Rules for Robot@Factory Lite

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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.

It was based on the original Robot@Factory with some mechanical and hardware simplifications. While in the original challenge the robot had to pick up the box with a forklift, in this version the robot can drag the box using an electromagnet. The dimensions will also be adjusted so that this competition can attract smaller robots whose control can be done with an embedded system or with a simple microcontroller. The floor will be replaced by a two-sheet A0 print, where black lines on white background can be used for robot localization. The layout will be simplified to facilitate the maneuvers related to the transport and collection. The incoming and outgoing warehouses location remains the same. In the first round, like the original challenge, it is necessary to move the boxes between the incoming and outgoing warehouses. In the second round some boxes must be processed by machines and in the third round some boxes will have to go through two processing machines. The goal will be to transport as many boxes as possible in the shortest time. The different boxes can be recognized by the robot through an RFID reader. Important files can be found at:
`https://github.com/P33a/RobotAtFactoryLite`.

All dimensions given herein, unless otherwise indicated, assume a tolerance of $\pm 5\,\%$.

2 The Robot

Each robot must fit into a rectangle with 25×20 cm and a maximum height of 20 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 $1.7 \times 1.2\,\mathrm{m}$. There are four 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). The competition area is presented in figure 3.1. The dimensions of the field are presented in figure 3.2.

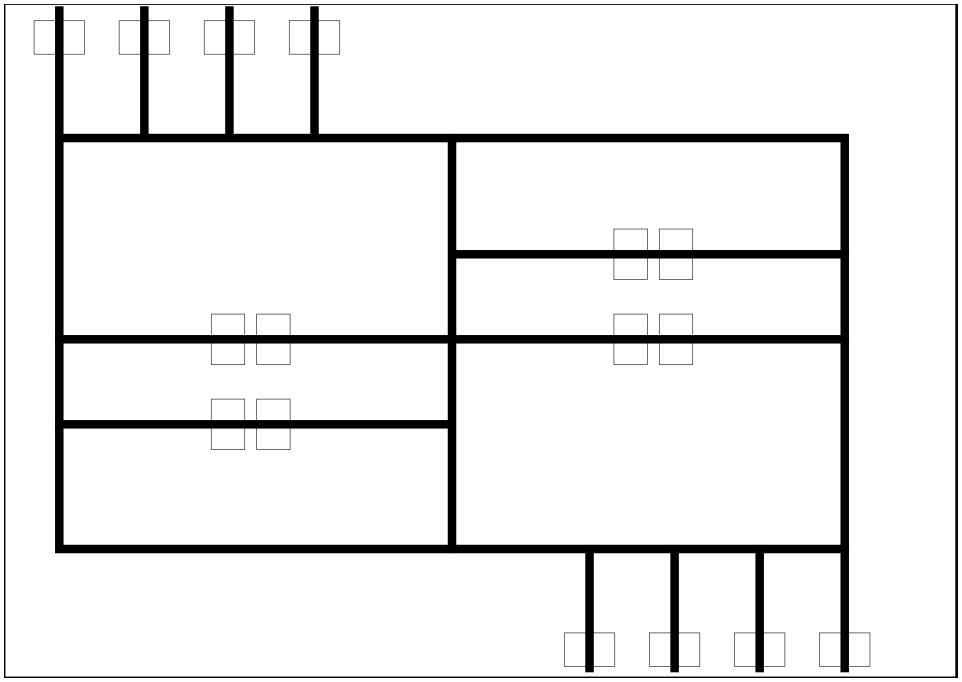

Figure 3.1: Competition area.

