



GAZEBO

# Simulation for robots

## Focus on accurate physical simulation

- Easy transition to and from simulation

- Remove hardware issues and resource constraints

## Support common robot control software

- Custom client code

- ROS interface

- Player interface

## Support sharing of resources

- New sensors, actuators, models, and environments

# Additional Benefits

## No real-time constraints

Simulate faster than realtime

## Regression testing

Use simulation for automated tests

## Universal test environment

Create benchmarks

Run a competition

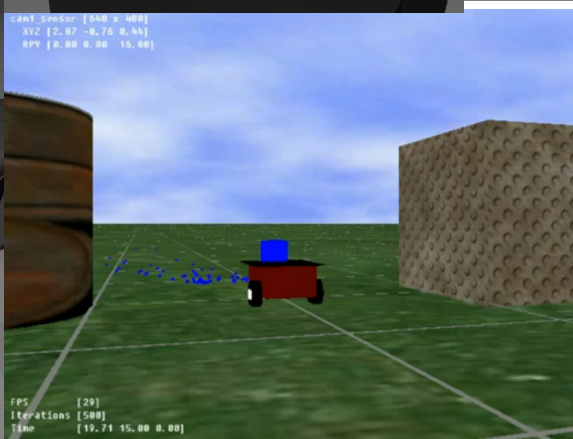
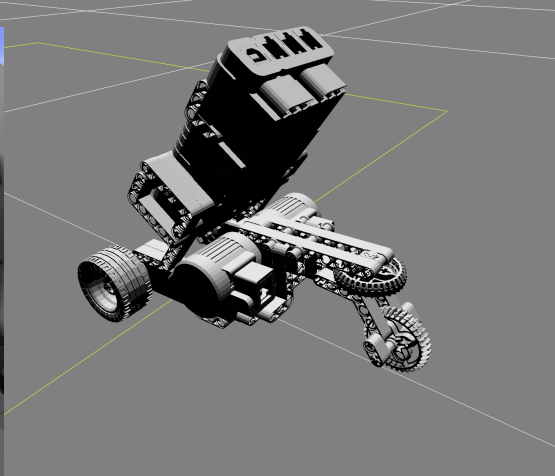
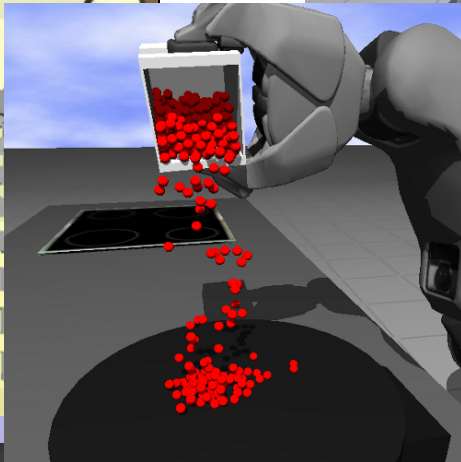
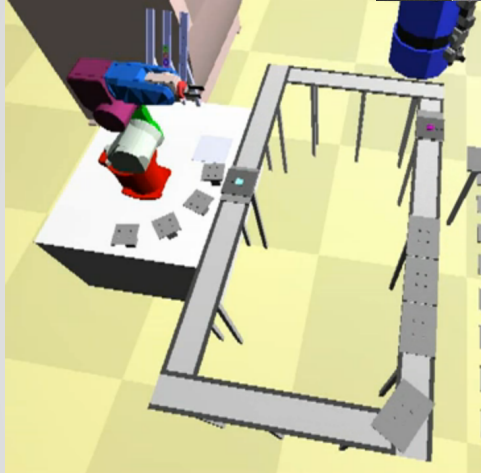
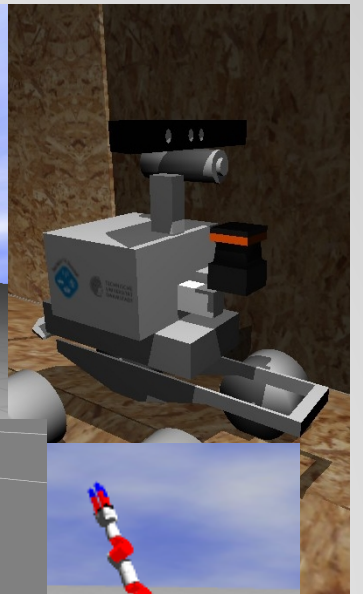
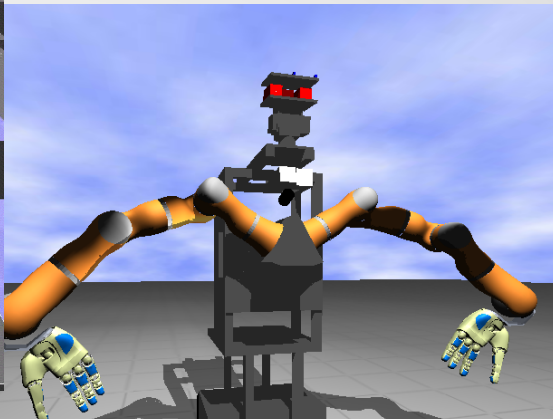
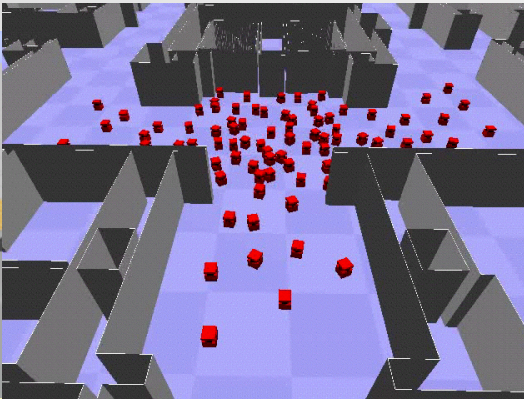
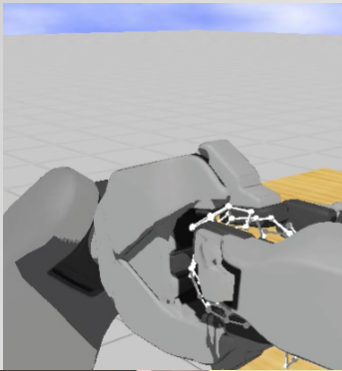
## Flexibility

