# FRC Robot Simulation Using Gazebo and Solidworks

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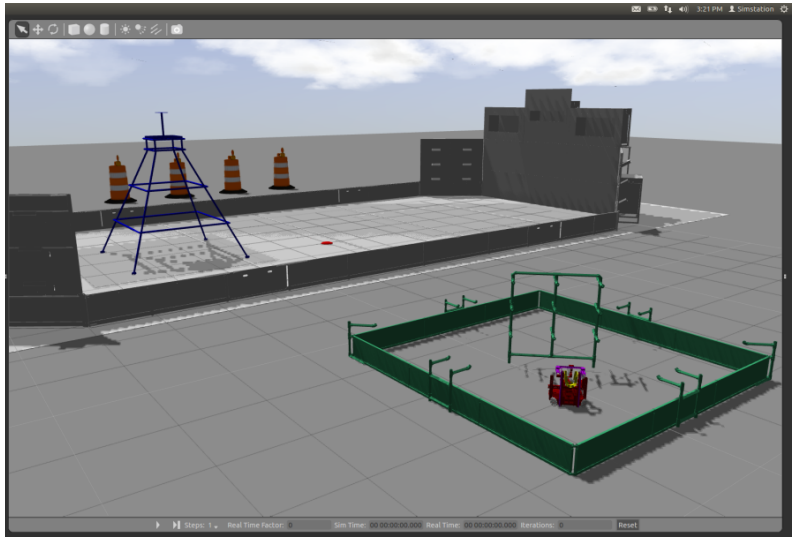
# What is Gazebo?

**http://www.gazebosim.org**

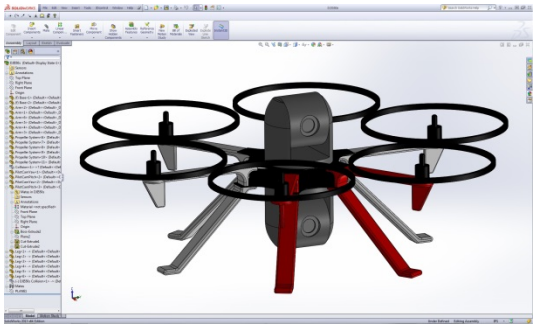
- Fully open-source robotics simulator (free)
- Interactive, real-time controller for robotic systems
- Physics package plus graphical interface
- Developed by robotics experts using ROS (robot operating system) architecture
- Allows arbitrary models to be loaded from CAD and other 3-D model repositories (i.e. Sketchup Warehouse)
- Ray tracing functionality enables simulation of a wide array of sensors:
  - Cameras (2-D / 3-D)
  - Scanning lasers
  - Kinect
- Growing library of robot / environment models
- Controller plugins written in C, C++, Python
- Can be run on Amazon cloud – no need for high-powered local machines
- Being validated for physical accuracy by NIST



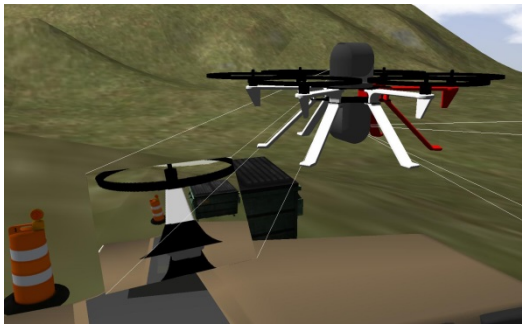
# How It Works

1. Develop model in CAD
2. Load CAD files into Gazebo
3. Build dynamic robot model in Gazebo (sensors, controls code)
4. Load simulation of FIRST arena / game in Gazebo (OSRF will help generate)
5. Specify human input devices
6. Simulate competition
   - Users send commands identical to those sent to a physical robot over a network
   - Publishes sensor feeds to operator terminal, subscribes to command inputs sent back to robot
   - Scoring modules can be set up to assess gameplay (e.g. rings emplaced, location / orientation of key objects)

