Rules for Robot@Factory

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1 Introduction

This competition aims to present a problem inspired on the deployment of autonomous mobile robots on a factory shop floor. One or more robots should be able to transport materials between warehouses or machines that process those materials. The robots must collect, transport and position the materials, self-localize and navigate while avoiding collisions with walls, obstacles and other robots. All dimensions given herein, unless otherwise indicated, assume a tolerance of $\pm 5\,\%$.

2 The Robot

Each robot must, with the exception of the fork for transporting the parts, fit into a rectangle with 45×40 cm and a maximum height of 35 cm. The robot must be completely autonomous and cannot establish any kind of communication with an external system that is not explicitly provided by the organization.

3 The Shop Floor

The competition area simulates a factory floor where there are warehouses and machinery. The maximum dimensions of this area are $3.5 \times 2.5\,\mathrm{m}$. There are eight machines available and two warehouses, one of which is used as the source of parts to be produced (the incoming warehouse) and the other is their final destination (the outgoing warehouse).

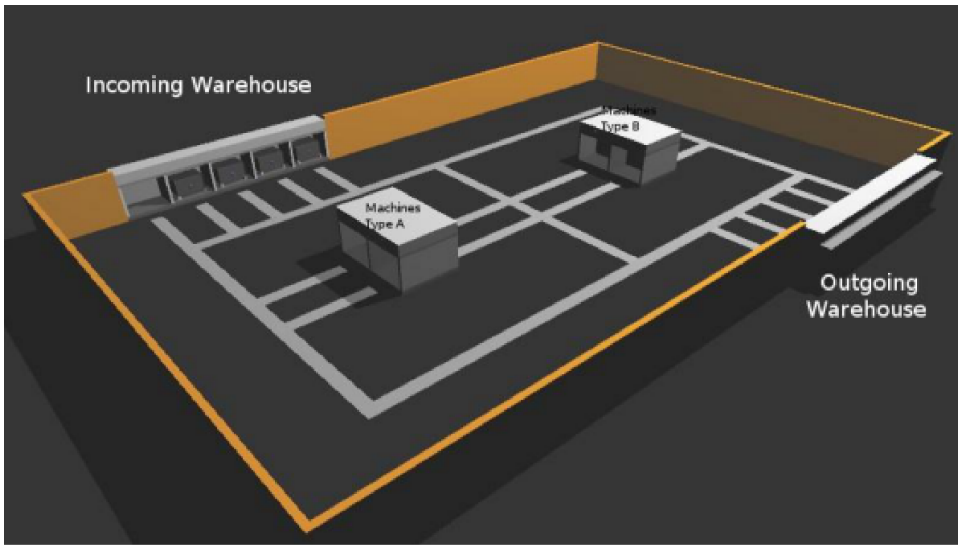

Figure 3.1: Competition area.

4 The Machines and the Warehouses

On each machine there is an area where the parts should be placed to be processed. It is the robot's responsibility the loading and unloading of the parts into the machines. After the part is placed on the machine it will be processed and during that time should not be withdrawn. All operations on the machines last 30 seconds. In the future, this time can be changed and/or vary from machine to machine.

