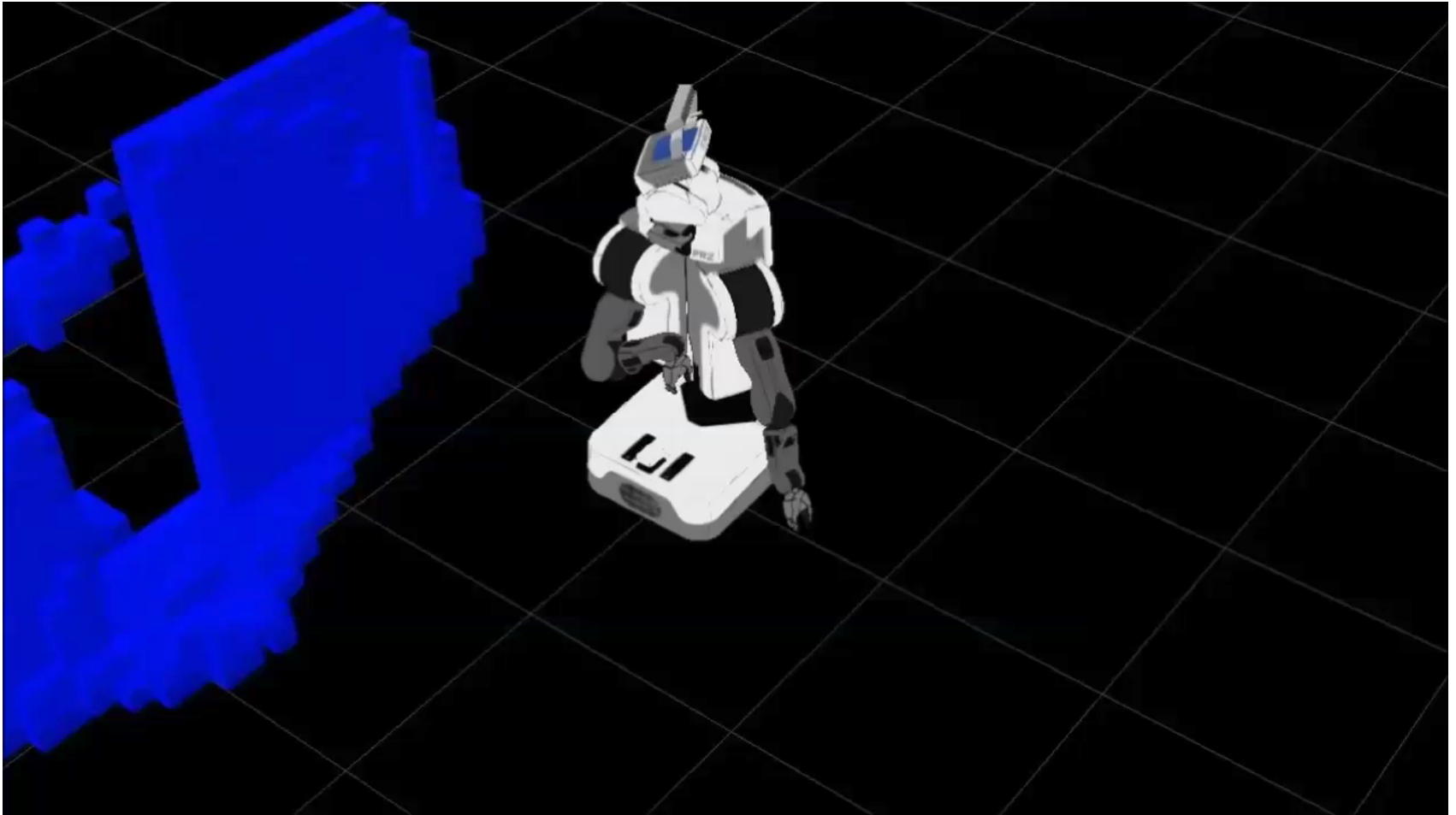
Sensor Data

- ## Point cloud
    - Output from laser/Kinect, etc.
    - Cannot encode unknown regions
    - Very large

- ## Octree (octomap [Hornung et al. 2013])
    - Store point cloud in a compact manner
    - Support multi-resolution
    - Encode occupied/free/unknown regions
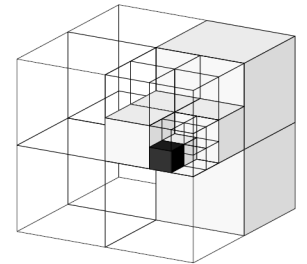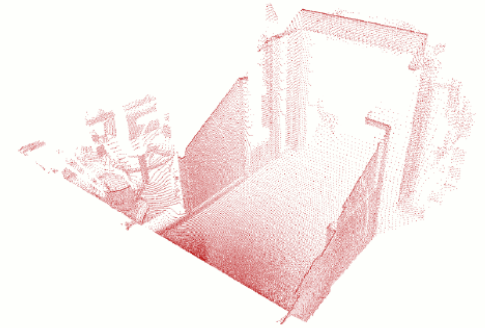
[Joint work with Willow Garage]

