Simulated Humanoid Robot Wrestling Competition

ICRA 2023 Robot Competition

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***Abstract*— This proposal introduces a new simulation-based robot competition to be held at ICRA 2023. The competition focuses on the development of advanced humanoid robot control software for a wrestling game. It relies on a calibrated simulation model of the NAO robot, running in the Webots simulator with realistic physics and sensor simulation. Being spectacular and fairly easy to get started with, this competition aims at gathering a large number of on-site and remote competitors. Since it relies on a fully open-source software stack, this competition is also meant to be re-used as a template for other simulation-based robot competitions.**

I. Introduction

Robot competitions are an essential tool to foster the research and development of new robotics systems. They motivate researchers by proposing them to address specific research challenges. They allow to compare different approaches against each other, to measure research progress over time and to keep researchers focused on well defined and relevant problems.

Although robot competitions have significantly developed over the past few years, we believe they could play a more important role in the robotics research community if they could get the commitment of even more researchers.

This competition proposal aims at drawing a strong interest from the robotics research community by providing a competition for which it is easy to participate and which provides spectacular results subject to attract a wider audience.

Moreover, we plan to provide the competition infrastructure as an easy-to-reuse open-source software stack template. The goal is to allow others to quickly organize their own simulation-based robot competitions with different scenarios.

II. Background

Several humanoid robot competitions already exist, the most famous being probably the RoboCup[6, 12] for which Cyberbotics has been developing a Webots-based simulation environment that is currently used in the official virtual competitions since 2021, see Figure 1. This realistic simulation environment is replicating the real set-up and rules as closely as possible, including the same number of robots on the field, the simulation of the field sponginess, realistic camera images, motor backlash in every joint of the robots, etc. An automatic referee was developed to replace the human referee and allow the automatic run of games in a cloud computing infrastructure. Competitors could submit their own robot designs which needed to be reviewed and approved by a human jury before participating to the official games.

The RoboCup Junior[13] and Eurobot[3] competitions also provide Webots-based simulation counterparts[4, 14] of their real set-ups.

The ROBO-ONE[11] competition takes place every year since 2002. It includes a ROBO-ONE auto category where two autonomous robots fight against each other in various wrestling games. This competition is pretty similar to what is proposed here, except that it involves real robots instead of simulations.

Cyberbotics has a long track record of organizing various robot competitions. The very first competition was organized during the 5th European Conference on Artificial Life (ECAL) which has held in Lausanne, Switzerland on September 13-17, 1999. During this competition, participants could develop robot controllers in simulation and transfer the results on real Khepera robots. This competition evolved during several years to become the Rat's Life competition[9]

Fig. 1. RoboCup Virtual Humanoid League (Webots screenshot).

Rank	Country	Flag	Rat's name	Author	Ready	Last update	Progress	Movies
			Ratatouille	Manuel	✔	Jun-05-2008 23:50	-	
2			golum	Laurent	✔	Jun-03-2008 13:25	+2	
3			Krysicka	Martin Pilat	✔	May-06-2008 12:26	-1	
4			AMT	Ares Macrotechnology	✔	May-24-2008 20:08	-1	
5			Bins.GPR	Ricardo Luis Binsfeld	✔	Apr-17-2008	-	

Fig. 2. Top 5 of Rat's Life leader board (out of 50+).

in 2008 where Khepera robots were replaced with e-puck robots. Figure 2 shows the top 5 of the leader board for the Rat's life competition which was gathering more than 50 teams. Starting from 2003, Cyberbotics organized the Roboka competition[2, 7] which relied on simulation only. The scenario of this competition involved two humanoid robots in a judo-like game. In 2008, Cyberbotics organized the RobotStadium competition[8] where teams of NAO humanoid robots were playing soccer, following the rules of the RoboCup Standard Platform League (SPL). In 2017, Cyberbotics published the robotbenchmark[15] web-service which proposes a dozen of simulation-based robotics challenges where competitors have to program in Python the behavior of various robots to perform specific tasks, ranging from wheeled robot wall following to humanoid robot race. This web-service includes 3D simulation playback on the web, as well as an interface to cloud-based simulation servers. From 2018 to 2021, Cyberbotics helped the Korean Advanced Institute of Technology (KAIST) to organize the AI World Cup [1] using Webots.

In 2022, Cyberbotics has developed a new cloud-based web-service named webots.cloud[16] where users can share 3D simulation models, simulation playbacks as well as live simulations. This new web-service is currently being extended to host user-contributed simulation-based robot competitions.

