

Junior Humanoid Soccer

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Preface

In the RoboCupJunior Humanoid soccer league, a team of two autonomous humanoid robots competes against another team in matches. They must look for a ball, trying to score into a color-coded goal in a special field built in a way that resembles the actual field for human soccer. Robots are required to have full autonomy from humans and technical design, and ingenious programming by their developers.

Participants of this challenge are required to give the best of their abilities in programming, robotics, electronics and mechatronics, but also to contribute on teamwork and knowledge sharing with other participants, regardless of culture, age or result in the competition

Design Construction and Programming have to be performed exclusively by the students

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Robots must be designed, constructed and programmed exclusively by student members of the team. Mentors, teachers, parents or companies should not be involved in the design, construction, assembly, programming and debugging of robots.

1. GAME PLAY

1.1 Game procedure and length of a game

The RCJ Humanoid Soccer games consists of two teams of robots playing soccer against each other. Each team has two autonomous robots. The match lasts two equal periods of 10 minutes. Players are entitled to an interval at half-time. The half-time interval must not exceed 5 minutes.

The game clock will run for the duration of the halves without stopping (except in the event when a referee wants to consult an official). The game clock will be run by a referee or a referee assistant.

Teams are supposed to be at their field table 5 minutes before their game starts. To be at the inspection table does not count in favor of this time limit. Teams can be penalized one goal per each elapsed 30 seconds at the referee's discretion if they are late for the game start. In any situation, when the goal difference reaches 10, the game finishes regardless of the state of the game clock.

Timeouts

A team may extend a stoppage of the game by taking a timeout. During a timeout robots may be serviced. Each team may take at most one timeout per period. If a team is not ready to resume the game when the referee wants to start the game, it has to take a timeout. If there is no timeout left, the referee will start the game anyway. A timeout ends automatically after 2 min. A timeout also ends when the team signals its end to the referee.

1.2 Pre-match meeting

Access to the field is given to both teams at least 15 minutes prior to the scheduled kick-off time. A coin is tossed and the team which wins the toss decides which goal it will attack in the first half of the match. The other team takes the kick-off to start the match. The team which wins the toss takes the kick-off to start the second half of the

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match. In the second half of the match the teams change ends and attack the opposite goals.

If both teams cannot agree on the color of their team markers, a coin is tossed and the markers are exchanged at halftime.

1.3 Kick-off

Each half of the game begins with a kick-off. All robots must be located on their own side of the field. All robots must be halted. The ball is positioned by a referee in the center of the field.

The team kicking off places their robots on the field first. Robots cannot be placed nor remain behind the goal line or in the outer area. Robots cannot be repositioned once they have been placed.

The team not kicking off will now place their robots on the defensive end of the field. All robots on the team not kicking off must be at least 30 cm away from the ball. (That means outside the center circle.)

Robots cannot be placed nor remain behind the goal line or in the outer area. Robots cannot be repositioned once they have been placed, except if the referee requests to adjust their placement to make sure that the robots are placed properly within the field positions.

On the referee's command (usually by whistle), all robots will be started immediately by each captain. Any robots that are started early will be removed by the referee from the field and treated as a damaged robot.

1.4 Human interference

Except for the kick-off, human interference from the teams (*e.g. touching the robots*) during the game is not allowed unless explicitly permitted by a referee. Violating team/team member(s) can be disqualified from the game.

The referee or a referee assistant can help robots to get unstuck, but only if the ball is not being disputed near them, and also if that situation was created from the interaction between robots (*i.e. it was not a design or programming flaw of the robot alone*). The

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referee or a referee assistant will pull back the robots just enough for them to be able to move freely again. Robots being able to autonomously reposition themselves can take any position on the field that is consistent with above requirements. Robots not able to autonomously reposition themselves, e.g. robots being carried around by human team members, have to start from a position not closer to the field halfway line than the outer line of the goal area. If all robots of the team executing the kick-off cannot autonomously reposition themselves, then one robot may be placed into the center circle.