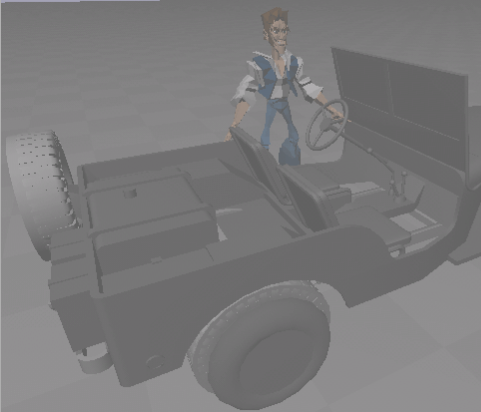
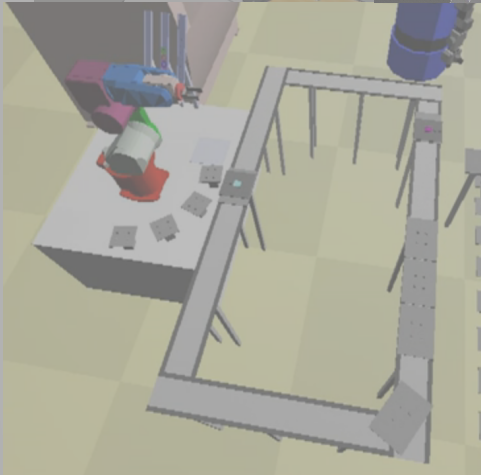
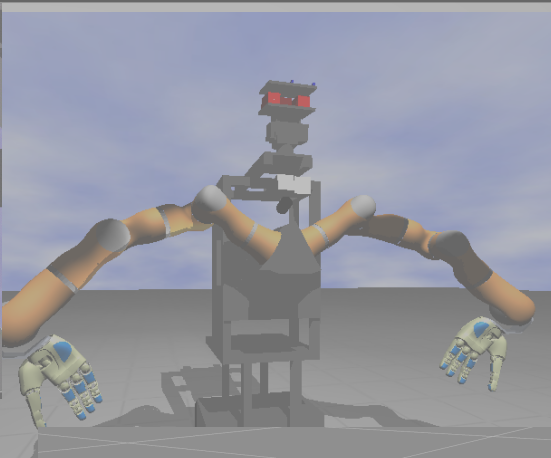
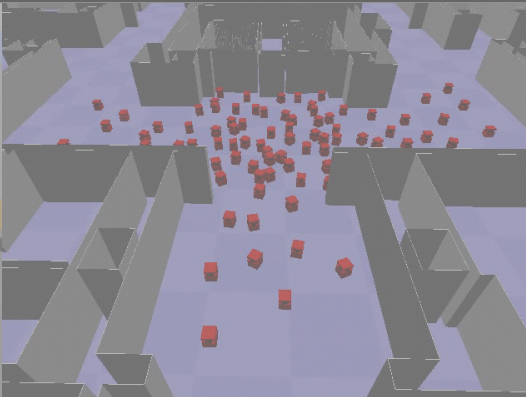
Handles a wide range of environments and tasks