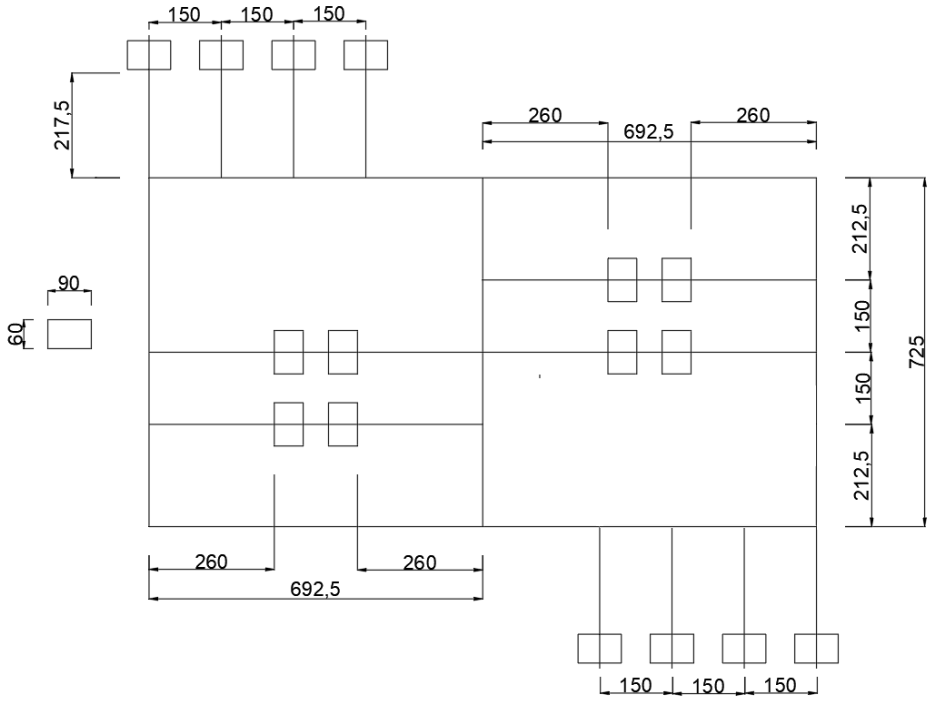

Figure 3.2: Dimensions.

4 The Machines and the Warehouses

On each machine there is an area where the parts should be placed to be processed (Input) and another one where the processed parts should be picked (Output) as illustrated in figure 4.1. It is the robot's responsibility the loading and unloading of the parts into the machines. After the part is placed on the left side of the machine (Input), it will be processed and should be picked on the right side (Output).

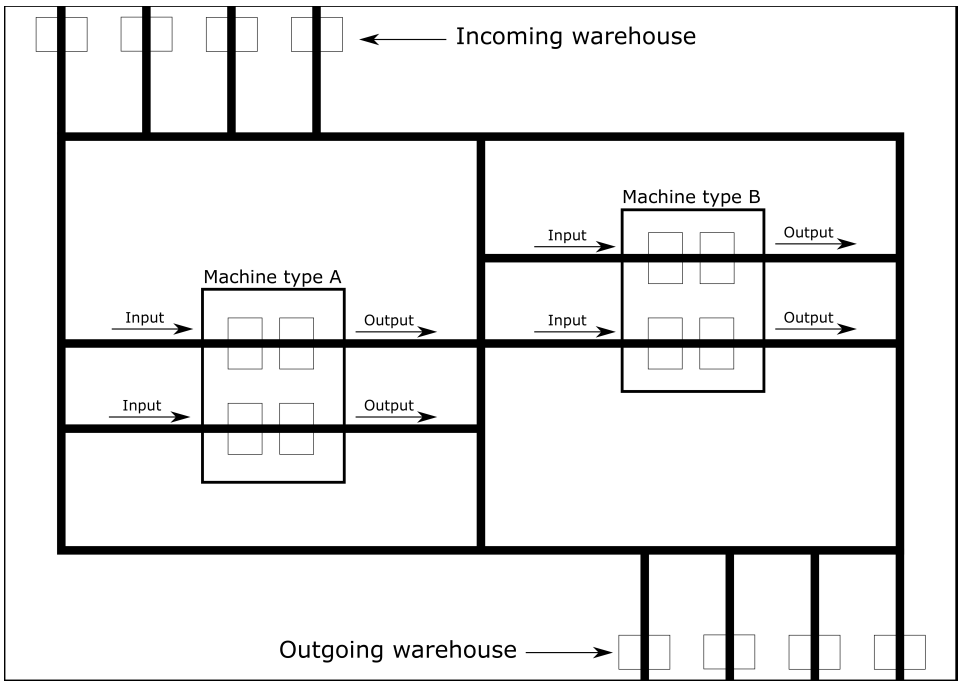

Figure 4.1: Machines and warehouses direction.

