

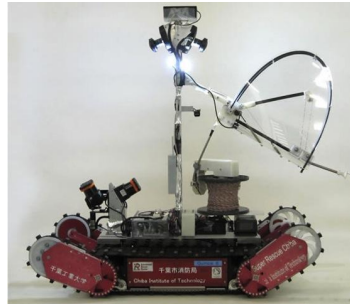
Gazebo in the DARPA Virtual Robotics Challenge

Simulating robots and environments for real-time competitions

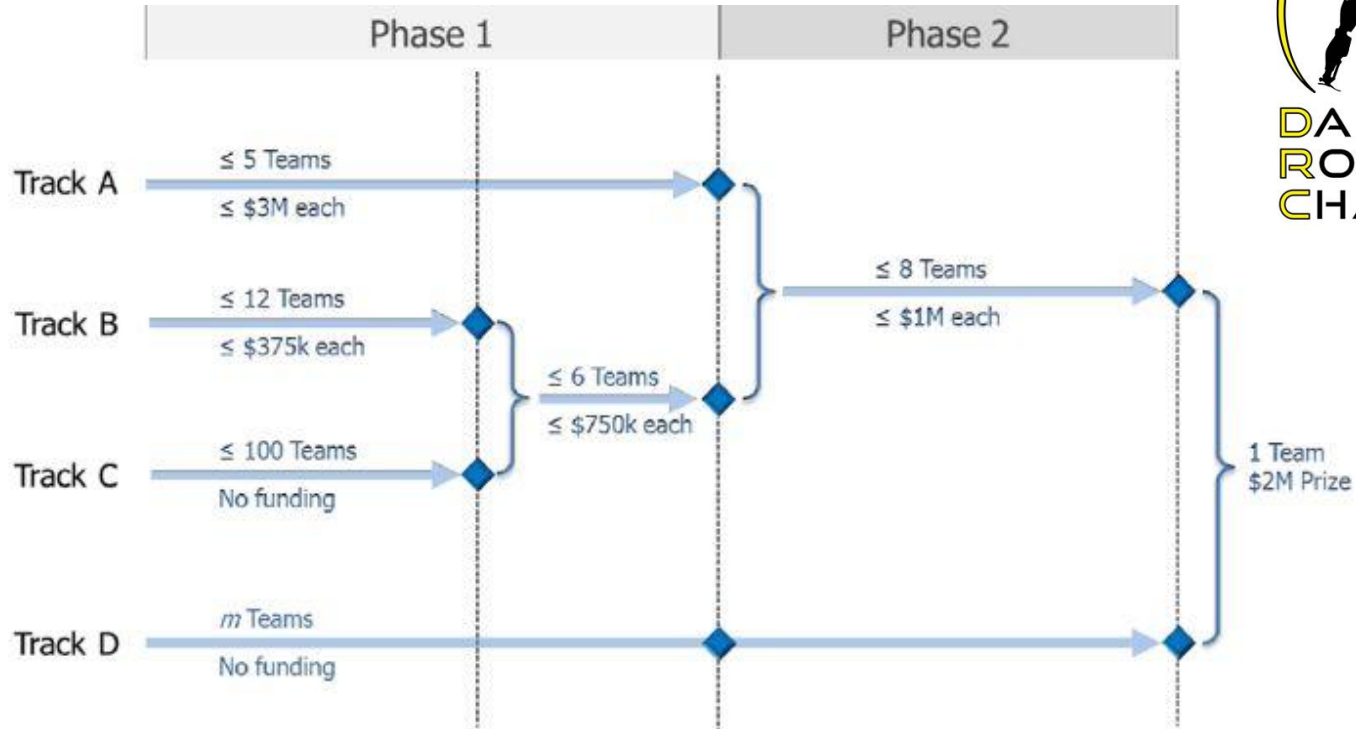
The Future of Robocup Rescue Simulation Workshop