Thin programmatic layer to Gazebo functionality







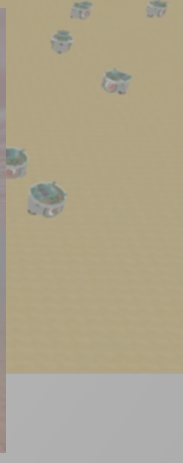
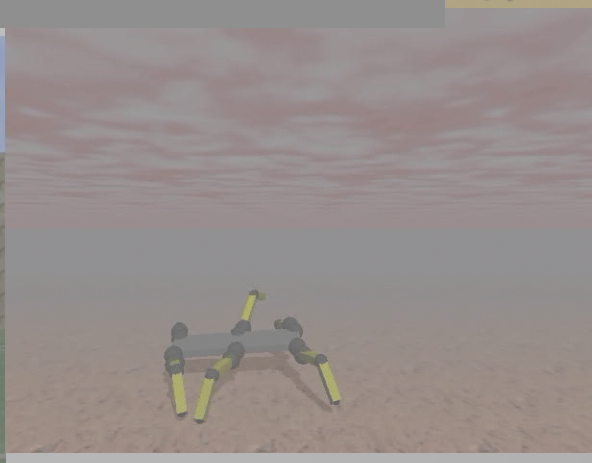
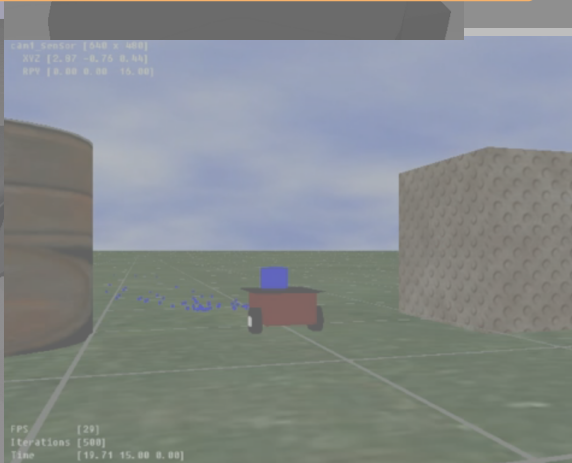
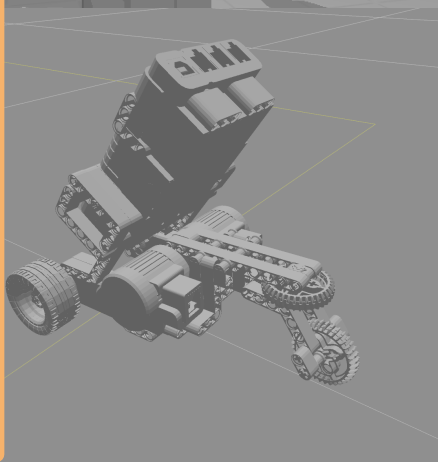
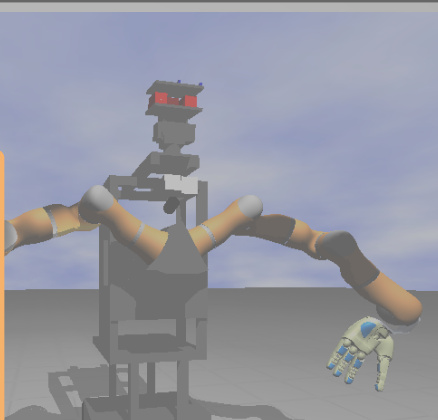
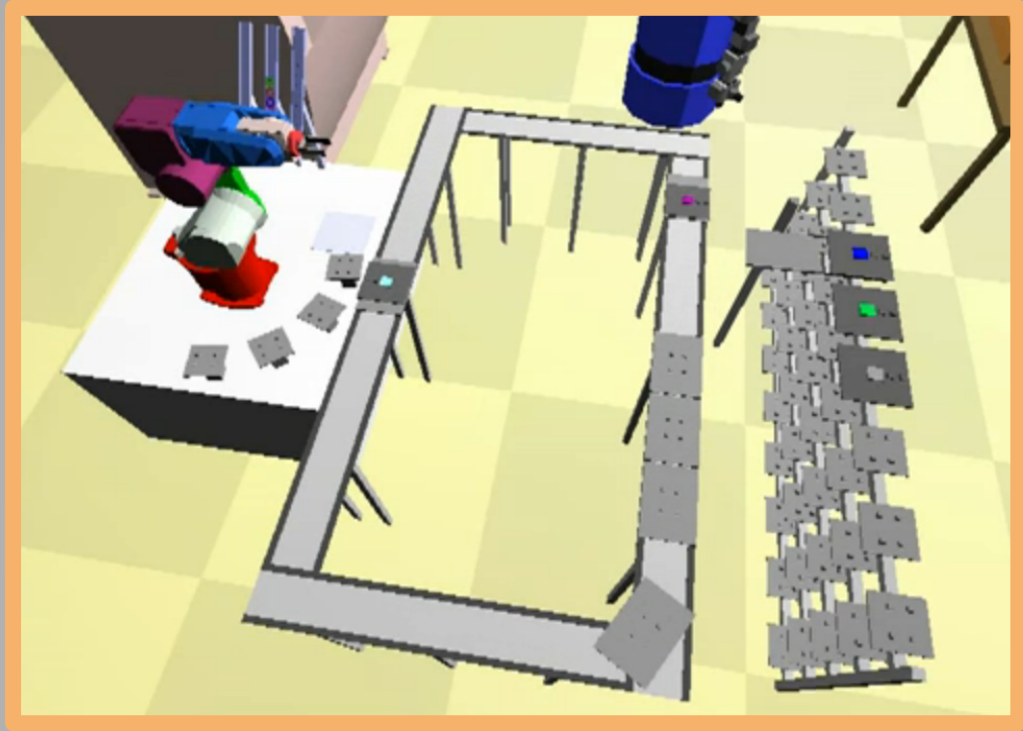
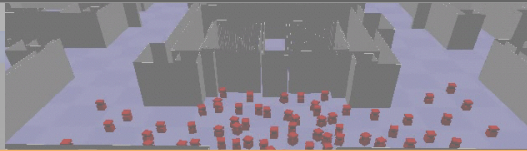


