RoboCup Virtual
Robot Manipulation Challenge

Supported by MathWorks

Participation Guide

Challenge Overview

Problem: In this challenge, your goal is to use MATLAB and Simulink to identify and sort bottles and cans into the appropriate recycling bins using a robot manipulator provided in dynamic virtual environments.

Simulation Environment: The manipulation environments used for this challenge are Gazebo worlds derived from the MathWorks documentation example Pick and Place Robot Manipulator. A virtual machine is used to run the RoboCup competition environments, instructions on installing this virtual machine can be found on the here. The robot manipulator used is a KINOVA Gen3. It is equipped with a RGB camera and a depth camera which both can be used when solving the challenge.

Rules:

- Participants must be registered in a RoboCup league
- Submissions must contain reproducible MATLAB and/or Simulink files. Any necessary file dependencies must be included.
- Robot perception algorithm must not use environment information available from the Gazebo API
- Any movement induced to the game objects must be a reaction to interactions with other environments components (Do not use Gazebo API to set positions or states)
- Modifications to the Virtual Machine Image and Gazebo worlds provided are not allowed
- Robot start position must be the same as in the Templates for RoboCup Virtual Robot Manipulation Challenge

Scoring

- Your model will be scored using the scoring rubric found on the last page.
- During the semifinals, your submission will be graded on an unknown 3rd world not provided in the Virtual machine.
    - Top 5 submissions from the qualification round will compete in the finals
- During the finals, your submission will be graded on a 4th world that may feature additional obstacles/items. Any new conditions will be provided to qualifying teams.

- Objects will not be reset during judging - If an object is knocked over, your algorithm should account for this.

Awards:

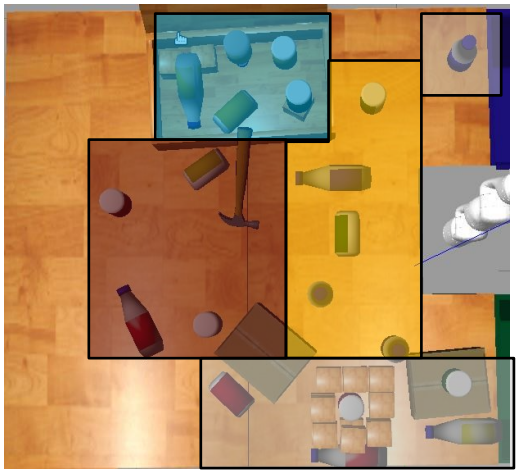
- Winners of the finals will win a grant for a RoboCup related research project for the 2023 season
    - The winners are guaranteed a grant but must submit a brief project proposal to the RoboCup Federation to confirm the research will be RoboCup related.

Important Dates:

Registration Opens	January 18th
Live Challenge Kickoff and Q&A	TBD
Technical Support and Development Q&A for teams	TBD
Submission deadline for qualification round	May 22nd
Announcement of teams qualified for finals	May 30th
Second submission deadline for teams qualified to finals	June 19th
Final round simulations and announcement of winners (Top 5 teams)	TBD (During RoboCup Finals)

Item Layout Conditions

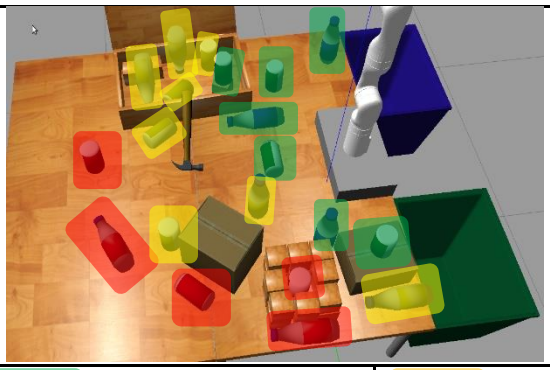
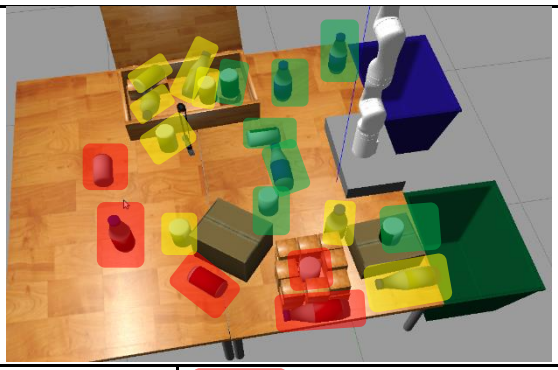
Items present in the virtual world will follow the conditions outlined below in the unknown environment that will be used for scoring.