5 The Parts

The parts to be transported by the robots have standard dimensions, the width and length of 90 x 60 mm, its height will be no less than 65 mm. There is a metal place with 20 x 80 mm placed in the box front wall (see figures 5.1 and 5.2). Each part has an RFID tag (placed inside the box and above the metal plate) that identifies the part type. When a part is put into a machine, the part is transformed in another part type. 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 three different part types, as presented in the next table:

Type	**Tag**
Final Part	Blue
Intermediate Part	Green
Raw Part	Red

Parts Details:

- Weigth: to be defined
- Color: Any color
- Height: 60 mm + 5 mm for the feet
- Width: 90 mm
- Depth: 60 mm

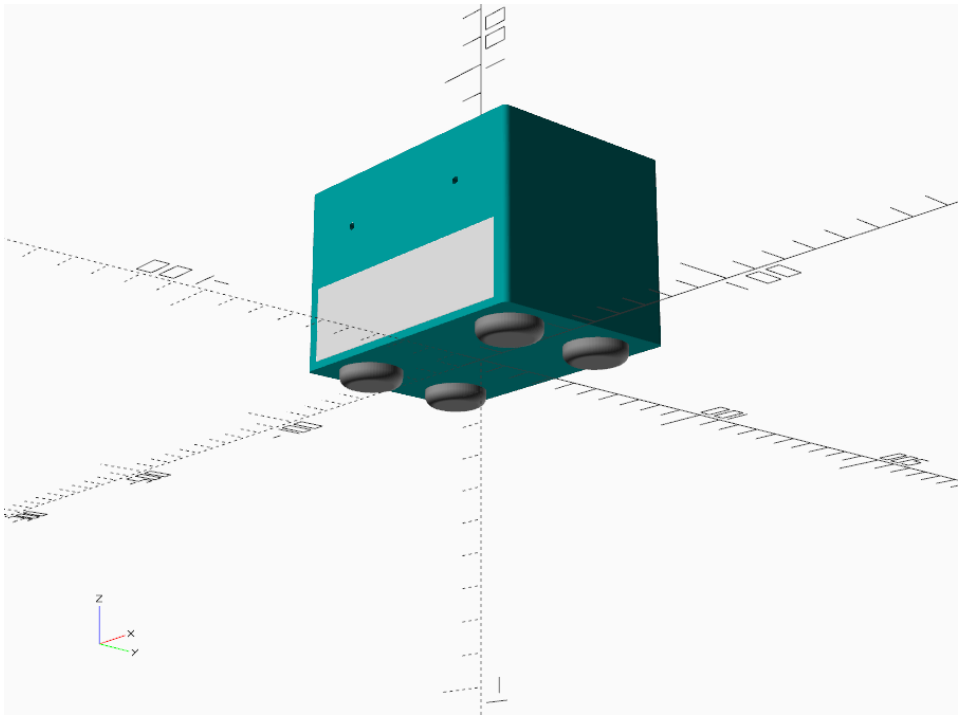

Figure 5.1: Parts.

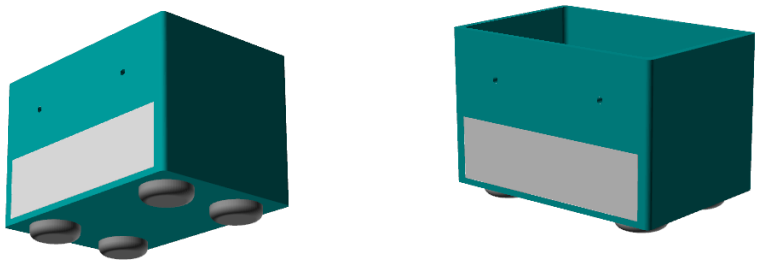

Figure 5.2: Parts.