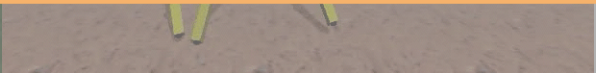
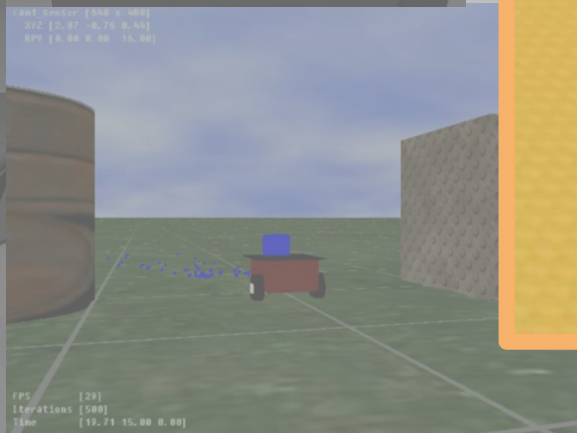
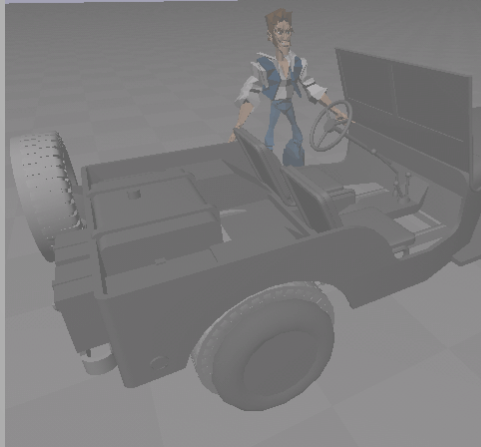
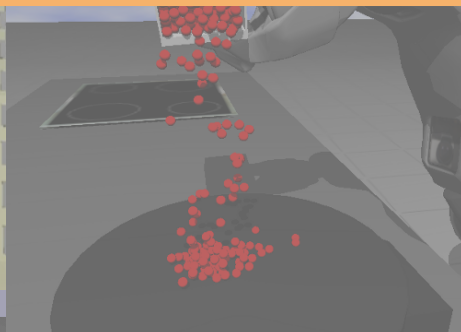
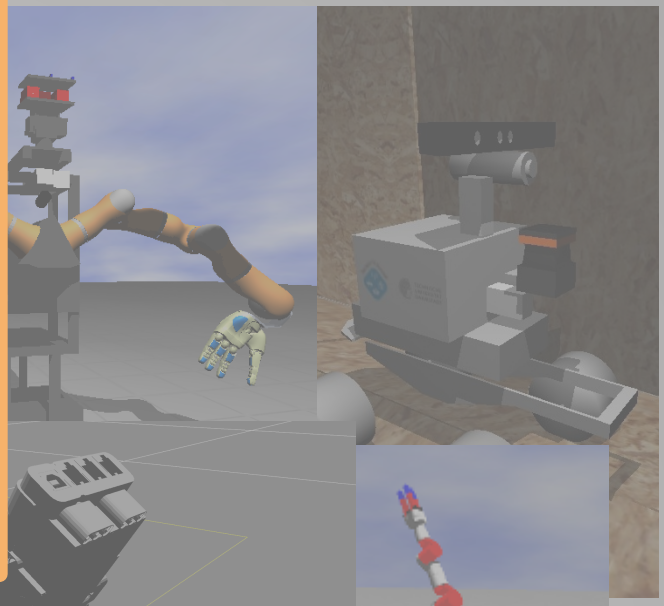
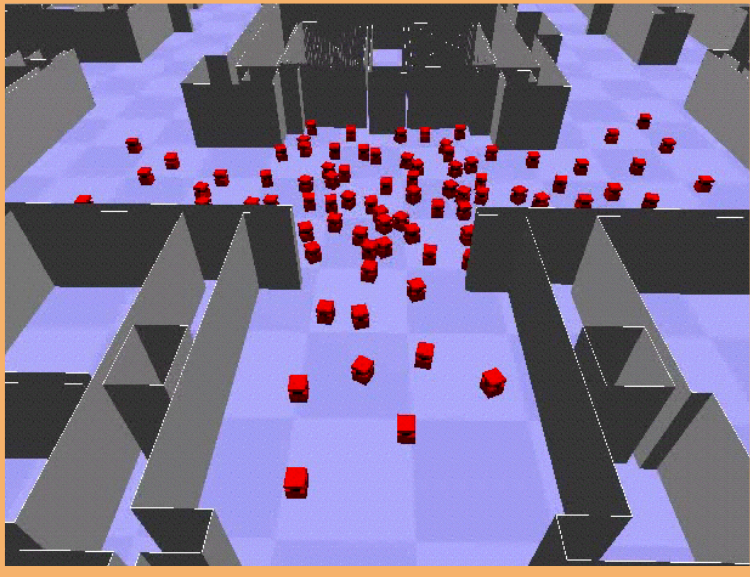
```
last sensor [500 x 500]
XYZ [2.87 -6.75 6.4]
RPY [0.00 0.00 15.00]

FPS [29]
Iterations [500]
Time [19.71 15.00]
```

