Introduction to a Simulation Environment – Gazebo

Welcome

Lab 2

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Today's Objectives

- Introduction to Gazebo
- Building a robot model in Gazebo
- Populating robot environment with simulated objects
- Writing plugins
- Sensors
- Interface with ROS

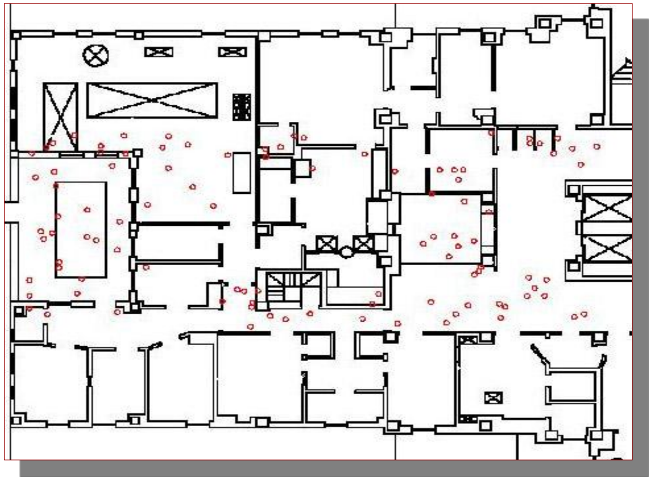
Working with Simulators

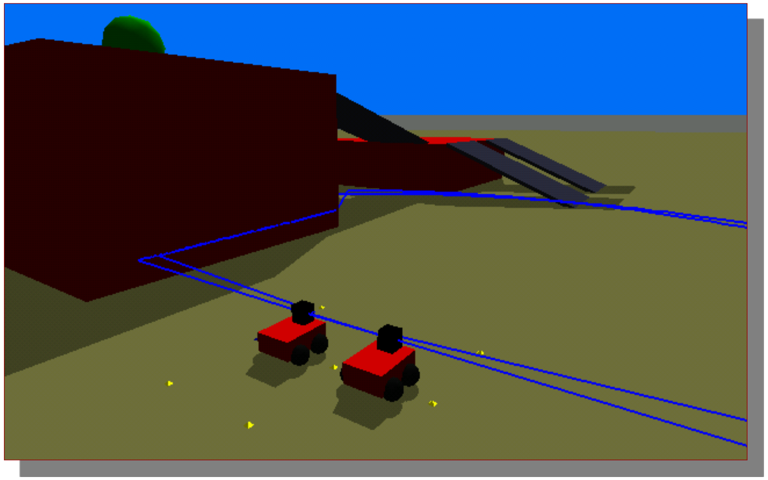
- What
  - Mimic the real world, to a certain extent
- When
  - Always!!
- Why
  - Save time and your sanity
  - Experimentation much less destructive
  - Use hardware you don't have
  - Create really cool videos
- How
  - Someone has probably already done it, so use it

Which Simulator?

<u>Stage</u>
- 2D
- Sensor-based
- Player interface
- Kinematic
- O(1) ~ O(n)
- Large teams (100's)

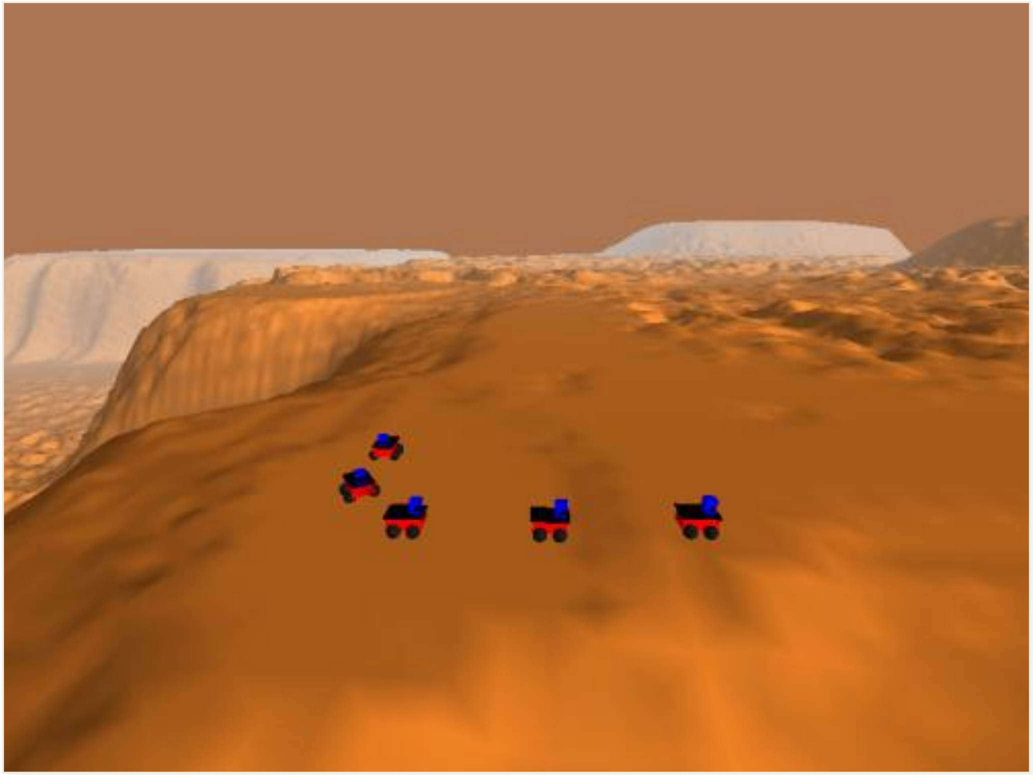
<u>Gazebo</u>
- 3D
- Sensor-based
- Player
- Dynamic
- O(n) ~ O(n^3)
- Small teams (10's)





