

HUMANOID ROBOT RACING RULES

***** NEW VERSION for 2016 - Read all sections carefully *****

Version 2.0 – January, 2016

1. INTRODUCTION

Humanoid robots attract interest from public and researchers around the world. However, coordination and fluidity of movement, while keeping balance to accomplish a given task, is still an open challenge for the humanoids.

In 2012, the IEEE RAS Latin American Robotic Council introduces a new robot competition category, with the purpose to develop humanoid robot coordination. The competition is called Humanoid Robot Racing – IEEE HRR.

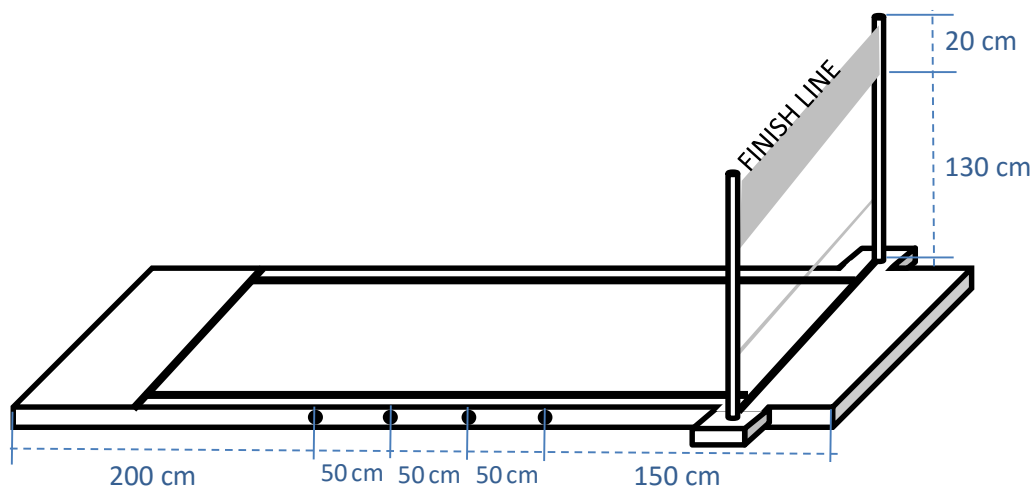
2. THE MAIN GOAL

Each IEEE robotics competition has a specific goal that leads the technology and scientific advances toward better robots for humans and for the world. The main goal of HRR competition is to motivate researches to develop and enhance the walking and running movements of a bipedal robot in order to develop best humanoid robot for human interactions in the future.

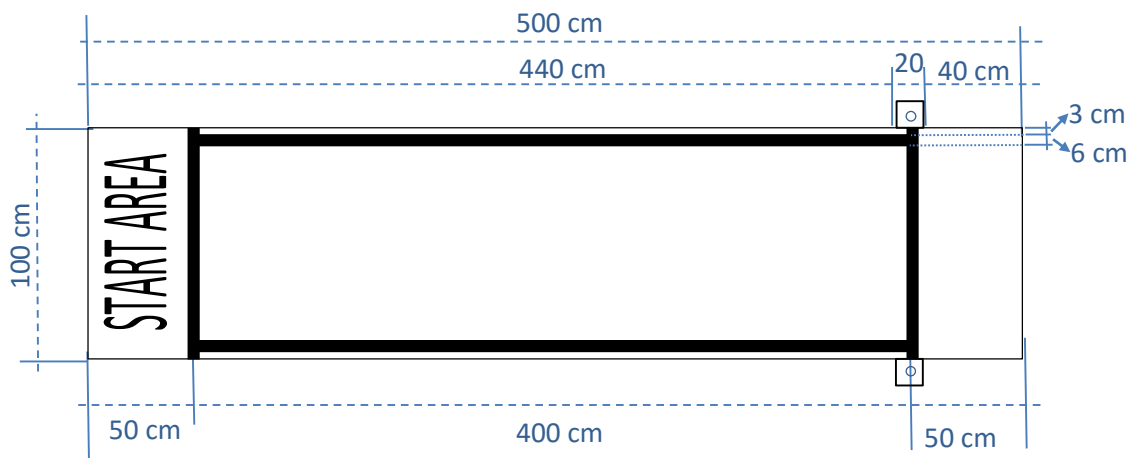
3. THE ARENA

The IEEE HRR competition takes place in a rectangular arena of 5.0 x 1.0 meters, as sketched in Figure below. The floor of the arena must be made of MDF, or equivalent material, with 15mm thickness and painted of matte white color. It must be seated on a flat, plain and even surface. Adjusting shims may be used, if necessary.