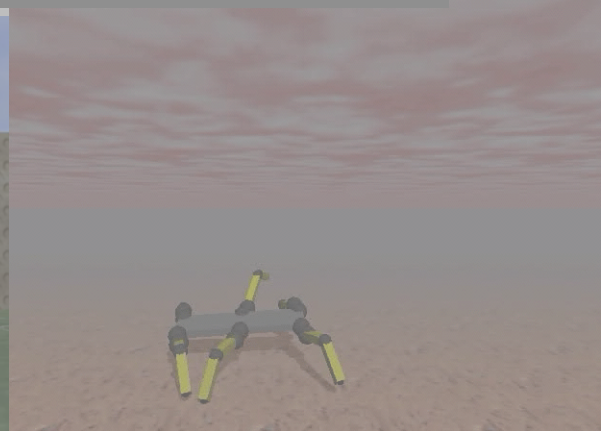
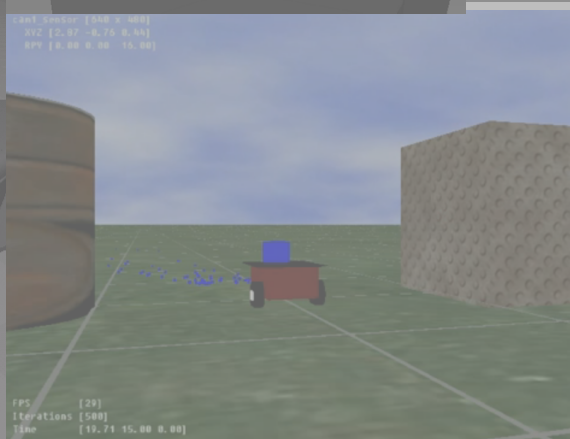
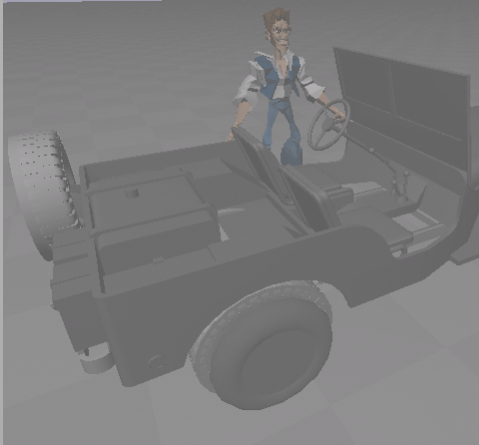
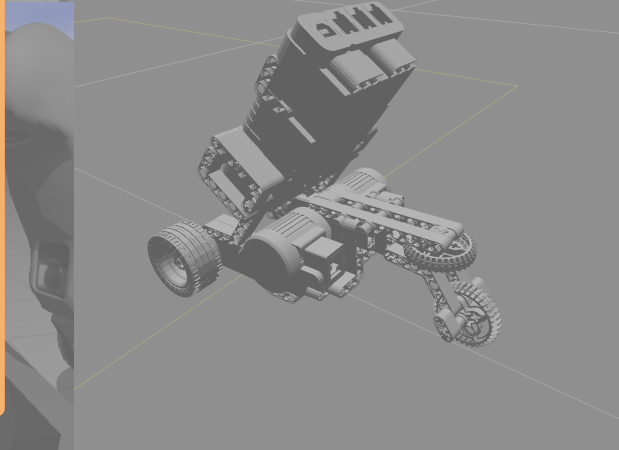
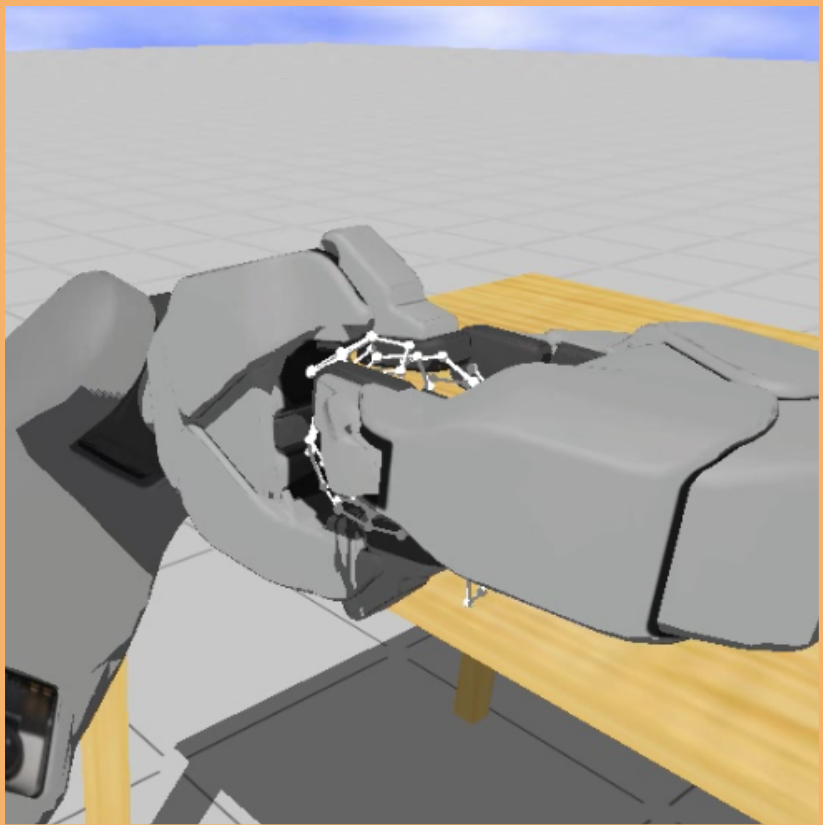