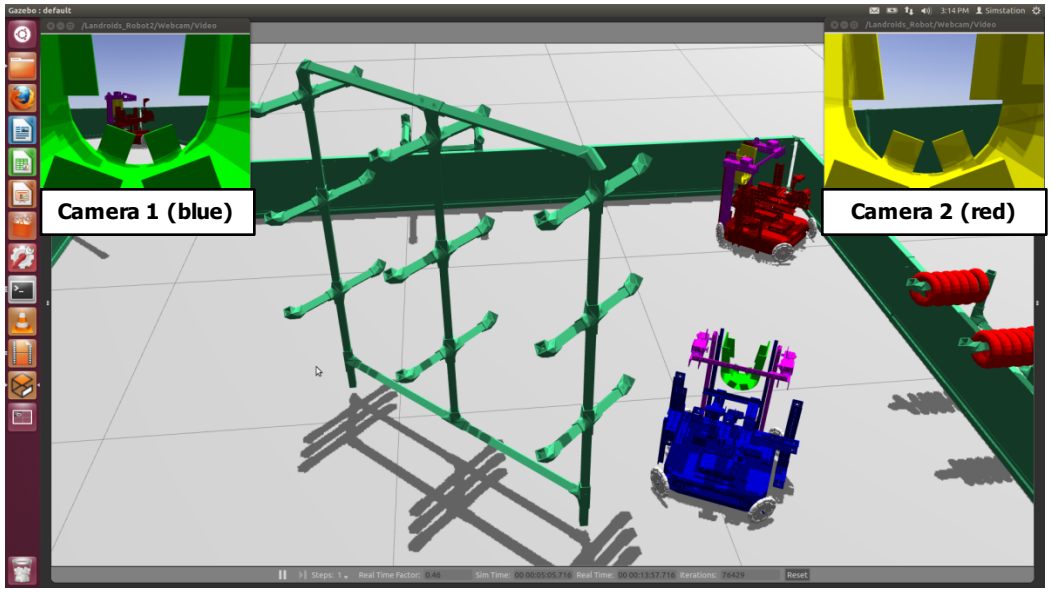
Robots modeled in CAD…



…are loaded into the virtual world.

