RoboCup Soccer Humanoid League Laws of the Game 2023/2024

March 17th, 2024

The humanoid league group photo of 2024

RoboCup Humanoid League Mailing List (for important announcements):
https://mailman.cc.gatech.edu/mailman/listinfo/robocup-humanoid

RoboCup Humanoid Forum (for rule discussion and questions):
https://hl.forum.robocup.org

RoboCup Humanoid League Home Pages:
https://www.humanoid.robocup.org/
https://www.robocup.org/leagues/3

Inspired by the Laws of the Game of the International Football Association Board, with amendments for the RoboCup Humanoid League.

Overview

Section I – Laws of the Game

Section II – RoboCup Humanoid League Competition Rules

Section III – Rules for RoboCup Humanoid League Technical Challenges (physical competition only)

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Section I

Laws of the Game

The Laws of the Game should be updated regularly to refer to the most recent FIFA document.

NOTES ON THE LAWS OF THE GAME

Modifications
Subject to the agreement of the member association concerned and provided the principles of these Laws are maintained, the Laws may be modified in their application for regional matches.
Any or all of the following modifications are permissible:

- size of the field of play

- size, weight and material of the ball

- width between the goalposts and height of the crossbar from the ground

- duration of the periods of play

- substitutions

Male and Female
References in respect of referees, assistant referees and officials have been changed from the original FIFA document to a gender neutral language. The reference to players, since they refer to robots in this context, have been kept in the male gender. However, we strongly encourage the FIFA to officially change their laws of the game to fully gender neutral language in the future in respect to all participants in the game.

Official languages
RoboCup Humanoid League Technical Committee publishes the Laws of the Game in English.

Field surface

Matches may be played on artificial surfaces with a height of approximately 30 mm.

The colour of artificial surfaces must be green.

Field markings

The field of play must be rectangular and marked with lines. These lines belong to the areas of which they are boundaries.

The two longer boundary lines are called touch lines. The two shorter lines are called goal lines.

The field of play is divided into two halves by a halfway line, which joins the midpoints of the two touch lines.

The centre mark is indicated at the midpoint of the halfway line. A circle with a radius of 0.75 m for KidSize and 1.5 m for AdultSize is marked around it.

Dimensions

The length of the touch line must be greater than the length of the goal line.

KidSize matches
 Length (touch line): approximately 9 m
 Width (goal line):   approximately 6 m

All lines must be of the same width, which must be approximately 5 cm.

AdultSize matches
 Length (touch line): approximately 14 m
 Width (goal line):   approximately 9 m

The goal area

Two lines are drawn at right angles to the goal line, 0.2 m from the inside of each goalpost for KidSize and 0.7 m for AdultSize. These lines extend into the field of play for a distance of 1 m and are joined by a line drawn parallel with the goal line. The area bounded by these lines and the goal line is the goal area.

The penalty area

Two lines are drawn at right angles to the goal line, 1.2m from the inside of each goalpost for KidSize and 0.7 m for AdultSize. These lines extend into the field of play for a distance of 2 m for KidSize and 3 m for AdultSize. They are joined by a line drawn parallel with the goal line. The area bounded by these lines and the goal line is the penalty area.
Within each penalty area, a penalty mark is made at 2.1m for AdultSize and 1.5m for KidSize from the midpoint between the goalposts and equidistant to them.

Goals

A goal must be placed on the centre of each goal line.

120 A goal consists of two upright posts equidistant from the corner flagposts and joined at the top by a horizontal crossbar. The goalposts and crossbar must be made of wood, metal or other approved material. They must be square, rectangular, round or elliptical in shape and must not be dangerous to players.

The distance between the posts is 2.6 m and the distance from the lower edge of the crossbar to the ground is 1.2 m for KidSize and 1.8m for AdultSize.

125 If the shape of the goalposts is square (viewed from above), the sides must be parallel or perpendicular to the goal line. The sides of the crossbar must be parallel or perpendicular to the field plane.

If the shape of the goalposts is elliptical (viewed from above), the longest axis must be perpendicular to the goal line. The longest axis of the crossbar must be parallel to the field plane.

If the shape of the goalposts is rectangular (viewed from above), the longest side must be perpendicular to the goal
130 line. The longest side of the crossbar must be parallel to the field plane.

Both goalposts and the crossbar have the same width and depth, which is not smaller than 8 cm and do not exceed 12 cm (5 ins). The goal lines must be approximately 5 cm of width. Nets which must not be green or white may be attached to the goals and the ground behind the goal, provided that they are properly supported and do not interfere with the goalkeeper.

135 The goalposts and crossbars must be white.

Safety

Goals must be anchored securely to the ground. Portable goals may only be used if they satisfy this requirement.

140 **The field of play**
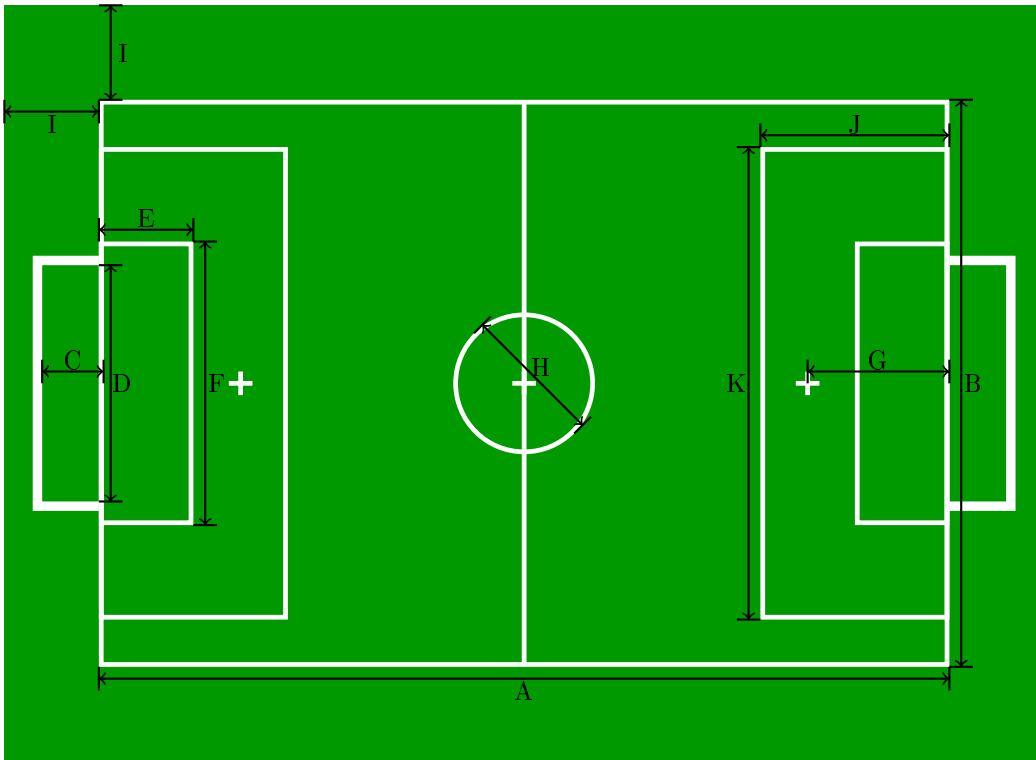
Figure 1: Humanoid robot soccer field: Kid Size (scale: 1/80)

Light Condition

The lighting resembles that of either artificial or natural light.
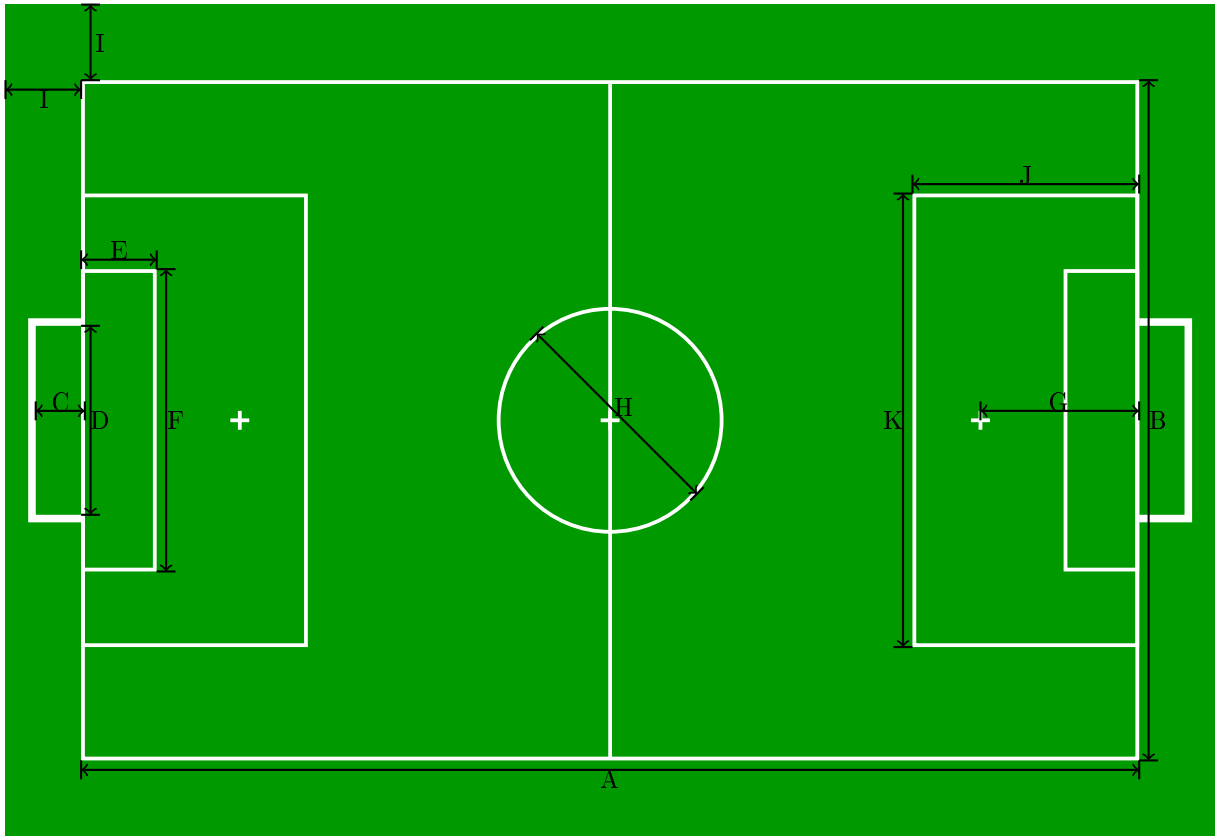
Figure 2: Humanoid robot soccer field: Adult Size (scale: 1/100)

Table 1: Approximate dimensions of the rectangular field of soccer play.

		KidSize	AdultSize
A	Field length	9 m	14 m
B	Field width	6 m	9 m
C	Goal depth	0.6 m	
D	Goal width	2.6 m	
	Goal height	1.2 m	1.8 m
E	Goal area length	1 m	
F	Goal area width	3 m	4 m
G	Penalty mark distance	1.5 m	2.1 m
H	Centre circle diameter	1.5 m	3 m
I	Border strip width (min.)	1 m	1 m
J	Penalty area length	2 m	3 m
K	Penalty area width	5 m	6 m

Qualities and measurements

The ball is:

- spherical

- is made of or resembles the weight, form, movement characteristics and appearance of leather or other suitable material

- FIFA size 1 for KidSize and size 5 for AdultSize leagues.

Replacement of a defective ball (physical competition only)

If the ball bursts or becomes defective during the course of a match:

- the match is stopped

- the match is restarted by dropping the replacement ball at the place where the original ball became defective, unless play was stopped inside the goal area, in which case the referee drops the replacement ball on the goal area line parallel to the goal line at the point nearest to where the original ball was located when play was stopped

If the ball bursts or becomes defective during a penalty kick or during kicks from the penalty mark as it moves forward and before it touches any player or the crossbar or goalposts:

- the penalty kick is retaken

If the ball bursts or becomes defective whilst not in play at a kick-off, goal kick, corner kick, free kick, penalty kick or throw-in:

- the match is restarted accordingly

The ball may not be changed during the match without the authority of the referee.

Number of Players

A match is played by two teams, each consisting of not more than four players in KidSize and not more than two players in AdultSize, one of whom must be designated as goalkeeper. A match may not start if either team consists of less than one player. In a virtual competition it is considered a forfeit if a team does not provide any software to play with for an upcoming game. If a team has not at least one player (who may be incapable to play) at the side of the field, it is considered a forfeit in a physical competition.

Number of substitutions (physical competition only)

Official competitions
Up to a maximum of two substitutes may be used in any match played in an official competition organised under the auspices of FIFA, the confederations or the member associations.
The rules of the competition must state how many substitutes may be nominated, from two up to a maximum of twelve.

Substitution procedure (physical competition only)

In all matches, the names of the substitutes must be given to the referee prior to the start of the match. Any substitute whose name is not given to the referee at this time may not take part in the match.

To replace a player with a substitute, the following conditions must be observed:

- the referee must be informed before any proposed substitution is made

- the substitute only enters the field of play after the player being replaced has left and after receiving a signal from the referee

- the substitute only enters the field of play at the penalty mark of the player's own half and during a stoppage in the match

- the substitution is completed when a substitute enters the field of play

- from that moment, the substitute becomes a player and the player he has replaced becomes a substituted player

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- all substitutes are subject to the authority and jurisdiction of the referee, whether called upon to play or not

Changing the goalkeeper

Any of the other players may change places with the goalkeeper, provided that:

- the GameController (virtual competition) or the referee (physical competition) is informed before the change is made

- the change is requested during a stoppage in the match

Infringements and sanctions (physical competition only)

If a substitute or substituted player or a team official enters the field of play without the referee's permission:

- the referee stops play (although not immediately if the substitute or substituted player does not interfere with play)

- the referee cautions him for unsporting behaviour and orders him to leave the field of play

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- if the referee has stopped play, it is restarted with an direct free kick for the opposing team from the position of the ball at the time of the stoppage (see Law 13 – Position of free kick)

If a named substitute enters the field of play instead of a named player at the start of the match and the referee is not informed of this change:

- the referee allows the named substitute to continue the match

- no disciplinary sanction is taken against the named substitute

- the number of substitutions allowed by the offending team is not reduced

- the referee reports the incident to the appropriate authorities

If a player changes places with the goalkeeper without the referee's permission before the change is made:

- the referee allows play to continue

- the referee cautions the players concerned when the ball is next out of play

In the event of any other infringements of this Law:

- the players concerned are cautioned

- the match is restarted with an indirect free kick, to be taken by a player of the opposing team from the position of the ball at the time of the stoppage (see Law 13 – Position of free kick)

Players and substitutes sent off (physical competition only)

A player who has been sent off before the kick-off may be replaced only by one of the named substitutes.

A named substitute who has been sent off, either before the kick-off or after play has started, may not be replaced.

Law 4 – The Players ('Equipment')

Safety

A player must not use equipment or wear anything that is dangerous to himself or another player (including any kind of jewellery).

The Design of the Robots

Robots participating in the Humanoid League competitions must have a human-like body plan, as shown in Fig. 3. They must consist of two legs, two arms, and one head, which are attached to a trunk.

