The *Micro-Rato2008 Contest*

Rules and Technical Specifications for the

Micro-Rato Modality

(2007/11/11)

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1. The Robot

1.1 Dimensions

The robot must fit completely in a box with a 30cm × 30cm base and with a maximum height of 40cm. However, all devices in the robot located above 25cm, when measured from the ground, should be confined to a vertical cylinder with a maximum diameter of 15cm. If the robot has moving parts, all possible configurations of the robot must comply with the herein defined limits.
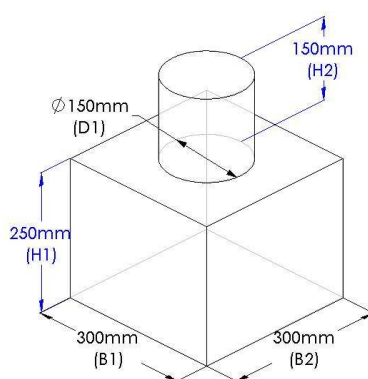
Figure 1 - Maximum dimensions of the robot

1.2 Motors

The locomotion of the robot is based exclusively on electric motors, powered by batteries.

1.3 Autonomy

The robot is a completely autonomous vehicle. All decisions are taken by the embedded electronic circuits, and all energy storage devices are also installed there. Inclusion of radio-frequency and infrared devices aiming the communication between the robot and other electronic devices, external to it, is not allowed.

1.4 Equipment

1.4.1 STOP and START buttons

The robot must include at least two buttons: the STOP button, which must be red, and the START button, which can be of any colour distinct from the previous one. The availability of these minimum set of buttons is mandatory. The robot must remain still until the START button is pressed and should immediately stop in response to any action upon the STOP button. Both buttons will be placed on the top of the robot in such a place that allows an easy access to them both. Other buttons or switches used by teams to control specific functions of the robot should be placed in such a way that no possible confusion

should arise between the late ones and the START/STOP buttons defined in these regulations.

1.4.2 <u>BEACON AREA and END OF TRIAL indicator</u>

The robot must include a special indicator with two distinct functions: signalling the arrival at the BEACON AREA and signalling the END OF TRIAL state. Activation of the BEACON AREA indicator implies the fulfilment (by the robot) of the first goal, while activating the END OF TRIAL indicator marks the completion of the trial. It is mandatory that this indicator is implemented as a red light source which can be easily spotted from at least 3 meters away.

Signalling the arrival at the BEACON AREA and the END OF TRIAL conditions must conform to the following rules:

Arrival at the BEACON AREA is signalled by lighting up the indicator, which must remain lit until the end of trial by the robot;

The END OF TRIAL condition should be signalled by flashing the indicator with a frequency between 1 and 2 Hz.

1.4.3 <u>Reflective band</u>

The robot must include a reflective band placed around it. This reflective band must be white and should surround the robot completely. It must be placed perpendicularly to the ground throughout its complete length. Its minimum height must be 5cm. Its inferior side must be always less than 4cm from the ground while its top side distance to the ground must be always greater than 7cm. The reflective band may include up to a maximum of 6 openings. The total area of these openings may not exceed 35cm^2 and the height of each of them may not be greater than 3cm.

1.4.4 <u>Identification</u>

The robot must display its name through a clearly visible rectangular surface not less than 12x4cm. This surface should be placed between a minimum of 7cm and a maximum of 25cm above the ground, and in such a way that do not obstruct access to the START and STOP buttons.

1.4.5 <u>Security</u>

The robot must include adequate security mechanisms according to its power and mode of locomotion, allowing their detention in situations that may pose danger to people or property. It is the organization responsibility to decide in which of the competing robots the existence of such security mechanisms is mandatory.

