RoboCup 2016
RoboCup Rescue Simulation League
Virtual Robot Competition

Rules Document

Technical Committee:
Francesco Amigoni, Masaru Shimizu, Sanaz Taleghani

Executive Committee:
Arnoud Visser

version 1.5: March 8, 2016

Abstract

The purpose of this competition is to provide a common benchmark to demonstrate scientific progress in the application of robotics to Urban Search and Rescue. The rules of this competition are loosely inspired by the rules of the RoboCup Rescue Robot League and Agent Competition. As in the Rescue Robot League, a devastated area has to be explored for victims by a team of robots controlled by an operator. Compared to the Rescue Robot League, the focus is on exploring larger areas with multiple robots rather than the mobility of individual robots. As in the Agent Competition, the disaster situation is not known before a competition run. The main difference between the two events is our focus on a realistic sensory and actuation in addition to planning.

The Virtual Robot Competition of this year comes after The Future of Robot Rescue Simulation Workshop [1] that has set a new milestone and designed an environment and scenario which are planned to be used inside the competition for some years. The rules reflect this fact.

1 Foreword

The design and implementation of a RoboCup Competition is an ongoing process that is possible thanks to many people around the world volunteering a significant part of their time to this event. Contributions include improvements to the simulation engine, creation of competition worlds, and running the competition itself. The generous contribution of all volunteers in the past is warmly acknowledged. They have enabled a competition that is sustainable without excessive human effort and can remain viable. This is especially true this year, after a big change in simulation platform, scenarios, and, as a consequence, in rules.

The rules described in this document and proposed for RoboCup 2016 Virtual Robot Competition strive to further the progress made on the *comprehensive mission*. Several years ago the competition also addressed several sub-problems in the form of elemental test runs as a qualification for the final rounds. Since these elemental tests considered very specific capabilities, namely teleoperation, mapping, and deployment of an *ad hoc* network, they were also easier to score automatically. One problem with such tests, however, is that scores do not always directly relate to performance, i.e., rescued victims, in the comprehensive mission. Furthermore, the setup of such tests enforces the types of approaches teams can take for solving the comprehensive mission. For example, focusing solely on multi-robot coordination without good mapping, no teleoperation, and no connected communication network could also lead to good performance in the comprehensive mission. Yet a team with such emphasize will

---

1 See https://staff.fnwi.uva.nl/a.visser/activities/FutureOfRescue/index.php, where several technical issues are also discussed under “Installation Requirements” and tutorial for the different days.

fail most elemental tests. To remove these artificial constraints the Technical Committee hopes that the focus on a single comprehensive mission will be beneficial for the competition, fostering a multitude of approaches that will be judged by a common performance metric. The main goal of this competition is finding victims and teams are evaluated according to the number of victims found and to the time required.

As usual, suggestions, constructive feedback, and volunteer work are welcome and needed.

All teams participating in the 2016 competition agree to follow the latest version of these rules.

2 League Objectives & Background

The major goal of this competition is to encourage intuitive operator interfaces and autonomous and semi-autonomous algorithms that can be used to supervising and control multiple heterogeneous robots operating in challenging environments. Additionally, we aim to have a competition with a low barrier of entry for new teams and possibilities for a variety of approaches. In this sense, the adoption of Gazebo as simulation framework allows to easily leverage on the large amount of code available in the ROS ecosystem.

This should allow permanent installations of servers, each with its own world, which can be used for testing in preparation of the RoboCup event. Further, it allows teams to test their approach prior to the competition which lowers the barrier of entry for new teams.

The challenges are then a result of the environments that robots are deployed in, while the metric remains the same. Additionally, to foster the competition aspect the scores are computable in real-time and can be displayed to an audience during each competition run, but won't be announced till all the teams have completed their map runs.

Finally, the scores should reasonably reflect performance for relevant real world problems that are modeled in simulation. Here, the simulation aspect of our league has the advantage of reproducible comparisons since all activity can be logged and ground truth data is readily available.

3 Comprehensive Missions

During the competition, indoor and outdoor search and rescue scenarios may be encountered. Before the run, the teams will be given basic information about the scenario. This will include the location of the disaster (indoor/outdoor) and possible dangers. Teams will be required to search for victims located in different places in the arena and park their robots "near" each victim (somewhere in radius of 1.5 meters around the victim, but Technical Committee has the final word on when a robot is enough "close"). Teams do not to submit any material to the referees for scoring, but Technical Committee may ask for maps generated by each team to compare their performance and release their outputs to other teams. Scoring will be made according to number of robots parked near victims and the time required to detect victims.

Only robots validated before the competition will be allowed to be used in the competition. The list of accepted robots and sensors is reported in this document (Section 8). Note that not every combination is possible. The sensor load will be examined and the Technical Committee reserves the right to disallow any unrealistic combination of robots and sensors.

Robot teams will be formed by a number of mobile robots, plus a base station (a robot that does not move) that provides interface to the operator.