(new:) Robots competing in the physical KidSize competition must be equipped with a handle, to be picked up safely and with no harm to the robot and the handler.
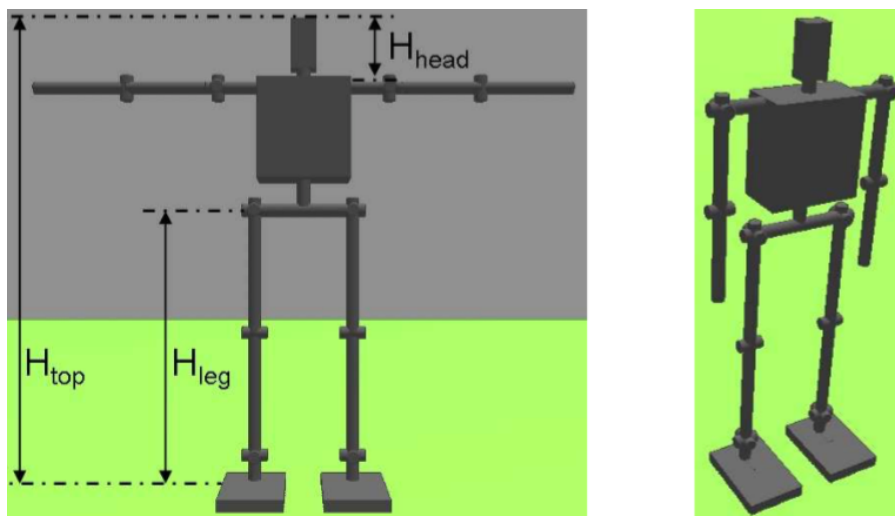
Figure 3: Example of a humanoid robot body plan (left) and standing upright pose (right)

The robots must be able to stand upright on their feet and to walk on their legs. KidSize robots need to be able to recover from a fall (get back to a standing position). The only allowed modes of locomotion are bipedal walking, running and jumping.

All actions of the robots must be kinematically equivalent to humanoid motions.

Robots competing in the physical competition must be equipped with an emergency stop button that makes the robot immediately desist with all motions, or ideally go limp and/or cut power to the actuators. In addition to the emergency stop button, robots may only have up to two additional physical or virtual buttons: One to start the robot behaviour and one to stop the behaviour. The buttons must be clearly labeled. If the robot has more buttons that cannot be detached, they must be visibly masked during the games. Body parts of robots competing in the virtual competition that are considered feet and arms must be marked in the virtual robot models.

Robot Height

Based on H_{top}, the following size restrictions apply:

- 40 cm $\leq H_{top} \leq$ 100 cm to play in the KidSize class,
- 100 cm $\leq H_{top} \leq$ 200 cm to play in the AdultSize class.

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H_{top} is defined as the height of the robot when standing upright (with fully extended knees, cf. Fig. 3 right) and H_{COM} denotes the height of the robot's centre of mass, measured using the device and the procedure described in Appendix. H_{top} is measured with the head of the robot oriented in such a way that it is tilted to either its maximum upwards tilt angle or the horizon line, whichever is lower.

Weight Restrictions

The robot's Body-Mass Index (BMI) is defined as follows: $\mathrm{BMI} = \frac{M}{H_{top}^2}$, where M is the mass of the robot in kg and H_{top} its height in meters. The following restriction applies:

- $5 \leq \mathrm{BMI} \leq 30$

Size Restrictions

All robots participating in the Humanoid League must comply with the following restrictions:

- Each foot must fit into a rectangle of area $\frac{1}{32}(2.2 \cdot H_{COM})^2$. A foot is defined as the minimum encapsulating rectangle covering all mechanical parts below the ankle joint. The encapsulating rectangle should be in a plane parallel to the bottom contact surface of the foot.

- The ratio between the longest and the shortest side of the encapsulating rectangle should be between 1.2 and 3.5

- The robot must fit into a cylinder of diameter $0.55 \cdot H_{top}$.

- The robot does not possess a configuration where it is extended longer than $1.5 \cdot H_{top}$.

- The length of the legs H_{leg}, including the feet, satisfies $0.35 \cdot H_{top} \leq H_{leg} \leq 0.7 \cdot H_{top}$.

- The height of the head H_{head}, including the neck, satisfies $0.1 \cdot H_{top} \leq H_{head} \leq 0.3 \cdot H_{top}$. H_{head} is defined as the vertical distance from the axis of the first arm joint at the shoulder to the top of the head.

- The leg length is measured while the robot is standing up straight. The length is measured from the first rotating joint where its axis lies in the plane parallel to the standing ground to the tip of the foot.

- The minimum length of the arm, measured from the first joint, is $H_{top} - H_{leg} - H_{head}$.

Sensors

Teams participating in the 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. In particular,

- In the virtual competition, no active external sensors may be used during the game. In the physical competition, the only active external sensor allowed is sound ("human-like" with respect to volume and frequency) with one loudspeaker on the robot. The loudspeaker may be placed in the head, neck or trunk of the robot. Any other active sensor (emitting light, sound, or electromagnetic waves into the environment in order to measure reflections) is not allowed.

- External 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.

- 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.

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- 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 union of the field of view of all cameras mounted on the robot must be less than 180 degrees. Also the pan-tilt motion of the 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. Therefore, 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 ± 90 degrees (measured from the horizontal line). Furthermore, if positioned at the centre mark the robot may not be able to see more than two goal posts in any tilt angle and in any standing or walking posture of the robot.

- Touch sensors, force sensors, and temperature sensors may be placed at any position on the robot.

- Sensors inside the robot may measure all quantities representing the local state of the system, including (but not limited to) voltages, currents, forces, movements, accelerations, and rotational speeds. They can be at any position inside the robot. Measurements from earth magnetic field sensors may not be used in the software and - in case of doubt - the code must be made available to members of the Technical Committee for inspection.

Communication and Control

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.

Robots may communicate only via the (wireless) network provided by the organizers, which must support the referee box. The total bandwidth of each robot belonging to one team may not exceed 1 Mbit/s. In the virtual competition, teams will not be able to monitor the robot communication and receive debug messages during an ongoing simulation. In the physical competition, the robots must not rely on the quality of the wireless network. They must be able to play if the network is of low quality. During a physical competition, only robots are allowed to communicate by WLAN. Any other computers of team members are only allowed to communicate by tethered LAN. No other wireless communication is allowed onsite. All other wireless hardware must be deactivated. A team may be disqualified if one of the team members violates this rule.

Robots in play may communicate with each other at any time during a game. Any kind of transmission from an external computer to the playing robots is prohibited. During a physical event, this implies that any monitoring is only done by receiving UDP communication from the robots using an external computer connected by tethered LAN to the official wireless router.
Substitute robots in a physical competition need to be turned away from the field in order to ensure they are not accidentally or purposefully sending game-relevant information to the robots in play.

Sending any direct or indirect transmission from an external computer to the robots is not possible during a virtual game. During a physical game, it has to take place during a timeout or any form of temporal absence and outside the field of play. Any time the robot handler or another team member is touching the robot, a cable is connected or another form of communication with the robot (including button clicks) take place, the robot is considered in service. The regular penalty time will start counting only after any type of communication with the robot has finished and will be reset whenever the robot handler attempts to service the robot again.

Teams may not use any type of communication with robots in play, in service or with robots serving their 30 seconds penalty time that contains information which reduces the need for autonomy in detecting the current game state of the robots, including the position of the ball, the location where the robot re-enters the field, the orientation of the robots own or opponents goal, and the position of team members or opponents. In a physical game, verbal communication is excluded from this rule. In case of doubt that a team violates this rule, the code must be made available to members of the Technical Committee for inspection.

During the game an official game controller/referee box will be used. It uses UDP to broadcast information to the robots like elapsed time, current score, game state (ready, set, playing, finished) and the robot-specific penalized state. The source code is open. Teams have to be able to use the referee box in order to respect the rules.

In KidSize, no humans are allowed on the field while the ball is in play. During a phyiscal game, robot handlers stay in a designated area and must receive permission from the referee prior to entering the field. Each team may designate only one person as robot handler. The robot handler of a team may not touch a robot of another team in order to avoid any (unintentional or intentional) damage to that robot.

The source code of the game controller/referee box is available from
https://github.com/RoboCup-Humanoid-TC/GameController, see also
https://www.robocuphumanoid.org.

Colours

- Robots must be mostly black or of dark grey colour (i.e. RAL 7011 Iron Grey or darker) and non reflective. Robots may also be coloured in aluminimum-like silver, grey or white but then their feet must be coloured black. Any colour used for the field (green, white) or colours similar to the opponent team's team markers must be avoided. Arms, legs and bodies of the robot must be of solid shape appearance.

- The robots must be marked with team markers. These markers are coloured red for one team and blue for the other team. The total visible area of all team markers (up to 20) on the robot's arms, legs and chest combined must be at least $0.06 \cdot H_{top}^2$. The visible area of the one to five largest team markers on each side (left, right, front and back) must be at least $0.015 \cdot H_{top}^2$. The team that during the first half plays the left side of the field (as viewed from the game controller table) plays in red, the team that plays the right side plays in blue. In the virtual competition, the color teams play in is randomly assigned and announced in the game plan.

- (new) The robots of each team must be uniquely identifiable. They must be marked with numbers or names. The goal keeper robot must be marked uniquely that it can be easily distinguished from the other robots of a team by the referees.

- The two teams must wear colours that distinguish them from each other and also the referee and the assistant referees.

Infringements and sanctions

In a virtual competition, the equipment of the players is checked by the Technical Committee prior to the tournament.

In the event of any infringement of this Law for a virtual tournament:

- The Technical Committee notifies the team in advance of the tournament about the violations and allows them to correct the equipment of the players.
- In case no valid robot model has been provided prior to the tournament, the team is excluded from participation.

In the event of any infringement of this Law occurring during a physical tournament:

- play need not be stopped
- the player at fault is instructed by the referee to leave the field of play to correct his equipment
- the player leaves the field of play when the ball next ceases to be in play, unless he has already corrected his equipment
- any player required to leave the field of play to correct his equipment must not re-enter without the referee's permission
- the referee checks that the player's equipment is correct before allowing him to re-enter the field of play
- the player is only allowed to re-enter the field of play before the respective penalty time is over

A player who has been required to leave the field of play during a physical game because of an infringement of this Law and who re-enters the field of play without the referee's permission must be cautioned.

Restart of play (physical competition only)

405 If play is stopped by the referee to administer a caution:

- the match is restarted by an indirect free kick taken by a player of the opposing team from the place where the ball was located when the referee stopped the match (see Law 13 – Position of free kick)

Decisions of the International F.A. Board

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Decision 1
Players must not reveal undergarments showing slogans or advertising. The basic compulsory equipment must not have any political, religious or personal statements. A player removing his jersey or shirt to reveal slogans or advertising will be sanctioned by the competition organiser. The team of a player whose basic compulsory equipment has political,
415 religious or personal slogans or statements will be sanctioned by the competition organiser or by RoboCup Federation Humanoid League .

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The authority of the referee

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Each match is controlled by a referee who has full authority to enforce the Laws of the Game in connection with the match to which they have been appointed. Decisions will be made to the best of the referees ability according to the Laws of the Game and the spirit of the game and will be based on the opinion or programming of the referee who has the discretion to take appropriate action within the framework of the Laws of the Game.

425 The games are overseen by the Technical Committee of the league, who ensures that the players and (simulated) environment is according to the laws of the game, and who may sanction unsportive behavior by teams.

Virtual Competition: Powers and duties

430 The autonomous Referee:

- enforces the Laws of the Game

- controls the match

- acts as timekeeper and keeps a record of the match

- stops, suspends or abandons the match, at their discretion, for any infringements of the Laws

435 - punishes the more serious offence when a player commits more than one offence at the same time

- takes disciplinary action against players guilty of cautionable and sending-off offences. They are not obliged to take this action immediately but must do so when the ball next goes out of play

- indicates the restart of the match after it has been stopped

- provides the appropriate authorities with a match report, which includes information on any disciplinary action
440 taken against players and/or team officials and any other incidents that occurred before, during or after the match

- indicates when the whole of the ball leaves the field of play

- indicates which team is entitled to a corner kick, goal kick or throw-in

- indicates whether, at penalty kicks, the goalkeeper moves off the goal line before the ball is kicked and if the
445 ball crosses the line

- communicates its decisions directly to the GameController.

The Technical Committee:

- ensures that any ball used meets the requirements of Law 2

- ensures that the players' equipment meets the requirements of Law 4

450 - stops, suspends or abandons the match because of outside interference of any kind

- takes action against team officials who fail to conduct themselves in a responsible manner and may, at their discretion, expel them from the field of play and its immediate surrounds

Physical Competition: Powers and duties

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The Referee:

- enforces the Laws of the Game

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- controls the match in cooperation with the assistant referees and, where applicable, with the fourth official

- ensures that any ball used meets the requirements of Law 2

- ensures that the players' equipment meets the requirements of Law 4

- acts as timekeeper and keeps a record of the match

- stops, suspends or abandons the match, at their discretion, for any infringements of the Laws

- stops, suspends or abandons the match because of outside interference of any kind

- stops the match if, in their opinion, a player is seriously injured and ensures that he is removed from the field of play. An injured player may only return to the field of play after the respective penalty time is over

- allows play to continue until the ball is out of play if a player is, in their opinion, only slightly injured

- ensures that any player bleeding from a wound leaves the field of play. The player may only return on receiving a signal from the referee, who must be satisfied that the bleeding has stopped

- allows play to continue when the team against which an offence has been committed will benefit from such an advantage and penalises the original offence if the anticipated advantage does not ensue at that time

- punishes the more serious offence when a player commits more than one offence at the same time

- takes disciplinary action against players guilty of cautionable and sending-off offences. They are not obliged to take this action immediately but must do so when the ball next goes out of play

- takes action against team officials who fail to conduct themselves in a responsible manner and may, at their discretion, expel them from the field of play and its immediate surrounds

- acts on the advice of the assistant referees regarding incidents that they has not seen

- ensures that no unauthorised persons enter the field of play

- indicates the restart of the match after it has been stopped

- provides the appropriate authorities with a match report, which includes information on any disciplinary action taken against players and/or team officials and any other incidents that occurred before, during or after the match

Decisions of the referee

The decisions of the referee regarding facts connected with play, including whether or not a goal is scored and the result of the match, are final.

In the physical competition, the referee may only change a decision on realising that it is incorrect or, at their discretion, on the advice of an assistant referee or the fourth official, provided that they have not restarted play or terminated the match.

Decision 1
A virtual referee (or where applicable, an assistant referee, fourth official or the Technical Committee) is not held liable for:
any kind of injury suffered by a player, official or spectator
any damage to property of any kind
any other loss suffered by any individual, club, company, association or other body, which is due or which may be due to any decision that they may take under the terms of the Laws of the Game or in respect of the normal procedures required to hold, play and control a match.

Such decisions may include:

- a decision that the condition of the field of play or its surrounds or that the weather conditions are such as to allow or not to allow a match to take place

- a decision to abandon a match for whatever reason

- a decision as to the suitability of the field equipment and ball used during a match

- a decision to stop or not to stop a match due to spectator interference or any problem in spectator areas (physical competition only)

- a decision to stop or not to stop play to allow an injured player to be removed from the field of play for treatment (physical competition only)

- a decision to require an injured player to be removed from the field of play for treatment (physical competition only)

- a decision to allow or not to allow a player to wear certain apparel or equipment

- a decision (where they have the authority) to allow or not to allow any persons (including team or stadium officials, security officers, photographers or other media representatives) to be present in the vicinity of the field of play (physical competition only)

- any other decision that they may take in accordance with the Laws of the Game or in conformity with their duties under the terms of FIFA, confederation, member association or league rules or regulations under which the match is played

Decision 2 (physical competition only)
In tournaments or competitions where a fourth official is appointed, their role and duties must be in accordance with the guidelines approved by the International F.A. Board, which are contained in this publication.

Decision 3 (physical competition only)
Where goal-line technology (GLT) is used (subject to the respective competition rules), the referee has the duty to test the technology's functionality before the match. The tests to be performed are set out in the FIFA Quality Programme for GLT Testing Manual. If the technology does not function in accordance with the Testing Manual, the referee must not use the GLT system and must report this incident to the respective authority.

Law 6 – The Assistant Referees (physical competition only)

Duties

Two assistant referees may be appointed whose duties, subject to the decision of the referee, are to indicate:

- when the whole of the ball leaves the field of play

- which team is entitled to a corner kick, goal kick or throw-in

- when a player may be penalised for being in an offside position

- when a substitution is requested

- when misconduct or any other incident occurs out of the view of the referee

- when offences have been committed whenever the assistant referees have a better view than the referee (this includes, in certain circumstances, offences committed in the penalty area)

- whether, at penalty kicks, the goalkeeper moves off the goal line before the ball is kicked and if the ball crosses the line

- (new) operate the game controller

Assistance

The assistant referees also assist the referee in controlling the match in accordance with the Laws of the Game. In particular, they may enter the field of play to help control the distances as defined by the laws of the game .