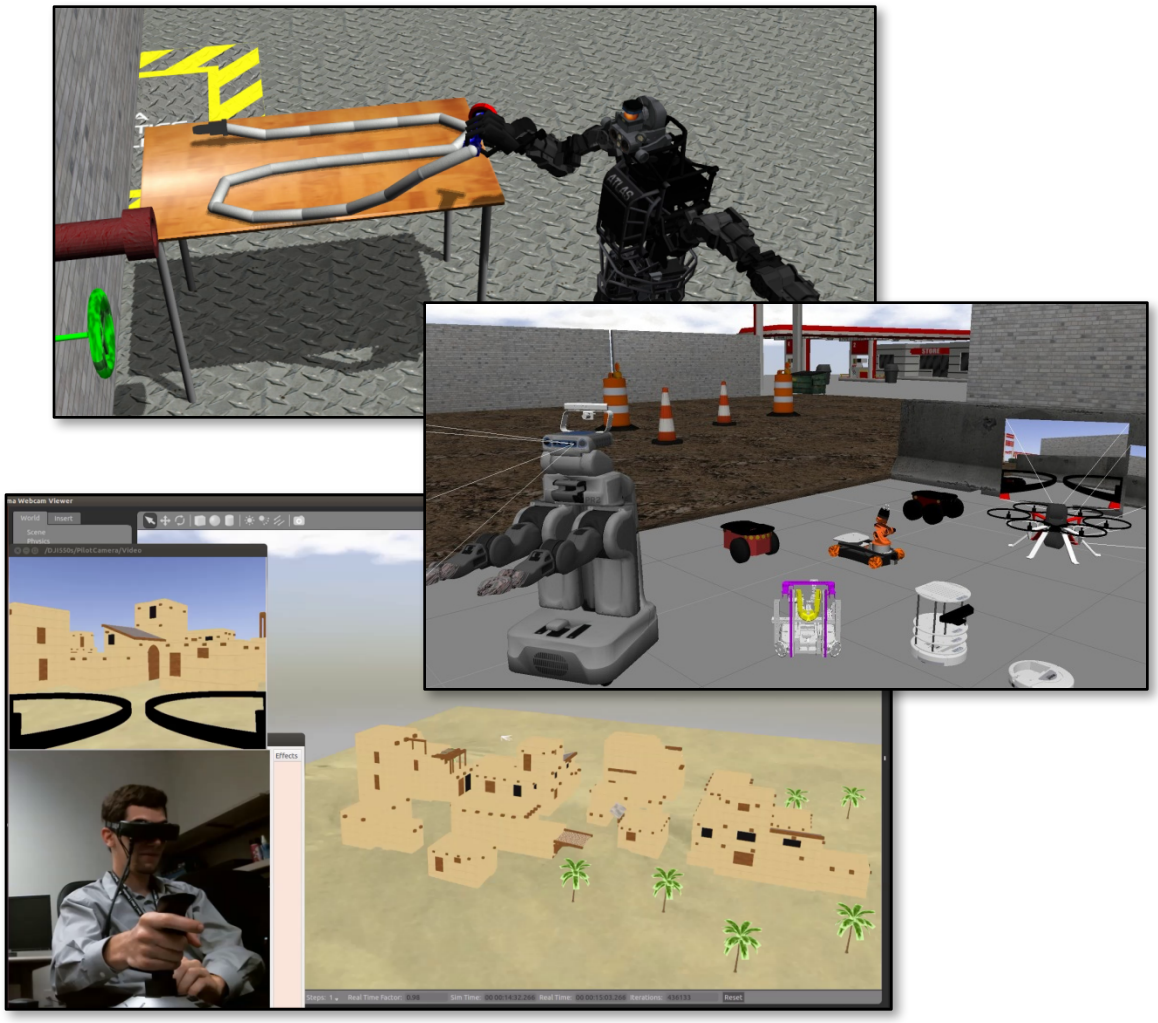


Sensors such as webcams parallel real-world behavior

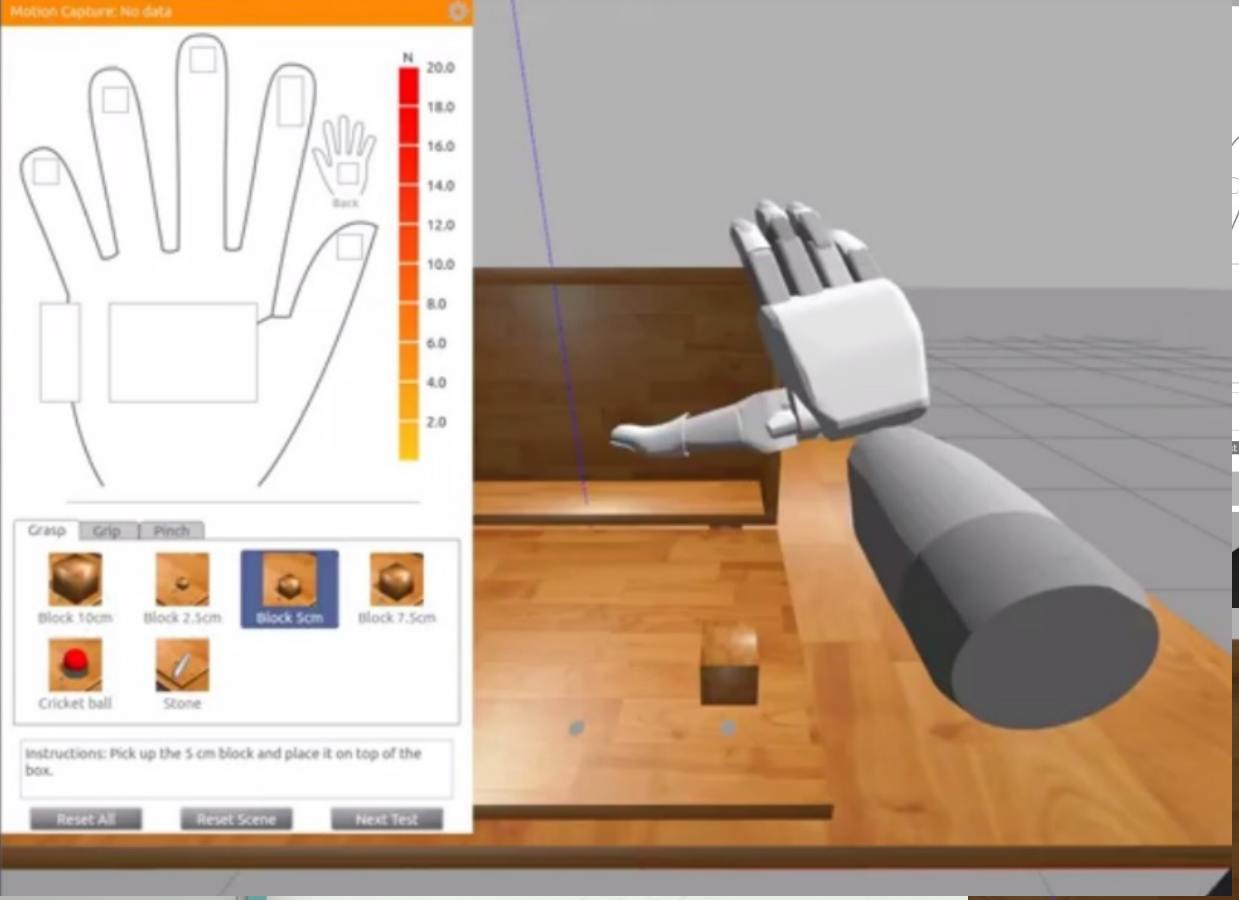


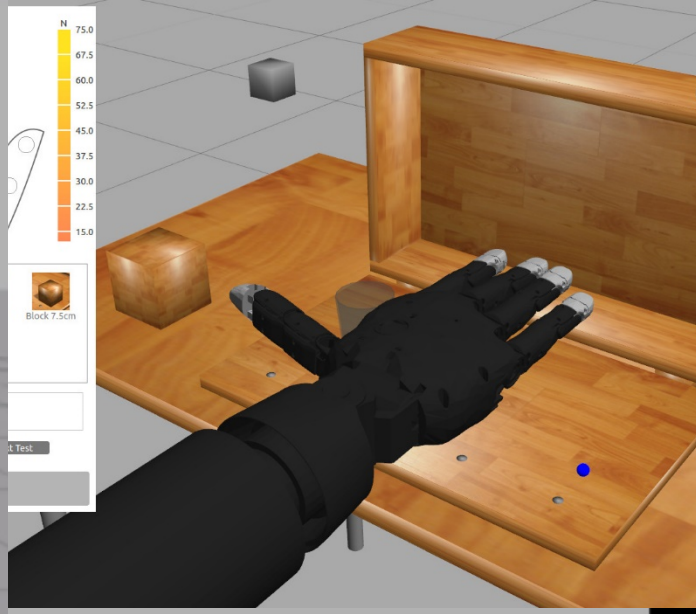
# Our Goal: Catalyze Robotics Development

1. Reduce robotics development costs / barrier to entry
2. Expedite software development during hardware build
3. Encourage better systems engineering through early design refinements
4. Continually improve robotic simulation through collaboration with robotics developers (new contact models, behavior libraries, structural dynamics models, etc.)