The arena must be marked with black stripes of approximately 6 cm width (3M® insulating tape, 3 x 19mm thickness) on the borders distant 3cm from the edge of the arena. It also contains a 20 cm wide finishing line tape positioned at 130 cm height. Details of the placement are depicted on the drawing in Figure below.

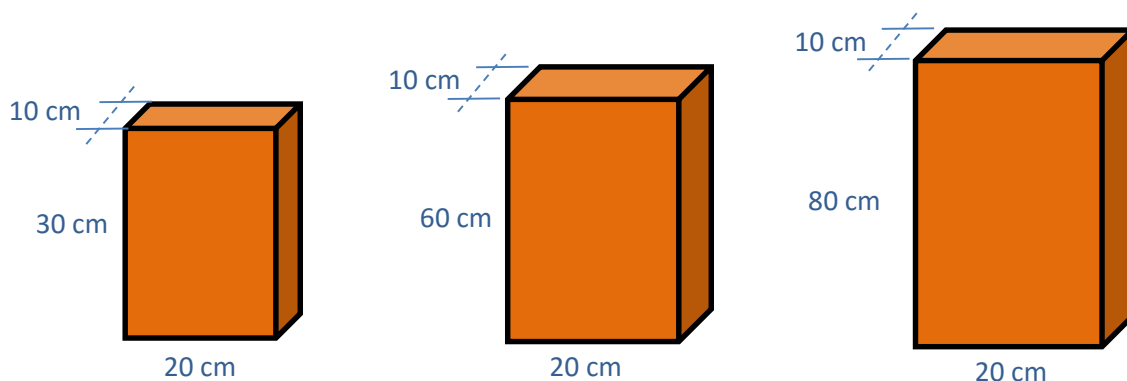


The rectangular MDF must have 4 holes for wooden dowel of 3,5mm of diameter on both sides. Wooden dowel is also called *cavilha* in Portuguese language and *perno de madeira* in Spanish.

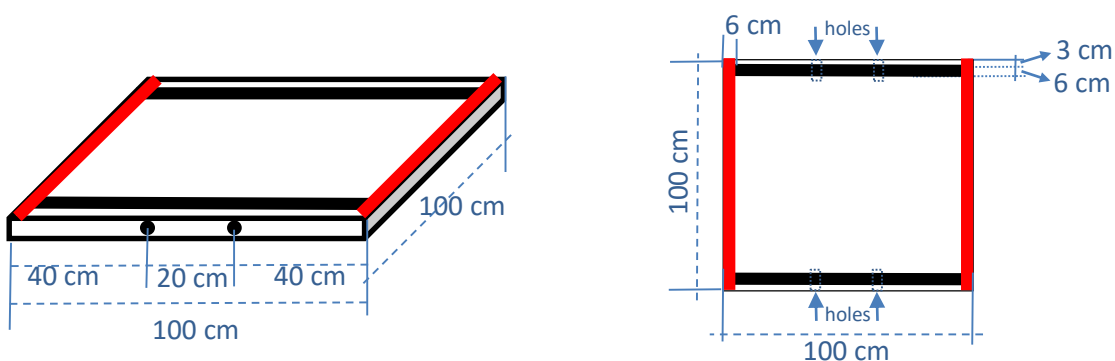


From 2016, the arena will have some challenges that require some extra pieces:

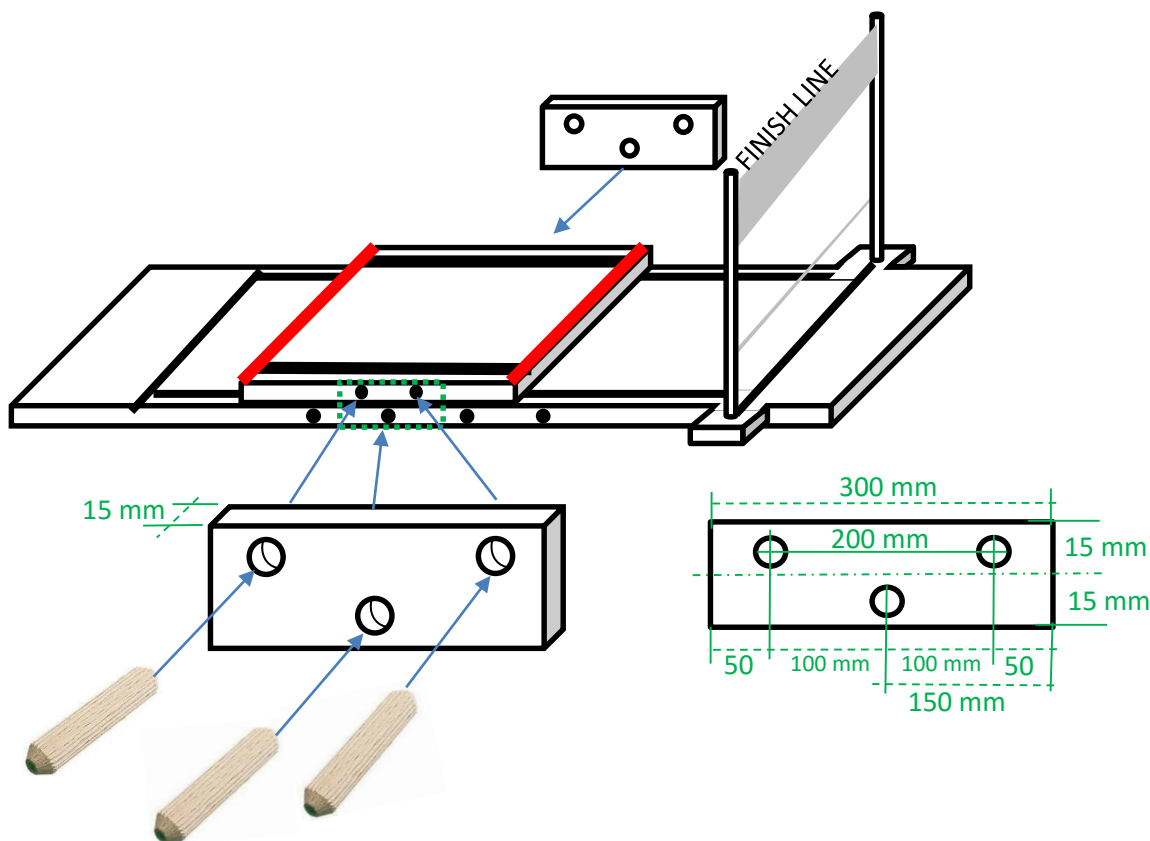
The first 3 (three) pieces are orange towers made of colored hard paper, or made by colored/painted of hollow wood, with 3 different heights and dimensions of 20cm x 10cm. The complete definitions of the towers are:



Another piece is a square of MDF or equivalent material, 100 cm x 100 cm with 15mm thickness and painted of matte white color. The square must be marked with black stripes of approximately 6 cm width (3M® insulating tape, 3 x 19mm thickness) on two opposite borders distant 3cm from the edge of the square and two red lines with approximately 6 cm without distance from the border on the others two sides of the square. There are 2 holes for wooden dowels on both the sides of black tapes.



This extra piece of wood in square form will be used as an obstacle over the running arena in the extra challenge. The piece can be positioned on the arena like the figure below:



2 (two) pieces of wood (MDF) with height equal of two thickness of MDF with 3 holes must be used to lock the square piece with arena in four position.

4. THE ROBOTS

Robots must have humanoid-like body plan. They must consist of two legs, two arms, and one head, attached to a torso. The robot must be able to stand upright on its feet and to walk on its legs. Every action or movement of the robot and its rotating joints must be kinematically equivalent to human being movements, i.e., they must rotate in the same directions and within same angles of their equivalent movements in ANY human being.

4.1. MOVEMENT

There is no restrictions of how the robot will move to complete the task. It means that the robot can move along the arena by walking and running on its feet, it can also run/walk forward, backward or side, it can crawl or rolling in the floor, in order to complete the task. However, the robot must act and perform movement that ANY human being can also do.