In the event of undue interference or improper conduct, the referee will relieve an assistant referee of their duties and make a report to the appropriate authorities.

Periods of play

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The match lasts two equal periods of 10 minutes. Any agreement to alter the duration of the periods of play must be approved by the Technical Committee in the virtual competition or mutually agreed upon between the referee and
555 the two teams in the physical competition, must be made before the start of play and must comply with competition rules.
In the virtual competition, teams are given a 2 minute time period between the robot models being spawned and the start of the match to allow for the software of the robots to start properly. The start of the match is defined as the game state changing to READY for the first half time. At the beginning of the second half time, each half
560 time in the extended period and the beginning of the penalty shootout, the autonomous referee will wait at least 15 seconds between spawning the robot models and transitioning to an active game state. Once the end of the match was declared by the referee and communicated by the GameController, teams receive a 2 minute time period to finish writing logs and properly shut down their program before the process will be terminated.

Half-time interval

565

In the virtual competition, there is no half-time interval between the two periods of play. In the physical competition, players are entitled to an interval at half-time.
The half-time interval must not exceed 5 minutes.
570 Competition rules must state the duration of the half-time interval.
The duration of the half-time interval may be altered only with the consent of the referee.

Allowance for time lost (physical competition only)

575 Allowance is made in either period for all time lost through:

- substitutions

- assessment of injury to players

- removal of injured players from the field of play for treatment

- wasting time

580 - any other cause

The allowance for time lost is at the discretion of the referee.

Penalty kick (physical competition only)

585 If a penalty kick has to be taken or retaken, the duration of either half is extended until the penalty kick is completed.

Abandoned match

An abandoned match is replayed unless the competition rules provide otherwise.

Set and Ready states

590

During the Set and Ready states, the game clock should not be stopped in both knock-out and round-robin games.

595 A kick-off starts both halves of a match, both halves of extra time and restarts play after a goal has been scored. Free kicks (direct or indirect), penalty kicks, throw-ins goal kicks and corner kicks are other restarts (see law 13-17).

If an infringement occurs when the ball is not in play this does not change how play is restarted.

Definition of kick-off

600

A kick-off is a way of starting or restarting play:

- at the start of the match

- after a goal has been scored

- at the start of the second half of the match

605 - at the start of each period of extra time, where applicable

A goal may not be scored directly from the kick-off by the team taking the kick-off. Either the ball must move entirely outside the centre circle or must be touched by another player before being kicked into the goal. If the ball is kicked directly into the goal a goal-kick is awarded to the opposing team.

Procedure

610

Before a kick-off at the start of the match or extra time for a physical competition

- a coin is tossed and the team that 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.

615 - the team that wins the toss takes the kick-off to start the second half of the match.

- in the second half of the match, the teams change ends and attack the opposite goals.

Before a kick-off at the start of the match or extra time for a virtual competition

- the autonomous referee decides randomly which team attacks which goal.

- the autonomous referee decides randomly which team has kick-off in the first half of the match.

620 - the team that was not given the kick-off in the first half of the match takes the kick-off to start the second half of the match.

- in the second half of the match, the teams change ends and attack the opposite goals.

Kick-off

- after a team scores a goal, the kick-off is taken by the other team.

625 - all players must be in their own half of the field of play

- the opponents of the team taking the kick-off are outside the center circle until it is in play

- the ball must be stationary on the centre mark

- the referee gives a signal

- the ball is in play when it is kicked and clearly moves[1] (new: as determined by the referee or 10 seconds after
630 the referee gave the signal)

---
[1]In the virtual competition, a move of at least 5 cm is considered clearly moving.

Infringements and sanctions

In the event of any other infringement of the kick-off procedure:

635 • the kick-off is retaken

Definition of dropped ball

640 A dropped ball is a method of restarting play when, while the ball is still in play, the referee is required to stop play temporarily for any reason not mentioned elsewhere in the Laws of the Game. In the virtual competition, the only reason for a dropped ball to be called is that the ball has moved less than 5 centimeters in the last 2 minutes of play.

Procedure

645 The game is continued at the centre 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 players of both teams must be outside the centre circle. The ball is in play immediately after the referee gives the signal. If a player moves too close to the ball before the referee gives the signal, a kick-off is awarded to the opponent team.

Infringements and sanctions

650

The ball is dropped again:

- if it is touched by a player before it makes contact with the ground

- if the ball leaves the field of play after it makes contact with the ground, without a player touching it

24

Ball out of play

The ball is out of play when:

660
- it has wholly crossed the goal line or touch line whether on the ground or in the air
- play has been stopped by the referee

Ball in play

665 The ball is in play at all other times, including when:

- it rebounds off a match official, goalpost, crossbar or corner flagpost and remains in the field of play

Goal scored

670

A goal is scored when the whole of the ball passes over the goal line, between the goalposts and under the crossbar, provided that no infringement of the Laws of the Game has been committed previously by the team scoring the goal.

If the kicking robot is touched by the robot handler in the physical competition or removed from the game due to a removal penalty before the ball passes the goal line, the goal does not count. The restart of the play will be a goal

675 kick for the opponents team. If another robot of a team is touched by the robot handler in the physical competition or removed from the game before the ball passes the goal line and it is not the kicker, the goal counts.

Note that if a penalized robot scores a goal against its own team, the goal is still considered as valid.

Winning team

680

The team scoring the greater number of goals during a match is the winner. If both teams score an equal number of goals, or if no goals are scored, the match is drawn.

Competition rules

685

When competition rules require there to be a winning team after a match or home-and-away tie, the only permitted procedures for determining the winning team are those approved by the International F.A. Board, namely:

- away goals rule

- extra time

690 - kicks from the penalty mark

- extended kicks from the penalty mark

Goal-line technology (GLT) (physical competition only)

695 GLT systems may be used for the purpose of verifying whether a goal has been scored to support the referee's decision. The use of GLT must be stipulated in the respective competition rules.

(suspended: Law 11 – Offside)

Direct and indirect free kicks and penalty kicks can only be awarded for offences and infringements committed when the ball is in play.

Direct free kick (physical competition)

A direct free kick is awarded to the opposing team if a player commits any of the following offences to a player of the opposing team:

- uses forceful contact that significantly destabilizes a player, such that walking and/or kicking is impeded. Examples for forceful contacts include falling into another player or walking carelessly into another player at significant speed.

- walks into another player for 4 to 5 seconds (even a fallen or getting up player), even if the 'force to push' is minimal.

A free kick is not awarded if one of the following exceptions occurs:

- The player committing the offence is stationary, including a player that is kicking, provided that the ball was close enough where a kick could have succeeded at the start of the kick motion.

- The player committing the offence is currently getting up.

- The player committing the offence is the current goal keeper and is currently chasing the ball, in it's own penalty area.

- Front to front contact between players with the ball between them does not lead to a free kick, unless one player walks at a significantly higher speed or with significantly more force that is impossible to stand for the other player.

- Any player proceeding to the ball whose side (i. e. arm, shoulder etc.) who only makes contact with another player is not committing an offence, even if the second player is not proceeding to the ball.

- A player that had an offence committed against himself can not simultaneously be called for a free kick offence himself.

A direct free kick is also awarded to the opposing team if a player commits any of the following offences:

- holds an opponent

- spits at an opponent

- handles the ball deliberately (except for the goalkeeper within his own penalty area)

- holds the ball for more than 5 seconds in a way that the ball cannot be removed from the player (a goal keeper may hold the ball up to 6 seconds on the ground or 10 seconds lifted up with one or both hands, a player performing a throw-in may lift the ball up with both hands for up to 10 seconds). More than half of the ball's volume must be outside the convex hull of the player, 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 player of a team is in the vicinity of the ball [2] , the convex hull is taken around all the player of a team, which prevent removal of the ball. Ball holding offences always occurs at the location of the ball.

If an offense did not happen within a radius of approx. 1 m around the current ball position, or if the ball is not in play, the direct free kick is replaced by a removal penalty. Ball holding leads to a free kick independently of the distance between the robots and the ball.

A removal penalty is also applied to any player touching the ball with part of its arm, except for the goalkeeper in its own penalty area or a player performing a throw-in.

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[2]defined as less than 0.375m in KidSize and 0.75 in AdultSize.

A direct free kick is taken from the place where the offence occurred (see Law 13 – Position of free kick). (new:) In the physical competition, if moving the ball to the place where the offence occurred would be to the disadvantage of the team to which the free kick is awarded, the referee allows play to continue.

Direct free kick (virtual competition)

A direct free kick is awarded to the opposing team if a player commits a foul according to the decision diagram presented in Fig. 4, with the values listed in Table 2.

Table 2: Decision values for the foul detection

Name	Notation	value	unit
Pushing time	T_p	1	s
Pushing period	T_{pt}	2	s
Vicinity distance	D_v	2	m
Distance threshold	D_t	0.1	m
Speed threshold	s_t	0.2	m/s
Direction threshold	θ_t	30	deg

A free kick is not awarded if one of the following exceptions occurs:

- The player committing the offence is the current goal keeper and is currently chasing the ball, in it's own penalty area.

- A player that had an offence committed against himself can not simultaneously be called for a free kick offence himself.

A direct free kick is also awarded to the opposing team if a player commits the following offence:

- holds the ball for more than 5 seconds in a way that the ball cannot be removed from the player (a goal keeper may hold the ball up to 6 seconds on the ground or 10 seconds lifted up with one or both hands, a player performing a throw-in may lift the ball up with one or both hands for up to 10 seconds). More than half of the ball's volume must be outside the convex hull of the player, 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 player of a team is in the vicinity of the ball[3] , the convex hull is taken around all the player of a team, which prevent removal of the ball. Ball holding offences always occurs at the location of the ball.

If an offense did not happen within a radius of approx. 1 m around the current ball position, or if the ball is not in play, the direct free kick is replaced by a removal penalty. Ball holding leads to a free kick independently of the distance between the robots and the ball.

A removal penalty is also applied to any player touching the ball with part of its arm, except for the goalkeeper in its own penalty area or a player performing a throw-in.

A direct free kick is taken from the place where the offence occurred (see Law 13 – Position of free kick).

Penalty kick

A penalty kick as defined by Law 14 is awarded if any of the above offences is committed by a player inside his own penalty area, irrespective of the position of the ball, provided it is in play.

Indirect free kick

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[3] defined as less than 0.375m in KidSize and 0.75 in AdultSize.

29

Is R_1 committing a forceful contact foul on R_2?

Flowchart nodes:

- R_1 and R_2 collide — yes → R_1 is Goalkeeper $\textsc{ownGoalArea}(R_1)$; no → No foul
- R_1 is Goalkeeper $\textsc{ownGoalArea}(R_1)$ — yes → No foul; no → R_2 is Goalkeeper $\textsc{ownGoalArea}(R_2)$
- R_2 is Goalkeeper $\textsc{ownGoalArea}(R_2)$ — yes → Foul; no → R_1 and R_2 have been in collision for T_p in the last T_{pt}
- R_1 and R_2 have been in collision for T_p in the last T_{pt} — yes → $\overline{R_1B} < D_v$; $\overline{R_1B} - \overline{R_2B} > D_t$; no → $|\vec{v}(R1)| > s_t$
- $\overline{R_1B} < D_v$; $\overline{R_1B} - \overline{R_2B} > D_t$ — yes → Foul; no → No foul
- $|\vec{v}(R1)| > s_t$ — yes → $\overline{R_1B} < D_v$; no → No foul
- $\overline{R_1B} < D_v$ — yes → $\textsc{movesToBall}(R_2)$ $\neg\textsc{movesToBall}(R_1)$; no → $|\vec{v}(R_1)| - |\vec{v}(R_2)| > s_t$
- $\textsc{movesToBall}(R_2)$ $\neg\textsc{movesToBall}(R_1)$ — yes → Foul; no → $\textsc{movesToBall}(R_1)$ $\textsc{movesToBall}(R_2)$ $\overline{R_1B} - \overline{R_2B} > D_t$
- $\textsc{movesToBall}(R_1)$ $\textsc{movesToBall}(R_2)$ $\overline{R_1B} - \overline{R_2B} > D_t$ — yes → Foul; no → No foul
- $|\vec{v}(R_1)| - |\vec{v}(R_2)| > s_t$ — yes → Foul; no → No foul

Legend:
- $\textsc{ownGoalArea}(R)$ denotes if R is in its own goal area
- $\vec{v}(R)$ denotes the speed of the CoM of R (filtered over several simulation steps)
- $\textsc{movesToBall}(R)$ denotes the fact that $\vec{v}(R) < s_t$ or the angle between $\vec{v}(R)$ and $\vec{RB}$ is below θ_t.
- When a decision node contain multiple lines, all should be satisfied
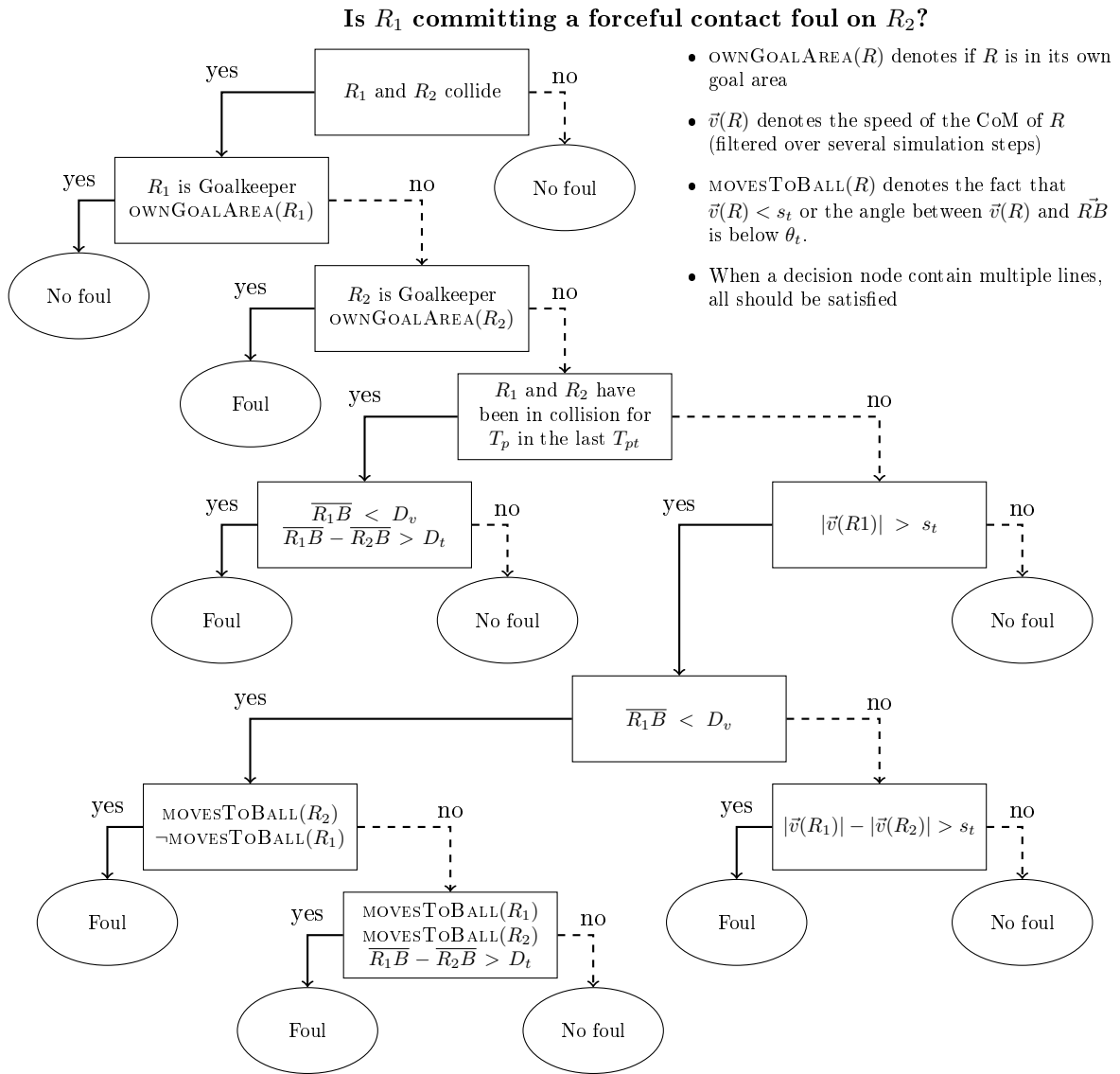
Figure 4: Is robot R_1 committing a forceful contact foul on R_2? This decision diagram is applied on every couple of robots from opposing teams.