The proposed competition will rely on the latest technologies developed by Cyberbotics and will be supervised by Olivier Michel, founder and CEO of Cyberbotics with the support of the Webots development team at Cyberbotics.

III. Rationale

Participating in a robot competition is an important investment for a researcher. Some competitions require that each participant designs a complex robot system from scratch, purchases some expensive hardware, spends a lot of time setting-up complex software systems and travels worldwide to attend the competition event physically. As a consequence, robot competitions often gather a limited number of competitors, which badly impacts their relevance and outcomes.

The proposed competition aims at tackling these problems in order to attract a large number of competitors. We aim at gathering more than 100 competing teams of out which 32 will be qualified to participate to the finals. The proposed competition includes essential features to achieve this goal:

- **Free**: The competition is based exclusively on free and open-source software. There is no registration fees, no requirement to attend physically an event.
- **Simple**: The registration procedure, software set-up, examples and documentation are designed to make the user experience extremely straightforward.
- **Quick**: The robotics challenge addressed is well balanced between scientific interest and quickly achievable results.
- **Open**: Competitors are free to use whatever programming language (Python, C, C++, Java, etc.), libraries and/or framework (ROS 1, ROS 2, YARP, OROCOS, Webots API, etc.). The only requirement is that their control program should run inside a Docker image executed on a Linux host.
- **Rewarding**: In addition to a cash prize for the winners, competitors will be proud to showcase their simulation results online and to be ranked in a leader board of 100+ competitors.
- **Popular**: Because of the nature of the competition, watching the game will be entertaining for a wider audience, thus bringing a lot of public attention to the scientific contributions of the competitors.

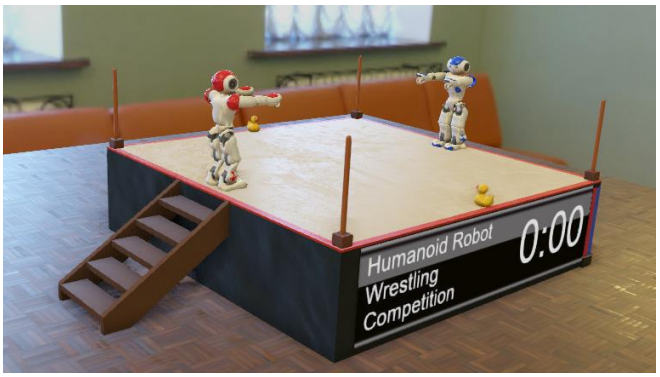

Fig. 3. Humanoid Robot Wresting Competition (Webots screenshot).

We believe that the humanoid wrestling scenario is a good compromise between scientific interest and development effort. Programming a single humanoid robot is easier than programming a full team of humanoid robots with different roles, communicating with each other, like in RoboCup soccer games. Nevertheless, it addresses a number of robotics research challenges that cannot be addressed on simpler robots, like differential wheels robots. Also, to help users getting started with their control program, we will provide several source code examples demonstrating how to control a humanoid robot.

IV. Scenario

The scenario of the competition is inspired from human wrestling games. However in this game, humans are replaced with autonomous humanoid robots that are programmed by competitors. During the game, each robot should try to tackle the other one in order to knock it to the ground or outside of the ring. Figure 3 shows a screenshot from Webots of the competition scenario. A 3D animation recorded from a preliminary simulation run is available online[10].

Like in professional wrestling, all shots are allowed. For example a robot may pick one of the two yellow ducks visible on Figure 3 and throw it at the other robot or use one of the sticks located in the corners of the ring to hit or push the other robot.

The robot models are NAO robots[5] and cannot be changed by the users. The robot controllers can access all the on-board simulated sensors and actuators as depicted on Figure 4, including:

- 25 motors and associated position sensors.

- 2 cameras.
- 2 sonars (distance measurement).
- 1 accelerometer.
- 1 gyro.
- 4 bumpers (touch sensors) in the feet.
- 2 force sensors (FSR) in the feet.
- 7 LEDs.