4 Running Missions

4.1 Simulation environment

Simulations will run in Gazebo 5 on a Ubuntu 14.04.4 LTS (Trusty 64 bit) with ROS Indigo machine [2]. During the competition, the organizers will provide two sets of machines (from now on each set will be called a cluster). Gazebo will be run in server mode on each cluster. One of the two clusters will be used by the team currently competing, while the second one will be used by the team setting up for the following competition round. Each team

[2] See installation notes at https://staff.fnwi.uva.nl/a.visser/activities/FutureOfRescue/day0.php.

has 20 minutes to setup on its cluster. The run starts at the scheduled time. If a team is not ready, time will start anyway. Each competition run lasts 20 minutes (exact time to be announced before the run). Each team will run its client code on its own machines. A single TCP/IP cable will be provided to the team to connect to a cluster.

Connection to the simulation server can happen using two modalities (each team can choose its preferred modality):

(a) Using the GazeboUsarSim plugin[3]; in this case, each team sends commands according to the GameBot protocol to the robots of the team.

(b) Using direct ROS control; in this case, each team sends commands according to the general ROS-Gazebo interface[4].

In both cases, the server runs Gazebo 5 plus the GazeboUsarSim plugin and robot_state_publisher ROS node. The teams know the IP address of the server. To ensure the fairness of the competition and the fact that teams are not cheating in communicating with the server, especially in case (b), for which the set of commands that can be sent to the simulator is not constrained, the Technical Committee reserves the right to inspect the code of the team at any time to ensure that the client controlling robots exchange with the simulator only data compatible with realistic situations. Reading data from sensors mounted on robots is realistic, sending commands to robot actuators is realistic. The Technical Committee reserves the right to decide about the interpretation of the term "realistic".

At the prescribed start time, the robots will be instantiated in the world. Starting poses of the robots forming a team will be provided as follows, according to the communication mode:

(a) In case the team uses GazeboUsarSim plugin: team has to retrieve robots position and orientation directly from the simulator using the GETSTARTPOSES command via the GazeboUsarSim plugin.

(b) In case the team uses direct ROS control: just before the run, the Technical Committee will provide a launch file built starting from a template provided by the team (and including the robot configurations the team would like to use) and modified with the starting poses of the robots (decided by the Technical Committee and identical to those returned by GETSTARTPOSES of option (a)).

All robots must be spawned at the start of a run, though teams can decide to activate them at their convenience.

4.2 Communication between robots

Communication between mobile robots and between them and the base station is based on realistic models.

In order to facilitate broader participation during the transition from USARSim to Gazebo, for the 2016 competition the communication between robots will be assumed to be unconstrained (both in terms of connections and of bandwidth).

Accordingly, in the competition at RoboCup 2016, the Technical Committee will not enforce any segregation of the code of different robots of the team. However, for future, the Technical Committee is exploring these two possibilities:

(1) One ROS master running with Gazebo, and separating robots and delivering messages according to their namespaces (for example, with ros_con gateway).

(2) One ROS master running with Gazebo and separate ROS masters for each robot (for example, using multimaster_fk).

This applies to physical robot-environment communications, which should be kept local. All other communications (operator-robot and robot-robot) will use in the future an equivalent of the Wireless Communication Server WSS[5], running on the server machine, that simulates constrained and intermittent wireless network links in a disaster setting, where multi-hop routing and autonomous behavior of robots are required. Currently, the Technical Committee is studying the suggestions for ROS-nodes that have this functionality[6]. All

[3] See https://github.com/m-shimizu/RoboCupRescuePackage and installation notes at https://staff.fnwi.uva.nl/a.visser/activities/FutureOfRescue/day1.php.

[4] See https://github.com/nkoenig/pioneer3at_demo for spawning multiple robots with different namespaces.

[5] The old WSS used in connection with USARSim was developed and documented by Max Pfingsthorn. The latest Windows version 0.6.1 is available on http://usarsim.cvs.sourceforge.net/viewvc/usarsim/usarsim/Tools/WSS/. This version of the WSS can also be compiled under Ubuntu and works in the noop mode (available at https://github.com/MRL-VR/WSS-Ubuntu thanks to Mohammad H. Shayesteh and Sanaz Taleghani). The Technical Committee will make any effort to have the distance mode ready as soon as possible, hopefully before the competition at RoboCup 2016.

[6] See for instance the rocon-gateway, multimaster-fkie or topic-proxy nodes suggested at https://staff.fnwi.uva.nl/a.visser/activities/FutureOfRescue/day5.php.

communications between robots and between robots and base station must go in principal through such WSS equivalent. As long as no such alternative is available for ROS-nodes, the teams may assume unlimited communication, but should be aware that this situation will change next year. In the future, the operator at the base station can send commands to a robot and will obtain measurements and video images from a robot only when that robot is in radio contact. The location of the base station and the wireless cutoff strength will be provided as *a priori* data and announced before each run. During the competition all socket communication to the robots will be logged. Therefore, we will be able to check for TCP-packages that bypass the Wireless Communication Server. Moreover, the Technical Committee Teams that violate this policy are immediately disqualified, and the reason for the disqualification will be posted on the web.