It is important to mention that any movement of the robot must be performed by motors in the joints. Obviously, wheels, wings, air compression, active magnetic fields or any kind of movement not presented in human being (or at least not proven to exist so far.... like Jedi's Force), are not allowed.

4.2. DIMENSIONS

There is only one category of robots. The minimum height size (H_{total}) of the robot is 25 cm and the maximum is 140 cm height. H_{total} is defined as the height of the robot when standing upright (with fully extended knees, cf. Fig. 1 below).

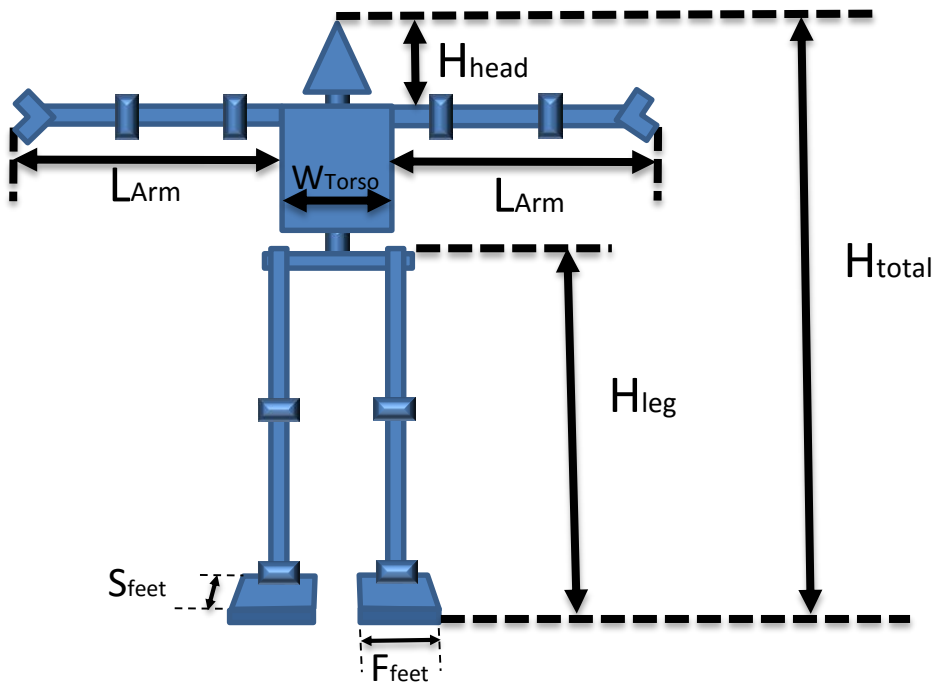


Figure 1 – Measurements of the humanoid robot for IEEE HRR competition

Considering the measures presented in Figure 1, the following size restrictions to all robots participating in the HRR applies:

- 1) $2 L_{ARM} + W_{TORSO} \leq 1.5 H_{TOTAL}$
- 2) $0.35 H_{TOTAL} \leq H_{LEG} \leq 0.7 H_{TOTAL}$
- 3) $0.05 H_{TOTAL} \leq H_{HEAD} \leq 0.25 H_{TOTAL}$
- 4) $F_{FEET} / S_{FEET} \leq 2.5$ ou $S_{FEET} / F_{FEET} \leq 2.5$ (longest size / short size ≤ 2.5)
- 5) Foot must be fit into a rectangle of area: $Foot \leq (0.45 H_{LEG})^2$

where :

- Both arms must be the same length.
- 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 most forward part of the robot must be its feet.

4.3. SENSORS

For robot sensors, two types are considered:

EXTERNAL SENSORS – Sensors that measure external state (e.g. sound, light). Examples of external sensors are bumpers (touch), laser pulses, cameras, microphones, ultrasound, infrared, hearing, taste, GPS, external temperature and any other sensor that collects data from the environment.

INTERNAL SENSORS - Sensors that measure internal states of the robot (e.g. posture, pitch, etc). Examples of internal sensors are balance, accelerations, internal temperature, encoders, voltage, currents, internal forces (joints), compass and other sensors that collect data from the posture or internal state of the robot.