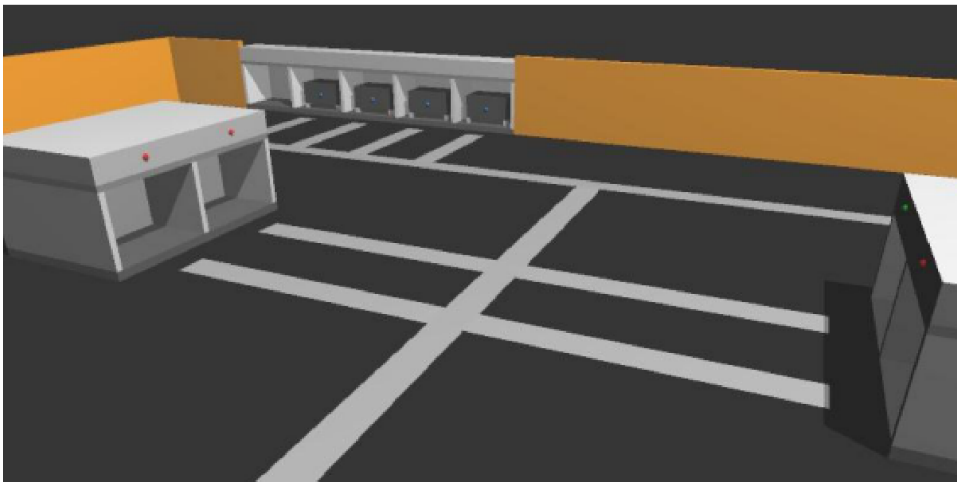

Figure 4.1: Machines and warehouses.

5 The Parts

The parts to be transported by the robots have standard dimensions, the width and length corresponding to a europallet with a scale of 1/10 (80 x 120 mm), its height will be between 30 mm and 50 mm. Each part has a RGB LED that emits a color that identifies the part type. When a part is put into a machine, which is able to process it, the part is transformed in another part type. This transformation is reflected on its LED color. The delay (or its statistical distribution) for each part/machine will be available to the teams, before the competition begins. There will be a maximum of 3 different part types.

Parts Details for 2015:

- Weigth: between 200 and 400 g
- Color: Shining Black. Cylindrical feet: metallic grey
- Height: 60 mm + 15 mm for the feet
- Width: 120 mm
- Depth: 80 mm
- Feet diameter: 6 mm
- Free space between the feet: 100 mm
- Border distance to feet: 4 mm
- LED height: 45 mm (measured from the floor).

5 The Parts

Figure 5.1: Parts.

6 Task Assignment Server

The presented server can replace the parts' LED color indication. It has the advantage that the robot can know the part type without the need to see them. A Wi-Fi server that informs the robot about the parts types will be available after the start of each run. The robot can repeat this request.

Current protocol description:

- The robot must send an UDP packet to the server asking the incoming warehouse parts information with the string: "IWP";
- The server will send an UDP packet to the robot with the part types (initial type letters) in the first line. As example of one configuration where the parts are Blue, Blue, Green, Green, Red: "BBGGR";
- In the case of a request before the run is started, the server information may be unreliable.

7 The Floor Markers

On the shop floor are white lines that can be used by the robots to find the way between warehouses and machinery. All the white lines have a width of 5 cm. Of course other guidance and localization schemes can be used by the teams. Four areas are set aside, near the corners of the "factory", where the teams can place their own markers to assist the robots in their localization or navigation. These areas are squares with 10 cm sides and the maximum height is 50 cm.

8 The Simulator

A full simulator of the competition environment is available for download from: `http://paginas.fe.up.pt/~paco/wiki/index.php?n=Main.SimTwo` The field dimensions are very close to the real field. The teams can model their own robots by editing an `xml` file.