An indirect free kick is awarded to the opposing team if a goalkeeper, inside his own penalty area, commits any of the following four offences:

- controls the ball with his hands for more than ten seconds before releasing it from his possession
- touches the ball again with his hands after he has released it from his possession and before it has touched another player
- touches the ball with his hands after it has been deliberately kicked to him by a team-mate
- touches the ball with his hands after he has received it directly from a throw-in taken by a team-mate

In the physical competition, an indirect free kick is also awarded to the opposing team if, in the opinion of the referee, a player:

- plays in a dangerous manner
- impedes the progress of an opponent

- prevents the goalkeeper from releasing the ball from his hands

- commits any other offence, not previously mentioned in Law 12, for which play is stopped to caution or send off a player

In the physical competition, if an offense did not happen within a radius of approx. 1 m around the current ball position, the indirect free kick is replaced by a removal penalty.

The indirect free kick is taken from the place where the offence occurred (see Law 13 – Position of free kick). (new:) In the physical competition, if moving the ball to the place where the offence occurred would be to the disadvantage of the team to which the free kick is awarded, the referee allows play to continue.

Disciplinary sanctions

The yellow card is used to communicate that a player, substitute or substituted player has been cautioned. In the virtual competition, the Technical Committee may use yellow cards to communicate that a team has been cautioned.

The red card is used to communicate that a player, substitute or substituted player has been sent off. In the virtual competition, the Technical Committee may use red cards to communicate that a team has been excluded from the tournament.

Only a player, substitute or substituted player and in case of a virtual tournament a team may be shown the red or yellow card.

The referee has the authority to take disciplinary sanctions from the moment he enters the field of play until he leaves the field of play after the final whistle (in the physical competition) or the game is started until the game was declared finished by the autonomous referee (in the virtual competition). In the virtual competition, the Technical Committee has the authority to take disciplinary sanctions against a team at any point during the tournament and in particular after a simulated game has been played and before the result was certified by the Technical Committee.

A player who or a team that commits a cautionable or sending-off offence, either on or off the field of play, whether directed towards an opponent, a team-mate, the referee, an assistant referee or any other person, is disciplined according to the nature of the offence committed.

Cautionable offences

A player is cautioned and shown the yellow card if he commits any of the following seven offences:

- unsporting behaviour (physical competition only)

- dissent by word or action (physical competition only)

- persistent infringement of the Laws of the Game (physical competition only)

- delaying the restart of play (physical competition only)

- entering or re-entering the field of play without the referee's permission

- receiving a second official warning from the referee

In a physical competition, a substitute or substituted player is cautioned if he commits any of the following three offences:

- unsporting behaviour

- dissent by word or action

31

• delaying the restart of play

Sending-off offences

A player, substitute or substituted player is sent off if he commits any of the following offences:

• serious foul play (physical competition only)

• violent conduct (physical competition only)

• spitting at an opponent or any other person (physical competition only)

• denying the opposing team a goal or an obvious goalscoring opportunity by deliberately handling the ball (this does not apply to a goalkeeper within his own penalty area) (physical competition only)

• using offensive, insulting or abusive language and/or gestures (physical competition only)

• receiving a second caution in the same match

In a virtual competition, a team is shown the red card and excluded from the tournament if it commits one of the following offences:

• using offensive, insulting or abusive language and/or gestures

• receiving a second caution in the same tournament

In the physical competition, a player, substitute or substituted player who has been sent off must leave the vicinity of the field of play and the technical area.

Types of free kick

Free kicks are either direct or indirect.

The direct free kick

Ball enters the goal:

- if a direct free kick is kicked directly into the opponents' goal, a goal is awarded

- if a direct free kick is kicked directly into the team's own goal, a corner kick is awarded to the opposing team

The indirect free kick

Ball enters the goal
A goal can be scored only if the ball is either kicked and clearly moves as determined by the referee[4] or has been touched by another player before being kicked into the goal :

- if an indirect free kick is kicked directly into the opponents' goal, a goal kick is awarded

- if an indirect free kick is kicked directly into the team's own goal, a corner kick is awarded to the opposing team

Procedure

All free kicks are taken from the place where the offence occurred, except:

- indirect free kicks to the attacking team for an offence inside the opponents' penalty area are taken from the nearest point on the penalty area line which runs parallel to the goal line.

- in the physical competition, free kicks to the defending team in their goal area may be taken from anywhere in that area

The ball:

- must be stationary

- is in play when it is kicked and clearly moves as determined by the referee[5] except for a free kick to the defending team in their penalty area where the ball is in play when it is kicked directly out of the penalty area. In both cases the the ball is also considered in play 10 seconds after the referee gave the signal.

Until the ball is in play all opponents must remain:

- at least 0.75m for KidSize and 1.5m for AdultSize from the ball until it is in play, unless they are on their own goal line between the goalposts

- outside the penalty area for free kicks inside the opponents' penalty area

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[4]In the virtual competition, a move of at least 5 cm is considered clearly moving.
[5]In the virtual competition, a move of at least 5 cm is considered clearly moving.

The referee blows the whistle (physical competition only), announces 'Free-Kick' blue or red and communicates "Direct / Indirect Free Kick" Blue/Red to the GameController or the assistant referee operating the GameController. The referee places the ball depending on the call and announces "Free Kick Ready" and communicates "Prepare Direct / Indirect Free Kick" Blue/Red to the GameController or the assistant referee operating the GameController. The player taking the free kick has up to 30 seconds to position themselves for the free kick. In the virtual competition, any player from the team taking the free kick may announce that the player is ready to take the free kick at any point by sending a message to the GameController. In the physical competition, the robot handler of the team taking the free kick can announce to the referee that the player is ready to take the free kick.

Players are guaranteed at least 15 seconds to move away from the ball. They may take up to 30 seconds if the team taking the free kick has not announced their robot is ready to take the kick off. Any opponent robot still illegally positioned is considered as an incapable player and must be removed from the field for 30 seconds removal penalty. The referee may decide to execute the free kick before 15 seconds have passed if the team taking the free kick have announced their robot is ready and if no opponent is illegally positioned. Once the free kick can be executed, the referee blows the whistle (physical competition only) and communicates "Execute Direct / Indirect Free Kick" Blue/Red to the GameController or the assistant referee operating the GameController.

Infringements and sanctions

If, when a free kick is taken, an opponent is closer to the ball than the required distance:

- the opponent receives a 30 second removal penalty

In a physical competition, if when a free kick is taken by the defending team from inside its own penalty area, the ball is not kicked directly out of the penalty area:

- the kick is retaken if the goal keeper managed to reach the ball within the time frame. Otherwise, the ball is in play again.

If a free kick was awarded to team A and any player of team A touches the ball before the referee announced the execution of the free kick:

- The ball is in play.
- The player touching the ball received a warning. For the second warning, the player received a yellow card. For the fourth warning, the player receives a second yellow card.

If a free kick was awarded to team A and any player of team B touches the ball before the referee announced the execution of the free kick:

- The free kick is retaken.
- The player touching the ball received a warning. For the second warning, the player received a yellow card. For the fourth warning, the player receives a second yellow card.

34

A penalty kick is awarded against a team that commits one of the) offences for which a direct free kick is awarded, inside its own penalty area and while the ball is in play.

A goal may be scored directly from a penalty kick.

Position of the ball and the players

The ball:

- must be placed on the penalty mark.

(new:) During penalty shoot-out, the player taking the penalty kick:

- must be properly identified (in the physical competition only)

The defending goalkeeper:

- must remain on or behind his goal line facing the kicker in the physical competition. In the virtual competition, it may be facing any direction. In any case, it needs to stay between the goalposts until the ball has been kicked

The Kicker:

- must be placed inside the field of play
- must be placed behind the penalty mark

The players other than the kicker must be:

- inside the field of play
- behind the penalty mark
- at least 0.75m for KidSize and 1.5m for AdultSize from the penalty mark

Procedure

If a penalty kick is taken during the normal course of play the same procedure as in regular direct free kicks is applied.

During penalty shoot-out:

- In the physical competition, after the players have taken positions in accordance with this law, the referee signals for the penalty kick to be taken
- In the virtual competition, the referee spawns the kicker and the goalkeeper.
- The player taking the penalty kick must kick the ball forward
- The ball is in play when it is kicked and moves forward[6]

The trial ends after 60 seconds. It may be extended until the ball comes to a complete stop if the ball is still moving at the time the 60 seconds are over. The trial also ends if the ball stops being entirely inside the goal area or leaves the field.

Infringements and sanctions

The same infringements and sanctions as in regular direct free kicks are applied.

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[6]In the virtual competition, a move of at least 5 cm is considered moving forward.

A throw-in is a method of restarting play.

A throw-in is awarded to the opponents of the player who last touched the ball when the whole of the ball crosses the touch line, either on the ground or in the air.

A goal cannot be scored directly from a throw-in:

- if the ball enters the opponents' goal - a goal kick is awarded

- if the ball enters the thrower's goal - a corner kick is awarded

Procedure

If the ball leaves the field it will be replaced on the field by the referee or an assistant referee. If the whole of the ball passes over a touch line the ball is placed on the touch line directly at the point at which the ball left the field.

Balls are deemed to be out based on the team that last touched the ball, irrespective of who actually kicked the ball.

After placing the ball, the same procedure and rules of executing a indirect free kick apply. Robots are also allowed to perform the throw-in with their hands, in this case:

- faces the field of play (in the physical competition only)

- has part of each foot either on the touch line or on the ground outside the touch line

- holds the ball with both hands in the physical competition and at least one hand in the virtual competition

- delivers the ball from behind and over his head (in the physical competition only)

- releases the ball within 10 seconds

If a robot tries to perform a throw-in with hands and fails to respect the rules, a free-kick is awarded to the opponent team.

Law 16 – The Goal Kick

A goal kick is a method of restarting play.

A goal kick is awarded when the whole of the ball passes over the goal line, either on the ground or in the air, having last touched a player of the attacking team, and a goal is not scored in accordance with Law 10.

A goal may be scored directly from a goal kick, but only against the opposing team. If the ball directly enters the
kicker's goal a corner kick is awarded to the opponents if the ball left the penalty area.

Procedure

If the ball leaves the field it will be replaced on the field by the referee or an assistant referee. If the whole of the
ball passes over the goal line the ball is placed on the touch line at the intersection with the centre line on the side of the field the ball went out.

Balls are deemed to be out based on the team that last touched the ball, irrespective of who actually kicked the ball.

After placing the ball, the same procedure and rules of executing a direct free kick apply.

₉₉₅ A corner kick is a method of restarting play.

A corner kick is awarded when the whole of the ball passes over the goal line, either on the ground or in the air, having last touched a player of the defending team, and a goal is not scored in accordance with Law 10.

A goal may be scored directly from a corner kick, but only against the opposing team; if the ball directly enters the kicker's goal a corner kick is awarded to the opponents.

₁₀₀₀ **Procedure**

If the ball leaves the field it will be replaced on the field by the referee or an assistant referee. If the whole of the ball passes over the goal line the ball is placed on the corner on the side of the field the ball went out.

₁₀₀₅ Balls are deemed to be out based on the team that last touched the ball, irrespective of who actually kicked the ball.

After placing the ball, the same procedure and rules of executing a direct free kick apply.

PROCEDURES TO DETERMINE THE WINNER OF A MATCH OR HOME-AND-AWAY

Away goals, extra time, kicks from the penalty mark and extended kicks from the penalty mark are the four methods approved for determining the winning team where competition rules require there to be a winning team after a match has been drawn.

Away goals

Competition rules may provide that where teams play each other home and away, if the aggregate score is equal after the second match, any goals scored at the ground of the opposing team will count double.

Extra time

Competition rules may provide for two further equal periods, not exceeding 5 minutes each, to be played. The conditions of Law 8 will apply.

Kicks from the penalty mark

Procedure

- The referee randomly[7] chooses the goal at which the kicks will be taken.

- In the virtual competition, the referee randomly chooses a team to perform the first penalty kick. In the physical competition, the referee tosses a coin and the team whose captain wins the toss decides whether to take the first or the second kick.

- The referee keeps a record of the kicks being taken

- Subject to the conditions explained below, both teams take five kicks

- The kicks are taken alternately by the teams

- In the virtual competition, at the beginning of every kick, the kicker and the goalkeeper are spawned at a position specified by their team according to Law 14.

- If, before both teams have taken five kicks, one has scored more goals than the other could score, even if it were to complete its five kicks, no more kicks are taken

- In the physical competition, a goalkeeper who is injured while kicks are being taken from the penalty mark and is unable to continue as goalkeeper may be replaced by a named substitute provided his team has not used the maximum number of substitutes permitted under the competition rules

- With the exception of the foregoing case, only players who are on the field of play at the end of the match in a physical competition, which includes extra time where appropriate, or which are serving their 30 second penalty time or are currently in service, are eligible to take kicks from the penalty mark

- In the physical competition, an eligible player may change places with the goalkeeper at any time when kicks from the penalty mark are being taken

- Only the eligible players and match officials are permitted to remain on the field of play when kicks from the penalty mark are being taken during a physical match.

- Unless otherwise stated, the relevant Laws of the Game and International F.A. Board Decisions apply when kicks from the penalty mark are being taken

Extended kicks from the penalty mark

Procedure

- All penalty shoots are taken on an empty goal.

- The player performing the penalty kick may enter the goal area.

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[7]In the physical competition, a coin toss will be used for taking the random decision.

- The team wins which...

    1. ... kicked the ball into the goal / scores more often. If this is a tie:

    2. ... kicked the ball into the goal area more often. If this is a tie:

    3. ... touched the ball in a larger number of the performed trials. If this is a tie:

    4. ... in sum needed less time to score the goals. If this is a tie:

    5. ... in sum needed less time to kick the ball into the goal area. If this is a tie:

    6. ... in sum needed less time to touch the ball

- If this is a tie a coin is flipped by the Technical Committee.

THE ADDITIONAL ASSISTANT REFEREE (physical competition only)

Additional assistant referees may be appointed under the competition rules. They must be active referees of the highest category available. The competition rules must state the procedure to be followed when a referee is unable to continue, and whether:

1. the fourth official takes over as the referee, or

2. the senior additional assistant referee takes over as the referee, with the fourth official becoming an additional assistant referee

Duties

Where appointed, the additional assistant referees, subject to the decision of the referee, are to indicate:

- when the whole of the ball leaves the field of play over the goal line

- which team is entitled to a corner kick or goal kick

- when misconduct or any other incident occurs out of the view of the referee

- when offences have been committed whenever the additional assistant referees have a better view than the referee, particularly inside the penalty area

- whether, at penalty kicks, the goalkeeper moves off the goal line before the ball is kicked and if the ball crosses the line

Assistance

The additional assistant referees also help the referee to control the match in accordance with the Laws of the Game but the final decision will always be taken by the referee. In the event of undue interference or improper conduct, the referee will relieve an additional assistant referee of their duties and make a report to the appropriate authorities.

Interpretation of the Laws of the Game and Guidelines for Referees

Please see the respective FIFA documents.

1085 (e.g. pp. 60 of http://resources.fifa.com/mm/document/footballdevelopment/refereeing/02/36/01/11/lawsofthegameweben_neutral.pdf)

Section II

RoboCup Humanoid League Competition Rules

Setup and Inspections (physical competition)

The competitions in the Humanoid League are preceded by a setup and inspection period of at least 24 h. During this time, every robot will be inspected by the league organizing committee for compliance with the design rules detailed in Law 4. Robots need to demonstrate the ability to walk (all sub-leagues) and stand up from front and back (KidSize). The teams must be able to demonstrate at least one successful stand-up action from each side during the robot inspection. All robots will be photographed during the inspection. A re-inspection becomes necessary after any change that could affect the compliance to the design rules. A re-inspection might be requested by any team leader up to 1 hour prior to a game.