March 1, 2016

DRC: Darpa Robotics Challenge

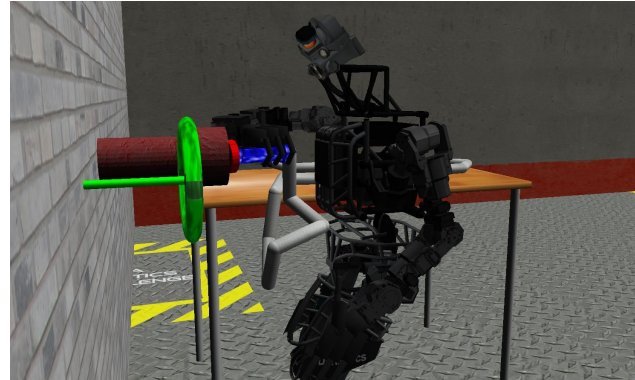
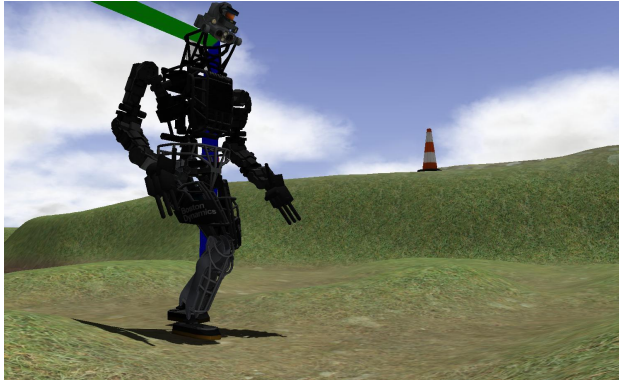
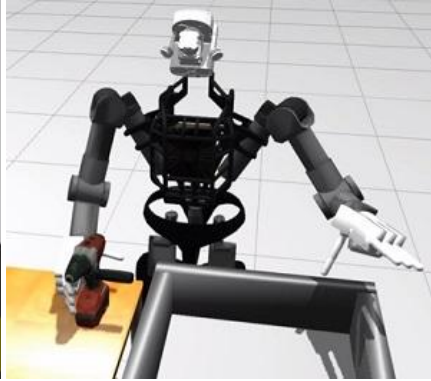
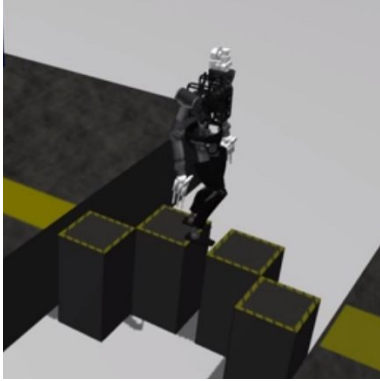


DRC Timeline





VRC: Virtual Robotics Challenge



VRC Overview

Cloud-based competition.

Simulate degraded communication.

Focus on partial autonomy.

Teams from 8 countries.

- Brazil, China, Germany, Israel, Japan, Korea, UK, US



Simulation and VRC

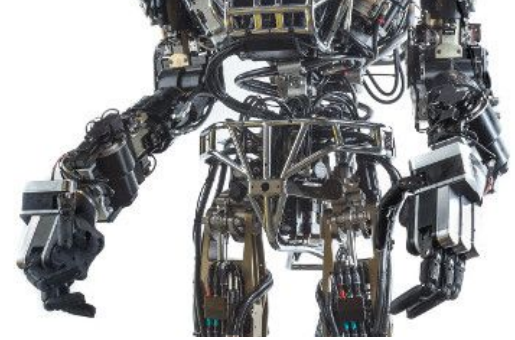
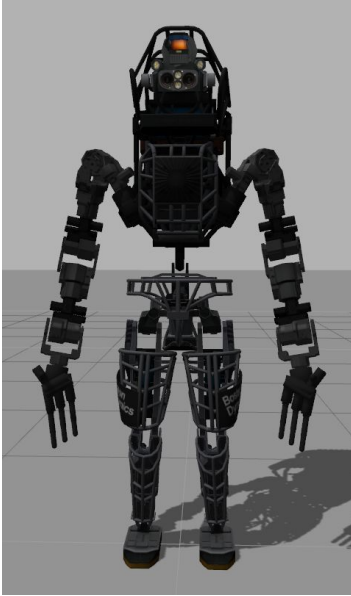
Why Simulation Based VRC?