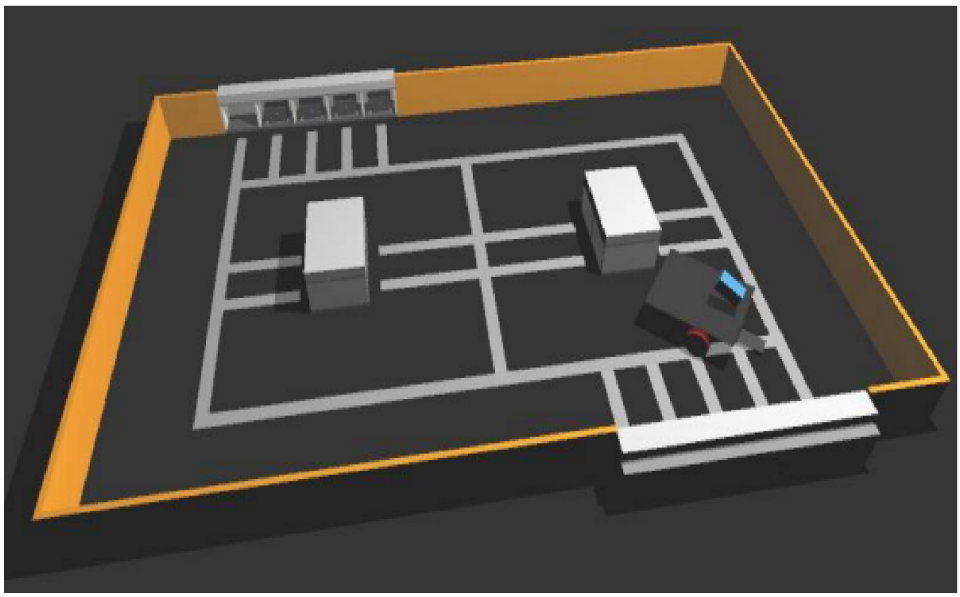

Figure 8.1: Simulator.

9 The Competition

The competition is divided into three rounds, preferably held on consecutive days. There may be different classes each with its competition. For example, one for the teams who only use the lines of the floors, walls or other markers to locate and another for teams that use its own localization system. Each team will have 10 minutes to do the initial tests on the field before the trial starts. During the trial a team can attempt as much runs as it is possible in its 10 minutes slot for the first and second round and 15 minutes for the third round.

For each trial, the final score is the total number of parts correctly placed in the outgoing warehouse. The best run is automatically considered. The time to finish plus any additional time penalization is used as the next criteria. The figure 9.1 shows the starting areas for the robots. For each run the robot must start inside the area marked as A. For the case where there are two robots (3rd round) the second robot must start inside area B.

9.1 First round

In the first round the objective is just to collect the five parts from the incoming warehouse and transport them to the outgoing warehouse as fast as possible. The five parts will be already placed on the incoming warehouse, ready to be moved. These parts have a blue led indicating that they are ready to be placed on the outgoing warehouse.

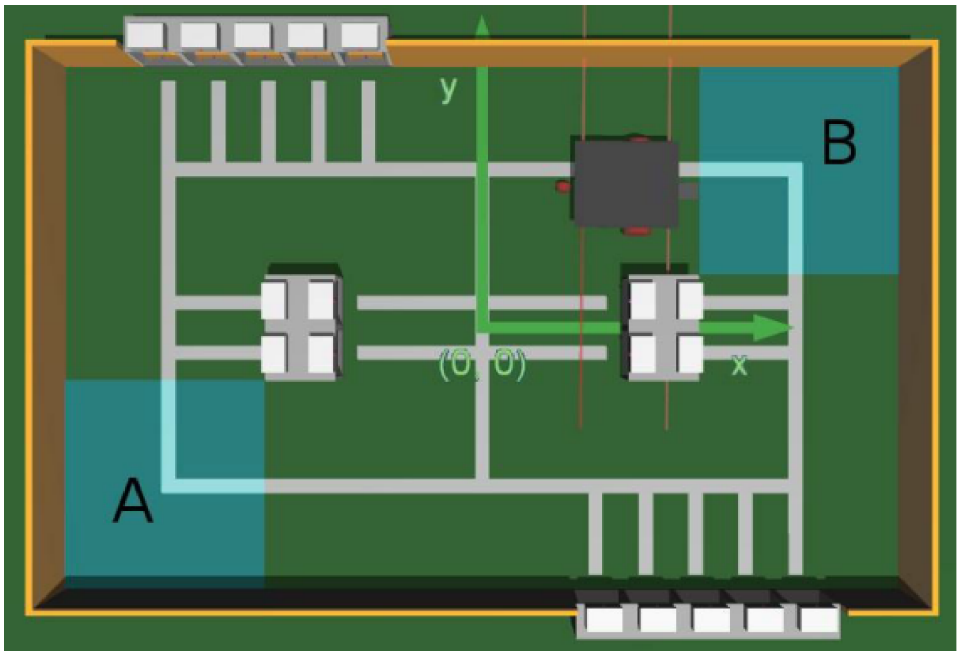

Figure 9.1: Starting areas.