Setup and Inspections (virtual competition)

Teams who do not want their robot model to be shared publicly should provide a non-disclosure agreement to the Technical Committee. This agreement will have to be signed by every team requesting access to the robot model, for reviewing or inspection.

The virtual competitions in the Humanoid League are preceded by a setup and inspection period. Teams need to submit a first draft of a file containing their robot model three weeks before the tournament. During the following week, every robot will be inspected by the league organizing committee for compliance with the design rules detailed in Law 4. Teams will then receive feedback and are granted a period of one week to change the robot model to be compliant with the laws of the game. A final file containing the robot model needs to be submitted at latest one week before the competition. A re-inspection becomes necessary after any change that could affect the compliance to the design rules. Changes to the robot model made less than one week before the tournament need to be submitted by e-mail to the Organizing Committee. The e-mail needs to contain the new file containing the robot model as well as a summary of the changes made and a justification for performing the changes. A re-inspection might be requested by any team leader and is guaranteed to be evaluated if submitted up to 12 hours prior to a game.

Referee Duty (physical competition only)

Each team must name at least one person who is familiar with the rules and who might be assigned for referee duties and for the technical inspection by the league organizing committee.

Competitions

The competitions consist of:

1. Regular tournament for KidSize (4 vs. 4),

2. Regular tournament for AdultSize (2 vs. 2),

3. Drop-In games for KidSize and AdultSize (physical competition only)

4. Technical challenges (physical competition only).

While teams do require only 1 robot to participate to the Drop-In, they need to present a full roster of robots for the soccer games[8]. During robot inspection, teams have to announce how many robots they can provide.
After Drop-In:

- Teams which cannot provide a full roster have to form a full team with one or more other teams from the same league to present a full roster.

- Teams which can provide a full roster are allowed to play as a full team on their own, but can also join other teams to form a combined team.

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[8] 4 in KidSize, 2 in AdultSize

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In case one or more teams are left and the total number of their robots is not sufficient to form a full roster, they are still allowed to play as a full team.
This ensures that:

- any team who registers to a physical competition can compete in the regular tournament, independently of the number of robots they bring.

- any team who brings a full roster is not required to merge with another team for the regular tournament of a physical competition.

Physical competitions start with the Drop-In tournament. The scores of the teams during the Drop-In tournament are used to establish a preliminary ranking used for seeding teams in the different round robins groups. If multiple teams join to form a full team, only the best score of the teams composing the full team is used [9].

If at least 16 full teams participate in a league, the teams are separated in two different divisions for the regular tournament:

- The best N full teams are qualified for the first round robin of division A [10].

- The other full teams are qualified for the first round robin of division B.

In the virtual competition, the qualification for division A and division B as well as the seeding for the round robin groups is determined prior to the first game of the main tournament. It may be based on an initial round of games, penalty shoot-outs, results from the previous RoboCup competition, or another similarly appropriate method determined by the Organizing Committee. The method of seeding needs to be announced at least one month prior to the start of the tournament.
Both divisions play separate round robins. The lowest ranked teams per group in division A will have a playoff with the highest ranked teams per group in division B. The winners of the playoff games are qualified for the second round robin of division A, the losers will play the second round robin in division B.
Thereafter, division A and division B proceed independently of each other and each will normally consist of a round robin stage, followed by a number of knockout matches.

In case there is less than 16 full teams, there is only one division with a first round robin and a number of knock-out games.

All teams of a group play once against each other. The round robin games may end in a draw. In this case, both teams receive one point. Otherwise, the winning team receives three points and the not winning team receives zero points.

For the AdultSize soccer games of a physical competiton, a specific rule for robot handlers applies. For every robot, one robot handler is allowed to stay near the robot such that the robot handler does not interfere with the game. Specifically, the robot handler:

- should position himself behind the robot at a distance of at least an arm length away from the robot's convex hull.

- must not block the vision of any of the robots on the ball or goals.

- must not block the path of any robot.

- must not touch any robot. Touching a robot is considered an offence that is penalised by a removal penalty of the robot handler's own robot according to the laws of the game.

- must not enter the radius of one arm length around the robot unless the robot is to be picked up or to avoid interference with the game. Violation of this rule results in a warning to the respective robot handler. After two warnings, the robot handler needs to be replaced similarly to the rule specified under "Request for Pick-up".

- has to be dressed in black clothes.

- may not communicate with the robot in any way, including verbally, while the robot is in play.

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[9] If the three teams A,B and C participate in the drop-in tournament, receive respectively 3.2, 4.5 and −1.6 points and form a full team, the score of their full team will be 4.5.

[10] N is either 8 or 12 depending on the number of full teams and has to be announced before the beginning of the tournament.

After games of a round robin have been played, the teams of a group are ranked based on (in decreasing priority):

1. the number of earned points,

2. the goal-difference,

3. the absolute number of goals,

4. the result of a direct match,

5. the time needed to score a penalty kick into an empty goal (up to five alternating attempts to score, until at least one team scored),

6. the drawing of a lot.

At least two teams of every group will enter the next round robin or the playoffs.

In the knock-out games of a tournament two further equal periods of 5 minutes each are played if the game is not decided after the regular playing time. After consulting the team captains, the referee can decide to skip the extra time and continue the game immediately with the five alternating penalty kick trials in the physical competition. If both teams agree, the regular penalty kick trials may be skipped and the extended penalty kick procedure applies instead.

The game plan needs to be announced prior to the start of the tournament.

Forfeits

A team that forfeits is disqualified from the competition. Forfeiting is defined as refusing to make a good faith effort to participate in a scheduled game[11].

- If a team chooses to forfeit a match in the round robin games the other team plays on an empty goal.

- If a team chooses to forfeit in a knock-out game before the quarter final, the other team continues in the competition.

- If a team chooses to forfeit in the quarter finals, it will be replaced by the runner up team in the round robin group that included the forfeiting team.

- If a team chooses to forfeit in the semi finals or the game for 3rd and 4th place, it will be replaced by the team that lost to the forfeiting team in the quarter finals.

- A team forfeiting the final match should announce its decision at least 30 minutes before the start of the 3rd vs 4th final. The league organization committee may impose a one year disqualification of the team and its members in case of avoidable delayed announcements.

- If a team chooses to forfeit the final after the game for 3rd and 4th place began, it will be replaced by the 3rd place winner, and the 4th place winner will be 3rd place. No new 4th place will be selected.

- If a team chooses to forfeit the final before the game for 3rd and 4th place, it will be replaced by the team that lost to the forfeiting team in the previous semi-finals. The team that lost to the forfeiting team in the previous semi-finals (i.e. the one initially being qualified for the game for 3rd and 4th place) will be replaced for the game for 3rd and 4th place by the team that lost to it in the respective quarter final.

Gameplay

In the virtual competition, a time period of 15 seconds is granted to teams between the start of the half time or penalty shoot-out and the beginning of the kick-off procedure.

Kick-off procedure

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[11]If robots are broken in the physical competition, then they should be placed on the field anyway. In the virtual competition, if the software is currently not running properly, a version should be submitted anyway as an indication that the team is willing to participate.

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- The referee gives the signal "READY" that all robots have to reach their own half of the field. During this phase, handlers are not allowed to interfere with the robots.

- After a period between 15 and 45 seconds the referee gives the signal "SET". In the virtual competition, the time of this phase is always 45 seconds. The referee calls robots illegally positioned to be removed. Handlers are not allowed to remove or touch the legally positioned robots. The robot playing the goal keeper has to be announced before the beginning of the game. Illegally positioned players do not suffer a removal penalty and are allowed to enter the field as soon as the game starts.

- The opponents of the team taking the kick-off are outside the centre circle until the ball is in play.

- The ball is placed stationary on the centre mark after the "SET" signal was given.

- The referee gives the signal "PLAY" or whistles (physical competition only). In the virtual competition, the time between the "SET" and "PLAY" signal is 5 seconds.

- The ball is in play when it is kicked and clearly moves as determined by the referee[12] or 10 seconds elapsed after the signal.

Robots can take any position on the field that is consistent with the above requirements.

For initial kick-off (to initially start or restart after a half-time interval), robots can be placed anywhere on the touch lines or goal lines on the respective team's own side outside of the goal, to autonomously enter the field from there. In the physical competition, robots must be facing the opposite touch line or goal line when being positioned. In case an illegal start position is chosen for a robot, it is considered illegally positioned and removed from the field. It is allowed to enter the field as soon as the game starts. For other kick-off situations and for dropped ball robots need to position themselves from the the position they were when the game was stopped.

Robots with autonomous positioning ability are given between 15 and 45 seconds in the physical competition and 45 seconds in the virtual competition for re-positioning after a goal has been scored by one of the teams before the "SET" signal for kick-off is given by the referee. All human team members must leave the field of play immediately after the "SET" signal and before the "PLAY" signal.

Game interruption procedure
This procedure applies for throw-ins, corners, goal kicks, direct free-kicks, indirect free-kicks and penalties called during a game. It ensures a minimal distance of D between objects that were moved during this phase. For KidSize, D is 50 centimeters and for AdultSize, D is 1 meter.

1. The referee blows the whistle (physical competition only), announces the offence and the game interruption (e.g 'Pushing Red - Direct Free-Kick Blue')

2. The referee communicates the game interruption and to which team it is awarded to the game controller or the assistant referee operating the game controller.

3. The robots are allowed 5 seconds to stand-up and stop any infringement to the rules. At the end of these 5 seconds, the referee places the ball according to the game interruption. In case a robot is located at a distance lower than D, the following actions are performed in order:

   (a) Move all penalized robots at a distance lower than D of the ball away, placing them according to the removal penalty rule so that they can finish serving their penalty somewhere else.

   (b) Apply a removal penalty on all fallen robots at a distance lower than D from the ball.

   (c) If previous steps were not sufficient to ensure distance D, the referee tries to find a nearby location for the ball that is at a distance of at least D from all objects. This location should respects the rule for the game interruption. In particular, there are no alternative location for penalties, goal kicks and corner kicks.

   (d) If previous steps were not sufficient, the remaining robots at a distance of less than D from the ball location are moved away from the ball, ensuring that they are at least at a distance of D from all objects, including the ball.

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[12]In the virtual competition, a move of at least 5 cm is considered clearly moving.

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4. The referee communicates that the Game Interruption is ready to the GameController or the assistant referee operating the GameController. The player taking the game interruption has up to 15 seconds to position themselves for the game interruption. In the virtual competition, any player of the team taking the game interruption may announce that the player is ready to take the game interruption at any point. In the physical competition, the robot handler informs the referee if the robot is ready to take the free kick. Opponent robots must move to a position at least 0.75 m for KidSize and 1.5m for AdultSize away from the ball. They are guaranteed 15 seconds to move away from the ball.

5. In a physical competition, the assistant referee announces that 15 seconds are over.

6. The referee announces that the game interruption is prepared after 15 seconds have passed. The referee may also announce that the game interruption is prepared before 15 seconds have passed if the team taking the game interruption has announced their robot is ready and if no opponent is illegally positioned.

7. Any opponent robot still illegally positioned is considered as an incapable player and must be removed from the field for 30 seconds removal penalty.

8. When the referee decides to execute the game interruption and all opponent robots are legally positioned or have been removed from the field, the referee announces that the game interruption can be executed to the GameController or the assistant referee operating the GameController. In case of a physical competition, the referee blows the whistle to announce the execution of the free kick. The team that was awarded the game interruption can kick now.

9. The ball is in play after it has been kicked and clearly moves as determined by the referee[13] or after 10 seconds.

The distance between the ball and the player of the opponent team is measured between the projection on the ground of the center of mass of both objects.

Penalty shoot-outs procedure
The referee decides randomly towards which goal the penalty shoot-outs will be performed. Then, each penalty trial is performed with the following procedure.

1. In the virtual competition, the striker is defined as the robot from the striker's team with the lowest ID without a red card. In the physical competition, the robot handler can decide which robot to place as a striker from the set of robots that were active on the field, penalized on the side line or in service in the end of the game time.

2. In the virtual competition, the goalkeeper is chosen based on the GameController information. In the physical competition, the same procedure as for selecting a striker applies.

3. In the virtual competition, both players are spawned at appropriate locations. In the physical competition, the respective robot handlers place the robots.

4. The state is set to SET

5. The ball is placed or spawned on the penalty mark.

6. The referee waits 15 seconds before sending signals to start the trial

7. The state is set to PLAYING.

The following additional rules apply to penalty shoot-outs:

- The ball holding rule does not apply during penalty shoot-outs.

- If the striker commits an offense, the trial ends immediately.

- If the goalkeeper commits an offense, it is removed for the whole duration of the trial.

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[13]In the virtual competition, a move of at least 5 cm is considered clearly moving.

Request for Pick-up (physical competition only)

A robot handler may request to pick-up a robot if and only if a robot is in a dangerous situation that is likely to lead to physical injuries. If a robot handler touches a robot without the allowance of the referee, the respective robot receives a yellow card and the robot handler an official warning. In AdultSize, a request for pick-up is implicitly granted if the robot is visible unstable or about to fall. After two warnings for robot touching, the robot handler may not serve as a robot handler again for the rest of the game and needs to be replaced by a different person from the team immediately. In case of repeated violations throughout the tournament, the Technical Committee can decide to permanently disallow a certain person from serving as a robot handler for the rest of the tournament.

Incapable Players

Players not capable of play (e.g. players not walking 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. In the physical competition, 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 standing or walking posture from a fall within 20 seconds receives a 30 seconds removal penalty.

If the ball is within a radius of 0.5 m around the goal keeper inside the goal area, the goal keeper has to show active attempts to move the ball out of this radius by walking towards the ball or moving the ball. If no attempt is shown for 20 seconds, the goal keeper is considered to be an inactive player and receives a 30 seconds removal penalty.

A player that stays outside of the artificial turf for 20 seconds is considered as an incapable player and receives a 30 seconds removal penalty.

Damage to the Field

A robot that damages the field, or poses a threat to spectator safety, will be removed from the field for a 30 second removal penalty.

Substitutions (physical competition only)

Up to two players per game can be substituted by other players of the same team. A substituted robot can come back in play but it counts as an additional substitution. 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. Changing places/roles between a field player and a goalie does not count as substitution.

Temporal Absence (physical competition only)

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 seconds elapsed after it was taken out. It has to enter the field from the team's own half of the field close to the penalty mark facing the opposite touch line, as indicated by the referee. The same rules as for *Removal Penalty* apply.

Manual Untangle of Robots (physical competition only)

If entangled robots fail to untangle themselves, the referee might ask designated robot handlers of both teams to untangle the robots. Untangling must not make significant changes to robot positions or heading directions. Untangled robots must be laid on the ground not closer than 50cm to the ball and in a way not gaining an advantage.

Removal Penalty

- Time penalties of 30 seconds for players are called by the referee. When a penalty is called in the physical competition, the designated robot handler has to remove the robot as soon as possible and by that interacting as little as possible with the game

- In the physical competition, the referee and assistant referees are in charge of timing the penalties and notifying the teams to put back their robots to play. In the virtual competition, the robots receive the signal that their penalty time is over automatically from the GameController.

- A field player or goal keeper suffering a time penalty will be removed from the field and is only allowed to re-enter the field from the team's own half of the field close to the penalty mark as indicated by the referee. In the physical competition, robots need to face the opposite touch line. The referee chooses the touch line further away from the ball if there is still an empty spot available. The first spot for a penalized robot on the touch line is on the same height of the penalty mark. Every consecutive spot is 60 cm (KidSize) or 100 cm

(AdultSize) away from the previous position, either towards the team's own goal line or towards the center line. A valid position must be at least 30 cm (KidSize) or 50 cm (AdultSize) away from the goal line and center line. A position is considered as being taken if a robot from any team is within a radius of 30 cm (KidSize) or 50 cm (AdultSize) of the penalty position. The referee always positions the robot on the penalty spot closest to the penalty mark. If two positions are available that are equally close, the referee chooses the position that is further away from the ball. In the virtual competition, robots get placed automatically by the autonomous referee. When placed, the robot joints are reset to their initial position and their velocities is set to 0.