- Enables broader participation
- Robotics development tool
- Non-competitive technology
 - Don't reinvent the wheel - make it open-source, available to all
- Simulator, a lasting legacy of the VRC

VRC Simulation Challenges

Atlas Model

- Models: Atlas (28) + MultiSense SL (1) + Sandia Hands (24) = 53 DOFs



Polaris XP900 (10 DOF)

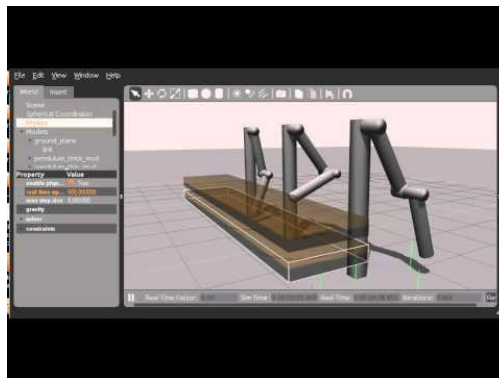
Modeling Special Environments

“Mud” plugin

- Simulate viscous drag
- Vehicle seat for stabilizing robot-vehicle interactions

Dynamic Constraints

- Screws for threading simulation
- Harness constraints for robot controller initialization



Physics Engine Requirements

Accuracy, fidelity vs performance

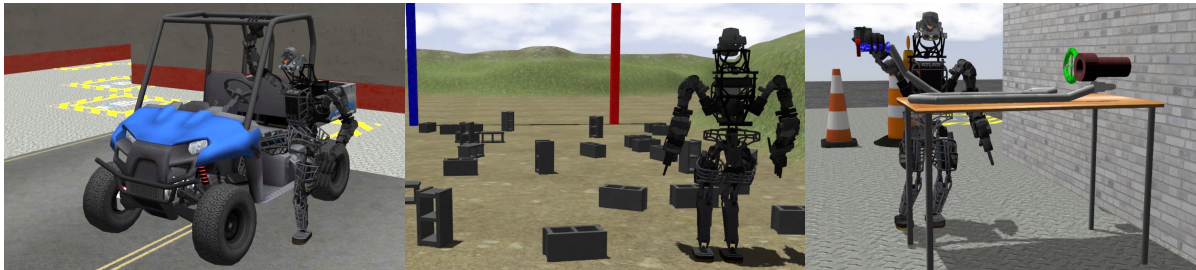
- Complete DRC tasks in simulation
- Simulation that "just works".
 - Unconditionally stable, divergence-free:
 - with 10 ~ 40 contacts
 - arbitrary joint torque applications
 - arbitrary collisions, contacts, poses
- Near real-time performance





Performance Metrics

- Got close to real-time performance, enough accuracy for task completion.
 - Walking@VRC (~8 contacts.)
 - ~1.15X RTF on typical “gaming” desktop (Intel i7 @ 3.5GHz nVidia GTX 750)
 - ~0.75X on Softlayer cloud GPU machines (Intel Xeon @3.0GHz nVidia k20)
 - Grasping@VRC with Sandia hand (~20~40 contacts.)
 - ~0.85X desktop vs. ~0.65X cloud