There is no restriction to sensors' types or quantities being used in a robot, except for cameras, which are limited to a stereo vision only (i.e., max. 2 cameras with an overlap). Monocular vision is also allowed. Only cameras (max. of two) must be placed in the Head of the robot. The other sensors, external or internal, must be placed in any part of the robot.

4.4. GENERAL RESTRICTIONS

Each robot must have the ability of fully independent locomotion, sensing, and processing. That is, all actuators, motors, power, computing, and sensing mechanisms must be incorporated into the robot. It is extremely prohibited any communication with external devices of any kind. No external power supply, teleoperation, remote control, Bluetooth communication, or remote brain of any kind is allowed. In resume, each robot must be fully autonomous and must perform its own control decisions.

A robot must not have in its construction anything that is dangerous to itself, another robot, human operators, or spectators.

5. THE RACE

The race happens with a single robot in the arena at a time, and the time available for the robot to complete the course is limited to **3 minutes**. The robot must start the race positioned entirely within the **START AREA**, behind the black line. No part of the robot, however small, can touch an imaginary wall which is supposed to be on the black line. The referee will notify the team to start the robot. Clock ticking starts when the robot starts to move forward.

If the robot does not move after three (3) referee start notifications, the race is terminated with no movement.

A robot completes the race when, and only when, part of it, however small, touches the **FINISH LINE**. The robot is not required to finish the race on the upright position. It is allowed to jump. If the robot falls, it must return to stand position by itself. During the entirety of the course, if any team member touches the robot, whether it is standing or fallen on the ground, the robot must be repositioned within the **START AREA**, without interruption of the clock.

The winner of the race will be the robot that completed the course in the shortest time. If no robot completes the course on its turn, the winner shall be the robot that reached the farthest position from the **START LINE**. If the team decides to stop the race prematurely, the position where the robot stopped will be considered as its traveled distance and the time elapsed will be considered 3 minutes.

Each robot has **5 (five) trials** in classification phase, or **3 (three) trials** for finals, to race and take official times (called official attempts), with at least 30 minutes interval in between trials. The best result of the robot will be considered for classification purposes and for defining the champions.

6. CHALLENGES

There are two extra challenges for HRR robots this year. The robots must run/walk along the arena with obstacles within two promising challenges.

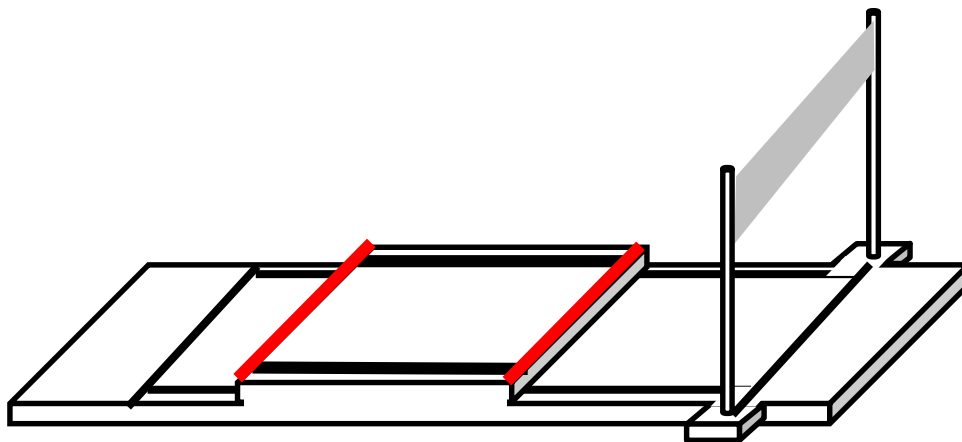


6.1. WATCH YOUR STEP CHALLENGE

This challenge demands the robot to walk through the arena watching its steps avoiding to stumble in slight unevenness in the floor. The square wood will be used and attached to the arena in order to simulate steps of a stairs. Each step is signalized by a red line.

The challenge will take a place in a specific time and day and all robots that want to try this challenge must present themselves at the arena to compete on schedule. For each robot, **3 tries of 5 minutes** each are allowed in order to complete the arena by overcoming the steps. There are 4 possible places where the square wood can be attached. Before each try of a robot, the place where the square wood will be placed must be decided by a random choice.

The arena, for this challenge, will look like the image below.



