2022 IEEE CoG

RoboMaster Sim2Real Challenge

Challenge Rules

Version1.2

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Organizer： Institute of Automation, Chinese Academy of Sciences

Content

1. Background

More and more AI algorithms are outperforming human players in simulation game tasks. However, there are many limitations when applying of AI algorithms in real-world environments. 2022 COG RoboMaster Sim2Real Challenge will fully explore the possibilities of AI algorithms in physical robots.

2022 IEEE CoG RoboMaster Sim2Real challenge aims at improving robot exploration and confrontation capabilities through simulation. The competition evaluates the robot's ability to locate, navigate, and fight against robots in dynamic environment, as well as the algorithm migration ability from simulation environment to physical system. The RoboMaster EP robot moves in a fully automatic manner to find and identify the target blocks, and then fights against the defensive robot.

1.1 Competition task

In the competition task, the team robot needs to activate the 5 target blocks in a specified order. After activating all 5 target blocks, the team robot fights against a defensive robot. In 3 minutes, the team wins when the team robot activates 5 targets and defeats the defensive robot at the fastest and safest speed.

The competition will be divided into two stages: Simulation Stage and Sim2Real Stage. In the first stage, the team robot only needs to complete the above tasks in the simulation environment. We will select the team robot with higher scores to participate in the second stage. In the second stage, we deploy the algorithms of team robots to the physical robot and test them in the real environment. At this stage, the algorithms need to deal with the difference between the simulated robot actuator and the physical actuator, and the state difference caused by the different environment. The algorithms can be adjusted according to the feedback data and results.

Figure 1-1 RoboMaster EP Robot

1.2 Tracks

The competition contains two tracks according to the different inputs of the team robots, and the teams can choose either track to participate in the competition.

1) Track 1: Complete information-based track
   The team robot can obtain its speed, position in the map, image, LiDAR at the current time, and the target block positions. The participants develop algorithm to output the speed command and the shooting command for the team robot.
2) Track 2: Image based-track
   The team robot only obtains the image at the current time, and the target block positions. The participants develop algorithm to output the speed command and the shooting command for the team robot.

2. Challenge Field

2.1 Overview

The challenge field uses a rectangular area of size 8.08× 4.48 m. It includes static obstacles and dynamic obstacles, as shown in Figure 2-1. Static obstacles are placed at a fixed position in the challenge field, and they have different sizes and heights. Dynamic obstacles (30cmx30cmx40cm) are 5 target blocks and a defensive robot. The initial positions of target blocks and defensive robot are randomized. The team robot needs to avoid collisions with static and dynamic obstacles during the competition.

