INDUSTRIAL MOBILE MANIPULATION CHALLENGE (IMMC)

Virtual Micro Challenge 2022 Rulebook

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1. Introduction

Virtual Micro Challenge 2022 is a part of the Industrial Mobile Manipulation Challenge[1] (IMMC) - an international initiative funded by EIT-Manufacturing[2], aiming to promote mobile manipulation technology and make progress in the field of human-machine co-working in manufacturing.

The development of mobile manipulators increases significantly, and we see first real-life installations, specifically in the manufacturing industry. However, the real-world environment constraint cannot be sufficiently solved in many cases, limiting these systems' utility. Thus, although also manufacturers see the promises of these systems, many possible use cases from manufacturing practice are still not easily feasible.

IMMC will deal with this problem with participants treating industrial-related problems and making progress in the field of human-machine co-working topics with manufacturing to positively influence mobile manipulator development. At Virtual Micro Challenge within IROS 2022, heterogeneous teams from different countries will compete in virtual exercises using a prefabricated mobile manipulator using ROS[3] and Gazebo to solve a real industry problem.

The participants need some knowledge in the area of robotics but will be supported by professionals and learning material to solve the problem in time. Each participating team will submit their solution to this challenge, followed by an award ceremony.

2. Organization of Virtual Micro Challenge 2022

2.1. Team Requirements and Registration

A team or an individual can take part in the Virtual Micro Challenge. Each team and individual must fill in the registration form by October 23, 23:59:59 CET to compete.

Link to the registration form:
https://forms.monday.com/forms/816c448df2e582b5929939bb1c295773?r=use1

2.2. System Requirements

To compete in the Virtual Micro Challenge participants are expected to have a setup that is compatible with ROS Noetic and Gazebo 11.

The codebase provided by organizers was successfully tested on a laptop with the following specs:

- CPU: Intel Core i7 8th Gen
- RAM: 8 GB
- Graphics: Intel UHD Graphics 620
- OS: Ubuntu 20.04

A certain configuration is up to a participant, thus is it not forbidden to use other ROS and Gazebo versions, operating systems, or a virtual machine. However, the scoring will be performed using the configuration mentioned above.

It is also expected that participants will join online Zoom[4] meetings, the support chat in Element[5], and use GitHub[6] for submissions.

2.3. Support Team

The support team is a group of people who are responsible for the preparation of the Virtual Micro Challenge environment and rules, and for providing information about it.

The team consists of engineers and researchers affiliated with organizations that are partners of the IMMC project:

- Denis Zatyagov, RoboHouse, Netherlands
- Patrick Killingseder, TU Wien, Austria
- Bernhard Reiterer, Joanneum Research, Austria
- Nima Rahmani Choubeh, Politecnico di Milano, Italy
- Bernhard Wallner, TU Wien, Austria

To get supported, a participant is expected to send a message with a request via the support chat.

Link to the support chat: https://matrix.to/#/#immc:matrix.org

2.4. Jury Team

The jury team is a group of people who are responsible for the evaluation of solutions submitted by participants.

The team consists of highly experienced representatives from industry and academia. Jury team members are affiliated with organizations that are partners of the IMMC project.

- Ozan Kugu M.Sc., Univ.Ass., TU Wien
- Prof. Dr. Doris Aschenbrenner, Aalen University
- Maximilian Papa, M.Sc., Proj.Ass., TU Wien
- Prof. Manuel Silva, Instituto Politécnico do Porto & INESC TEC
- DI Matthias Weyrer B.Sc., Joanneum Research Forschungsgesellschaft mbH

2.5. Milestones, Schedule and Location

All given times are CET time zone. Year 2022.

Registration is closed	October 23, 23:59:59
Opening ceremony	October 24, 10:00 - 12:00
Participants develop and submit solutions	October 24 - October 27
Submission is closed	October 27, 23:59:59
Submissions evaluation	October 27 - November 7 (can be postponed depending on the number of submissions)
Leaderboard is published	November 14 (can be postponed depending on the number of submissions)

Virtual Micro Challenge is taking place completely online.