- In the physical competition, after the robot has been placed at the position indicated by the referee and with both feet entirely outside the field of play the robot handler announces to the assistant referee that the robot is ready to get back in. The 30 seconds penalty start counting from the point of announcement. From this point onwards the robot handler may not touch or interfere with the robot in any other way (including button presses). If any part of the robot touches the field of play (including touch lines) or the robot handler touching the robot before the 30 seconds expired, the time is reset. In the virtual competition, the penalty time starts counting immediately after the robot was repositioned to the side line by the autonomous referee.

- The GameController or the assistant referee operating it will:

    - Penalize the robot as soon as the referee calls the penalty.
    - Marks the penalty time counting down as soon as the robot handler announced the robot being ready to walk in (physical competition) or it is placed on the penalty position outside the field (virtual competition)
    - In the physical competition, the assistant referee resets the penalty time whenever the robot handler touches the robot or the robot touches the field of play

- The penalty is automatically removed after 30 seconds of penalty have expired.

Timeouts (physical competition only)
A team may call for a timeout before kick-off after a goal was scored, the start of a new half, or a drop ball was called and before a penalty shoot-out. During a timeout robots may be serviced. Each team may take at most one timeout per period during regular game time and one additional timeout during all of the extended time and penalty shoot-out. 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 120 s. A timeout also ends when the team signals its end to the referee.

Referee Timeouts (physical competition only)
The head referee may call a timeout before kick-off after a goal was scored, the start of a new half, or a drop ball was called and before a penalty shoot-out if they deem it necessary. A referee timeout should only be called in dire circumstances - one example might be when the power to the wireless router is down. However, when and whether to call a referee timeout is left up to the head referee.
Referees may call multiple timeouts during a game if needed. Teams may do anything during these timeouts, but they must be ready to play 2 minutes after the referee begins a timeout. The referee should end the timeout once they believe the circumstance for which the timeout was called has been resolved. In cases where the circumstance for which the timeout was called is not resolved within 10 minutes, the Technical Committee should be consulted regarding when/if play should continue.
The team who would have kicked off if the timeout had not been called shall kickoff when the game resumes.

Timeout and Restart by Technical Committee (virtual competition only)
Two members of the Technical Committee that are not directly involved with any of the team currently playing the game can decide to pause or restart the simulation in case of severe technical difficulties with the simulator, the network, the computer instances or any other equipment involved in running the simulated games. A timeout can be taken multiple times throughout a game if necessary. The Technical Committee must publish a written report of the amount and reasons for any timeout taken or restart of the game.

Disciplinary sanctions against robots
Yellow and red cards given to robots only accumulate for the current game and are cleared again after the end of each game. Warnings against robot handlers and/or teams have to be reported to the Technical Committee after each game. They are recorded and accumulated for the whole tournament.

Disciplinary sanctions against teams (virtual competition only)
A team is cautioned by the technical committee and may be shown a yellow card if it commits any of the following offences:

- unsporting behaviour, in particular by deliberately and repeatedly using limitations of the automated referee to their advantage

- dissent by word or action

- persistent infringement of the Laws of the Game

- delaying the restart of play

Result publication (virtual competition only)

In case the simulation can be performed and rendered in real time, a video of the simulated game will be streamed simultaneously to the match being played. In case the simulator does not allow for real-time games and rendering, the video will be streamed after the match was performed and the rendering was completed. Teams will get access to log files of the game and their robot software immediately after the video of the match has ended.

Software changes (virtual competition only)

Teams can update their software during the tournament. The software they intend to use for the next round of games needs to be submitted at latest X hours before the video stream of their next game is scheduled, the value of X is provided to teams at the beginning of the tournament and it can be different for round-robin games and knock-out games.

Drop-In Games (physical competition only)

Organisation

Each participating team will contribute one drop-in player for each drop-in game. The drop-in player may be chosen from all available robots of the team and does not have to be the same in all drop-in games. Each drop-in player will compete in games with many different teams composed of randomly chosen drop-in players. In each game, the opponent will be a similarly composed team of randomly selected drop-in players. The exact number of games played by each drop-in player depends on the number of teams that participate in the competition. A minimum of 4 drop-in games will be played by every team.

The drop-in players will be allocated to teams randomly at least 24 hours before the first game takes place. The allocation to teams for the individual games is randomly chosen and changes for every single game. Some teams might play one more Drop-In game than others.

Rules

All normal game rules apply to this competition. The only exceptions are:

1. The games are played with 5 players in a KidSize team and 3 players in an AdultSize team. If there is an insufficient number of participants, games may be played 4 vs. 4 or 3 vs. 3 for KidSize or 2 vs. 2 for AdultSize.

2. Games may end in a draw.

3. Each of the players has a jersey number from the set 1, 2, 3, 4, 5, resp. 1, 2, 3.

4. Drop-in teams will wear the blue and red team colours.

5. In AdultSize, one robot handler per competing robot is allowed. In KidSize, the teams have to agree on one robot handler per team.

Removal of incapable players has to be enforced strictly.

Communication

Teams are strongly encouraged to implement the mitecom team communication protocol which is available at https://github.com/RoboCup-Humanoid-TC/mitecom or the Protobuf-based communication protocol which can be found at https://github.com/RoboCup-Humanoid-TC/RobocupProtocol

Selection of the Referees

Referees will be drawn from the remaining participating teams, or if needed, due to a low number of teams, the TC and OC will provide referees. Referees for a match may be picked among the pool of available referees from any size class.

Scoring

When a goal is scored, all players of the scoring team on the field receive 1 point and the player who scored the goal receives an additional 1 point if it was not an own goal. A robot is considered to be on the field if both feet of the robot are fully inside the field area. The player who scored the goal receives the points regardless of its position on the field. Incapable players, penalized players, players outside the field or players having been removed for any other reason, e.g. service, will receive no point. When a goal is suffered, all players of the team suffering the goal receive -1 points, including incapable players, penalized players or players having been removed for any other reason, e.g. in service. Points from all games are summed up. For players who played one or more games more than the others, only the points of those games with the higher scores are considered.

Drop-in players are initially ranked according to the arithmetic mean. If there are ties, the tied players are ranked according to the number of games played, the maximum points awarded in a single game and the number of goals scored (in this order). The three most highly ranked players of a sub-league receive a 'Best Player' certificate.

If the three best drop-in players can not be identified with the scheme provided above, an additional game with players drawn group wise (from the groups of equally high ranked players with a total number of points greater than zero) from the highest-ranked players is to be played.

If there are still ties a penalty shoot out among the equally high ranked drop-in players with a total number of points greater than zero takes place.

Example

There are 20 participating players for 4 KidSize Drop-In teams (A, B, C, D). Games shall be A-B, A-C, A-D, B-C, B-D, C-D. For the first game (A-B), Player 1 is randomly drawn for Team B and plays the game with the other team members. For the second game (A-C), player 1 is not drawn. For the third game (A-D), player 1 is drawn for team A and plays the game. For the fourth game (B-C), player 1 is drawn to team C and plays the game. Now player 1 will be removed from the drawing, because the number of 3 games was reached. If there would be only 19 participants, player 1 may be drawn for the final game.

Assuming teams with player 1 to score a single goal in every game (with player 1 on the field), then player 1 will have a score of 3 and an arithmetic average of 1.

Technical Challenges (physical competition only)

The technical challenges consist of:

1. Push Recovery (AdultSize)

2. Collaborative Localization (KidSize)

3. Goal Kick from Moving Ball (KidSize and AdultSize)

4. Parkour (KidSize and AdultSize)

5. High-Kick (KidSize and AdultSize)

For details on the technical challenges, please refer to Section III of this document.

Best Humanoid Award (physical competition only)

The teams of the Kid and Adult size classes that have participated in the drop-in competition are ranked in separate lists to determine the overall best humanoid.
The ranking is based on the aggregated number of points earned in the individual competitions.

The points earned in the technical challenge are used directly.

For the software challenge the winner receives 30 points. The second best team receives 21 points. The third best team receives 15 points.

For the Drop-In challenge the winner receives 30 points. The second best team receives 21 points. The third best team receives 15 points.

For the soccer games the winner receives 60 points. The second best team receives 42 points. The third best team receives 30 points.

The teams ranked first in the KidSize and AdultSize lists are candidates for the best humanoid. The final ranking between the three candidates is determined by the points earned in the individual competitions as stated above. The best KidSize or AdultSize team with the most overall points wins the best humanoid award. If there are ties, the average goals scored per game is used to determine the ranking of the three eligible candidates. If there are still ties, the president of the RoboCup Federation breaks the tie.

Trophies

A trophy is awarded to the winner of the soccer tournament in each of the individual size classes (physical competition only). In case there are two divisions, trophies are only awarded to the teams of division A. Teams of Division B might be awarded certificates.

A trophy is awarded to the teams second and third in the KidSize 4-4 soccer game and the AdultSize 2-2 soccer game. In case of less than 9 teams participating in a size class the team ranked third will be awarded a certificate instead of a trophy. In case of less than 6 teams participating in a size class the team ranked second will also be awarded a certificate instead of a trophy.

In a physical competition, a trophy is awarded to the team ranked first on the technical challenges and certificates are awarded to the teams second and third in the technical challenges. In case less than 15 teams participate to a size class, the team ranked first at technical challenges will be awarded a certificate instead of a trophy. A certificate is awarded to the team that performed best in the software challenge. A certificate is awarded to the team ranked second in the Best Humanoid list. A 'Best Player' certificate is awarded to the three most highly ranked Drop-in players. In case 20 teams or more participate to a class size, the team ranked first on Drop-in is awarded a trophy instead of a certificate. A team can only receive a 'Best Player' certificate if their total amount of points is greater than 0.

In a physical competition, the Best Humanoid Award is awarded to the team ranked first in the Best Humanoid list, it can either be a trophy or a certificate.

The number of trophies awarded depend on the number of teams participating to a class size and is summarized in Table 3.

Conflict Resolution

It is the responsibility of the team leader to inspect the other team's robots an hour (physical competition) or twelve hours (virtual competition) in advance of a game. Any concern regarding the rule compliance of any of the robots, including the amount, size and colour of the team markers, must be brought to the attention of the referee during a physical competition or the Technical Committee during a virtual competition. If the referee is unavailable during a physical competition, they have to be brought to the attention of the Technical Committee instead.

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Number of teams	Regular soccer games	Technical challenges	Drop-in games
1 to 5	1st		
6 to 8	1st, 2nd		
9 to 14	1st, 2nd, 3rd		
15 to 19	1st, 2nd, 3rd	1st	
20	1st, 2nd, 3rd	1st	1st

Table 3: Trophies awarded depending on the number of teams participating in a class size.

Every result of a game needs to be certified by at least two members of the Technical Committee not directly involved in any of the teams playing in that game. Doubts concerning a serious violation of any rule during a specific game must be brought up to a member of the Technical Committee and investigated before signing the result. By signing the result sheet, a team agrees that the result came off in a fair game. Concerns must be brought to the attention of the Technical Committee within half an hour of the completion of the video stream (virtual competition) or game play (physical competition). If a team brings up an official concern to the Technical Committee, a meeting of the Technical Committee must be called as soon as possible. If the team of a member of the Technical Committee is directly involved in the game in question, the respective member is excluded from the meeting. At least three members of the Technical Committee need to be part of the meeting and the decision process. If less than three members of the Technical Committee are available, members of the Organizing committee or, if necessary, Trustees or members of committees from other leagues have to be called into the meeting. Members of these meetings may request to inspect the hardware, robot model and software of any team involved in the issue. In a virtual tournament, they will receive access to the rendered video of the simulation and any log file produced by the simulator, GameController and automated referee. If serious violations of rules or recurrent unsportive behavior are detected, the committee may, among others, decide to invalidate the result of the game in question or take disciplinary actions against a team as defined in Law 5, depending on the severity of the rule violation. The decision of the committee meeting need to be announced to the whole league. If teams receive a warning or yellow card for unsportive behavior and are requested to make changes to their code for the next game, they need to receive a period of at least four hours to make the requested change. If their next game was scheduled earlier than this, the game needs to be postponed.

Announcement of code and hardware usage

Teams are required to clearly state during the qualification process:

- in their software description part of the application material, they need to state what part of the code is based on another team's code base. This needs to be declared for each software section individually. If the code of a team builds on another team's code, they need to clearly state their own changes and contributions. Failure to acknowledge the usage of another teams software can lead to disqualifications (if major parts are built on other team's software without announcing this) or can lower the score of future submissions to the Humanoid League.

- Clearly state in their robot description whether their robots or major components are bought or used from another team or a company (this includes rebuilding robots based on open hardware models of other RoboCup teams). Again, modifications and a team's own contributions need to be clearly marked.

In case they decide to use software or hardware by another team after the qualification material has already been approved a team needs to write an e-mail to the Humanoid League mailing list.

Acknowledgements

These rules evolved from previous versions of the RoboCup Humanoid League rules. We would like to thank Henry Yen for the conversion of the rules into a basic LaTeX version in 2010. The 2008 version of the rules was compiled by Pasan Kulvanit and Oskar von Stryk, the 2007 version of the rules by Emanuele Menegatti and the 2006 version by Sven Behnke, who did a remarkable job improving the rule document and gearing it towards the FIFA Laws of the Game. The improvements of the 2005 version were compiled by Norbert Michael Mayer. Philipp Allgeuer

significantly contributed to the conversion of the 2017 rule book to LaTeX. Other input came earlier from the rules of the RoboCup MiddleSize and Four-Legged Leagues.

The rules were continuously discussed within the technical committee of the humanoid league and also on the humanoid league forum. The following members of the technical committee for 2023 were responsible for crating the first version of the rules for the virtual Humanoid RoboCup league: Reinaldo Bianchi, Reinhard Gerndt, Jasper Güldenstein, Maike Paetzel-Prüsmann, Alessandra Rossi and Sebastian Stelter. Special thanks go to Martin Friedmann, Sebastian Mielke and Timon Giese for the contribution of several figures and to Philipp Allgeuer for his contributions to the 2019 version of the rules. We thank the authors of the original design and schematics of the center of mass measurement device described in the appendix.

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Section III

Rules for RoboCup Humanoid League Technical Challenges (physical competition only)

1595   The technical challenges consist of the following individual challenges:

- Part A: Push Recovery (AdultSize)

- Part B: Collaborative Localization (KidSize)

- Part C: Goal Kick from Moving Ball

- Part D: Parkour

1600   - Part E: High Kick

Only the robots that passed the robot inspection are allowed to participate in the technical challenges. At any point, two robots are considered active during the technical challenges. One player can be substituted by another player of the same team. No hardware modifications of the robots are allowed for the Technical Challenge (i.e., a robot cannot be modified from the configuration it had in the soccer games).

1605   The team scheduled for the Technical Challenge must have access to the field five minutes prior to the scheduled starting time. The referee will give the start signal at the scheduled time.

Method of scoring

1610   The Technical Challenge consists of four parts: B, C, D and E for KidSize and A, C, D and E for AdultSize. Each of the parts can be attempted multiple times, in any order. The team might terminate a trial at any time, in order to reattempt the same part or switch to another part of the challenge. A trial terminates automatically when 25 minutes elapsed after the referee gave the start signal. This concludes the Technical Challenge for the team. The time is taken for each of the trials, if completed successfully. Ranking in the individual challenges is determined according 1615   to the rules defined for each individual challenge. For each part, the highest ranked fully successful team receives 10 points. The second fully successful team receives 7 points. The third fully successful team receives 5 points. All other teams who were fully successful in this part of the challenge receive 3 points. In case a team with only partial success has been ranked first, second or third in a challenge, they receive 5, 3 or 2 points respectively. Teams with only a partial success ranked fourth or lower do not receive any points.

1620   ### Robot Handlers During the Technical Challenge

During an ongoing trial of a technical challenge the robot handler is not allowed to interact with the robot's sensors in any way. In the moment the handler either touches the robot or interacts with the robot in any way, the trial is 1625   finished and counted as unsuccessful.