	Won't change – Items will remain the same. No changes to orientation, position, or shape.
	Shape change – Items may switch color and item type (from can to bottle and vice versa). No changes to orientation or position.
	Random item bin – This bin will contain the same items (1 blue can, 3 yellow cans and 2 yellow bottles) but the items may change position or orientation.
	Orientation change – Items will remain in the same position but may change orientation. I.e., rotated

Example worlds

The two provided example worlds show how the layout conditions can affect the unknown environment used for testing the submitted algorithm.

World 1	**World 2**
	

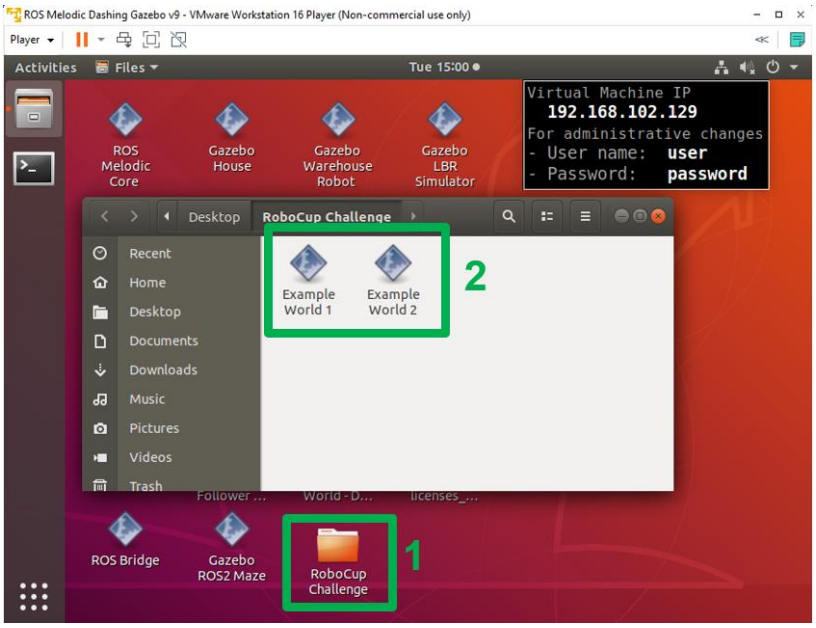
10 Points	20 Points	30 Points

Getting Started

Virtual Machine

Gazebo and the world files are all pre-installed in a provided MathWorks virtual machine. Go to this link and follow the instructions to download the virtual machine on your computer.

With the virtual machine launched you should see the following files on the desktop.



The example worlds for this challenge can be found in the folder named 'RoboCup Challenge.' To open the world in Gazebo, simply click on the world that you want to open.

MATLAB and Simulink

To help you get started, templates on how to control the manipulator using MATLAB and Simulink are provided. These are just examples on how to control the manipulator, the models don't have to be used in your submission. These templates use ROS to control the robots.

The Simulink model contains a 'Gazebo Pacer' block. This block can be used to sync Simulink and Gazebo to run at the same simulation time. However, this block isn't required to use the Simulink model. See this documentation page for more information.

MATLAB and Simulink Learning resources:

- Templates for RoboCup Virtual Robot Manipulation Challenge
- MATLAB Academy (MATLAB/Simulink/Stateflow/Deep Learning Onramps)
- MATLAB and Simulink Robotics Arena
- MathWorks Support for RoboCup (Request complimentary license)
- MATLAB and Simulink Documentation
- Questions on MATLAB and Simulink? roboticsarena@mathworks.com

Scoring Rubric

Submitting Models *(30 points)*	*Points*
All files needed to run algorithm are included in submission. Recommendation: Use a MATLAB or Simulink project, and verify using MATLAB Dependency Analyzer or Simulink Dependency Analyzer	5
Video of algorithm working is submitted.	5
Code is reproducible without any errors.	20
Using Sensors *(80 points)*	
Effective use of RGB camera. Data processed from the RGB camera leads to successful classification of at least one bottle or can.	40
Effective use of depth sensor. Data processed from the depth camera leads to successful classification of at least one bottle or can.	40
Placing Items in Correct bins *(380 points)* *Cans go in the Green bin* *Bottles go into the Blue bin*	
Green Can	10 per can *(4 cans available)*
Yellow Can	20 per can *(4 cans available)*
Red Can	30 per can *(3 cans available)*
Blue Bottle	10 per bottle *(3 bottles available)*
Yellow Bottle	20 per bottle *(4 bottles available)*
Red Bottle	30 per bottle *(2 bottles available)*
Deductions • Item placed in wrong bin: - 10 • Item falls on floor: - 5	
Bonus Points *(30 points)* *Points will be awarded regardless of whether the item is placed in a bin.*	
Robot lifts at least one item from table in the Shape change region	10
Robot retrieves at least one item from random item bin.	20
Total Possible Score	**520**