2.6. Challenge Process

Participants are expected to do the following:

1. Join the Opening ceremony and get an introduction to the Virtual Micro Challenge.
2. Carefully read the Rulebook.
3. Clone the repository with the Virtual Micro Challenge code.
   Link to the repository: https://github.com/wddler/immc

4. Work on the solution.
5. Optional: ask the Support Team for support.
6. Submit the solution.
7. Wait for the leaderboard announcement.
8. In case of prize-winning place: get in contact with the organizers, and provide the necessary data.

3. Virtual Micro Challenge Setup and Task

In essence, the setup consists of a Gazebo world representing an abstract factory floor, a mobile manipulator with a gripper, a set of objects to be moved, and a set of orders specifying which object should be moved to a certain location.

3.1. Setup: Environment

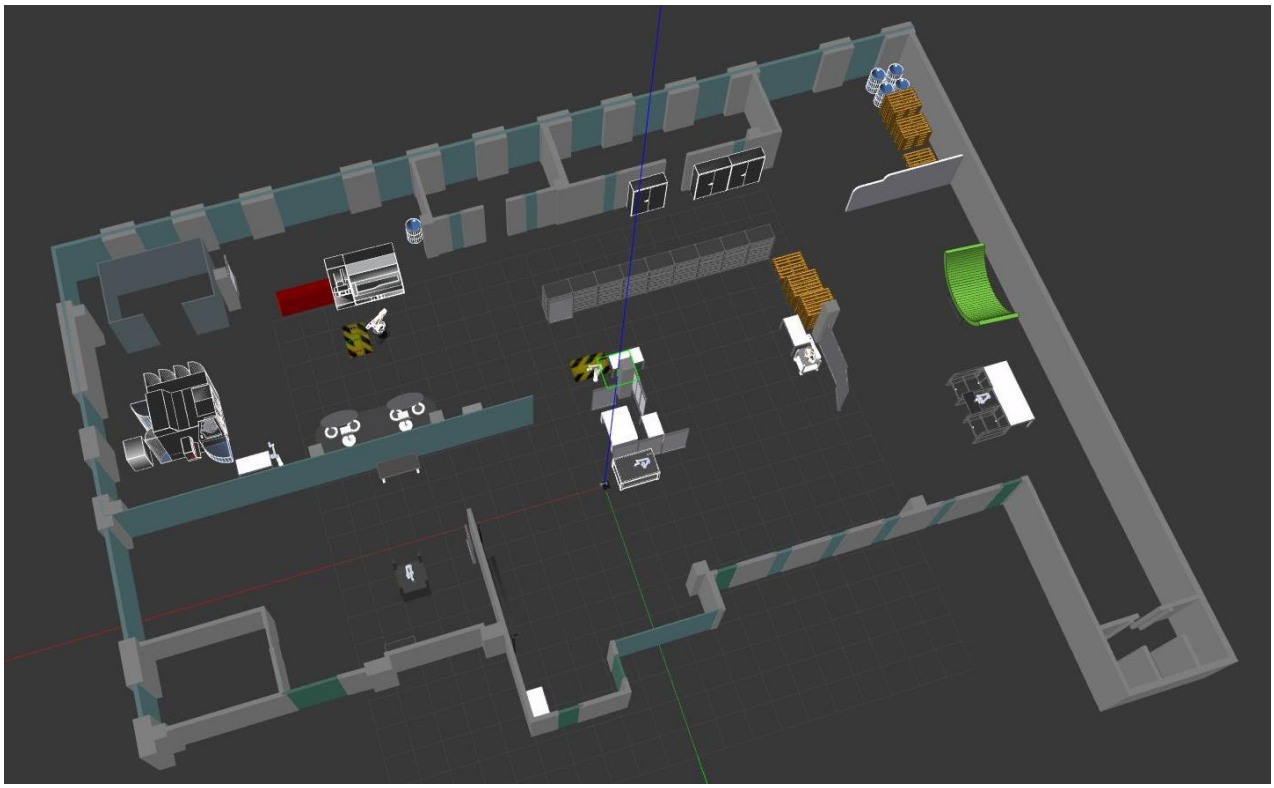

Figure 1: An overview of the Factory environment in Gazebo simulator.