Gazebo

- Simulates robots, sensors, and objects in a 3-D dynamic environment
- Generates realistic sensor feedback and physical interactions between objects



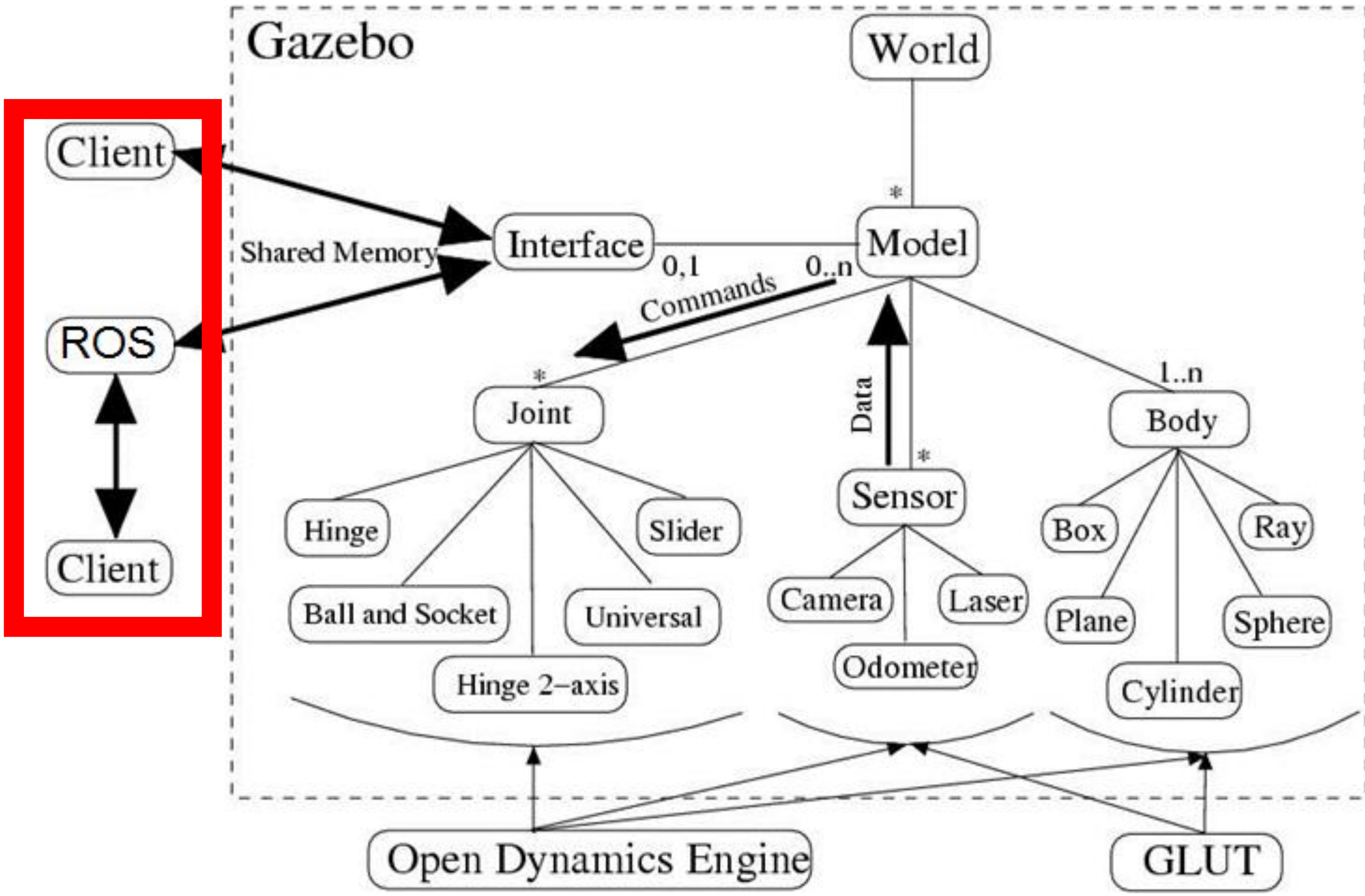
Gazebo (Cont.)