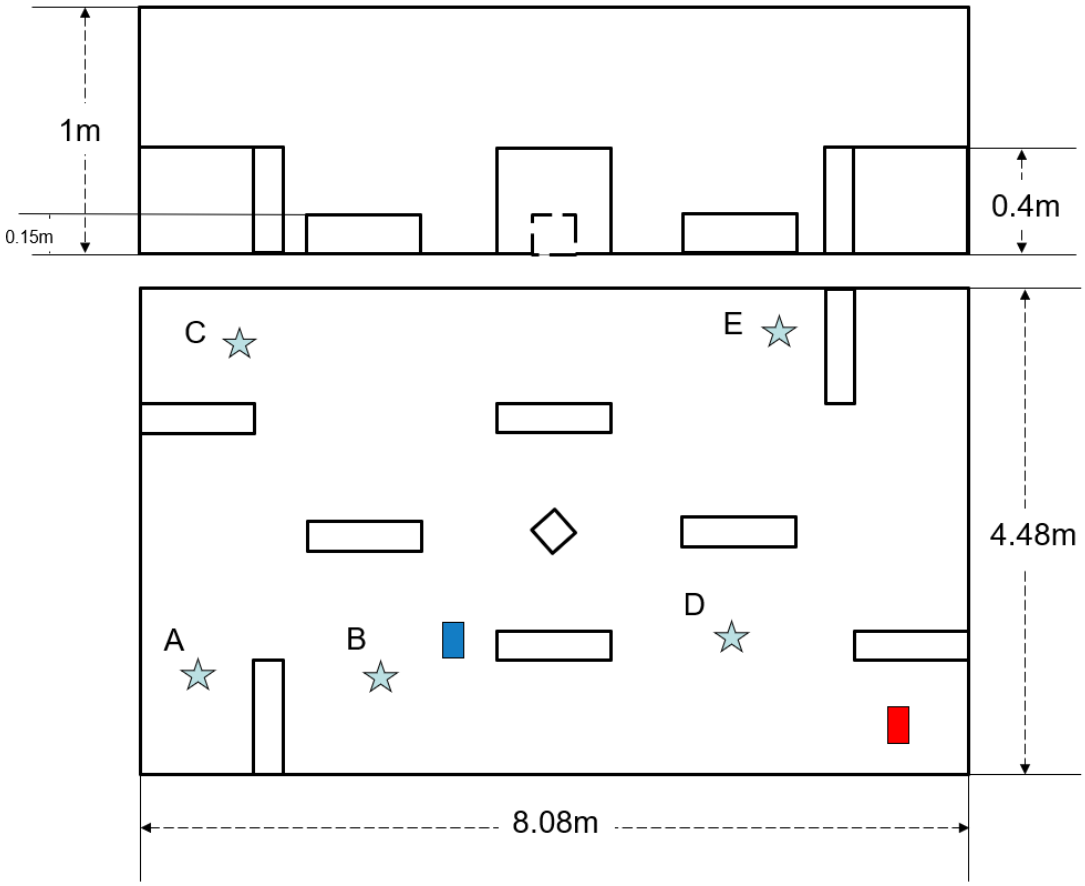

Figure 2-1 The dimensional drawings of the challenge field

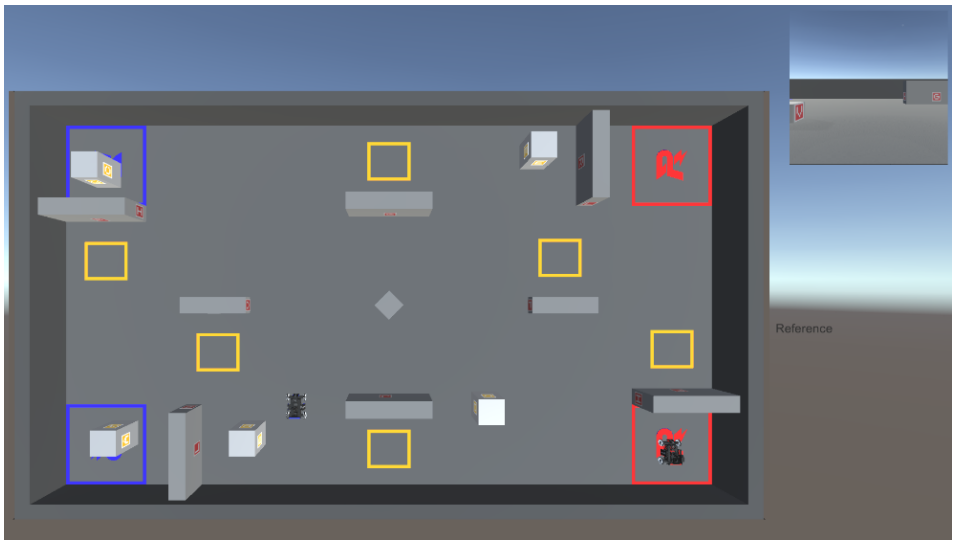

Figure 2-2 The diagram of the simulation scenario

2.2 Initial Position

Initial position of the team robots：

When the competition starts, the team robot is initially placed at a random location on the challenge field. The robot's position is known for Track 1 but unknown for Track 2.

Initial position of target block：

When the competition starts, the target blocks randomly appear at 5 positions in the challenge field, and the target block locations are sent to the team robots as known information. There are 5 target blocks to be activated in the challenge field, and each target block has a corresponding activation label attached to each face, as shown in Figure 2-3.

Initial position of Defensive robot:

When the competition starts, the position of the defensive robot appears randomly in the challenge field. During the phase of finding the 5 target blocks, the defensive robot is in a silent state and will not move or shoot. When all 5 target blocks are activated in sequence, the defensive robot is activated and starts to move and shoot the team robots. During the battle phase, the position of the defensive robot is known.

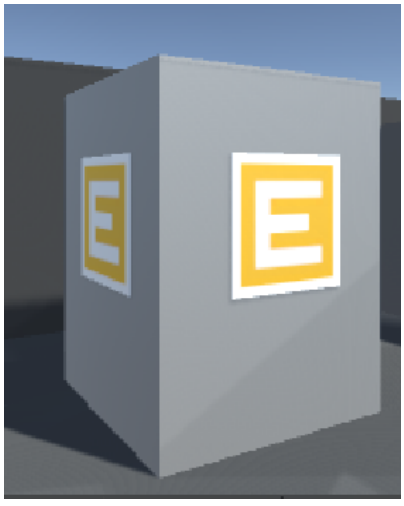

Figure 2-3 An example of the target block

3. Simulation Platform

3.1 Overview

The simulation platform for the competition is Unity 2020.3.12. Unity is one of the best 3D simulation platforms with high flexibility and rich interfaces. Organizing committee will provide an end-to-end executable task library and Unity Lab, for teams to use during the competition.

3.2 Data Interface

Organizing committee provides the environment and the baseline algorithm on GitHub. The environment interface will be encapsulated in the CogEnvDecoder library. Participants can install it in their own environment configuration. The dependencies required by the algorithm will be published in the requirement.yaml file, and the interface information of the environment will be given in the file api_test.py in GitHub. For more information, please visit the competition GitHub: https://github.com/DRL-CASIA/COG-sim2real-challenge.

The environment interface gives the precise position information of both robots, the noise-free LiDAR data, image data, and all the information collected during the competition. The participants can define the reward functions applicable to their algorithms based on the given data. However, during the test submission code, the position of the own robot used is added with a uniformly distributed deviation of 0.5m (the deviation is fixed for the same episode of the test, and the deviation is uniformly distributed between episodes) and a uniformly distributed noise of 0.1m (the noise is different between each step and is uniformly distributed). The LiDAR is added with 0.05m of measurement noise. Participants need to consider the generalization performance of the intelligence under this condition when training the algorithm.