Desired end state: serve as self-sustaining, definitive tool for modeling of robotic systems – "SPICE for robotics"

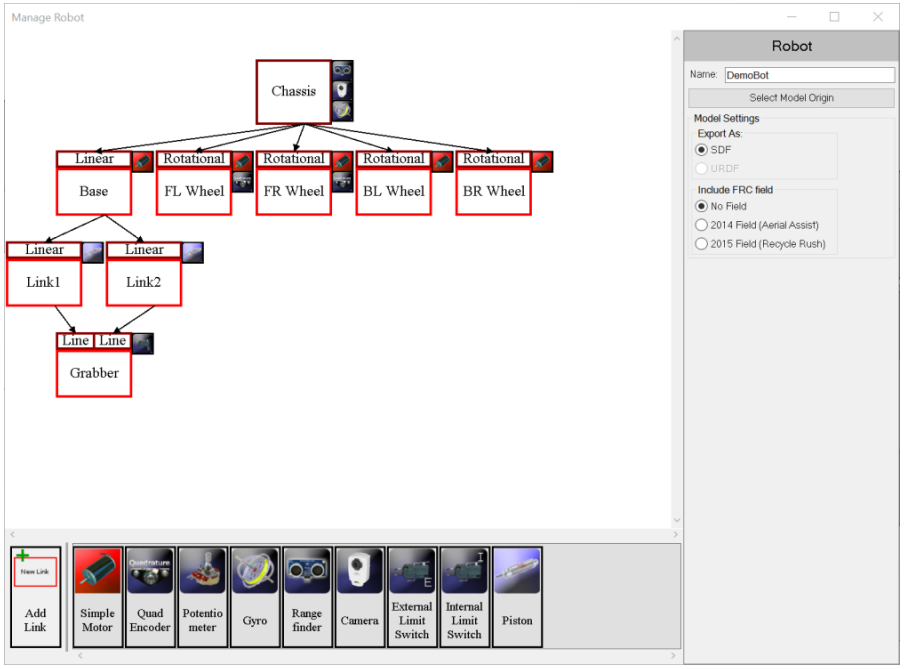

Motion Capture: No data
N
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
Back
Grasp
Grip
Pinch
Block 10cm
Block 2.5cm
Block 5cm
Block 7.5cm
Cricket ball
Stone
Instructions: Pick up the 5 cm block and place it on top of the box.
Reset All
Reset Scene
Next Test


N
75.0
67.5
60.0
52.5
45.0
37.5
30.0
22.5
15.0
Block 7.5cm

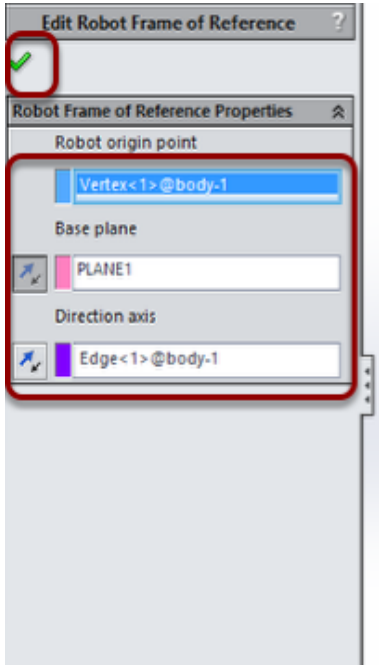
Polhemus head tracker
Polhemus arm tracker

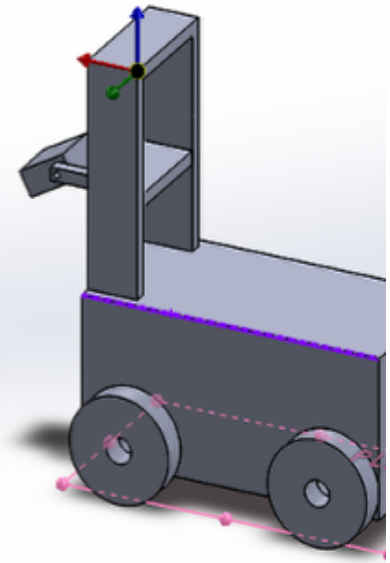
# Create Complex Models within SolidWorks