Proximity Queries/Planning With Active Sensing

Dynamic Scenes: Real-Time Planning

- High DOF Planning
- Constraints
    - Collision free motion
    - Smooth trajectories
    - Dynamic stability
    - Perception
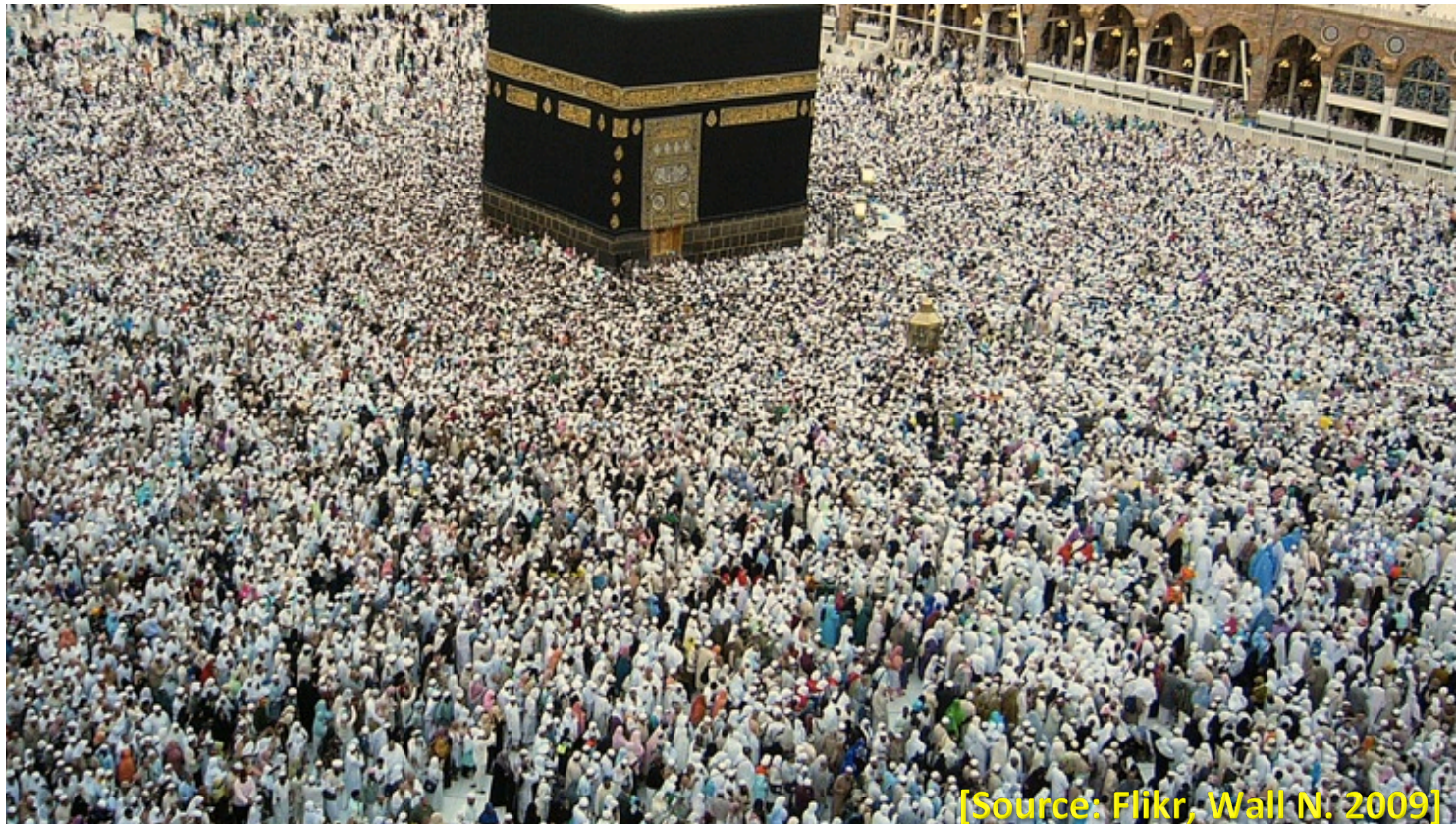   - Natural looking motion?

Use of commodity hardware (GPUs)

[Joint work with Kheddar, AIST]

Motion Planning: Grand Challenges

Crowds: Motion Planning in High Density

- Navigation amongst other humans and obstacles
- Constraints: Generate human-like behavior (kineodynamic constraints, protocols, illogical, etc.)

[Source: Flikr, Wall N. 2009]

Dense Human-Planning

- Computer Graphics
- City Planning/Pedestrian Dynamics
- Computer Vision/Tracking
- Robot-human interaction

©New Line Cinema 2003

[Prassler, Sholz, & Fiorini 2001]

EVACUATION PLANNING: AIRPLANES