1.5 Ball movement

1.5.1 A robot cannot hold a ball. Holding a ball means taking full control of the ball by removing all of its degrees of freedom. Examples of ball holding include fixing a ball to the robot's body, surrounding a ball using the robot's body to prevent access by others, encircling the ball, or somehow trapping the ball with any part of the robot's body. Opposing robots must be able to access the ball.

1.5.2 A dropped ball is a way of restarting the match after a temporary stoppage which becomes necessary, while the ball is in play, for any reason not mentioned elsewhere in the rules. In particular, the referee may call a game-stuck situation if there is no progress of the game for 1 min.

1.5.3 The game is continued at the center mark. A goal can be scored directly from a dropped ball. The procedure for dropped ball is the same as for kick-off, except that the robots of both teams must be outside the center circle. The ball is in play immediately after the referee gives the signal.

1.5.4 If a player moves too close to the ball before the referee gives the signal, a kick-off is awarded to the opponent team.

1.5.5 The ball is out of play when it has wholly crossed the goal line or touch line whether on the ground or in the air or when play has been stopped by the referee.

1.5.6 The ball is in play at all other times, including when it rebounds from a goalpost, crossbar, human, or robot and remains in the field of play.

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1.6 Incapable Players

1.6.1 Players not capable of play (e.g. players not able to walk on two legs, players not able to stand, or players with obvious malfunctions) are not permitted to participate in the game. They must be removed from the field. It is up to the referee to judge whether a player is capable of play.

1.6.2 The referee may ask the team leader of a player suspected to be incapable of play to demonstrate playing ability at any time.

1.6.3 A field player that is not able to get back into a stable standing or walking posture from a fall within 20 seconds will be removed from the field for 30 seconds removal penalty and has to re-enter the field.

1.7 Scoring

A goal is scored when the ball strikes or wholly crossed the goal line. Goals scored by either an attacking or a defending robot have the same end result: they give one goal to the team on the opposite side. After a goal, the game will be restarted with a kick-off from the team who received the goal against. Before a kick-off, all damaged robots are allowed to return to the playing field immediately if they are ready and fully functional.

1.8 Goalie

1.8.1 The robot moving first into the penalty area on a team's defending side completely (with every part of it) is designated as goalie until a part of it leaves the penalty area.

1.8.2 The goalie must stand up after jump or after lie down within 10 seconds

1.9 Damaged robots

If a robot is damaged, it has to be taken off the field and must be fixed before it can play again. Even if repaired, the robot must remain off the field for at least one minute or until the next kickoff is due. If all robots have moved out of bounds, the penalties are discarded and the match resumes with a neutral kickoff.

A robot is damaged especially when:

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- it does not respond to the ball, or is not able to move (it lost pieces, power, etc.),
- it continually moves into the goal or out of the playing field

Computers and repair equipment are not permitted in the playing area during game play. Usually, a team member will need to take the damaged robot to an “approved repair table” near the playing area, located inside the competitors’ working area. A referee may permit robot sensor calibration, computers and other tools in the playing area, only for the 5 minutes before the start of each half.

After a robot has been fixed, it will be placed on the unoccupied neutral spot nearest to where it has been taken off, and not directly aiming towards the ball. A robot can only be returned to the field if the damage has been repaired. If the referee notices that the robot was returned to the field with the same original problem, s/he could ask the robot to be removed, and proceed with the game as if the robot had not been returned.

Only the referee decides whether a robot is damaged. A robot can be taken off or returned only with the referee’s permission.

2. The Number of Players

A match is played by two teams, each consisting of not more than two players, one of whom must be designated as goalkeeper. A match may not start if either team consists of less than one player.

2.1 Incapable Players

2.1.1 Players not capable of play (e.g. players not able to walk on two legs, players not able to stand, or players with obvious malfunctions) are not permitted to participate in the game. They must be removed from the field. It is up to the referee to judge whether a player is capable of play.