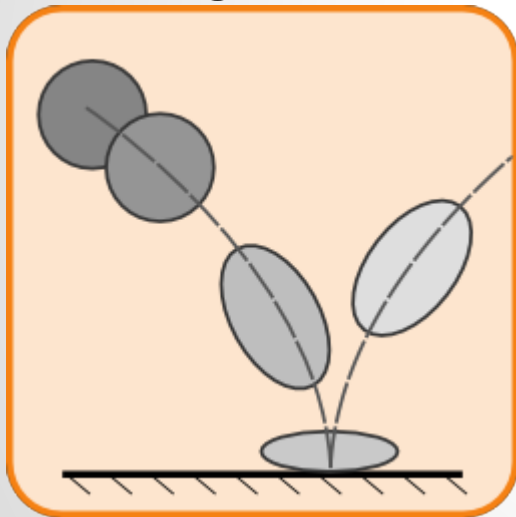






# Architecture

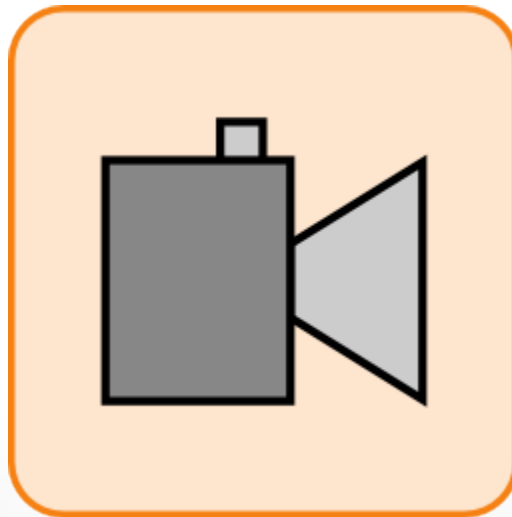
## Physics



### Rigid Body Dynamics

ODE  
Bullet

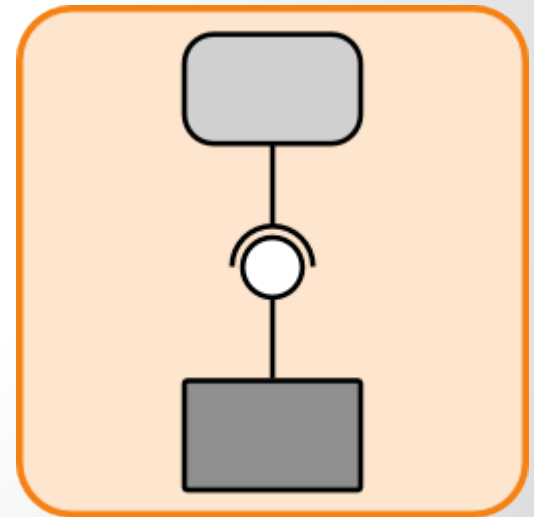
## Visualization



### OpenGL

OGRE

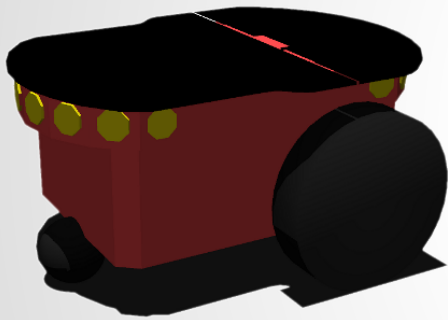
## Interfaces



### Plugins and IPC

Google Protobuf  
Boost

# Robot Models



## Simple platforms

Built-in shapes  
Mesh skinning



## Realistic physical properties

Meshes as collision objects  
Mass and inertia properties  
Surface friction  
6 joint types



## Full sensor suite

Laser range finders  
Mono/Stereo cameras  
Kinect  
Contact  
Joint force/torques