Each robot that completes the task and reaches the FINISH LINE from the START AREA overcoming the GAPS will receive a CERTIFICATE of WATCH YOUR STEP CHALLENGE COMPLETE.

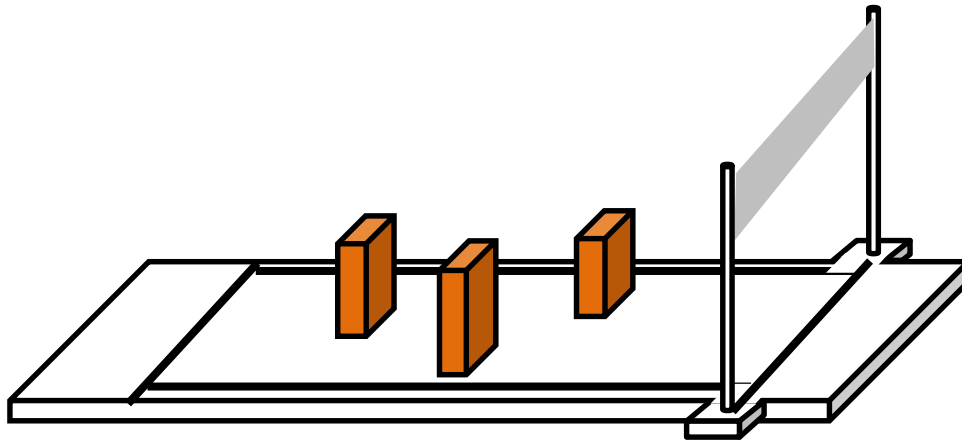


6.2. PAY CLOSE ATTENTION CHALLENGE

This challenge demands the robot to walk through the arena avoiding obstacles of different heights. The ORANGE TOWERS will be placed in random places over the arena and the robots must try to complete the arena by deviating the obstacles without let them fall.

The challenge will take a place in a specific time and day and all robots that want to try this challenge must present themselves at the arena to compete on schedule. For each robot, **3 tries of 5 minutes** each are allowed in order to complete the arena by avoiding touch the obstacles. Before each try of a robot, the obstacles will be placed on the arena randomly.

The arena, for PAY CLOSE ATTENTION CHALLENGE, will look like the image below.



Each robot that completes the task and reaches the FINISH LINE from the START AREA by avoiding collapse all obstacles will receive a CERTIFICATE of PAY CLOSE ATTENTION CHALLENGE COMPLETE.

7. EXTRA PRIZES

Besides the regular prizes, that award the first, second and third places in racing competition, some extra prizes will be given for each robot that reaches some interesting performances during the competition or get itself successful in any given challenge.

Certificates will be provided for each astonishing performance and for each challenge completed. Each robot is allowed to reach top performance and receive one or more of the following CERTIFICATES:

- **HARD TO FAIL PRIZE:** a certificate will be provided for each robot that makes all official attempts to take time in racing competition without fall or lose the arena.
- **BEATING PREVIOUS RECORD:** a certificate for each robot in which its average speed (m/s) is higher than the best average speed obtained by a robot up to the previous year (for this prize, it is considered only the teams from Latin America).
- **BEST NEW RECORD:** for the robot that would receive the BEATING THE RECORD and got the best time in this competition (the champion). This certificate will replace the BEATING THE RECORD certificate for the champion.
- **CHALLENGE COMPLETED:** a certificate for a robot that completes any proposed challenge;
- **GO-and-STOP PRIZE:** a certificate for each robot that STOPS after passing the finish line autonomously in any attempt.
- **MURPHY PRIZE:** for a robot that during the tests and calibration phases completes the arena and successfully reaches the finish line, but when the attempt become official, it fails.
- **LUCKY LOSER PRIZE:** For a robot that fails every time in test phases but surprisingly completes the arena by successfully reaches the finish line only during the official attempt.