- In KidSize robot handlers are not allowed to enter the field vicinity of the robot during a trial, unless the referee asks them to remove a robot.

- In AdultSize one robot handler is permitted to stay on the field near the robot during a trial.

Part A: Push Recovery (AdultSize only)

The goal of the push recovery challenge is to withstand a strong push while walking.

Cushioned plastic bottles partially filled with sand (or similar) will be suspended on a rope of fixed length, and swung into the robot as a pendulum to apply the push. Bottles of mass 3 kg, 5 kg and 10 kg will be available, where the default mass to use will be 3 kg in AdultSize. If a robot completes a fully successful trial with the default mass for its size class, then a larger bottle may be used in further trials.

The length of the rope L (between 1.5 and 2 meters, measured from the point of attachment to the centre of mass of the bottle) will remain fixed for all trials of a particular size class. The rope is attached to a frame of adjustable height, which is used to adjust the centre of mass of the bottle at the moment of impact to be as close as possible to the height of the centre of mass of the robot. Where this is not possible, the centre of mass of the bottle should strike a solid part of the centre of the hips of the robot. For this and other purposes, the centre of mass of the bottle should be clearly marked.

Each trial consists of three pushes—a push from the front, a push from the back, and a push from either the front or the back, in any order. To apply a push, the bottle is released from a particular position, and allowed to swing into the robot in such a way that the impact occurs when the rope is vertical. The amount of retraction of the bottle is measured by the ground projected distance D from the centre of mass of the bottle, to the attachment point of the rope. Before each trial (set of three pushes), the team must declare what value of D should be used (limited to $0.75L$ for practical implementation concerns). A push is successfully absorbed if after receiving the push the robot returns to a stable walking cycle, as perceived by the referee. The robot must be walking in place (with a normal step frequency) both before the push, and after it has stabilised itself again.

For a complete trial to be fully successful, the robot needs to successfully absorb all three pushes. For a trial to be partially successful, the robot needs to successfully absorb two of the three pushes. The robots are ranked by the following metric (higher is better):

$$M = \frac{\sqrt{H}}{h_c} \cdot \frac{m_B}{m_R} \cdot \frac{h_i}{h_c}$$

where we have the following:

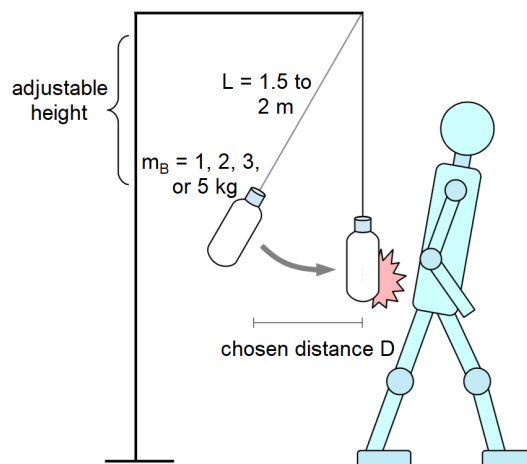|			
M	Ranking metric	H	Vertical height fallen by the bottle $= L - \sqrt{L^2 - D^2}$
m_B	Mass of the bottle	h_i	Height of the centre of mass of the bottle at impact
m_R	Mass of the robot	h_c	Height of the centre of mass of the robot

Figure 5: Setup for the push recovery challenge.

Part B: Collaborative Localization (KidSize only)

The goal of the collaborative localization challenge is to have a robot without a working vision system (R_K) to kick a ball into the goal with the help of another robot (R_H), which is able to see the ball and guide R_K in this task. Results of the technical challenge are based on a batch of three runs.

Run Setup

The initial setup of a run is as follows:

1. The vision-less robot R_K is placed inside the centre circle by the team taking the technical challenge.

2. The helper robot R_H is placed anywhere inside the field by the team taking the technical challenge.

3. The ball is placed roughly on the segment parallel to the goal line passing through the penalty mark, between the two goal posts, by the referee, after the two robots were positioned (Fig. 6).

4. The referee blows the whistle to start the run.

5. Teams may start the robots manually by pressing a button when the run starts. But robots must not be touched after the referee blew the whistle.

6. A chronometer is started when the referee blows the whistle.

Run evaluation

The chronometer is stopped when the run ends. The causes for the end of a run and the possible results are as following:

- *Failure*

  - The ball has not been touched by R_K after 2 minute.
  - The ball is touched by the helper robot R_H, at any moment.

- *Partial success*

  - The ball was kicked by R_K but leaves the field without scoring a goal.
  - The ball was kicked by R_K, stopped rolling inside of the field, and has not been touched again by R_K after 2 minute.

- *Success*

  - The ball was kicked by R_K and a goal was scored.

Trials and ranking

A trial consists of three different runs.
During a run both robots R_K and R_H can move, but if the ball is touched by R_H the run ends in Failure.
A trial is considered as successful if at least 2 runs from the batch resulted in *Success*. A trial is considered as partially successful if at least 2 runs resulted in *Success* or *Partial success*.
The teams are ranked according to the following criteria on their best batch:

1. Number of *Success*.

2. Number of *Partial success*.

3. Average time for *Success* runs.

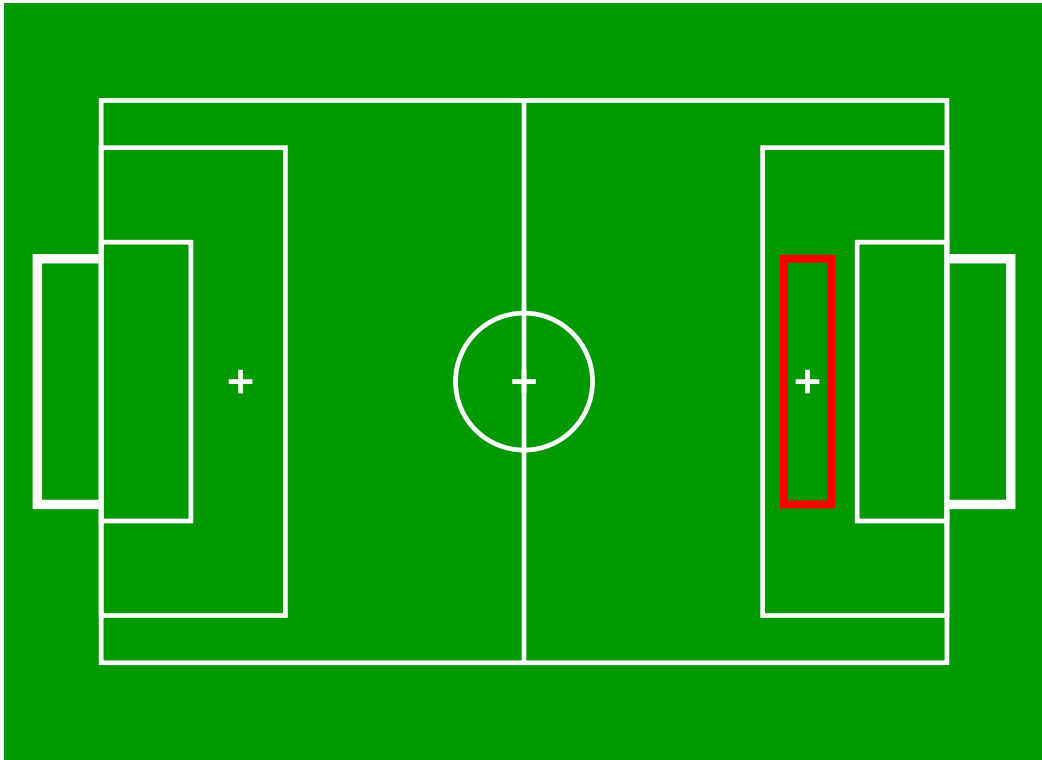4. Average shortest distance of the ball to the goal line for *Partial success* runs.

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Figure 6: Ball initial location for the collaborative localization challenge.

Part C: Goal-Kick from Moving Ball

The goal of the goal-kick from a moving ball challenge is to kick a moving ball into the goal. Results of the technical challenge are based on a batch of three runs.
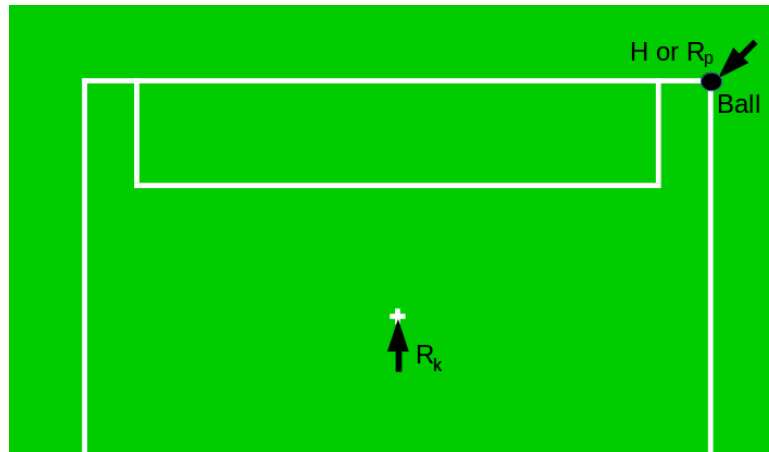
Run Setup

Figure 7: Setup for the moving ball challenge.

The initial setup of a run is presented in Fig. 7, procedure is as follows:

1. The ball is placed on one corner of the field as chosen by the team taking the technical challenge.

2. The robot R_K is placed on the penalty mark.

3. The pass of the ball may either be performed by a human member from the team H or another robot, R_P. If the pass is performed by a robot, the team may place R_P after the referee has placed the ball. R_p can be placed anywhere on the field, at least 1m away from the ball.

4. The referee blows the whistle to start the run.

5. Teams may start the robot R_P manually by pressing a button when the run starts. But R_K must not be touched after the referee blew the whistle. If the pass is performed by a human, then the human is not allowed to wait before kicking. Once the whistle is blown the human as 2 seconds to kick the ball, otherwise the run is retaken.

6. A chronometer is started when R_P or H kicks the ball.

Run evaluation

The chronometer is stopped when the run ends. The causes for the end of a run and the possible results are as following:

- *Failure*

  – The ball has been touched twice by R_P, H or R_K.
  – R_k executed the kick motion but failed to kick the ball.
  – The ball was kicked by R_k but leaves the field without scoring a goal.

- *Retake*

  – The ball stops rolling or leaves the field before R_k attempted to kick.

  – The ball *bounces* on R_k rather than being kicked by R_k and R_k did not try to execute the kick motion before.
  – The pass is performed by a human and the human did not kick 2 seconds after the whistle was blown.

- *Partial success*

  - Ball was kicked by R_k but stopped rolling inside of the field.

- *Success*

  - Ball was kicked by R_k and a goal was scored.

Trials and ranking

A trial consists of three different runs, each run ending with a *Retake* is restarted and do not count. A trial is considered as successful if at least 2 runs from the batch resulted in *Success*. A trial is considered as partially successful if at least 2 runs resulted in *Success* or *Partial success*.

The teams are ranked according to the following criteria on their best batch:

1. Number of *Success* where the pass of the ball was executed by a robot

2. Number of *Success* where the pass of the ball was executed by a human

3. Number of *Partial success* where the pass of the ball was executed by a robot

4. Number of *Partial success* where the pass of the ball was executed by a human

5. Average time for *Success* runs, from first touch by R_p or H until goal is scored

6. Average shortest distance to the goal line for *Partial success* runs

Part D: Parkour

The goal of the Parkour TC is to have a robot going up one platform, staying on top of it, and going down without falling on the ground.

The minimum height must be at least $1/5^{th}$ of the robot height and must be a multiple of 5 cm.

The robot can touch the platform with its limbs (arms and legs), but no other part of the robot is allowed to touch it.

The platform will have an area of approximately 60 × 60 cm.

Run Setup

The initial setup of a run is as follows:

1. The robot is placed in front of the platform as high as chosen by the team taking the technical challenge.

2. The referee blows the whistle to start the run.

3. Teams may start the robot manually by pressing a button when the run starts. But the robot must not be touched after the referee blew the whistle.

4. A chronometer is started when the referee blows the whistle.

Run evaluation

The chronometer is stopped when the run ends. The causes for the end of a run and the possible results are as following:

- *Failure*

    - The robot is not able to go up the platform.
    - The robot falls without going up the platform.
    - The robot touches the platform with a part of the body that is not a limb.

- *Partial success*

    - The robot is able to go up the platform, with both the feet touching thread (the top of the platform), but falls before being able to go down.
    - The robot is able to go up the platform, with both the feet touching thread (the top of the platform), and, to prevent the robot from falling, a human handler touches the robot at this moment.

- *Success*

    - The robot goes up and down the platform, without falling, and stays up, without moving, for 5 seconds.

Trials and ranking

Teams are ranked based on their best 2 consecutive results.

A trial is considered as successful if at least 2 runs in a row resulted in *Success*. A trial is considered as partially successful if at least 2 runs in a row resulted in *Success* or *Partial success*.

The teams are ranked according to the following criteria on their best batch:

1. The maximum height the robot successfully managed to achieve on a *Successful* trial divided by the height of the robot.

2. The maximum height the robot managed to achieve on a *Partially Successful* trial divided by the height of the robot.

3. Average time of a *Successful* trial.

4. Average time of a *Partially Successful* trial.

Part E: High-Kick Challenge

The goal of the high-kick challenge is to kick the ball in the goal at maximum height. At each attempt, the team announces the minimum height their robot tries to achieve. The minimum height must be at least 2/3rd of the ball's diameter and must be a multiple of 1cm.

The ball is then placed on the penalty mark and the team may position the robot freely but at least 30cm away from the ball. After the start signal, the robot may move the ball to any position before attempting a kick from the ground. Only kicks count that score a goal of at least the minimum height. The trial ends unsuccessfully when the ball leaves the field, or when the robot touches the goal obstacle or the ball touches the front of the goal obstacle.

The robots are ranked by the maximum height they successfully managed to kick the ball into the goal.

Part F: Obstacle Navigation Challenge
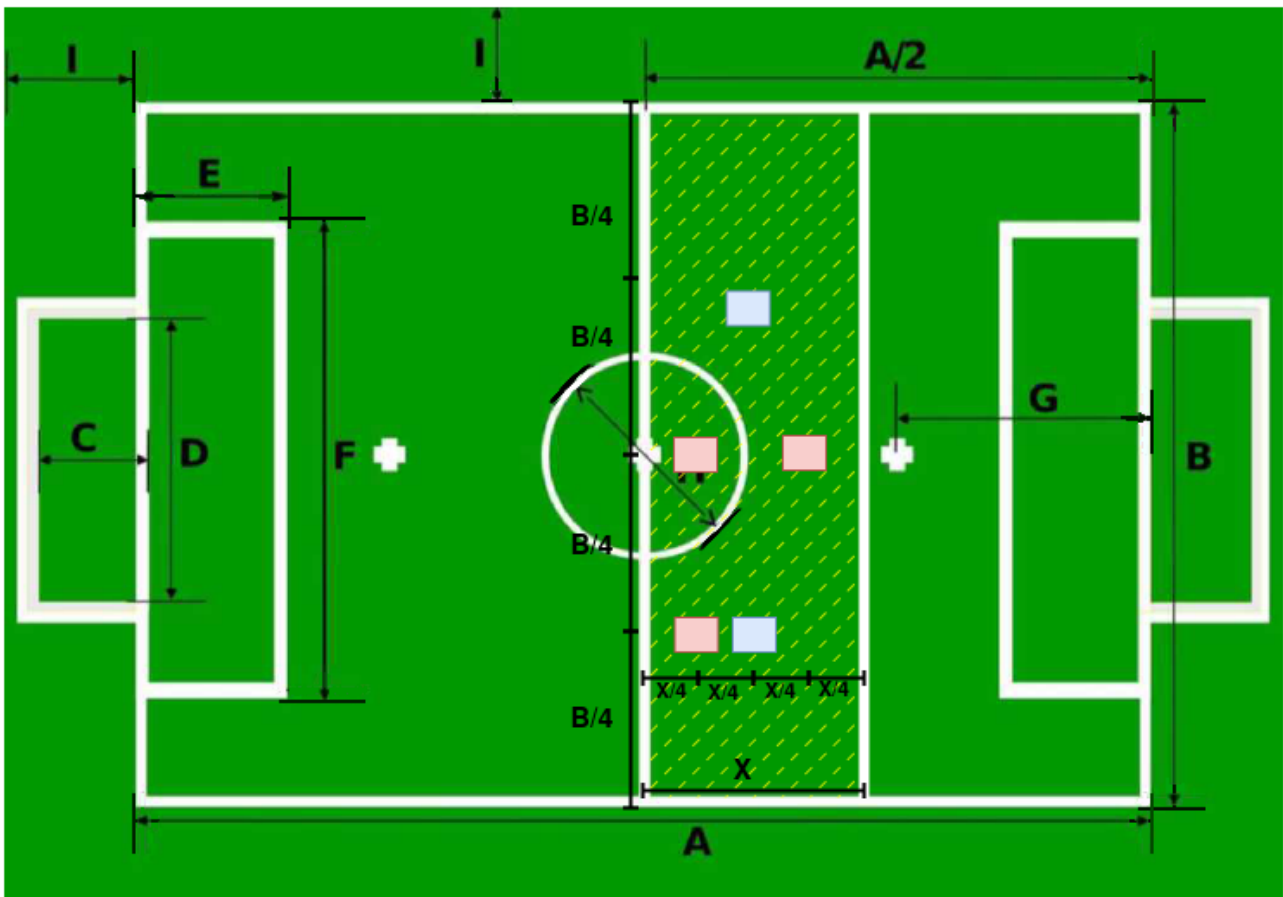
Figure 8: Setup for the Obstacle Navigation Challenge

The goal of the Obstacle Navigation Challenge is demonstrate robots' ability to avoid collision with obstacles.