Gazebo: Multiple Multibody Dynamics Solvers

Open Dynamics Engine

Robotics, gaming

bitbucket.org/odedevs/ode



Bullet

Gaming, animation, Sony, AMD

github.com/bulletphysics/bullet3



Simbody

Biomechanics, Stanford

github.com/simbody/simbody



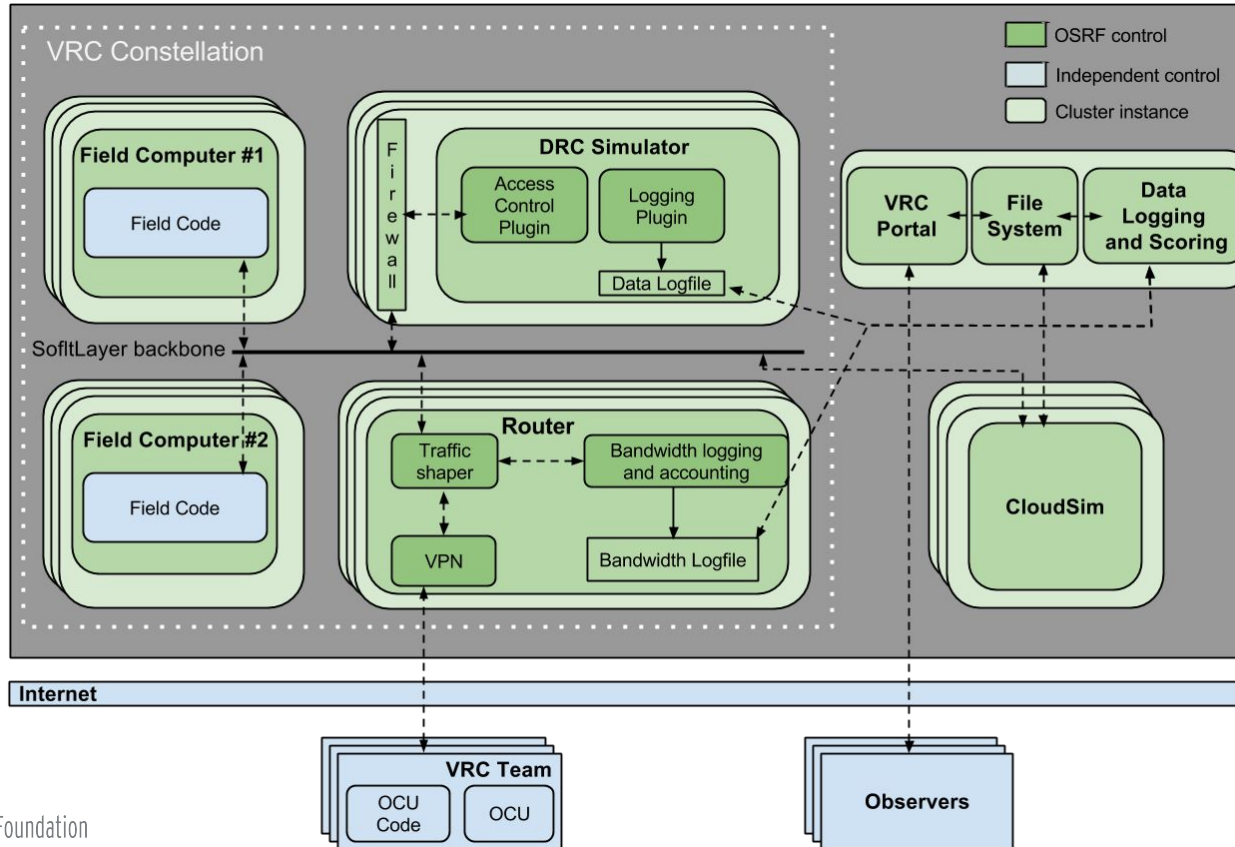
DART

Robotics, animation, Georgia Tech

github.com/dartsim/dart



Cloud Based Simulation Competition



CloudSim and GzWeb Gazebo Simulator in the Cloud

CloudSim - Cloud-hosted robot simulation - CloudSim - Cloud-hosted robot simulation - Chromium

CloudSim - Cloud-
cloudsim.io/en/

CloudSim

CloudSim - Cloud-hosted robot simulation

BY INVITATION ONLY [FOR NOW]
BROUGHT TO YOU BY OPEN SOURCE ROBOTICS FOUNDATION

Get Started

WHAT IS CLOUDSIM?