9.2 Second round

In the second round, some of the five parts present in the incoming warehouse must be placed in a machine for processing. After the completion of this operation they can be carried into the outgoing warehouse. These parts have a green led, which differentiates them from those that are already processed and can be taken directly to the outgoing warehouse. For each attempt the position of the parts in the warehouse will vary (that position is only defined after the robot crosses the border of the A region). To soften the additional difficulty, there will be two parts whose position is already defined at the beginning. This allows a team, with no ability to distinguish the pieces, to still be able to perform some part of the challenge. The other three parts have their starting position randomly drawn. So, in the second round a type B (blue) part will be placed in the slot that is near the corner. A type G (green) part will be in the opposite slot.
Something like: | B | X | X | X | G | where X means either a type B or G part. (Two of the Xs will be a type B part and one X will be a type G part).

For this round there is an additional rule that every attempt must be spaced by at least one minute. Is only possible to resume an attempt one minute after the moment when the previous attempt was initiated. This limits the maximum number of attempts to less than 10.

9.3 Third round

In the third round, some parts in the incoming warehouse should be placed sequentially in more than one machine to be completely processed. These parts will have a red led. Because of this there will be three types of parts in play:

Part "color"	**Type**	**Where it should be placed**
Blue	Final Part	Outgoing warehouse
Green	Intermediate Part	Machine type B (figure 3.1)
Red	Raw Part	Machine type A (figure 3.1)

In this round, a type B (blue) part will be placed in the slot that is near the corner. There will only be one fixed part. The positions are only defined after the robot crosses the border of the A region.
Something like: | B | X | X | X | X | where X means either a type R, B or G part. (One of the Xs will be a type B part, two Xs will be a type G parts and one X will be a type R part).

For this round there is an additional rule that every attempt must be spaced by at least one minute. Is only possible to resume an attempt one minute after the moment when the previous attempt was initiated. This limits the maximum number of attempts to less than 15.

In this round, the teams can use two robots simultaneously.

9.4 Solving problems with the robot during the race

If at any time a team considers that the robot is in a situation which does not expect to be able to recover, the team may ask to stop the run and access to the robot. During the intervention on the robot, the

time does not stop. To start another run, the team must position the robot, ask the referee permission and when it is given may restart the robot. After the team asks for permission to restart the referee must reposition any random element so that information is not available to the robot operator. After asking permission to restart, the team must only restart the robot, further tweaks are not allowed.

9.5 Closed Park

Fifteen minutes before the start of each round the robots must be placed in the closed park, preventing teams from having access to the robot until a predefined period before the start of their trial. During this period, the team must have full access to the field. After that time, which is signalled by the referees, the team must prepare the robot to start its trial.

9.6 Final Classification

The team with the highest total number of Final Parts placed on the outgoing warehouse is the winner. If there are teams with the same total number of parts, the team that took less time to achieve that has the advantage. The total time is calculated using the team's best run for each round.

10 Jury, Referee and time keeping

10.1 Jury

The jury is the maximum authority in the interpretation and application of the herein defined rules or in every deliberation regarding issues that may be missing from them. Its mission is to verify the compliance of the robots with these rules during technical verifications, and support the referee, during the competition, in their audit and enforcement.

Through its authority, the jury ensures justice in the application of rules and regulations.

Decisions of the jury board are final. Appeal from jury decisions is not possible.

The Jury is appointed by the Organizing Committee.

10.2 Referee

The referee ensures the correct application of the competition rules and gives permission, if necessary, for team members to enter the track area during the initial trial tests. The referee may also stop the trial test whenever necessary to dialog and consult the jury.

Regarding any issues that may be missing in these rules the referee must, in all cases, consult the jury.

The referee is appointed by the Organizing Committee.

10.3 Time keeping

Timing keeping is provided by an automatic integrated control system. This system includes two independent clocks: a time totalizer, responsible for measuring the time of the race test, and a time counter responsible for measuring the time of each trial.