2. Field of game
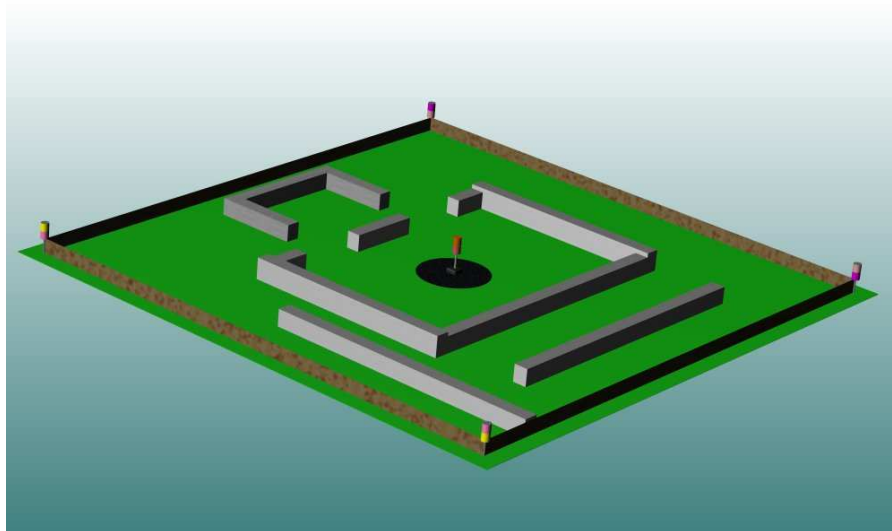
Figure 2-Example of the field of game

2.1 Dimensions

The field of the game is a square with 7,5 x7,5 meters. All shown or given dimensions have an accuracy of + /-10% (unless otherwise specified).

2.2 Floor

The floor of the field of game will be covered by an industrial green carpet (ref. EXPOR, colour 341, fab. Andrade e Ferreira - Ovar) which guarantees a good coefficient of infrared light reflection.

2.3 Walls

The field of game is surrounded by walls 20cm high. The walls are made of wood or equivalent material, with a clear colour, and presenting a good coefficient of reflection for infrared light. The walls are placed upright with a tolerance of + /-5 degrees.

2.4 Corners

One coloured cylindrical marker, with 22cm in height and 11cm in diameter, is placed in each of the four corners of the field of game. These cylinders are placed upright, 20cm above the floor, on top of walls that delimit the field of game. Each cylinder is coloured with two different colours being the border between the two colours the circumference that divides the cylinder at its middle plane. The cylinders are coloured in pink, blue and yellow according to the pattern shown in Figure 3.
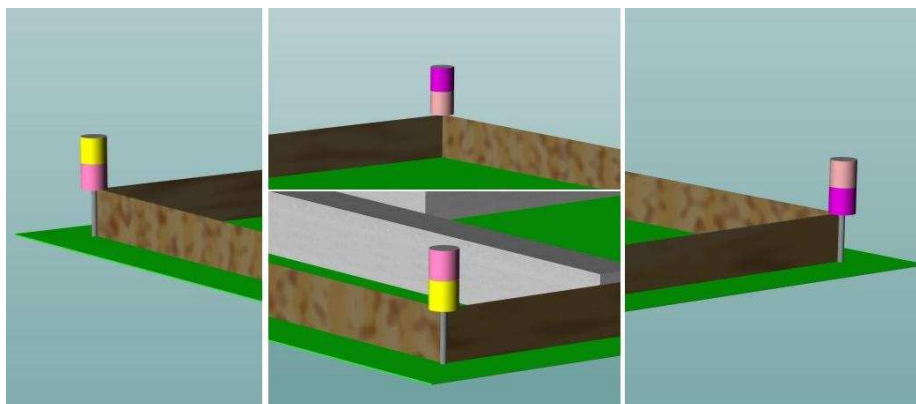
Figure 3: Distribution of the colours yellow, blue and pink in cylinders placed in the corners of the field of game.

2.5 Departure area

For each leg of the competition, an area with 1m x 1m, enough for the placement of four robots, will be defined in the periphery of the field of game. This area is considered to be the DEPARTURE AREA.

2.6 Obstacles

The field of game will include a set of obstacles. The exact position of these obstacles is only revealed at the beginning of the competition and will remain constant throughout each leg. These positions can, however, be changed between legs by decision of the organization or under suggestion of the jury.