6 Task Assignment Server

The presented server can replace the RFID reader. Is has the advantage that the robot can know the part type without the need to be near 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). As example of one configuration where the parts are Blue, Green, Green, Red: "BGGR";
- 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 black lines that can be used by the robots to find the way between warehouses and machinery. All the black lines have a width of 30 mm. 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: `https://github.com/P33a/SimTwo/releases`. The simulation environment also allows to be controlled by a hardware-in-the-loop technique through a serial port from an arduino device. Source code and all the necessary tools are provided.
The field dimensions are very close to the real field. The teams can model their own robots by editing an `xml` file.

9 The Competition

The competition is divided into three rounds, preferably held on consecutive days. 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 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 area for the robot and the machines types with the input and output places. For each run the robot must start inside the green area.

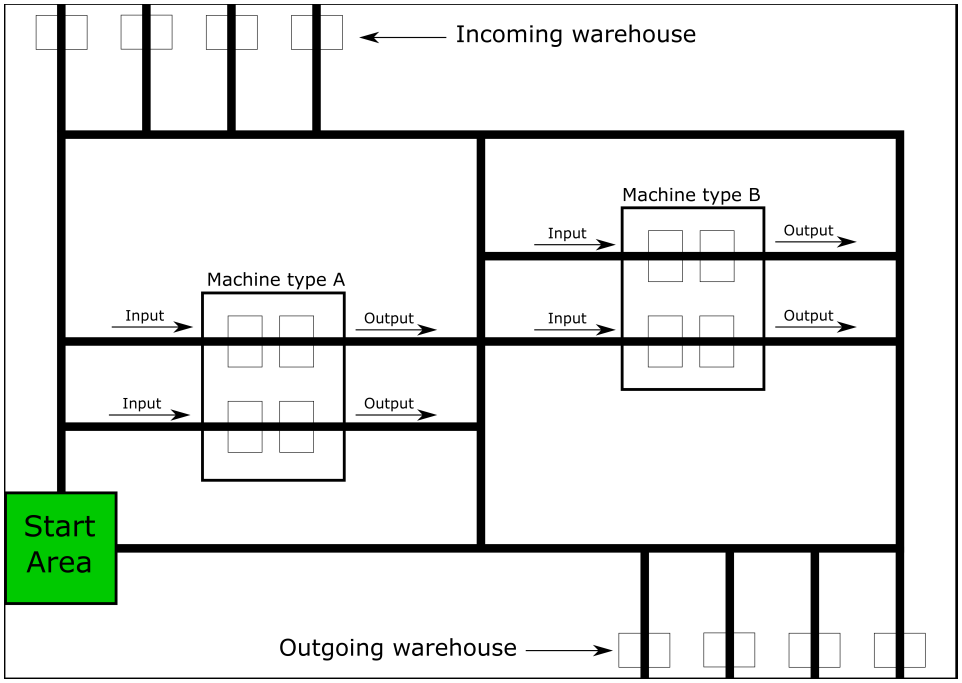

Figure 9.1: Starting area.

9.1 First round

In the first round the objective is just to collect the four parts from the incoming warehouse and transport them to the outgoing warehouse as fast as possible. The four parts will be already placed on the incoming warehouse, ready to be moved.

9.2 Second round

In the second round, some of the four 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.

A table that maps the RFID codes that differentiates the parts from those that are already processed and can be taken directly to the outgoing warehouse will be published. 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. Because of this there will be three types of parts in play:

Type	**Where it should be placed**
Final Part	Outgoing warehouse
Intermediate Part	Machine type B
Raw Part	Machine type A

A table that maps the RFID codes that differentiates the parts from those that are already processed and can be taken directly to the outgoing warehouse will be published. 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.

9.4 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.