2.1.2 The referee may ask the team leader of a player suspected to be incapable of play to demonstrate playing ability at any time.

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2.1.3 A field player that is not able to get back into a stable standing or walking posture from a fall within 20 seconds will be removed from the field for 30 seconds removal penalty and has to re-enter the field. Players not capable of play (e.g. players not able to walk on two legs, players not able to stand, or players with obvious malfunctions) are not permitted to participate in the game. They must be removed from the field. It is up to the referee to judge whether a player is capable of play. The referee may ask the team leader of a player suspected to be incapable of play to demonstrate playing ability at any time. A field player that is not able to get back into a stable standing or walking posture from a fall within 30 seconds will be removed from the field for 30 seconds removal penalty and has to re-enter the field.

2.2 Substitutions

Up to two players per game can be substituted by other players of the same team. The referee must be informed prior to the substitution. A substitute only enters the field after the player being replaced left the field and after receiving a signal from the referee. Any of the other players may change places with the goalkeeper, provided that the referee is informed before the change is made and that the change is made during a stoppage of the match. Exchanging a field player with a goalie does not count as substitution.

3. TEAM

3.1 Regulations

A team must have more than one member to form a RoboCupJunior team to participate in the International event. A team member(s) and/or robot(s) cannot be shared between teams. Each team member needs to carry a technical role.

Each team must have a **captain**. The captain is the person responsible for communication with referees. The team can replace its captain during the competition. A team is allowed to have only the fewest possible members beside the field during game play: they will usually be the captain and an assistant team member.

3.2 Violations

Teams that do not abide by the rules are not allowed to participate.

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Any person close to the playing field is not allowed to wear any orange, yellow or blue clothes that can be seen by the robots (to avoid interference). A referee can require a team member to change clothes or to be replaced by another team member if interference is suspected.

The referee can interrupt a game in progress if any kind of interference from spectators is suspected (*e.g., clothing colors, camera flashes, mobile phones, radios, computers*).

This needs to be proved to an OC member if a claim is placed by the other team. A team claiming that their robot is affected by colors has to show the proof/evidence of the interference.

4. The Design of the Robots

For the construction of a robot, any robot kit or building block may be used as long as the design and construction are primarily and substantially the original work of a team. This means that commercial kits may be used but must be substantially modified by the team. It is allowed neither to mainly follow a construction manual nor to just change unimportant parts. Indications for violations are the use of commercial kits that can basically be assembled only in one way or the fact that robots from different team(s), built from the same commercial kit, all basically look or function the same.

Robots must be programmed exclusively by student members of the team. Mentors, teachers, parents or companies should not be involved in the programming and debugging of robots.

For the programming of the robots, any programming language, interface or integrated development environment (IDE) may be used. The use of programs that come together with a commercial kit (especially sample programs or presets) or substantial parts of such programs are not allowed. It is not allowed to use sample programs, not even if they are modified.

Robots must be constructed in a way that they can be started by the captain without the help of another person.

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Robots participating in the RCJ Humanoid Soccer League contests must have a human-like body plan. They must consist of two legs, two arms, and one head, which are attached to a trunk. The robots must be able to stand upright on their feet and to walk on their legs. The only allowed modes of locomotion are bipedal walking and running. All actions of the robots must be kinematically equivalent to humanoid motions.

4.1 Robot Height and Width

H_{top} is defined as the height of the robot when standing upright (with fully extended knees, body and head)

$$30 \text{ cm} < H_{\text{top}} < 50 \text{ cm}.$$

W_{top} is defined as the width of the robot when standing upright (with fully extended hands)

$$W_{\text{top}} < 50 \text{ cm}.$$

4.2 Robot Weight

- The maximum weight for robots allowed to play is 5 kg.
- The minimum weight for robots allowed to play is 1.5 kg.

4.3 Sensors

Teams participating in the RCJ Humanoid League competitions are encouraged to equip their robots with sensors that have an equivalent in human senses. These sensors must be placed at a position roughly equivalent to the location of the human's biological sensors.