2.6.1 Dimensions

Obstacles have different heights, which may vary between 20 and 50cm. The minimum width and/or length of an obstacle is 10cm.

2.6.2 Colours and materials

The obstacles will be made in cardboard coated with non glossy white paper, or equivalent material, presenting a good coefficient of reflection for infrared light.

2.6.3 Layout of obstacles

The minimum distance between two obstacles that are not joined together is 50cm. The same rule applies for distances between obstacles and the external walls.

2.7 Beacon

2.7.1 Beacon Area

The BEACON AREA is identified by a ring in black material, marked on the floor, with a minimum radius of 50cm and a maximum radius of 60cm. This black ring has a low coefficient of reflection for infrared light, which is not necessarily zero. The BEACON is at the centre of this black ring. The BEACON AREA might have different locations in the field of game for different legs of the competition.
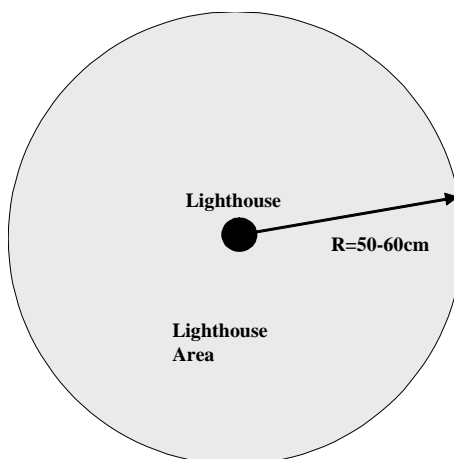
Figure 5- Beacon Area.

2.7.2 <u>Dimensions</u>

The Beacon body is 50cm (+ /-1cm) in height and the Beacon infrared emitters are placed 28cm above the ground. The Beacon is supported on a rectangular base 10cm wide, 15cm in length and 5cm in height. The base of the Beacon is covered to about 10cm in height, measured from the floor, with a good infrared reflective material. Two coloured cylinders with 11cm in diameter and 11cm in height are placed vertically above the beacon infrared light emitters. Their colours are pink and orange, respectively (figure 6).
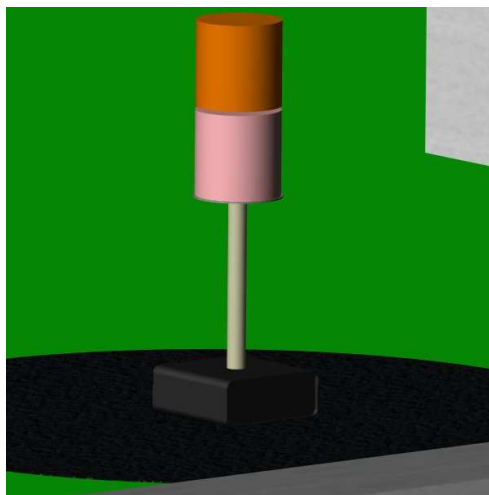
Figure 6-Image of the Beacon.

2.7.3 <u>Radiation</u>

The beacon emits infrared radiation with a wavelength of 940nm. This signal is modulated using 600 Hz on-off keying over a carrier of 40kHz. The "duty-cycle" of the modulating signal (600 Hz) is 30%. A total of 12 leds (MLED 81 or equivalent) are used in this beacon, arranged equidistantly along a circle with 7 cm of outside diameter. These leds are electrically fed in series. The instant supply current of the leds, when active, is 60 mA. (Note: All figures have an accuracy of + / -10%).
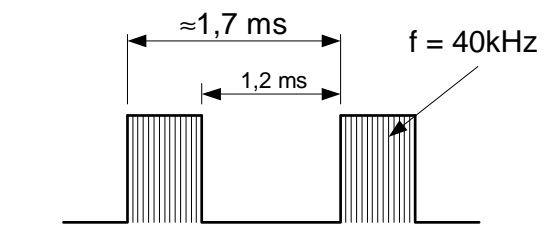
Figure 7- Beacon signal time diagram.