## Specify Joint, Links, and Plugins



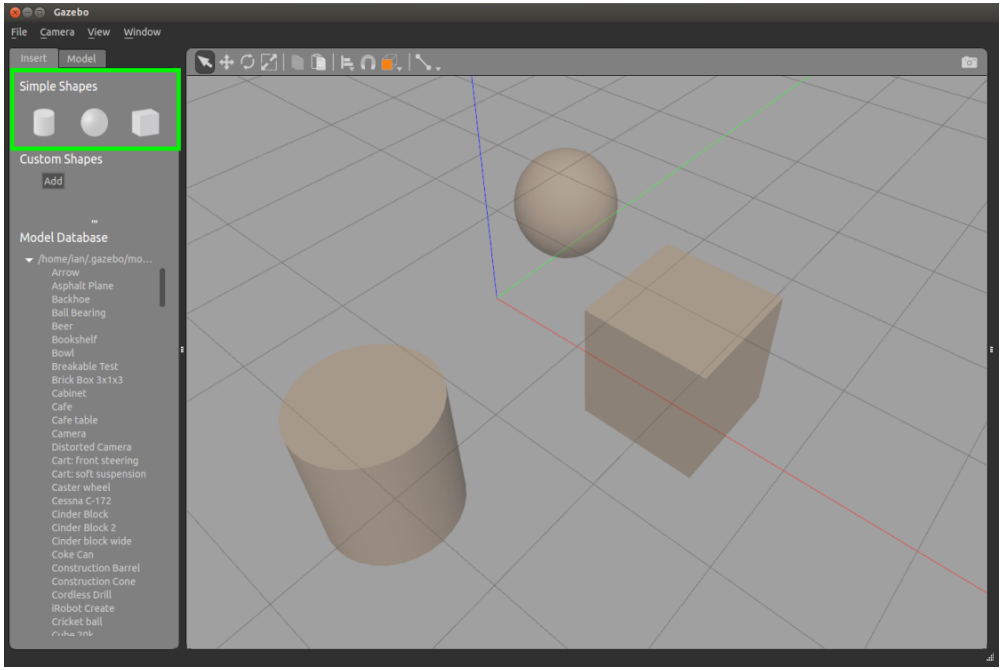

## Collision models & Visual models



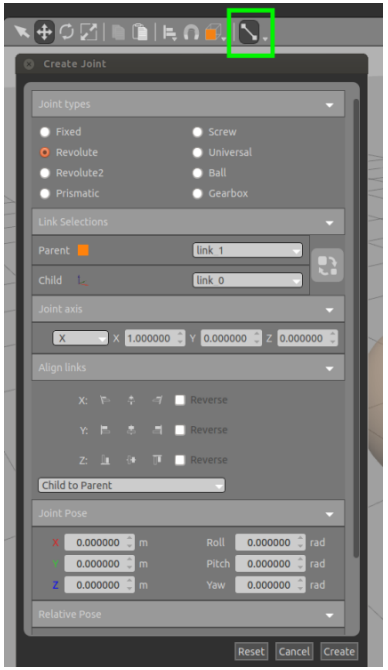



# Create a model or modify an existing one in the Model Editor

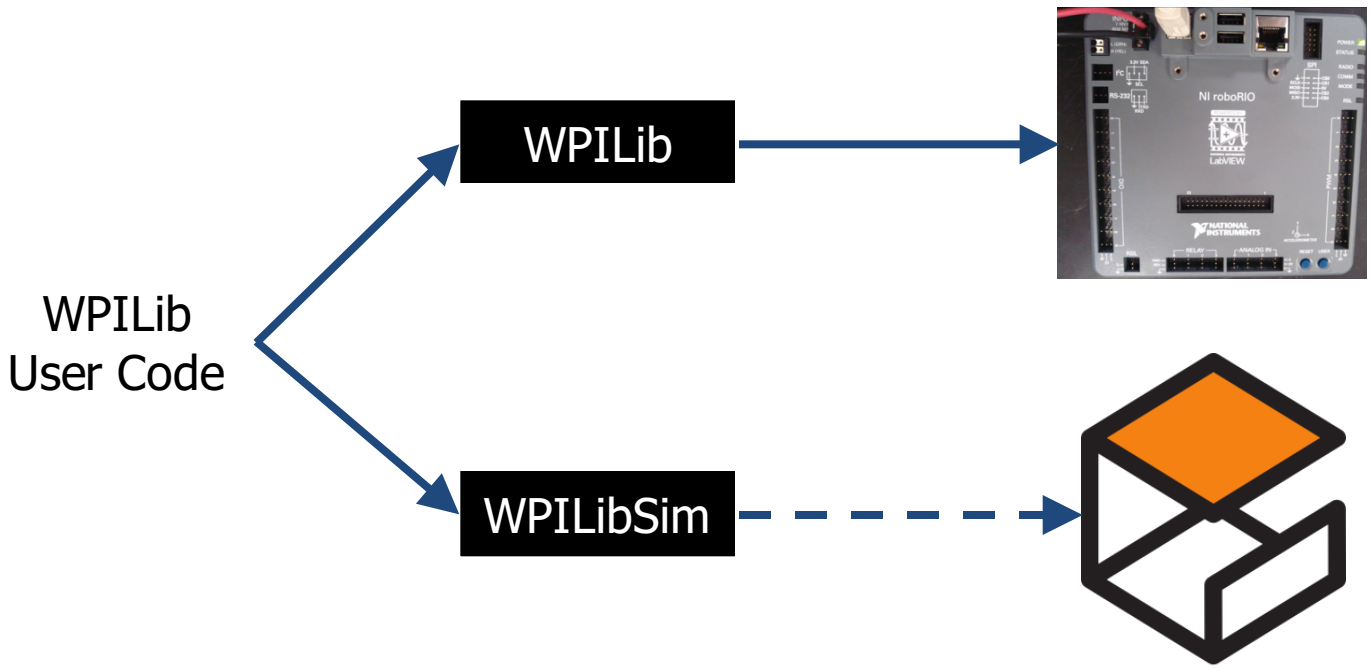
## Use basic shapes




## Create Joints



# Run WPILib code on a RoboRIO, laptop, or a server



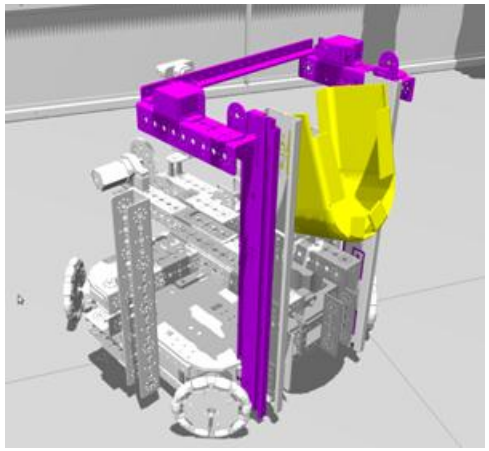
# Run WPILib code on a RoboRIO, laptop, or a server

- Limitations
  - No deformable objects
  - Not fully API compatible with WPILib
- Run tests are on hardware and in gazebo
  - We test our code on hardware
  - Simulation provides an alternative
- Windows support
- Simulation Competition?
  - One robot, auto scored by gazebo

# Gazebo has direct benefits to FIRST

## For Students

- Focus more on autonomy, less on teleop
- Encourage greater use of CAD
- Allow software teams to program robots early in the build season
- Extend FIRST season with virtual events
  - Encourages continued software development
  - Promotes greater continuity post-K12
- More scrimmages with more teams – virtual field manager for unlimited gameplay around the globe
  - Test gameplay strategy with real robot models
  - Shake out robot code before regionals
- Allow remote mentor participation – easier to get help, less burden on teachers
- Robots become portable – students can work from home
- Training / tutorials can be offered digitally

## For FIRST Staff

- Test new game designs and gameplay for design committee
- Offer arenas too hazardous for physical gameplay
  - Incorporate more real-world challenges
  - More difficult tasks – 50' Ultimate Ascent tower?
- Faster expansion to new schools worldwide
  - Offer no-cost virtual competition track
  - Expose schools without robotics expertise via simulated 'walkthroughs' of robotics control