Rules of Demo Challenge on

Benchmarking Service Robots

Draft 1.2

1 Field and Facilities

The size of the indoor competition area is about 7m×7m, where part of the ground may be uneven (within 3cm of ups and downs) and there may be some obstacles on the floor. Obstacles include, but are not limited to: hollow obstacles (such as arches), furniture, small common objects, or even moving persons. Large obstacles such as arch and furniture are part of the field.

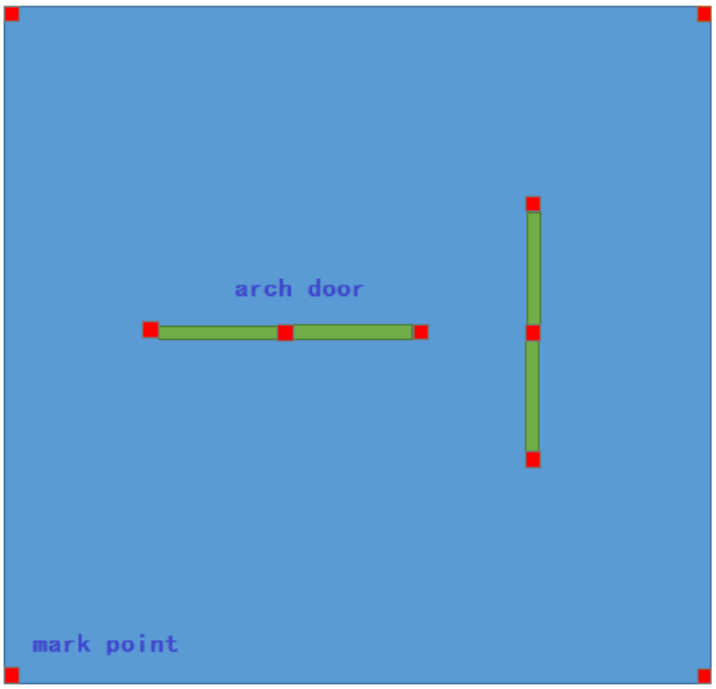

Figure 1 The competition area

Figure 1 illustrates the setup of the competition area, where there are two sets of double arches (the greed blocks). The 10 landmarks (the red points in Figure 1) are given as shown in Figure 1. Among these landmarks, six are located on the arches and the other four are located in the corners. The coordinates of the landmarks in the

Motion Capture System (MCS) are provided for the participants to map the local coordinates of their robot to the coordinates of the MCS system.

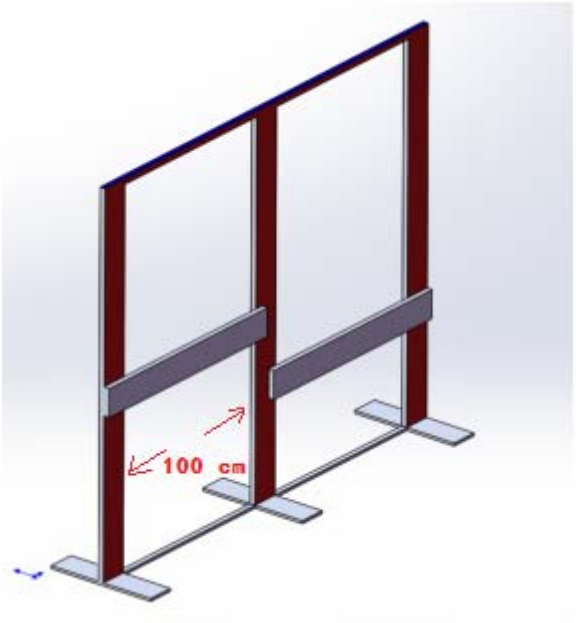

Figure 2 Arch

The double arch is shown in Figure 2. The door width is 100cm. There is a slider for each door, the height of which is adjusted randomly by the judge before a test in competition. A robot must decide autonomously whether it is able to go through a door according to its own height and the height of the slider on the door.

Figure 3 Sample load

The shape of loading objects used in the competition is shown in Figure 3. Teams are responsible for mounting these objects on their robots. There are two types of loading objects with the following mass and dimensions: (i) 20kg: 20*14.5*14.5cm; (ii) 10kg: 16.5*10.5*13cm.

A Motion Capture System is installed and covers the whole competition area. The MCS is able to measure the movement of a robot within the field with high accuracy in real-time, and automatically record the measurements. The recorded data is used to evaluate the performance of the robots in the competition.

2. Requirements to Robots

A robot qualified for this competition is expected to have a basic mobile platform (i.e., a robot base) and extended sensors such as camera, LRF, etc. The hardware cost of the basic mobile platform (including the costs of materials and components) or the market retail price (not discounted or second-hand price) should be less than 10,000 RMB (about 1,600 USD). The hardware cost or the market retail price (not discounted or second-hand price) of extended sensors should be less than 50% of the basis mobile platform.