3. Technical verification and certification

All robots must be made available to the Jury of the competition up to a time defined by the organization, so that they can be subject to technical verification and certification regarding their adequacy to the herein defined rules. These technical verification and certification will comprise two distinct components: STATIC technical verification and DYNAMIC technical verification.

3.1 STATIC technical verification

The aim of the static technical verification is to observe and verify the compatibility of all mechanical, electrical, electronic, dimensional and interaction elements of the robot, with the rules set of the competition.

3.2 DYNAMIC technical verification

The dynamic technical verification is targeted at seeing whether the robot displays an appropriate dynamic behaviour, good enough to achieve the objectives of the competition. To that end, the robot should be able to travel along a corridor 50cm wide by 3m long, at the end of which there is a BEACON AREA with its beacon. Some obstacles may be placed along this corridor. The robot must necessarily make that journey in a maximum time of 1 minute, without changing the position of the obstacles and stopping on the BEACON AREA as defined by the rules of competition. The dynamic technical verification also includes a test to the operation of the START and STOP buttons.

3.3 Appeal

Whenever a robot is not certified on either of the verification tests, the team will be informed by the Jury of the reasons that led to its disapproval. In such cases, the team has a moratorium of 30 minutes during which they can rectify the aspect or aspects that have not been previously approved. After this period of time, the robot can be presented a second time to the Jury for technical re-evaluation. Non approval in this re-evaluation will determine the final non-certification of the robot for the competition.

4. The competition

4.1 Goals

The competition has two main goals, which the robots have to meet in sequence. Any attempt to achieve the second goal without having attained the first one will not be considered valid.

4.1.1 First goal (go to BEACON AREA)

The first goal is to go from the DEPARTURE AREA to the BEACON AREA, within the maximum time limit, with as less penalties as possible.

4.1.2 Second goal (return)

Having achieved the first goal, the second goal is to return from the BEACON AREA to as close as possible the DEPARTURE AREA, with a minimum of penalties.

4.1.3 General goal of the competition

The purpose of the robot trial is to achieve the first goal (reach the BEACON AREA) and then meet the second goal (return to the area of DEPARTURE AREA), with a minimum of penalties.

4.1.4 Time limits

The total time limit for each trial is four minutes, while the time limit for achieving the first goal is three minutes.

4.2 Ranking

4.2.1 Compliance with the first goal (go to BEACON AREA)

For purposes of resolving tie classifications, the performance in achieving the first goal is measured by the time spent by the robot from the instant of departure to the properly activation of the BEACON AREA signalling. This time is converted into points by the following formula:

$$1 \text{ point} = 1 \text{ second}$$

4.2.2 Compliance with the second goal (return)

The fulfilment of the second goal is measured by the distance from the DEPARTURE AREA to the point where the robot immobilised itself.

This distance is measured by the shortest path around the obstacles. The resolution of this measurement is 50cm.

Any robot that, after achieving the first goal, stops its motion for more than ten seconds on the BEACON AREA (even if the vertical interception between the robot and black ring is partial), will be given the distance corresponding to the point at which the BEACON AREA is placed in the field of game.

The distance measurement is converted into points by the formula

$$1 \text{ point} = 5 \text{ cm}$$

4.2.3 Trial classification

The classification of robots is established by:

[Points awarded for the second goal] + [Sum of all penalties]

ranked in ascending order.

In the event of a tie, the robot with the lower score in achieving the first goal will be ranked first.

If a tie still remains after the previous rule, the robot with the lower sum of penalties will be ranked first.

4.3 Organization of the competition

The competition is divided into four legs. In each leg the robots compete 3 to 3 or exceptionally 4 to 4. This is an organization decision, based on the number of robots attending the competition. In each leg there will be a draw which will establish the order in which the robots compete.

4.3.1 Robot selection between legs

All robots certified for competition will carry out their trials at the first two legs. At the third leg, only the 12 top robots will compete. After this third leg a fourth and final leg will be disputed between the three robots with better overall classification.

4.3.2 Classification on each of the legs

At the end of the first leg, classification of robots will be established by the scores obtained in this leg.