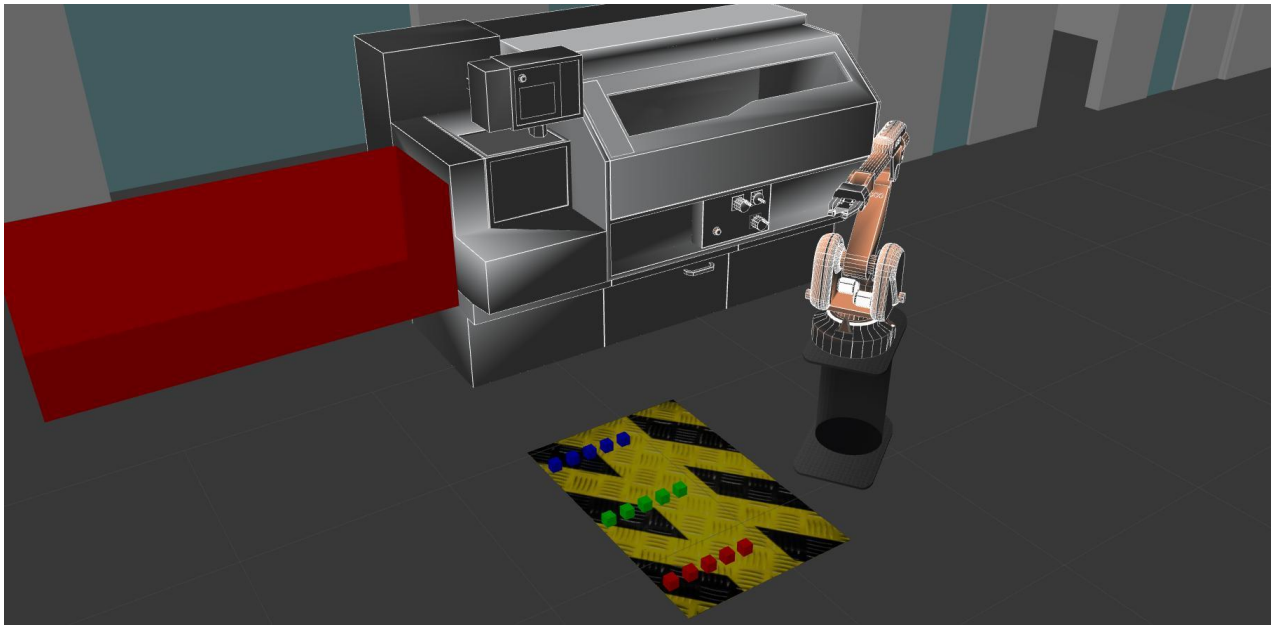

Figure 2: The Input Area (stock) of the Factory environment in Gazebo simulator.