4. Rules

One challenge round lasts 180 seconds. It starts after the team robot and the 5 target blocks are randomly initialized. The team robot begins to find the 5 target blocks and activate them in a fixed order (ABCDE). After the target block activation finishes, the defensive robot is activated and fights against the team robot. They shoot

projectiles with each other. When the projectile hits the armors of robot, the robot health point (HP) is reduced. Team robot needs to maintain its own HP to fight against the defensive robot as much as possible.

4.1 Target Block Activation Conditions

During the competition, the team robot needs to activate the target blocks in sequence, meeting all of the following conditions：

1. The distance between the team robot and the target block < 1m
2. No obstacle between the team robot and the target block
3. The angle between the orientation of the team robot and the line between the team robot and the target block < 30 degrees.
4. Activation in the order of ABCDE (for example, before activating the target block C, it needs to activate target block A and B in turn, otherwise the target block C cannot be activated)

4.2 Robots Battle Mechanism

At the start of a challenge round, the defensive robot appears as a static obstacle in the challenge field. After all 5 target blocks are activated, it enters the battle phase. The defensive robot is activated and begins to move and shoot the team robot.

At a challenge round, each robot initially has 800 HP. The shooting frequency of both robots is 1Hz. The number of projectiles is 24 and one projectile hit triggers 100 HP reduction. When more than 24 shooting commands are given, the shooting command will not be executed.

4.3 Score Calculation

After one challenge round, the team robot score is calculated by:

Score=$60\times N+0.5\times(D+H)-T-10K$，mainly considering the following parts：

1. Score for activating target blocks is $60\times N$，where the reward for activating a target block in order is 60, N is the number of successfully activated target blocks, and the maximum score is 300；
2. Score for the battle with defensive robot is $0.5\times(D+H)$，where the initial HP is 800, the damage to the defensive robot is D=800-the left HP of defensive robot, the left HP of team robot denotes H, and the maximum score is 800；

3. Total time spent in a challenge round is T (s). The team robot is expected to complete the task quickly. The longer it takes, the lower the score is. The maximum deduction is 180；
4. The penalty of collisions: $K = 2 \times T_k$, T_k is the continuous collision time (in seconds). The longer collision happens, the lower the score is, up to 3600 deductions。

For example：the team robot successfully activates 5 target blocks and defeats the defensive robot. It has 100HP left, and the continuous collision time is 5 seconds. The challenge round spends 150 seconds. Then the total score is 60×5+0.5×(800+100)-150-10×(2×5)=500。

5. Challenge Procedure

The competition consists of three stages: Simulation Stage, Sim2Real Stage, and the Leaderboard Stage.

5.1 Simulation Stage

In Simulation Stage from May 11 to June 10 2022, participants need to develop algorithms in the simulator Unity to complete the challenge task. Details are as follows：

1. Participants download the Unity environment via the GitHub given on the competition website and configure the development environment by referring to the official documentation；
2. Participants develop algorithms in Unity and submit the code to the competition website；
3. Based on the code test results on Unity, the organizing committee decides the teams to enter the Sim2Real Stage.

5.2 Sim2Real Stage

In the Sim2Real Stage from June 12 to July 30 2022, participants need to optimize the algorithm based on the feedback of code test results on the real scenarios. Details are as follows:

1. Participants submit the code to the competition website；

2. Organizing committee downloads codes and deploys them to the EP robot to perform challenge tasks；
3. The test data and video are sent back to the participants；
4. Participants optimize algorithm based on the feedback。

5.3 Leaderboard Stage

Organizing committee will announce the competition results in August 2022。

The final code submitted by each team will be deployed to the physical EP robot; the data and scores during the competition will be posted on the competition website.

6. Schedule

Tabel 6-1 Schedule

Kay date	Activity	Note
Apr 1, 2022- May 10, 2022	Registration	Publish challenge rules and related materials
May 11, 2022- Jun 10, 2022	Simulation Stage	
Jun 11, 2022	Submission code	Participants submit codes to the competition website
Jun 12, 2022 – Jul 30, 2022	Sim2Real Stage	Feedback the code test results on the real scenarios
Jul 31, 2022	Submission code	Participants submit codes to the competition website
Aug, 2022	Leaderboard Stage	Publish the competition results

7. Participation

Participants register on the competition website, and then form a team. The team requirements are as follows:

1. Each participant is allowed to join only one team；
2. Each team must have between 1-3 members；
3. The awards are only open to undergraduate and graduate students；
4. Each team can have 1-2 instructors；
5. The competition website :
   https://eval.ai/web/challenges/challenge-page/1513/overview。

8. Award

Table 8-1 Award

Award	Ranking	Num	Prize
Outstanding Prize	1st Place	1	500USD (Before Taxes)
1st Prize	2st Place	1	Mavic mini
2st Prize	3st Place	1	RoboMaster TT
3st Prize	4st Place	1	Osmo Mobile5