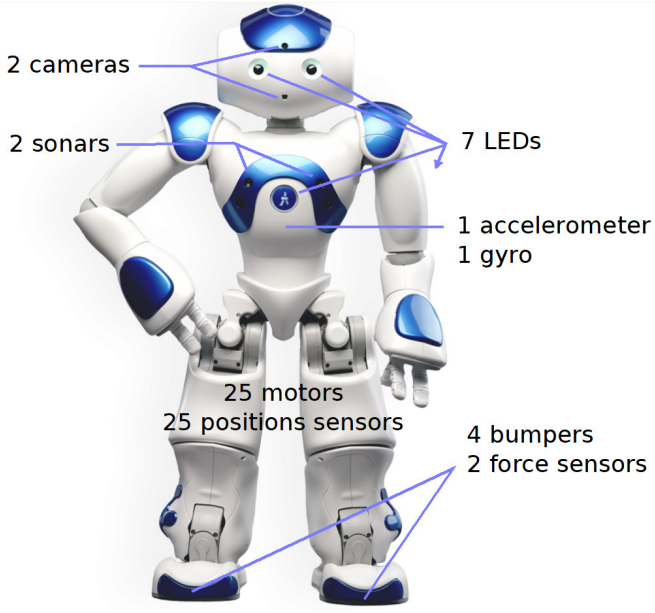

Fig. 4. NAO robot with available simulated devices.

V. Draft Rules

A game lasts until one of these two conditions occurs:

- **Knock-out**: If the altitude (along Z axis) of the center of mass of one robot remains below a given threshold for more than 10 seconds, then the other robot is declared the winner and the game is immediately over. This may happen if a robot falls down and cannot recover quickly or if it falls off the ring.
- **Time-out**: If no knock-out happened after 5 minutes, the robot having the greater ring *coverage* is declared the winner and the game is over. In the unlikely case of *coverage* equality, the winner is determined randomly.

The *coverage* reflects how far a robot has moved inside the ring. It is computed over the time frame of a game from its maximum and minimum positions along the X and Y-axes, respectively X_{max}, X_{min}, Y_{max} and Y_{min}, using the following formula:

$$coverage = X_{max} + Y_{max} - X_{min} - Y_{min}$$

VI. Workflow

A. Registration

Entering the competition is simply a matter of forking a GitHub template repository, modifying its content and registering this fork on the competition website. The GitHub repository of the competitor can be private to avoid disclosing its contents to other competitors. However, competitors should add the competition organizer as a collaborator to their private GitHub repository so that the competition script can check-out the repository content to run the games.

B. Development

The development workflow is depicted on Figure 5. In order to modify the sample code from the template GitHub repository, competitors should check it out on their local machine, and install Webots. The template repository contains a sample opponent against which new developments can be tested. The Docker file of the template repository can be changed to include useful dependencies such as specific python modules, libraries, ROS 2, etc. Once the competitors are satisfied with their new version of robot controller, they can commit it to the main branch of their repository.

C. Evaluation

The evaluation script checks out the controller code from the main branch of every competitor repository and runs games. The outcome of these games is automatically published online, including 3D animations of the games and the updated ranking of the leader board.

The evaluation takes place in security sandboxes. Each robot controller runs in its own Docker virtual machine to be isolated from the other and from the simulator. Only one communication channel between robot controllers and the simulator is open. This allows the controllers to receive sensor data and send actuator commands. These security sandboxes prevent the controller code to cheat by affecting the behavior of the other competitor or the behavior of the simulator. It also prevents the controller code to compromise the security of the host machine.

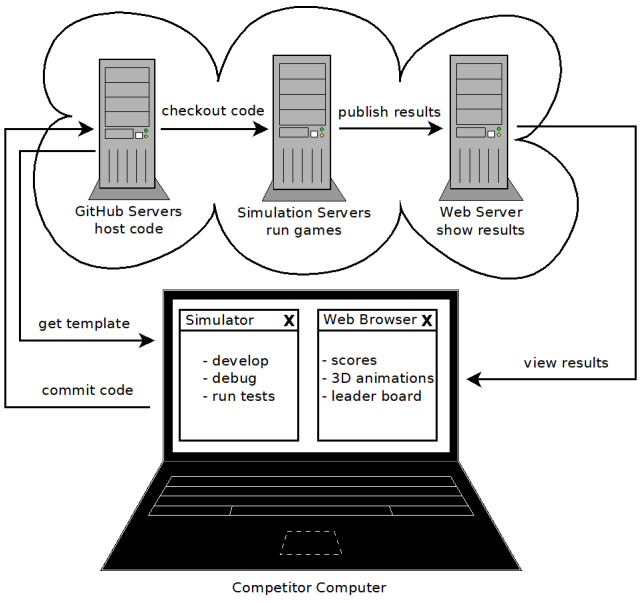

Fig. 5. Competitor Development Workflow

VII. Schedule

A. Qualification

The competition will be open for registration from December 1st, 2022 until May 22nd, 2023. During this period of time, competitors may submit as many new versions of their controller as they want. Every 24 hours, an evaluation round will run automatically in the cloud and the results, including 3D animations and updated leader board, will be published online immediately.