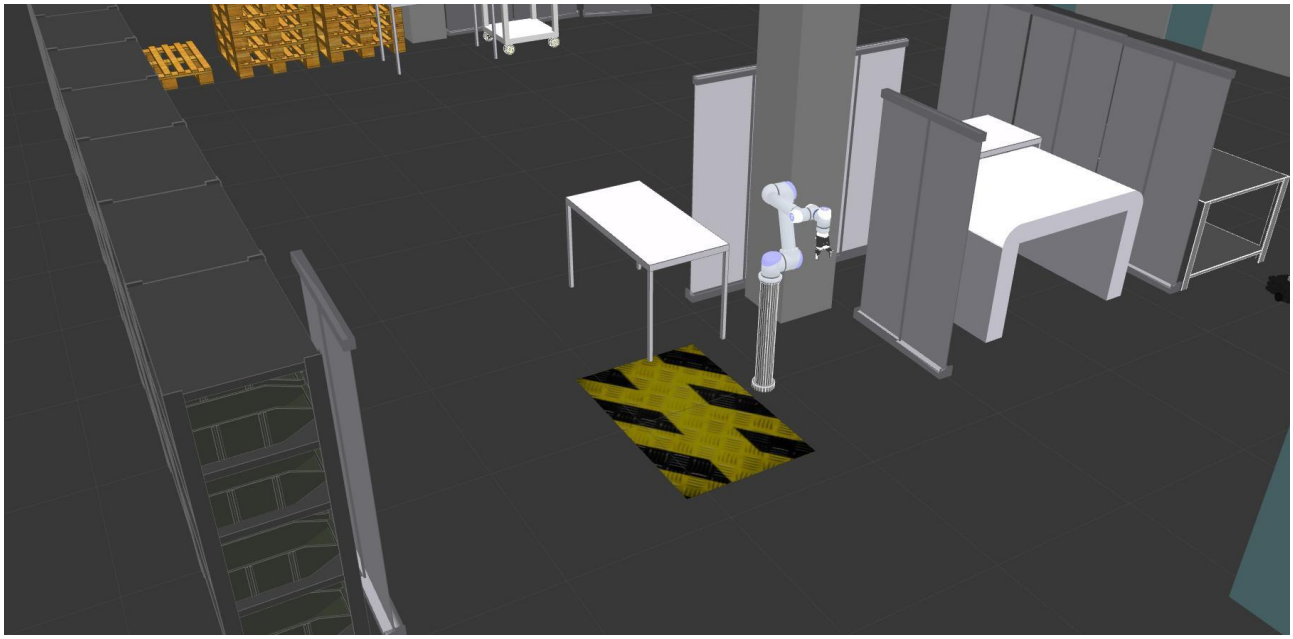

Figure 3: The Output Area (delivery) of the Factory environment in Gazebo simulator.

3.2. Setup: Mobile Manipulator

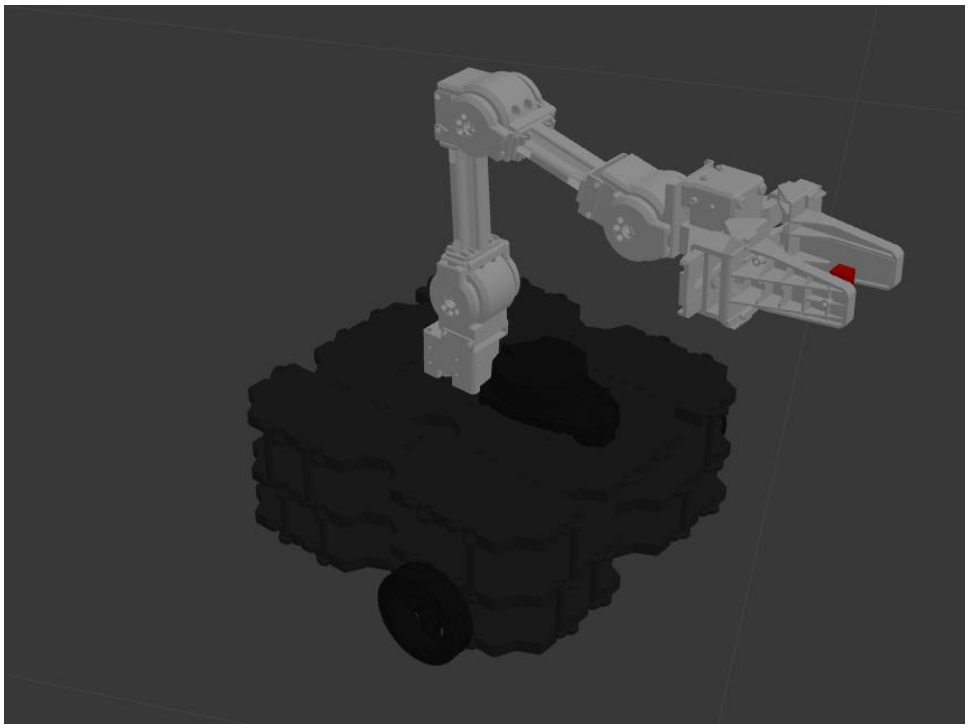

Figure 4: The mobile manipulator in Gazebo simulator.

Mobile manipulator consists of a Turtlebot3 mobile base (waffle_pi model) and OpenManipulator robot arm with two fingers pinch gripper. The mobile manipulator can be controlled using MoveIt framework and ROS Navigation stack.