Currently images acquired by cameras onboard of simulated robots can be processed by the client if modality (b) is used. If, instead, modality (a) is used, images cannot be currently transferred to the base station via GazeboUsarSim. The Technical Committee will put any effort in fixing it before the competition at RoboCup 2016[7].

5 Performance Metrics

For scoring purposes a team member is counted as a human operator as soon as the human operator:

- starts a robot, enters initial points,
- actively drives a robot around,
- stops a robot before the run is over (for example, to prevent it from bumping into victims),
- is involved in any way in the victim recognition process.

Each team can have only one human operator for each run.

Let m be the number of victims a team detected successfully and t be the completion time for the team, i.e., the time until either all M victims in the arena have been found or the maximum mission time T is exceeded. The score of a team is calculated with one of the following two formulas announced by Technical Committee before each run:

$$Score = 50 * \left[10m + \left(1 - \frac{t}{T}\right)\right]\alpha$$

$$\text{Score} = [10\text{m} + 10\beta\text{MS}]\,\alpha$$

Where α $(0.1 < \alpha < 2)$ is proportional to the difficulty level of the map, defined by the map designer, β is a constant $(0.1 < \beta < 1)$ that balance the weight of finding victims and of exploring the environment, and S is the ratio of the area explored by robots, which is measured as follows. Each map has a number N of "focal points"[8] defined by the map designer (for example, focal points are intersections of corridors and other relevant points according to the environment[9]), but unknown to the teams. Explored area ratio S is calculated as n/N, where n is the number of focal points that are in the map of the portion of the environment explored by robots of a team.

To encourage safe robot behavior any victim crashed into by a robot causes the team a 20% score penalty for that victim (which then gets 8, instead of 10, points).

Besides, before each run, the Technical Committee can communicate to the teams that operators are not allowed to control the robots manually (*handoff period*) for k minutes, during which robots are supposed to explore automatically.

6 Open Source Policy

The winning teams are required to provide a fully functioning copy of their software to the organizers before the final ceremony. Failure to do so will result in team disqualification. All other teams are also requested to provide

---

[7] In the past, with USARSim, images from camera where managed by an image server is developed and documented by Prasanna Velagapudi, which was available at http://usarsim.svn.sourceforge.net/viewvc/usarsim/Tools/ImageServer/.

[8] Focal points mimic the idea of "map fiducials" used in the RoboCup Rescue Robot League (see rules for the 2015 competition at: http://wiki.ssrrsummerschool.org/doku.php?id=rrl-rules-2015.

[9] In future competitions, focal points could be automatically generated from a map. For example, considering an indoor map, focal points can be generated according to a Voronoi decomposition of the map.

their code, though not before the awards event. The software will be posted on (or linked from) http://www.robocuprescue.org/ giving proper credit to the authors. Source code for previous competitions is available at the aforementioned web page.

All data logs collected during the competition can be made available on the web for public use, including, but not limited to, scholarly work devoted to performance evaluation and benchmarking.

7 Summary

The intention of the competition is to stimulate research in robotics that allows for autonomous and safe exploration of significant parts of the environment providing aid to first responders to rescue victims. The organizing committee has the obligation to make the competition a fair challenge.

8 Allowed Robots and Sensors

Teams can use combinations of the following robots (whose models are available in Gazebo) with following sensors which are currently tested and work properly:

P3AT (odometry, camera, battery, sonar, gps, laser range finder)
P2D (odometry, camera, batter, sonar, gps, laser range finder)
Turtlebot (odometry, camera, battery, sonar, gps, laser range finder)
Quadrotor (camera, battery, gps, laser range finder)

Sensor data can have added noise.

Sensor load will be examined. The Technical Committee reserves the right to disallow any unrealistic combination of robots and sensors. Prior to the competition, the technical committee can publish a number of reasonable configurations that can be used during the competition. Additionally, when during the competition unrealistic behavior is detected for a robot or sensor, this device can be excluded for further usage during the rest of the competition.

9 Acknowledgments

Special thanks to Amir. H. Abdi, Behzad Tabiban, Andreas Kolling, Stephen Balakirsky, and Stefano Carpin who co-authored rules of the previous years.

10 List of known open issues

The Technical Committee will put any effort in solving the following issues before the RoboCup 2016 competition (* denotes urgent issues)

- * Models of victims in Gazebo.
- * Support for cameras via GazeboUsarSim.
- Distance mode for WSS.
- * Check models of robots and sensor configurations (especially, battery, sonar, and gps).
- Segregation of robots of a team within ROS.
- * Create sample of launch file.
- * Check “gazebo-white-ip”: list of IP addresses that can access Gazebo and that should be disabled for prevent cheating.