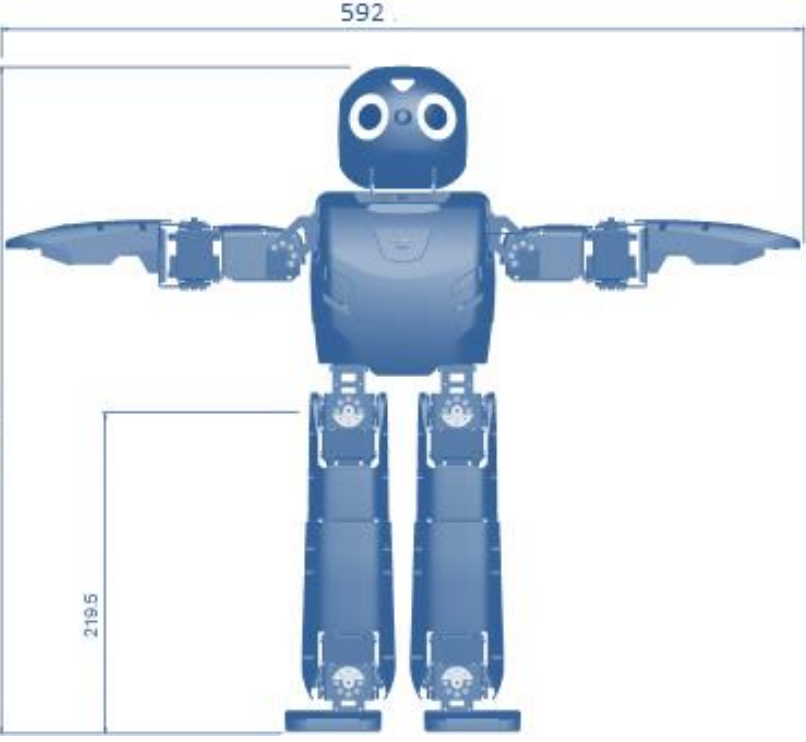
8. PARTICIPATION REQUIREMENTS OF THE HRR COMPETITION

To participate of the Latin American Robotics IEEE HRR competition, teams must be composed of undergraduate students of any educational institution of any country. To register, teams must submit a document describing the development and operation of the robot (TDP), in IEEE format. This TDP will be used by the winner teams to make a brief presentation to the other competitors. Please verify the deadlines on the event's website.

6.1. TEAM DESCRIPTION PAPER (TDP)

Any team is allowed to compete in IEEE HRR competition if a TDP (Team Description paper) is accepted by the organization (chair) of the category. The TDP must follows the rules bellows:

1. Must be in IEEE format (available by the organization)
2. Must have at least 4 pages including REFERENCES.
3. Must have the following table with complete information (example in blue):

ROBOT PICTURE		ROBOT DIMENSIONS			
		Max height	45,45 cm		
		Max width	59,2 cm		
		Max leg	21,95 cm		
		Number of Cameras	2		
		DOF – Degrees of Freedom	20 (6 DOF leg x2+ 3 DOF arm x2 + 2 DOF neck)		
		Skeleton Materials	Plastic and Aluminium		
		Processor / Main Board Specs	1.6 GHz Intel Atom Z530 on-board 4GB		
		Type of Motors / Specs	Dynamixel MX-28		
		INTERNAL SENSORS		EXTERNAL SENSORS	
		Name/type	Function/description	Name/type	Function/description
Compass	For orientation	Stereo Camera	For detection of the arena to run		
Accelerometer	To detect falls	Touch	To detect the contact of feet to the ground		
Encoder	In order to control the arms and legs angles				
Elastic Joint / Impedance	To obtain the force in each joint				
Gyroscope	To control the robot balance				
EMF	To detect any disturb in the Force				

9. EXTRAORDINARY SITUATIONS DURING THE COMPETITION

Any situation not covered under the above mentioned rules, or disputes about score, will be ruled by the referees and organizers of the competition. It is important to mention that any fact that it is not explicit in the rules cannot be automatically considered as allowable in the competition. Missing facts will always be treated as **extraordinary situation** and it must be judged as allowable or not by the organization, always following the main goal of the competition.

10. THE JURI

The JURI will be composed of three members. One of the organizing chairs, one assistant of the event organization and one member chosen among the teams not competing on that particular match, chosen before it starts.

VERSION CONTROL

- v1.0 - Feb 2012 - Launched the first draft of the competition
- v1.1 - March 2012 - Some mistakes and typos corrected
- v2.0 - Jan 2016 - Included restrictions for humanoid shapes; introduced challenges and extra prizes; specified some details for TDP's.