3.3. Setup: Objects

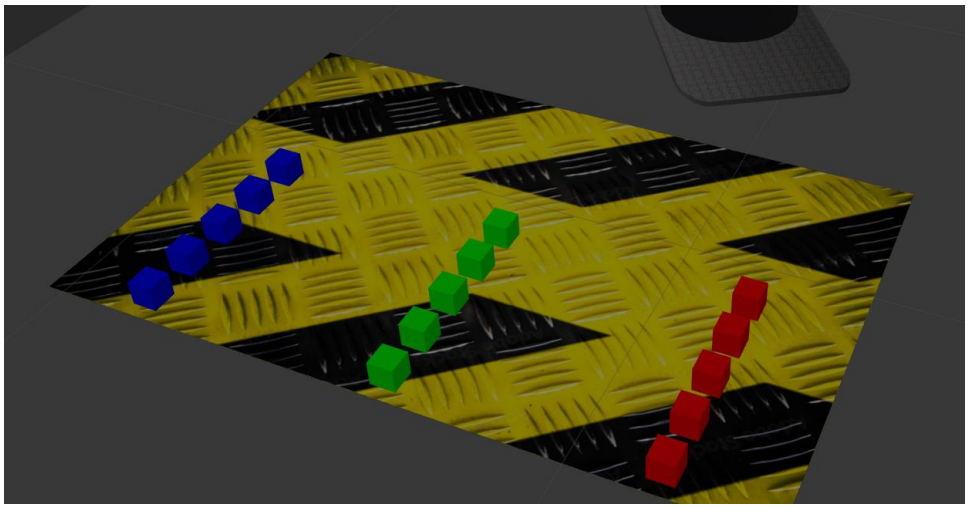

Figure 5: The set of objects in Gazebo simulator.

The set of objects is represented by five cubes of red, green, and blue colors (15 in total) located by default at the Input Area (stock).

3.4. Setup: Set of Orders

An order is a data structure represented by ROS message type Order.msg. It has the following fields:

uint32 id
string[] objects
geometry_msgs/Point desired_location

A set is a collection (list) of orders. There are two sets of orders that will be used in the Virtual Micro Challenge: a training set and a test set.

The training set is supposed to be used by participants to develop solutions. The training set is implemented in the code by default.

The test set is supposed to be used by the Jury team during the evaluation of the solutions. The test set is hidden from the participants. The only difference from the training set is the number of orders in total, their id, and objects in there. The desired location is the same.

The set of orders can be fetched by the call of the "pending_orders" service.

4. Challenge Task

To perform the virtual micro challenge, each participant must write a program to control the behavior of the simulated mobile manipulator in order to fulfill a set of pick-and-place orders.

The starting point in the challenge is launching
immc_bringup/launch/immc_bringup_factory.launch

This launch file will:

- Run the Gazebo simulator with the factory world.
- Spawn the mobile manipulator at the origin of the factory world.
- Run the move_group interface to control the arm and the gripper.
- Run the navigation stack to control the mobile base.
- Provide the map of the factory world to the map server for autonomous navigation.
- Spawn objects for manipulation at the input are (stock).
- Run order manager node.

A solution developed by a participant is expected to have the following capabilities. The mobile manipulator must perform autonomously.

1. Call a service "*pending_orders*". The service will respond with a collection (list) of orders. For the specification refer to the content of the *immc_msgs* package.
2. Handle response of the service "*pending_orders*": get information about required objects and drop location (desired_location) associated with an order. A participant might want to choose a certain order from the list to execute first.
3. Command the mobile manipulator to move to the required object and pick it. It can be decomposed further:
    a. Determine the location of the object. Implementing your own solution for it is acceptable. A participant might want to use a logical camera, RGB camera, Depth camera, or other options. For a logical camera please refer to Gazebo documentation[7].
    b. Command the mobile base to move to the object's location close enough to grasp the object. A participant might want to use the "*move_base*" action for it.
4. Command the robot arm to grasp the object. A participant might want to use "*moveit_commander*" for it together with pre-fabricated arm and gripper positions such as "*pre-grasp*", "*home*", "*transportation*", "*pre-release*", "*full_open*", "*close*".
    a. Due to the high complexity of precise grasping in simulation, it is acceptable to use fixed joints between the gripper and the object. For details please refer to the *gazebo_ros_link_attacher* package[8].
5. Command the mobile manipulator to move to the output area (delivery) and drop the object.
6. Repeat steps #3 and #4 as many times as needed to bring all objects required for the order. Carrying multiple objects simultaneously is acceptable in case there was contact between each object and the "*base_link*" of the mobile platform.
7. Submit the order by calling the service "*submit_order*" and providing the order id. The order manager will check objects and their location corresponded to the order and respond with a boolean true in case of a successful order or false in case objects are missing at the desired location.