- gzserver
  - executable runs the physics update-loop and sensor data generation
  - This is core of Gazebo, and can be used independently of any graphical interface
- Gzclient
  - executable runs the QT based user interface
  - provides a nice visualization of simulation, and convenient controls over various simulation properties

Gazebo Components

- **World File:** Contains all the elements in a simulation, including robots, lights, sensors, and static objects. This file is formatted using SDF (Simulation Description Format), and typically has a .world extension.
- **Model File:** A SDF file used to describe a single model.
- **Environment Variables:** For storing environment, communication settings
- **Gazebo Server+Client :** The two main components of a simulation.
- **Plugins :** A simple mechanism to interface with the simulation world

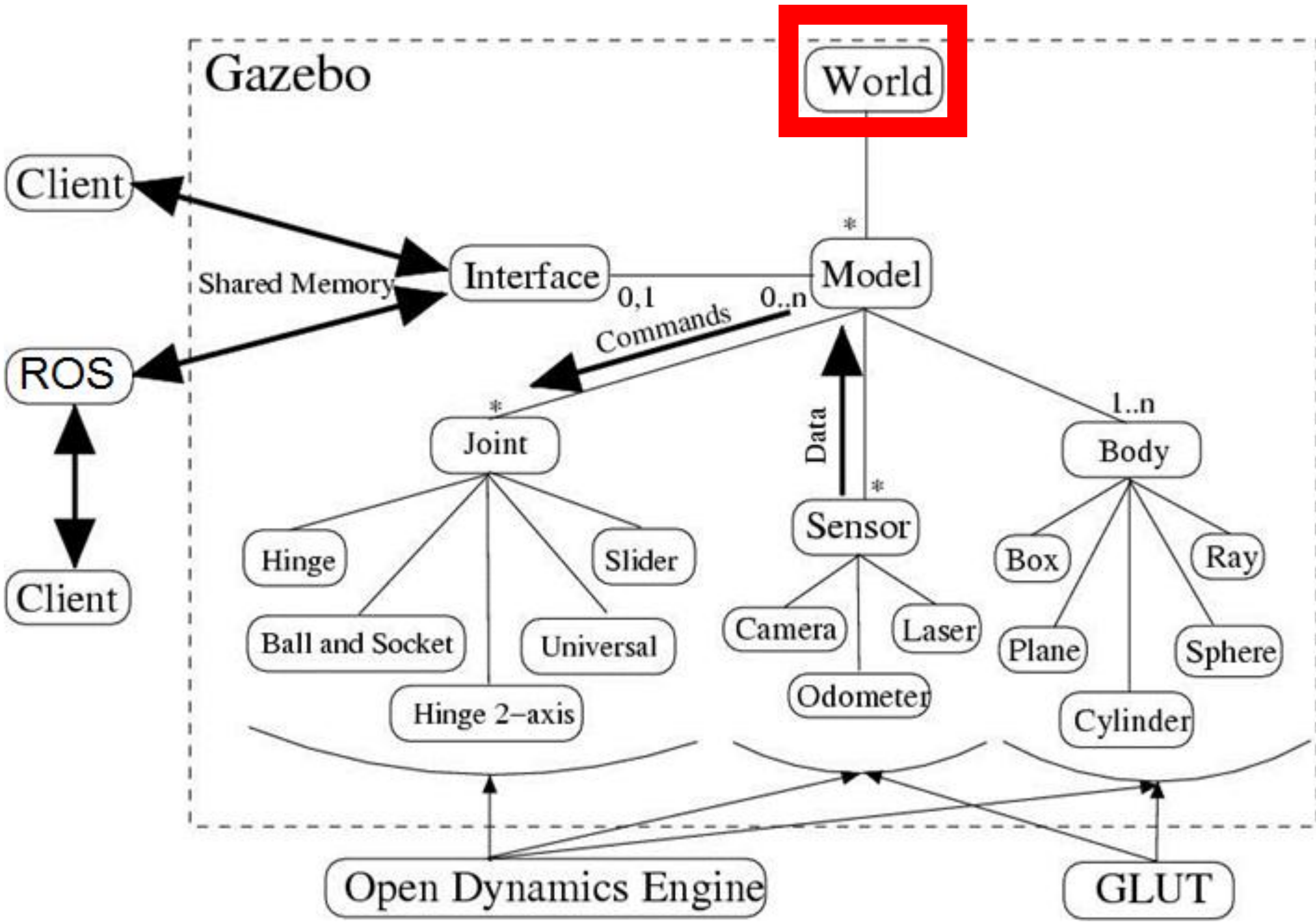
Gazebo Architecture



Gazebo Client Code

- Client code (your program), can interface to Gazebo in two ways
  - libgazebo
    - Shared Memory, direct interface
    - Fast, but requires more work
  - ROS
    - Simulation transparency
    - Get all of ROS's goodies
    - Recommended for most cases
    - Gazebo was part of ROS

Gazebo Architecture



World File

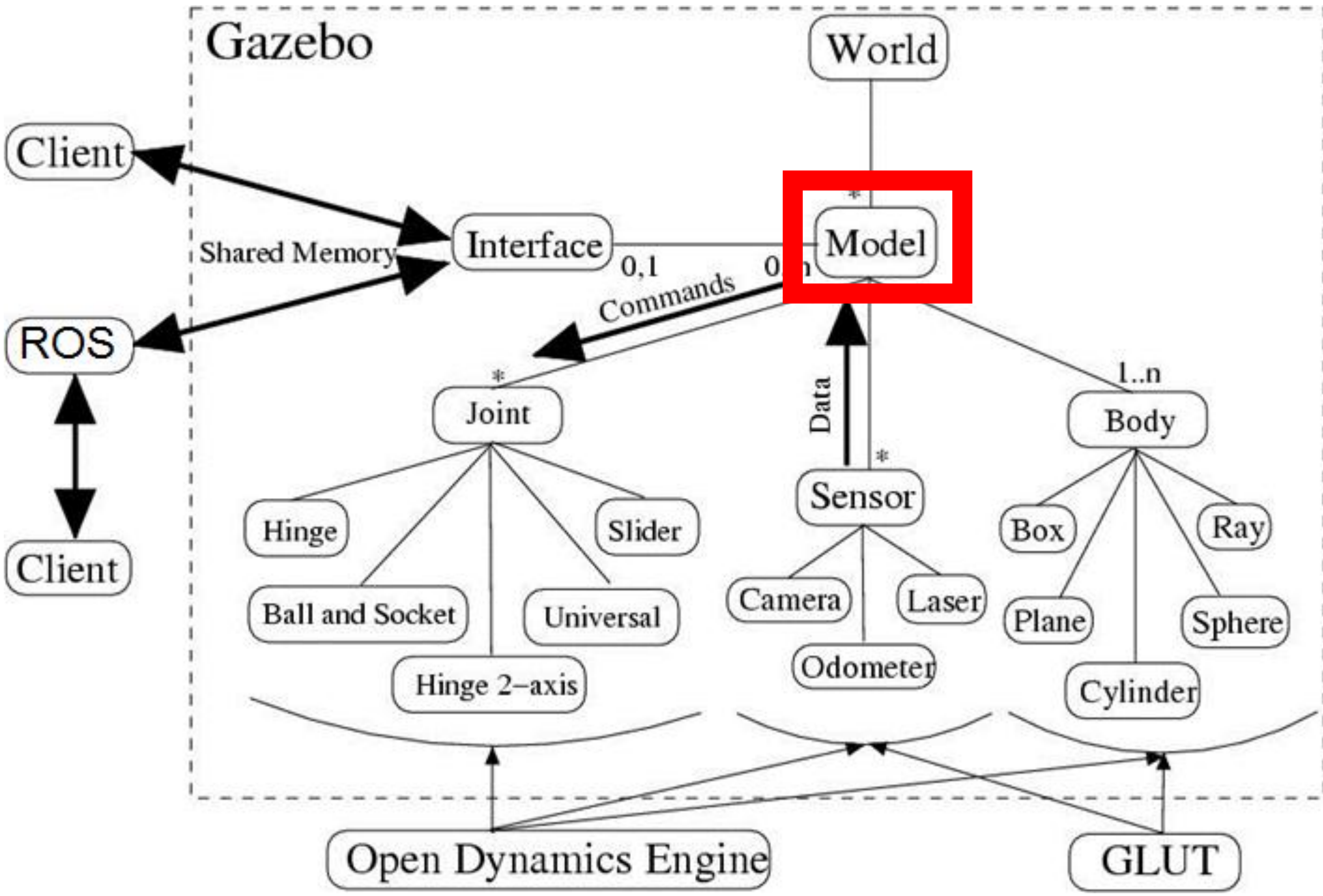
- A world is composed of a model hierarchy
  - Models define simulated devices
  - Models can be nested
    - Specifies how models are physically attached to one another
    - Think of it as “bolting” one model to another