CloudSim provides robot simulation as a web application. Through the combination of advanced simulation software and cloud computing, CloudSim makes it easy to simulate robots and environments. In addition to simulation management, CloudSim offers the ability to visualize and interact with the simulated 3D world right in your browser. Try out CloudSim and discover a low-cost way to use robot simulation technology.

HOW DOES CLOUDSIM WORK?

CloudSim handles all the work of provisioning cloud-machines and launching simulation. All that you have to do is select what you want to simulate. Once a simulation machine is up and running, you can visualize the 3D world in your browser and programmatically interface to simulation through a secure network connection.

WHAT CAN I DO WITH CLOUDSIM?

CloudSim gives you a simple interface to cloud-hosted robot simulation software. Through the CloudSim interface, you can control instances of simulation, view all the simulations that you have run in the past, and easily manage payment options. Here, we list just a few uses for CloudSim.

- Continuous Integration
- Classroom & Collaboration
- Parallel Experimentation

gz3d - Mozilla Firefox

ASEE ETLI 2013 - T... gz3d

54.183.41.237:8080

Google

Real Time: 01 12:38:34
Sim Time: 01 11:02:47

Insert Robots

- Simple Arm ...
- Simple Grip...
- TurtleBot
- YouBot

3D simulation environment showing a robot arm and a ball.

Not all cloud providers are equal

Amazon EC2 machines

- Simple to setup

- Pay by the hour

- Initial tests showed adequate performance

Last minute change

- All Amazon machines virtualized → Unpredictable latency

- Jump ship to Softlayer

VRC Security

Between teams

- No snooping on teams

- VPN: Secure communication between teams and clouds

Within team

- A team should not directly access simulation

 - Firewall

 - Added white lists to Gazebo

- Randomized schedule: Teams complete tasks in random order

Silver lining

Adjustable control loop

- Pause simulation to absorb network latency

- Parameterized window from 0 → n seconds

Cross-provider cloud infrastructure

- Cloud simulation for Amazon, Softlayer, OpenStack

The entire system works!

VRC Practice (Dress Rehearsal)

Test cloud server management

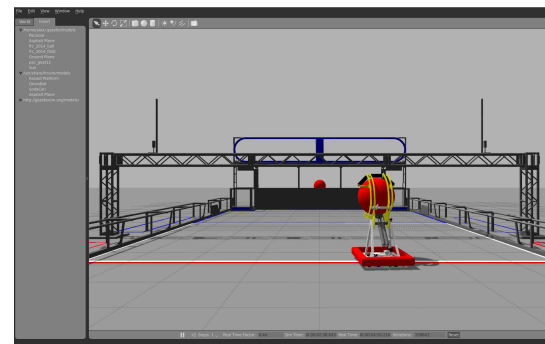
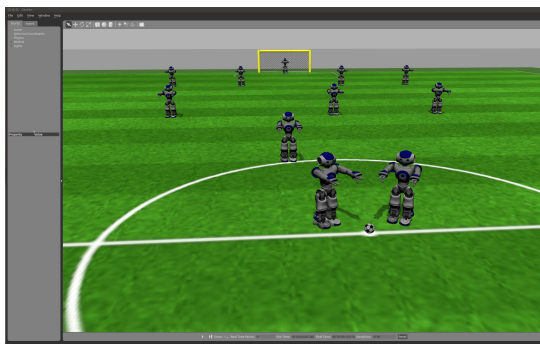
Test scoring, logging

Test communication channels for participants, referees, tech support

Teams are on different time zones

Education

- FIRST: Use simulation for design, development, and testing
- Robocup:
 - soccer: Simulated Nao and simplified dynamics
 - rescue: Large indoor and outdoor search and rescue environments
 - @home: Autonomous robots operating in home environments
 - logistics: Flexible material and information handling in industry



Future

Windows & OSX support

Open-source walking controller

GUI Tools: Model editor, plotting, video creator

Improve multiple physics engine support