The ranking update procedure is inspired from the bubble sort algorithm: New competitors are introduced at the bottom of the leader board, e.g., at last position, when they register. Let N be the total number of competitors ranked in the leader board. During an evaluation round, $N-1$ games are played. The competitor ranked at position N plays a game against the competitor ranked at position $N-1$. If the former wins, the two competitors swap their positions, otherwise the ranking remains unchanged. The new holder of position $N-1$ then plays against the holder of position $N-2$. Again if the former wins, they swap their position. This is repeated at position $N-2$, $N-3$, $N-4$, etc. until position 1. This algorithm allows a new comer to reach the first position in a single evaluation round, e.g., like an air bubble rising from the bottom of a glass of water up to the surface. Also, a competitor can loose only one position during a single evaluation round.

At the end of the qualification period of time, the 32 best ranked competitors will be selected to participate the finals.

B. Finals

The finals will be held physically at the ICRA 2023 conference in London from May 29th to June 2nd. The competitors may attend physically or remotely. The games will be played in real time on a simulation server and displayed with a video projector on a large screen. The tournament will be held according to the scheme depicted in Figure 6:

- May 29th: 1/16 finals (32 teams, 16 games)
- May 30th: 1/8 finals (16 teams, 8 games)
- May 31st: quarterfinals (8 teams, 4 games)
- June 1st: semifinals (4 teams, 2 games)
- June 2nd: third place game and final (4 teams, 2 games)

C. Ranking

The leader board will be updated accordingly: the winner of the final will be set at position 1 while the loser will be set at position 2, the winner of the third place game will be set at position 3 while the loser will be set at position 4. The losers of the quarterfinals will be set at positions 5 to 8, respecting the same relative ranking order they had before the finals. The losers of the 1/8 finals will be set at positions 9 to 16, respecting the same relative ranking order they had before the finals. Finally, the losers of the 1/16 finals will be set at positions 17 to 32, respecting the same relative ranking order they had before the finals. The position of competitors ranked below the 32nd rank will remain unchanged.

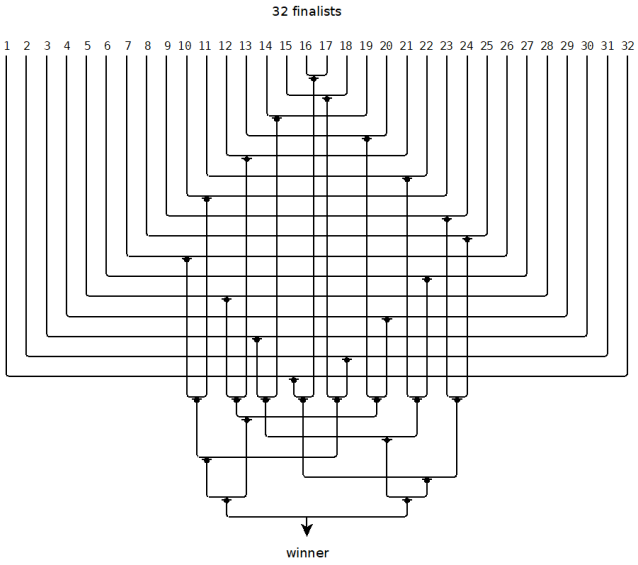

Fig. 6. Finals Schedule

VIII. Prize

The winner of the final will receive a crypto-currency cash prize of 1 Ethereum (about US$ 1320, as of September 26th, 2022) sponsored by Cyberbotics during the closing ceremony, immediately following the final game. More prizes (cash and items) may be available depending on the outcome of the sponsorship campaign currently conducted by Cyberbotics for this competition.

IX. Infrastructure

The games should take place in a large conference room to welcome both competitor teams and spectators. It should be equipped with a video projector, a large screen and a decent Internet connection. Cyberbotics will provide a powerful simulation server for running the competition games. The competitors should develop their controller programs on their own machines and upload their code on their GitHub repository registered for the competition.

X. Conclusion

We plan to organize this competition on the long run on the Internet. The competition will basically never stop and competitors could enter it any time. Prizes will be given to the leaders of the competition on a regular basis, based on finals organized during robotics events, such as ICRA. Our goal is to establish this competition as a standard and help others to create their own competition with different scenarios based on this open-source template.

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