Worldfile snippet:

•Pioneer with a sick laser attached
•Sick’s <xyz> relative location to Pioneer

```
<model:Pioneer2AT>
  <id>robot1</id>
  <model:SickLMS200>
    <id>laser1</id>
    <xyz>0.10.0 0.2</xyz>
  </model:SickLMS200>
</model:Pioneer2AT>
```

Gazebo Architecture



Models

- Each model contains a few key properties:
  - Physical presence (optional):
    - Body: sphere, box, composite shapes
    - Kinematics: joints, velocities
    - Dynamics: mass, friction, forces
    - Appearance: color, texture
  - Interface (optional):
    - Control and feedback interface (libgazebo)

Components of a Model

- **Links**: an object may consist of multiple links and can define following properties, e.g. wheel
  - **Visual**: For visualization
  - **Collision**: Encapsulate geometry for collision checking
  - **Inertial**: Dynamic properties of a link e.g. mass, inertia
  - **Sensors**: To collect data from world for plugins
- **Joints**: connect links using a parent-child relationship
- **Plugins**: Library to control model

Example Model File

```
<model name="my_model">
 <pose>0 0 0.5 0 0 0</pose>
 <static>true</static>
  <link name="link">
   <inertial>
    <mass>1.0</mass>
     <ixx>0.083</ixx>     <!-- for a box: ixx = 0.083 * mass * (y*y + z*z) -->
     <ixy>0.0</ixy>       <!-- for a box: ixy = 0 -->
     <ixz>0.0</ixz>       <!-- for a box: ixz = 0 -->
     <iyy>0.083</iyy>     <!-- for a box: iyy = 0.083 * mass * (x*x + z*z) -->
     <iyz>0.0</iyz>       <!-- for a box: iyz = 0 -->
     <izz>0.083</izz>     <!-- for a box: izz = 0.083 * mass * (x*x + y*y) -->
    </inertia>
   </inertial>
.......
```

```
...............
 <collision name="collision">
      <geometry>
       <box>
        <size>1 1 1</size>
       </box>
      </geometry>
  </collision>
  <visual name="visual">
      <geometry>
       <box>
        <size>1 1 1</size>
       </box>
      </geometry>
   </visual>
  </link>
 </model>
```

Task 1: Perform the following Gazebo Tutorials

- Build a Robot
  - Model structure and requirements
  - Make a model
  - Make a Mobile Robot
  - Import Meshes
  - Attach Meshes
  - Add a Sensor to a Robot

Task 2: Perform the following Gazebo Tutorials

- Build a World
  - Building a world
- Write a plugin
  - Plugins 101
  - Model plugins
  - World plugins
- Sensors.
  - Sensor Noise Model (Ray Laser noise)

Task 3: Perform the following Gazebo Tutorials

- Connect to ROS
  - Installing gazebo_ros_pkgs
  - Using roslaunch
  - Gazebo plugins in ROS
    - Adding Plugins
    - Differential Drive
  - ROS communication
  - ROS plugins

Lab Assignment

1. Create a wheeled mobile robot with a Hokuyo laser scanner attached on it.
2. Use an existing plugin for the mobile robot drive system.
3. **Bonus**: create your own plugin for the robot drive system
4. Use Rviz to visualize odometry and laser scan topics.
5. Create a ROS node to communicate with robot odometry and laser range scanner data. Use the robot wheel odometry to estimate the wheels velocity (Hint: inverse kinematics). To navigate the robot use existing teleop node.