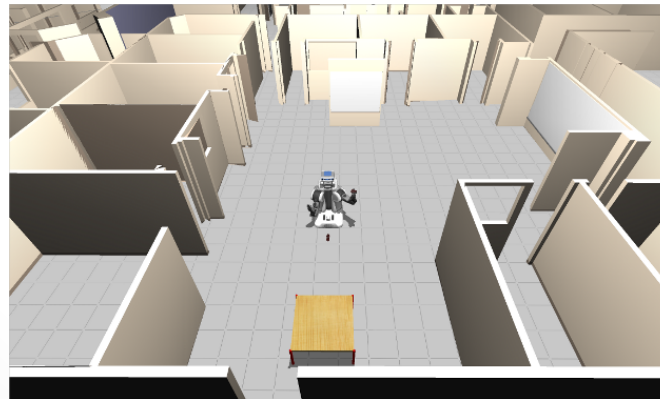
# Environments

## Simple

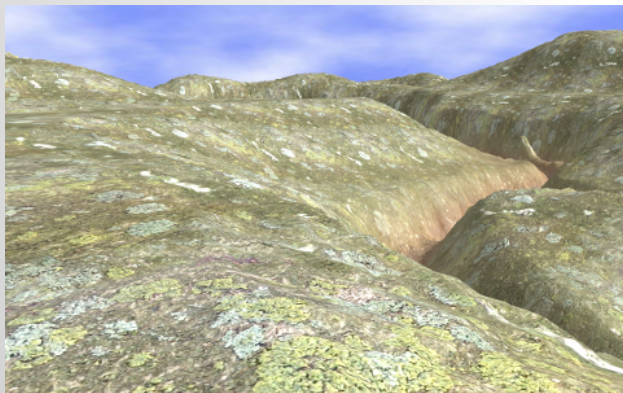


Focused scenario  
Manipulation  
Perception

## Indoor



Path planning  
Mobile manipulation  
Clone real environment



Aerial robots  
Outdoor mobile and legged robots

## Outdoor



# Gazebo Demo

## Part 1: Canyon fly-through

Custom terrain generated from a greyscale image

Animated quadrotor

Thanks to Johannes Meyer and Stefan Kohlbrecher

## Part 2: Pioneer2dx and office environment

Player interface used to drive the Pioneer2dx

Laser range finder sensor visualization

## Part 3: PR2 and YouBot

PR2 object manipulation using ROS Interactive markers

## Part 4: Character animation

Experimental animation of characters using skeletons

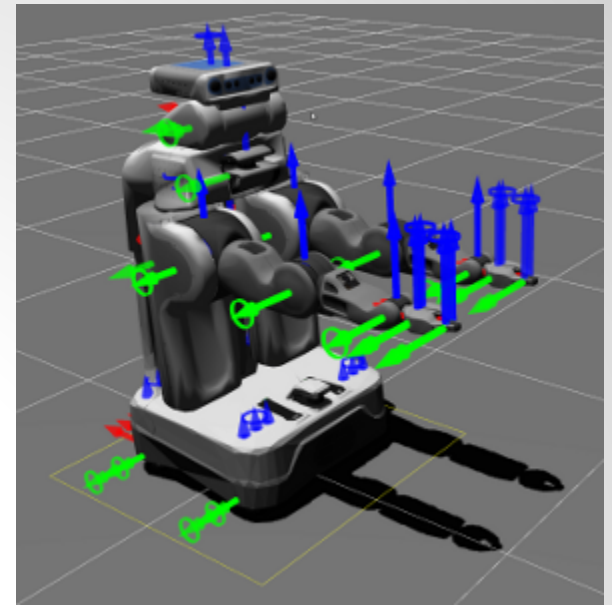
Thanks to Mihai Dohla

# Tools

## Command line tools

System inspection