3. Tests

3.1 Tests in Stage 1

In Stage 1, robots are allowed to use only odometer as sensor. The robots are required to complete several tasks (such as moving in a straight line or turning) under different load conditions (e.g., empty, 10kg, 20kg, etc.). Based on the feedback from the odometer of the robot and the measurement data collected by MCS, the accuracy of the robot’s movement for performing the tasks is computed.

Each team can request to try an extra load once, which must exceed the maximum routine load pre-specified for all participating teams at least 20kg, i.e., 20kg of load increase than the maximum routine load.

3.2 Tests in Stage 2

In Stage 2, a robot is allowed to use sensors besides the odometer to build a global map of the field in advance before test. The map will also be used for evaluating the robot's performance.

In the competition area the robot is required to reach 7 waypoints in the correct order (specified by the judge) under different load conditions. The waypoints and their order will be given by the judge. A robot should stop for 10 to 15 seconds at each waypoint, which indicates that the robot is showing its arrival of that waypoint.

The maximum time for completing the task (T_{max}) is set in advance for all tests of Stage 2. A test is ended mandatorily when a robot has used up the maximum time T_{max} in the test.

The scoring criteria include: duration of completing the tasks, precision of reaching the waypoints, colliding with obstacles.

3.3 Finals

The top 8 teams in the first two stages are qualified for the final competition. The tasks in the finals are similar to that of Stage 2, with probably a higher level of difficulty. The detailed rules about the finals will be announced soon.

4. Scoring System

4.1 Scoring System for Stage 1

(1) Given an empty load, measure the difference between the feedback of the robot and the ground-truth data from the MCS during the tasks, such as moving in a straight line or turning at a given spot according to the following formula

$$\psi_0 = a\frac{\left|l_{mcs} - l_{robot}\right|}{l_{mcs}} + (1-a) * \frac{\left|\theta_{mcs} - \theta_{robot}\right|}{\theta_{mcs}}$$

where *a* and *1-a* are the weights for the tasks of moving in a straight line and turning at a given location, respectively (a = 0.4). l_{mcs} and l_{robot} are the moving distance measured by the MCS system and the robot itself, respectively. Similarly, θ_{mcs} and θ_{robot} are measurement of the robot's rotation angles measured by the MCS system and the robot itself, respectively. The final score is obtained as the best of several ψ_0.

(2) The same rules are used for the tasks under different load conditions (e.g., 10kg, 20kg, etc.). Teams requesting to try an extra load that exceeds the maximum routine load will be rewarded with an additional score.

(3) The score ψ_{robot} is computed by averaging the scores obtained under different load conditions. The final score of Stage 1 is computed as follows

$$\chi_{\text{robot}} = \frac{\psi_{\max} - \psi_{\text{robot}}}{\psi_{\max} - \psi_{\min}} \bullet 100$$

4.2 Scoring System for Stage 2

In a test, if a robot stops and stays for 10-15 seconds within 30cm of the target waypoint, the robot is considered successfully reaching the waypoint. The MCS measurement data is used to decide if a robot has successfully reached the target location and to measure how far the robot has stopped from the target waypoint.

If a robot successfully reaches a target waypoint *i*, the score it gets at the waypoint is computed as follows

$$S_i = 100/num \times (1 - error/2\delta)$$

where *num* is the number of target waypoints, *error* is the distance error and δ=30cm. Here the highest score is 100/*num*. If a robot does not successfully reach a target waypoint *i*, then it gets score 0 over the waypoint.

If a robot collides with an obstacle in a test, it will get penalty score of 0.3×100/*num*.

If a robot is able to go through an arch without collision (the width of arch is 100cm), it gets score of 0.5×100/num. If a robot goes through an arch more than once consecutively without successfully reaching a target waypoint or going through another arch, then only the first time is considered successful.

The total score of a robot in a test of Stage 2 is defined as follows

$$\sum S_i + n \times 0.5 \times 100/num - m \times 0.3 \times 100/num$$

where *n* is the number of successful passing through arches and *m* is the number of collisions with obstacles.

Each team has two chances and the highest score of the two tests is taken as the

final score of the team in Stage 2.

All teams are required to make a short report on their research and development work at the BSR 2015 workshop, which will be held in July 20. A team's report will be scored by all other teams. These scores will be taken as part of evaluation for qualification of entering finals. The detailed rules of the evaluation will be released later.

4.3 Scoring System for the Finals

The overall score σ of a team for the first two stages is defined as follows

$$\sigma = \text{the score in Stage 1} \times 30\% + \text{the score in Stage 2} \times 70\%$$

The score of a team in the final is composed of: (1) the overall score of stages 1 and 2; (2) the objective score in the final; and (3) subjective score. The objective score in the final is made by the same rules as in Stage 2. The subjective score is decided by human judges who grade the map generated by each team automatically, using a percentage grading system.

The overall score of a team in the competition = $\sigma \times 40\%$ + the objective score in final×30% + the subjective score in final×30%

5. Explanations of the Rules

The rules are explained by the technical committee.