At the end of the second leg, classification of robots will be established by the sum of the score obtained in this leg and the score obtained in the first leg. For purposes of resolving tie ups the sum of the scores for attaining the first goal will be considered.

At the end of the third leg, the classification of robots will be established by the sum of the score obtained in this leg and the best of scores obtained in the two previous legs. For purposes of resolving tie ups the sum of the score for attaining the first goal on the third leg with the best score for attaining the first goal in the two previous legs will be considered.

In the fourth and final leg, only scores obtained in this leg will be considered.

4.4 Operation

4.4.1 Startup

The robots will be placed entirely within the DEPARTURE AREA, where they should stay still until the start signal is given by the referee. After the start signal is given each robot should be started by an element of each team by pressing the START BUTTON.

The exact position of robots in the DEPARTURE AREA will only be known by the teams when all the robots are ready to start the trial.

4.4.2 Attaining of the first goal

The first goal is attained when the robot enters the BEACON AREA, stops for at least 2 seconds, and, once stopped, activates the BEACON AREA indicator. This signal will only

be valid if it occurs with the robot properly stopped within the BEACON AREA. The BEACON AREA indicator must then remain active until termination.

4.4.3 Termination (attaining the second goal)

The robot ends its trial by stopping its movement, shutting down all emitters and activating the END OF TRIAL indicator. This signal will only be valid if activated after the total arrest of the robot. The termination is considered to be valid only and only if the robot stops its movement and activates the END OF TRIAL indicator in a valid way.

Any stoppage longer than 10 seconds will be considered as an end of trial (termination).

4.4.4 Immobilization of the robot

Movement detentions lasting more than ten seconds are not allowed. A robot that stops for more than 10 seconds is deemed to have finished the trial, whether or not it has activated the END OF TRIAL indicator.

4.5 Abnormal circumstances

4.5.1 Interruption of a trial

The referee may decide to interrupt the trial when he needs to consult the jury. For this purpose the referee should require the suspension of the trial timing and, simultaneously, press the robots STOP buttons. This will be achieved with the support of an organization supporting team. Later on, the robots can be either restarted at the exact place where they have been stopped, or their trial can be terminated in advance.

4.5.2 Restart of a robot

Restarting of a robot after a trial interruption must be made at the place where it was previously stopped. It will be the referee himself, with the help of the supporting team, who will press the START button of the robots, while indicating the chronometer team to restart the counting of time.

4.5.3 Early termination of the trial

The jury can decide to early terminate one or more robots trial, whenever their behaviour so determines and, in particular, in all cases of "hostile behaviour" or "disastrous trial" (see 4.6.13 and 4.6.14). In this case, the trial is terminated for the robots in question. If this happens, these robots are awarded with the maximum time plus the penalties already incurred, including the termination outside regular time. In these circumstances it is up to the jury to decide whether there was serious prejudice for other robots and, if so, decide for the repetition of the trial only for those robots.

4.6 Penalties

4.6.1 Collisions with fixed obstacles without layout change

Collisions against boxes or walls that do not significantly alter their position on the field of game imply a penalty of 11 points.

4.6.2 Collisions with fixed obstacles with a clear layout change

Collisions against boxes or walls that significantly alter their position on the field of game imply a penalty of 100 points.

4.6.3 Collisions between robots

Collisions between robots imply, as in the case of collisions with fixed obstacles, a penalty of 11 points. It is up to the referee to determine which of the robots must bear the responsibility for the collision.

4.6.4 Invalid BEACON AREA signal

Each time the robot activate the BEACON AREA indicator without fulfilling the rules, it will be penalized with 9 points.

4.6.5 Stopping at the BEACON AREA without activating the indicator

Whenever the robot enters the BEACON AREA and stops itself for more than 2 seconds without activating the BEACON AREA indicator, it will be considered that the robot achieved the first goal but a penalty of 7 points will be awarded to it.

4.6.6 Termination without shutting down all IR emitters

Any robot that ends its trial without shutting down all emitters will be seen as exhibiting a hostile attitude. The penalties corresponding to this behaviour will therefore be applied.