Setup

Figure 8 shows the setup of the challenge.
A section of the field (marked dashed in yellow) is partitioned of using white tape.
The width of the field strip X is 1.5m for KidSize and 3m for AdultSize. The length of the field strip B is defined by the field sizes of KidSize and AdultSize.
Five obstacles are placed on the field. The obstacles are blue or red as specified by the team colors. Their height is 0.4m for KidSize and 1m for AdultSize. Their width is 0.4m for KidSize and 0.6m for AdultSize.
Nine locations are possible for obstacle placement at increments of $\frac{1}{4}$ X and B respectively. Not more than two obstacles shall be placed next to each other (i.e. at the same $\frac{1}{4}$ increment of B) to allow the robot to pass. The placement and color of obstacles shall be randomized for each attempt using for example the roll of a dice and/or a coin flip.

Execution

1. The robot is placed on the side line of the field (marked as A in Figure 8) in the middle of the field strip.

2. Teams may start the robot manually by pressing a button.

3. A chronometer is started when the robot starts moving (including head movements).

4. The run stops when the robot fully exits the field strip, reaches the opposite side. The team may abort the run.

5. The chronometer is stopped when the robot touches the sideline on the opposite side of the field.

Evaluation

- Failure

  - The robot fully exits the field strip
  - The robot knocks over an obstacle

- Partial success

  - The robot partially exits the field strip or touches an obstacle but touches the sideline on the opposite side of the field.

- Success

  - The robot touches the sideline on the opposite side of the field and does not touch any obstacles and does not partially or fully exit the field strip.

Ranking
Teams are ranked on their best run according to the following criteria:

1. Duration of a *Successful* run

2. Duration of a *Partially Successful* run

Part G: Software Challenge

In addition to the technical challenges, a software challenge is conducted to allow teams to present their recent research.

Participating teams have to create a poster (A3 or A2), and prepare a short 5 minutes oral presentation which additionally explains and shows the idea and results of this approach. If there is a monitor on site, it can be used for
the presentation. However, this depends on the location and the teams should be prepared to give their presentation only with their poster if necessary.

Teams are encouraged to publish the code for their approach to enable a fast progress in the league. However, only the top 3 ranked teams are required to publish their code with instructions within one month after the competition.

Scoring

The winner will be decided by a vote among the team leaders using the Condorcet method[14]. Each participating team will vote for their top teams in order (excluding themselves). Teams are encouraged to evaluate the presentations based on the following criteria:

- Novelty

- Benefit to the league

- Documentation

- Ease of transfer to other teams

At a time decided by the designated referee, within one hour of the last demonstration if not otherwise specified, the captain of each team will submit the team's rankings by filling out a form. Any points awarded by a team to itself will be disregarded. The points awarded by the teams will be summed and thus form the score of this challenge
which is then converted according to the formula described in the beginning of this section.

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[14]https://en.wikipedia.org/wiki/Condorcet_method

Appendix

Additional Material

Center of mass measurement

This sections presents the official procedure to measure H_{COM}, the height of the center of mass of the robot used in Law 4. It also provides instructions on how to build the measuring device used in the procedure.

Construction of the measuring device

The dimensions of the device are different for KidSize and AdultSize. In this section, H_{max} denotes the maximum height allowed for the according league (see Law 4). W denotes the width of the measuring device (60cm for KidSize, 115cm for AdultSize).

The required materials are:

- 1 measuring tape of length H_{max}

- An aluminium plate ($H_{max} + 5cm$ by $W - 6cm$)

- A wooden board - Plywood with:

    - Length: $H_{max} + 20cm$ for KidSize, $H_{max} + 40cm$ for AdultSize
    - Width: W
    - Thickness: $1.5cm$ for KidSize, $3cm$ for AdultSize

- Two acrylic plates with: the same length as the wooden board, $3cm$ width and 2-3mm thickness.

- 4 Aluminium pipe straps of same size

Steps for building the measuring device

1. Glue two acrylic plate on each side of the wooden board as shown in Fig 9a.

2. Draw a white line on the middle of the board, over the acrylic plates.

3. Screw 4 aluminimum pipe straps at the back-middle of the wooden board, aligning horizontally as shown in Fig 9b. This is to determine whether the robot weight is balanced.

4. Bend 4cm of the aluminimum plate to 90 degrees and tape the H_{max} measuring tape as shown in Fig 9c.

Measuring the center of mass

1. Place the robot flat onto the aluminium plate holding, touching the bottom of the bended aluminium plate.

2. Ensure that the robot is in an upright pose[15] as shown in Fig 10a.

3. Align the metal frame holding with the wooden board as shown in Fig 10b.

4. Slowly, slide the aluminium plate to towards the other end until the wooden board is balanced as shown in Fig 10c.

5. Record the reading shown by the white line in the middle of the wooden board pointing to the measuring tape, as shown in Fig 10d.
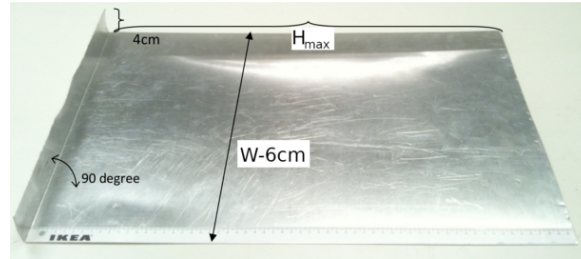
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[15]see Fig 3, in Law 4
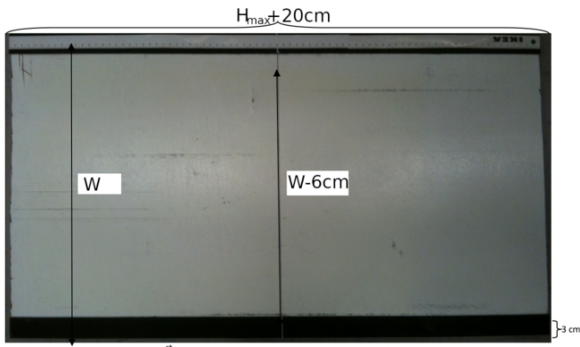
(a) Gluing two acrylic plates on the wooden board

(b) Aligning pipe straps on the wooden board
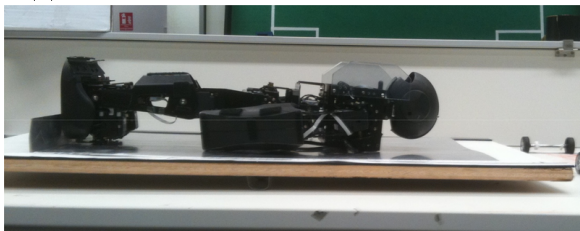

(c) Bending the aluminimum plate

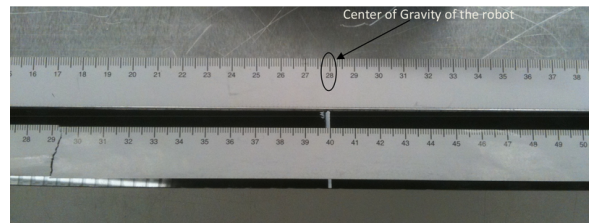Figure 9: Building the measuring device for H_{COM}

(a) Laying robot upright on measurement device.

(b) Aligning metal frame holding with wooden board.

(c) Balancing the wooden board by sliding the aluminium plate.

(d) Reading H_{COM} on the device

Figure 10: Procedure for measuring H_{COM}

The parkour technical challenge is composed of piled platforms.
The minimum height is 1/5th of the robot's height. The main platform's height is 5 cm, and it has an area of 60x60
1875 cm. When the platforms are stacked, they form a stack with resultant height of a multiple of 5cm.
This document provides two different options to build the piled platforms and presents technical drawings using a 3D
grass model. [16]

Materials

1880

- 2 wooden platforms [dimensions 60 x 60 x 5 cm] (see Figure 11)

- 3 squares of turf[17] [dimensions 60 x 60 cm] (2 square as backup)

- Option 1:

  - 28 L-shape wooden supports [dimensions 20x20x7 cm and height 5 cm] (see Figure 12a)
1885 - 48 wooden dowels[18] [dimensions 6 mm x 40 mm]

- Option 2:

  - 14 straight wooden supports [dimension around 40x7 cm and height 5 cm] (see Figure 12b)
  - 12 wooden dowels[19] [dimensions 6 mm x 40 mm]

- 4 hook-and-loop fasteners for one platform and the turf, for a total of 8 hook-and-loop fasteners (see Figure 11)

1890 - 2 hook-and-loop fasteners [dimension around 30 x 7.5 cm]
  - 2 hook-and-loop fasteners [dimension around 40 x 7.5 cm]
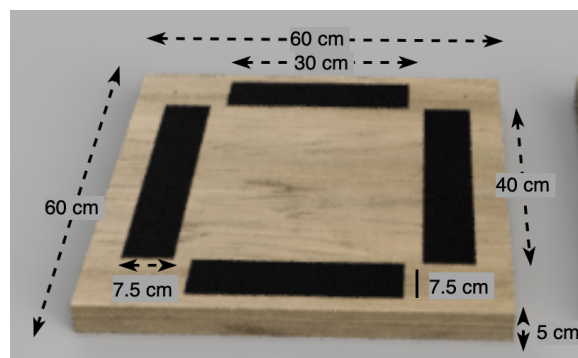

Figure 11: Top of the Parkour platform with hook-and-loop fasteners.

Common instructions

1895 The top of the top platform is covered with turf (see Figure 13a) The turf is attachable and detachable using hook-
and-loop fasteners (double adhesive velcro tape - one side attached to the platform, one side attached to the back
of the turf piece).
To increase the height of the platform, add the 4 wooden dowels (see Figure 13b) in the holes on the top surface of
the platform and add the external supports. Holes in the platform should be 2 cm deep.

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[16] From: https://www.cgtrader.com/free-3d-models/plant/grass/green-lawn-8d4341d7-6281-40e9-8872-d429512a3b3b.
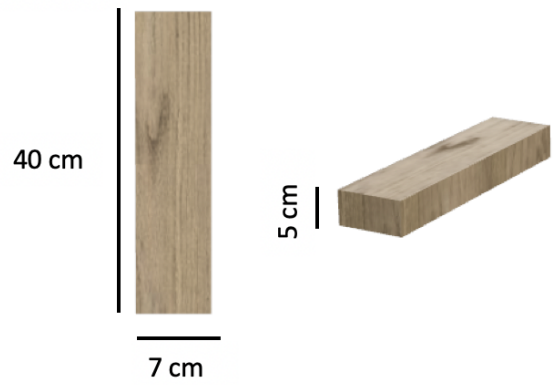[17] Same turf used for games fields
[18] Having extra wooden dowels as spare is recommendable in case they break
[19] Having extra wooden dowels as spare is recommendable in case they break
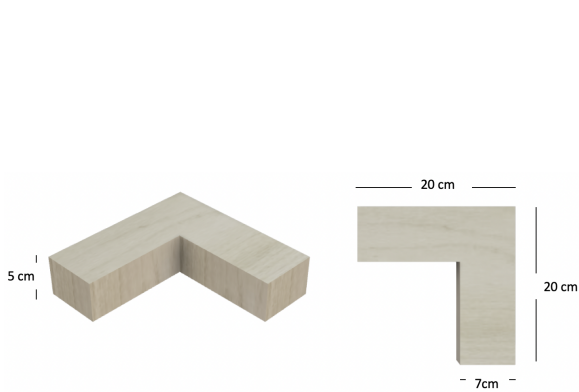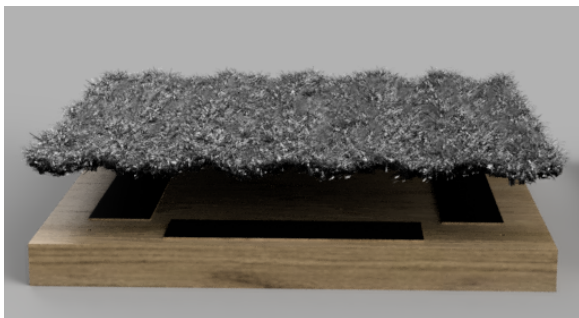
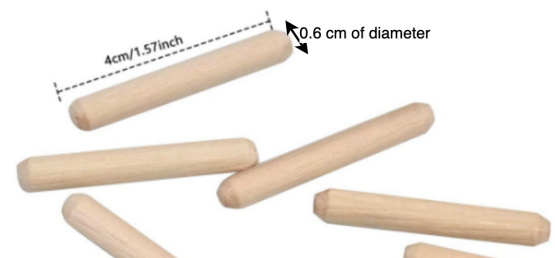(a) L-shape wooden support.

(b) Straight wooden support.

Figure 12: Different support options for the Parkour platform.

(a) Platform with turf on top.

(b) Wooden dowels.

Figure 13: Common assembly parts for both options.

Option 1: increase the height of the platform with L-shape wooden supports

4 L-shape wooden supports are fixed on the 4 corners of the lower platform to increase the height (see Figure 14a). Each L-shape wooden support needs to fixed on the wooden platforms lower and upper with the wooden dowels to be stable (see Figure 14b).

Option 2: increase the height of the platform with straight wooden supports

2 wooden supports are fixed on two sides of the lower platform to increase the height (see Figure 15a). Each wooden support needs to fixed on the wooden lower and top platforms with the wooden dowels to be stable (see Figure 15b).

(a) Lower platform with Option 1 L-shape wooden supports for increasing height.
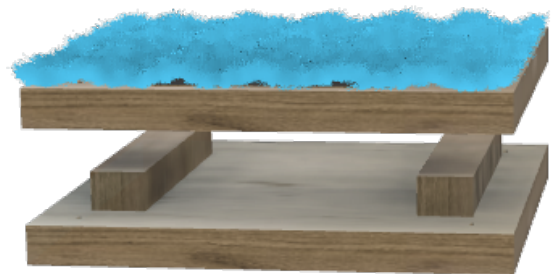

(b) Lower and upper platform with Option 1 L-shape wooden supports for increasing height.

Figure 14: Option 1: using L-shape wooden supports.

(a) Lower platform with Option 2 straight wooden supports for increasing height.

(b) Lower and upper platform with Option 2 straight wooden supports for increasing height.

Figure 15: Option 2: using straight wooden supports.