1. Sensors, such as cameras and up to two microphones, may not be placed in the legs or arms or the torso of the robots. They must be placed in the robot's head and above any neck joint.
2. The field of view of the robots is limited at any time to 180 degrees. This means that the maximum angle between any two points in the overlap of the field of view of all cameras mounted on the robot must be less than 180 degrees. The pan-tilt motion of the

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head and the cameras mounted on the robot's head is restricted to be more human like not only with respect to the field of view but also to the range of motion of the neck joints. The mechanism to pan the camera is limited to 180 degree pan which means ± 90 degrees from the position looking straight ahead. The mechanism to tilt the camera is limited to ± 45 degrees (measured from the horizontal line).

3. The number of cameras is limited to a stereo vision setup (i.e., max. 2 cameras with a large overlap) only. Monocular vision is also allowed.
4. Touch sensors, force sensors, and temperature sensors may be placed at any position on the robot.
5. Sensors inside the robot may measure all quantities of interest, including (but not limited to) voltages, currents, forces, movements, accelerations, magnetic field and rotational speeds. They can be at any position inside the robot.

4.4 Communication and Control

4.4.1. Robots participating in the Humanoid League competitions must act autonomously while a competition is running. No external power supply, teleoperation, remote control, or remote brain of any kind is allowed.

4.4.2. Robots are not allowed to use any kind of communication during game play unless the communication between two robots is via Bluetooth class 2 or class 3 (range shorter than 20 meters) or via any other device that communicates using 802.15.4 protocol (e.g., *ZigBee* and *XBee*). Teams are responsible for their communication. The availability of frequencies cannot be guaranteed.

All other wireless hardware must be deactivated. A team may be disqualified if one of the team members violates this rule.

4.4.3. No humans are allowed on the field while the ball is in play. Robot handlers must receive permission from the referee prior to entering the field. The robot handler of a team may not touch a robot of another team in order to avoid any damage to that robot.

4.5 Colors and Markers

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4.5.1. Robots participating in the Humanoid League competitions must be mostly black or of dark grey and non-reflective color. Robots may also be colored in aluminium-like silver, grey or white. Any color used for the field (green, yellow and blue) or the ball (orange) or similar colors must be avoided.

4.5.2. The robots must be marked with team markers. These markers are colored Cyan RGB (0,255,255) for one team and Magenta RGB (255,0,255) for the other team. Robot arms must be covered by team markers. From each side of the robot, at least one team marker must be visible on an arm. The marker must be at least 5cm in height and as wide as the arm of the robot as seen from that side.

4.5.3. The goal keeper robot must be marked uniquely that it can be easily distinguished from the other robots of a team by the referees.

4.6 Robustness

Robots participating in the RCJ Humanoid League competitions must be constructed in a robust way. They must maintain structural integrity during contact with the field, the ball, or other players. Their sensing systems must be able to tolerate significant levels of noise and disturbance caused by other players, the referees, robot handlers, and the audience.

4.7 Handling

Robots are encouraged to feature a handle attached in the neck area for vertical lifting. They should tolerate this without causing harm to themselves or the person holding the handle.

4.8 Temporal Absence

Servicing robots on the playing field is not permitted. A robot may be taken out of the field for service, after receiving permission from the referee. Taking out a robot for service does not count as a substitution. A serviced robot may not come into play again before 30 s elapsed after it was taken out.

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4.9 Safety

4.9.1. Robots participating in the RCJ Humanoid League competitions must not pose any danger to humans, other robots, or the field of play. This specifically includes constructions that are objectively able to cause said dangers, for example poles sticking out of the robot. Anyone is allowed to take every action necessary to prevent urgent harm.

4.9.2. The robots must be constructed in a way that offenses are avoided. Robots violating the safety requirements will be excluded by the referee from the ongoing game. They may be excluded by the league organization committee from the remainder of the tournament.