4.6.7 Achieving the first goal without entering fully into the BEACON AREA

If, while achieving the first goal, the robot immobilize itself for more than 2 seconds partially within the BEACON AREA (that is, its vertical projection on the floor only partially intercepts the black ring), with or without activation of the BEACON AREA indicator, it will be considered that the robot achieved the first goal but a penalty of 8 points will be awarded to it.

4.6.8 Stopping outside BEACON AREA while pursuing the first goal

If, while pursuing the first goal, the robot immobilizes itself for more than 2 seconds completely outside the BEACON AREA, and even if activates the BEACON AREA signal, it is considered that the robot has not reached the first goal.

4.6.9 Invalid END OF TRIAL indication

Each time the robot activates the END OF TRIAL signal without meeting the rules for this purpose, a penalty of 9 points will be awarded to it.

4.6.10 Completion of trial without activation of the END OF TRIAL signal

A robot that, while trying to achieve the second goal, stops for more than ten seconds without activating the END OF TRIAL signal, is considered to have finished its trial but incurs in a penalty of 21 points.

4.6.11 Not achieving the first goal within the maximum time limit

A robot that does not meet the first goal within the established time limit is given a score of 680 points plus already incurred penalties.

4.6.12 Not achieving the second goal within the maximum time limit

A robot that, having achieved the first goal, does not end its trial within the established maximum time limit is given a score of 540 points plus already incurred penalties.

4.6.13 Hostile behaviour

Any robot behaviour that interferes or deliberately causes harm to other robots beyond the interference caused by the normal coexistence in the field of game is considered to be

hostile behaviour. Examples of this are the non-turnoff of all transmitters after termination, the deliberate and repeated collision with the other robots or the intentionally drop of parts or substances in the field of game. After confirmation by the Jury, the trial of the robot that show hostile behaviour will be terminated in advance. The jury can even decide for the disqualification of the offending robot.

4.6.14 Disastrous trial

In the case of a robot performing a disastrous trial, e.g., constantly breaking the rules, the referee may stop the trial for consulting the jury. Having analysed the robot behaviour, the jury can decide either for the continuation or the early termination of trial for this robot.

4.7 Technical Assistance

During the competition "Periods of Technical Assistance" will exist. These periods will extend for an amount of time to be determined by the organization but will necessarily occur between legs. During these Periods of Technical Assistance teams will be allowed to repair, reprogram or perform other types of technical assistance to their robots, provided that such acts do not conflict with the requirements stipulated in these rules. The verification of the adequacy of robots to the rules of the contest may be decided by the jury at any time. Any robot that enters a trial in non regular conditions will be disqualified.

4.7.1 Closed Park

Outside the Periods of Technical Assistance the robots will be kept in custody on a closed park accessible only to the Jury. The teams should ensure that the robots are ready to work when they are removed from the closed park to start its trial. In particular, care should be taken to ensure the integrity of the software installed on it.

5. Jury, referees and chronometer team

5.1 Jury

The Jury is the maximum authority in the interpretation and application of the rules of the Micro-Rato contest. Its mission is to verify the compliance of robots to the herein defined rules during the technical verifications and during the competition, and support the referee in the audit to these same rules. It is the jury only competence to apply the more serious penalties such as disqualification for hostile behaviour and/or disastrous trial.

Through its authority, the Jury ensures fairness in the application of rules and regulations. Decisions of the Jury are final and from them no appeal is allowed.

The Jury is appointed by the Organizing Committee.

5.2 Referee

The referee ensures the compliance with the rules of the game and gives permission, if necessary, to enter the field of play during the trials. The referee may also stop the trial whenever he feels it's necessary to consult the Jury.

Regarding all issues that may show up no covered by these rules the referee has the obligation of consulting the Jury.

The referee is appointed by the Organizing Committee and will, in turn, appoint three members of a helping team that will support him whenever required.

5.3 Chronometer team

The timing of the trials will be assured by a Chronometer team appointed by the Organizing Committee. The activation, stop and restart of the timing clocks will be triggered by an explicit sound signal (whistle) produced by the referee.