8. Repeat all the steps until the list of pending orders is empty. This is the end (finish) point in the challenge.

The training set of orders:

```
-
  id: 1
  objects:
    - red_cube
    - blue_cube
  desired_location:
    x: -1.0
    y: -4.67
    z: 0.0
 -
  id: 2
  objects:
    - green_cube
  desired_location:
    x: -1.0
    y: -4.67
    z: 0.0
 -
  id: 3
  objects:
    - green_cube
    - red_cube
    - blue_cube
  desired_location:
    x: -1.0
    y: -4.67
    z: 0.0
```

5. Requirements for solution submissions

1. The mobile manipulator must fulfill the set of orders autonomously.
2. Participants are not expected to change the pilotfactory.world except for adding plugins for sensing and perception capabilities.
3. Participants are not expected to change the mobile manipulator description files except for adding sensing and perception capabilities.
4. Participants can change the control interface of the mobile manipulator both for the mobile base and for the robot arm.
5. Participants can use the mapping capabilities of the navigation stack to update the map of the environment.
6. A solution must be located in a dedicated ROS package.
7. A solution must contain instructions on launching it. Ideally, it should be one script or a launch file with comments.
8. A solution must contain a link to the video recording that captures the fulfillment of the set of orders.

9. To submit a solution participant can create a branch in the IMMC repository on GitHub.
10. Other changes in the environment provided by the organizers must be discussed with the support team prior to the implementation.
11. A participant must be ready to provide comprehensive information about the solution in case of a request from the Jury team in reasonable time (up to 2 working days).

6. Evaluation

Evaluation will be conducted by the Jury team after October 28.

The Jury team will evaluate solutions that are submitted on time and meet requirements.

The support team will run each solution with the training and test sets of orders and the Jury team will allocate points to the participant according to the rules below.

Points should be gained for:

- Completing the main task (see 4. Challenge Task)

Points should be taken away for:

- Collisions with the environment
- Dropping item while grasping or carrying
- Lack of task completion
- Doing restarts

There is also a maximum time duration limit of the virtual micro challenge per each team, which is 60 min.

	Max. duration	60 Min.
Scoring	**Positive Scoring**	
	The output area reached (starting from the start point)	+5 Points
	One item grasped	+10 Points
	One item placed in the right location	+10 Points
	One order accepted	+10 Points
	The finish point reached	+5 Points
	Time bonus	+X Points (left over time in seconds multiplied by 0,154)
	Negative Scoring	
	One collision with the environment	-5 Points
	One item dropped	-10 Points
	Restart from the beginning (max. 2 restarts allowed)	-20 Points

	Irrelevant item at the output area (delivery) after all orders fulfilled	-10 Points
	Please note: The total number of points per team cannot be negative. (Total amount >= 0 Points). In the case of the same number of points (tie), the solution, finished all of the tasks in the shortest time, will be chosen as tie breaker.	

After solutions are evaluated, the Jury team will create a leaderboard and send it to the participants via email.

7. Awards

The winning participants are going to be awarded.

A participant, which collects the highest number of points at the end of the challenge, will be ranked in the 1st place. Based on it, a participant with the 2nd highest number of points will earn the 2nd place and the one with the 3rd highest amount the 3rd place. The awards of the places are listed below:

- **1st place:** Arduino Braccio or equivalent
- **2nd place:** RPLIDAR or equivalent
- **3rd place:** Raspberry Pi 400 Kit or equivalent

An exact item depends on the stock availability.

The support team will try to arrange delivery to locations, specified by the winners. In case of not feasible delivery, the prize can be collected at the location specified by the support team.

Other Terms and Provisions

The organizers reserve the right to change the terms above as the last resort.

References

[1] Industrial Mobile Manipulator Challenge (IMMC) https://www.immchallenge.eu/

[2] Industrial Mobile Manipulator Challenge (IMMC) https://www.eitmanufacturing.eu/news-events/activities/industrial-mobile-manipulator-challenge-immc/

[3] Robot Operating System https://www.ros.org/

[4] Zoom video conferencing app https://zoom.us/

[5] Element messaging app https://element.io/personal

[6] GitHub https://github.com/

[7] Example of a Logical Camera sensor https://classic.gazebosim.org/tutorials?tut=logical_camera_sensor&cat=sensors

[8] gazebo_ros_link_attacher ROS package https://github.com/pal-robotics/gazebo_ros_link_attacher