5. Fouls and Misconduct

5.1 Ball Manipulation

Manipulation of the ball by robot players is guided by the following principles:

5. 1.1 Players may exert force onto the ball only by direct physical contact with one of their body parts, excluding their hands, arms, and shoulders (with the exception of the goalkeeper within his own goal area).

1. The ball may be kicked with the whole foot. Kicking devices which differ from the human body are not allowed.

1. Contact with the ball must be instantaneous. Actively touching the ball for more than 1 s is considered ball holding. Inside the goal area, the goalkeeper may hold the ball for not more than 10 s on the ground or not more than 15s lifted up with one or both hands. Physical contact may be exerted repeatedly by the same player, if the ball is free to move between contacts for the majority of the time.

1. It will also be considered ball holding, if the ball cannot be removed from a robot by other players for more than 1s. More than half of the ball's volume must be outside the convex hull of the robot, projected to the ground, for the ball to be considered removable. If the ball enters the convex hull repeatedly, it must be removable in between for the majority of the time. If more than one robot of a team is

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in the vicinity of the ball, the convex hull is taken around all the robots of a team, which prevent removal of the ball.

5.2 Physical Contact

Contact between robot players is guided by the following principles:

1. Physical contact between players of different teams must be minimized.
2. If physical contact is unavoidable, the faster moving robot must make efforts to minimize the impact.
3. The goal keeper enjoys special protection inside its goal area. The attacking player always has to avoid to obstruct the goalie in any way. Any contact between the goalie and an attacking player inside the goal area is considered an obstruction. During walking or standing the goalkeeper is not allowed to stretch out its arms to the side, front or back to maximize the area around it which cannot be entered by a player by making improper use of this rule.
4. Extended physical contact must be avoided. Both robots must make efforts to terminate contact, if the contact time exceeds 3 s.

5.3 Attack and Defense

5.3.1. Not more than one robot of each team is allowed to be inside the goal or the goal area at any time. If more than one robot of the defending team is inside its goal or goal area for more than 10 s, this will be considered illegal defense. If more than one robot of the attacking team is inside the opponent's goal or goal area for more than 10 s, this will be considered illegal attack.

5.3.2. The referee may delay the call of illegal defense or illegal attack if the robots make serious attempts to leave the goal area or if they are hindered from leaving the goal area by robots of the opponent team. The referee allows play to continue when the team against which an illegal defense or illegal attack has been committed will benefit from such an advantage and penalizes the original offence if the anticipated advantages does not ensue at that time.

5.3.3. The player committing an illegal defense or an illegal attack will be removed from the field for 1 min. removal penalty.

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6. FIELD

6.1 Kind of field

There is only one kind of field for all sub-leagues.

6.2 Dimensions of the field

The playing-field is 122 cm by 183 cm. The field is marked by a white line, which is part of the playing-field. Around the playing-field, beyond the white line, is an outer area of 30 cm width. The floor near the exterior wall includes a wedge, which is an incline with a 10 cm base and 2 cm rise for allowing the ball to roll back into play when it leaves the playing field. Total dimensions of the field, including the outer area, are 182 cm by 243 cm. It is recommended that the field be positioned 70 to 90 cm off the ground.

6.3 Walls

Walls are placed all around the field, including behind the goals and the out-area. The height of the walls is 22 cm. The walls are painted matte black.

6.4 Goals

The field has two goals, centered on each of the shorter sides of the playing field. The goal inner space is 60 cm width, 50 cm high and 20 cm deep, and box shaped. Nets are attached to the goals and the ground behind the goal, provided that they are properly supported and do not interfere with the goalkeeper. The mesh size for this net is suggested to be less than 4 cm in order to keep the risk of entanglement low. The upper side of the goal should not be covered by a net in order to allow for easy access to the robots from above.

The goal “posts” are positioned over the white line marking the limits of the field. The cross-bar is exactly over the white line. The interior walls, nets and the cross-bar of each goal are painted, one goal yellow, the other goal blue.