Insert and remove models

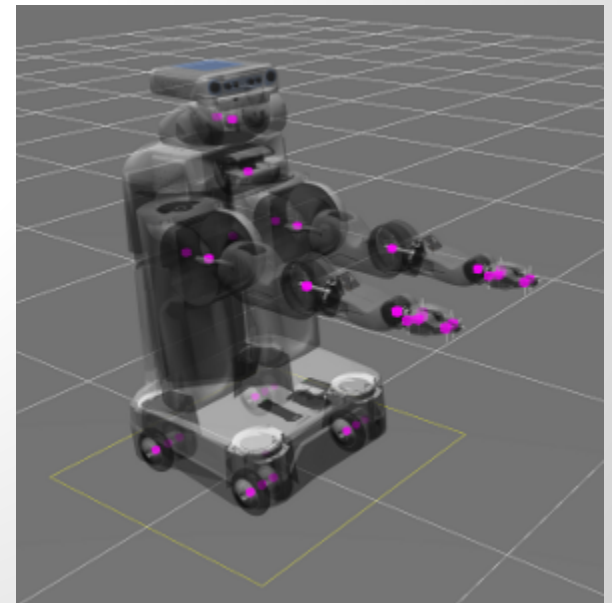


## Graphical tools

Model placement

Joint and mass visualizations

Sensor visualizations



# Resources

## Robot models

Distributed in Gazebo

Work in progress

Online model database

Graphical model builder

## Environments

Distributed in Gazebo

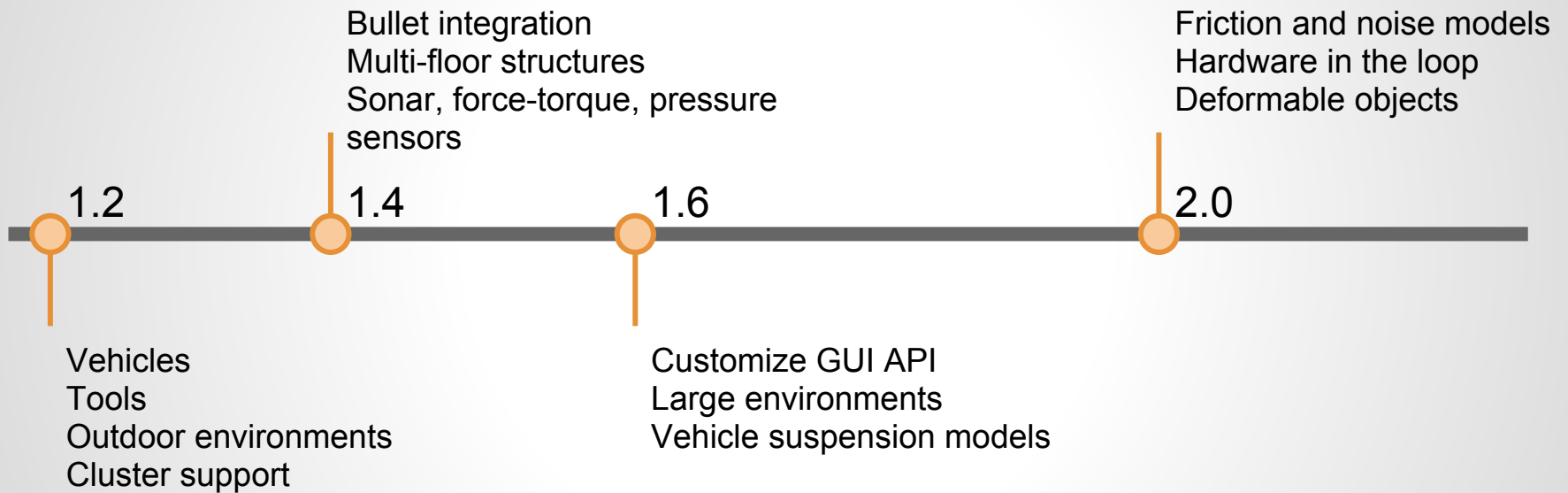
Google's 3D warehouse

Google Sketchup or Blender

## Help

<http://gazebosim.org>

# Roadmap



# Community

## Support and Contributing

<http://gazebo-sim.org/support.html>

## Wiki

<http://gazebo-sim.org/wiki>

## Kforge project

<https://kforge.ros.org/projects/gazebo/>

# Thank you



**Physics Lead**  
John Hsu



**Core Contributor**  
Mihai Dolha



**Co-Founder: Retired**  
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## Contributors

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