6.5 Floor

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The floor consists of dark green carpet on top of a hard level surface. The carpet should be of a quality that will resist the wear and tear of spinning wheels. All straight lines on the field should be painted and have a width of 20 mm.

6.6 Center circle

A center circle will be drawn on the field. It is 60 cm in diameter. It is a thin black marker line. It is there for referees and captains as guidance during kick-off.

6.7 Penalty areas

In front of each goal there is a 30 cm wide and 90 cm long penalty area.

The penalty areas are marked by a black line of 20 mm width. The line is part of the area.

A robot is considered inside the penalty area when it is completely inside.

6.8 Lighting and Magnetic Conditions

The fields should be placed in a way that the influence by external infrared light is as low as possible and that the magnetic field of the earth is disturbed as little as possible. Perfect conditions cannot be guaranteed, however. Teams must come to tournaments being prepared to calibrate their robots based on the lighting and magnetic conditions at the venue.

7. BALL

Balls for the tournament must be made available by the organizers. Organizers are not responsible for providing balls for practice.

7.1 Specification

The Technical Committee has been able to identify two balls that meet the technical specifications outlined below and are available worldwide. None of these balls have been marked official. That means it is not guaranteed that one of these balls will be used at the international event. However, the official ball will not be much different. These balls are:

A matte, hollow, orange ball, which can be obtained from:

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- <http://schweikert-shop.he-hosting.de/index.php?cat=2259&lang=ENG&product=93011>

The Mylec ball that was previously used in the Major category

- <https://www.amazon.com/Mylec-Weather-Bounce-Hockey-Orange/dp/B002LBDA30>

7.2 Diameter

The diameter of the ball is required to be 65mm +- 5mm. A well-balanced ball shall be used.

7.3 Drop Test

The ball must be able to resist normal game play. As an indication of its durability, it should be able to survive, undamaged, a free-fall from 1.5 meters onto a hardwood table or floor.

7.4 Coloration

The ball shall be of orange color. Since the definition of the orange color in general is not easy, any color that a human would deem to be orange and is substantially different from the other colors used on the field is acceptable. There should be no distractive markings on the ball.

7.5 Surface

The surface of the ball shall be smooth and matte. Engravings on the ball's surface are tolerated. The ball should not reflect light. The inside of the ball should be hollow.

7.6 Weight

The ball should be no heavier than 80 grams and no lighter than 60 grams.

8. CODE OF CONDUCT

8.1 Fair Play

It is expected that the aim of all teams is to play a fair and clean game of robot soccer. It is expected that all robots will be built with consideration to other participants.

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Robots are not allowed to cause deliberate interference with or damage to other robots during normal game play. Robots are not allowed to cause damage to the field or to the ball during normal game play.

Humans are not allowed to cause deliberate interference with robots or damage to the field or the ball.

8.2 Behavior

All participants are expected to behave themselves. All movement and behavior is to be of a subdued nature within the tournament venue.

8.3 Help

Mentors (teachers, parents, chaperones, and other adult team-members including translators) are not allowed in the student work area unless it is explicitly but temporarily permitted by a member of the Organizing Committee. Only participating students are allowed to be inside the work area.

Mentors must not touch, build, repair or program any robots.

8.4 Sharing

The understanding that any technological and curricular developments should be shared among the participants after the tournament has been a part of competitions.

8.5 Spirit

It is expected that all participants, students, mentors and parents alike, will respect the RoboCupJunior mission. *It is not whether you win or lose, but how much you learn that counts!*

8.6 Violations / Disqualification

Teams that violate the code of conduct can be disqualified from the tournament. It is also possible to disqualify only a single person or a single robot from further participation in the tournament.

In less severe cases of violations of the code of conduct, a team will be given a warning by showing it a yellow card. In severe or repeated cases of violations of the code of conduct, a team can be disqualified immediately without a warning by showing it the red card.