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Prototyping Small Robots for Junior Competitions: MicroFactory Case study

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Abstract:
In this paper it is discussed the proposal of a small robot prototype to be applied in the MicroFactory competition, a downsized version of the Robot@Factory competition. The MicroFactory is intended to help junior competitors to make the transition from the Junior Leagues to the senior competition Robot@Factory. The Robot@Factory competition takes place in an emulated factory plant, where Automatic Guided Vehicles (AGVs) must cooperate to perform tasks. To accomplish their goals the AGVs must deal with localization, navigation, scheduling and cooperation problems, that must be solved autonomously.

Keywords:
Mobile robot competitions, AGVs, Prototyping

1. INTRODUCTION

Robotic competitions are an excellent way to foster research and to attract students to technological areas (1). The robotic competitions present standard problems that can be used as a benchmark, in order to evaluate and to compare the performance of different approaches. Although there are many robotic competitions (2) (3) (4) (5), there is the need to create new ones, in order to solve new challenges. The factory environment is a prime candidate to use robots in a variety of tasks. A competition where mobile robots are tackling transportation problems in the shop floor is a challenge that can foster new advances in service robots and manufacturing (6)(7)(8). The Robot@Factory is an official competition of the Robotics Portuguese Open, presenting problems that occur when using mobile robots to perform transportation tasks. The robots must be able to navigate, cooperate and to self-localize in an emulated factory plant, to transport and handle materials in an efficient way. The introduction of a downsized version of the Robot@Factory is intended to help junior competitors to make the transition from the Junior Leagues to the senior competition Robot@Factory. The downsized version of the Robot@Factory competition, the MicroFactory, reduces significantly costs for competitors and also for the organization, when compared with the standard competition. A picture of the 2006 edition of Robotics Portuguese open can be seen in Figure 1.

Fig. 1. Robotics Portuguese Open

The paper is organized as follows: After a brief introduction the Robot@Factory competition is described, then a proposal of its downsized version is described, where it are discussed its benefits, when compared with the standard competition. Then it is detailed a proposal of a MicroFactory robot prototype and finally some conclusions and future work are pointed out.

2. ROBOT@FACTORY COMPETITION

In this section it is presented the Robot@Factory competition description and the rules that teams must follow in order to qualify for participation. This competition is an official competition of Robotica, the Main Robotics Portuguese Competition, since 2011. The official competition arena is shown in Figure 2.

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Fig. 2. Competition arena.

2.1 Robot dimensions

Each robot must fit within a cuboid of 45 x 40 x 35 cm. The robot must be completely autonomous and cannot establish any kind of communication with external systems that are not explicitly provided by the organization.

2.2 Competition arena

The competition arena, shown in Figure 2, emulates a factory shop floor where there are warehouses and machinery. The dimensions of this area is 3.5 x 2.5 m. There are eight machines available and two warehouses. One of them is used as a raw material storage and the other one is used as a destination.

2.3 Machinery and warehouses description

Each machine provides an area where the pieces should be placed in order to be processed by the machine. The robot must pick and place the part materials from the machine. While the part is placed in the machine it is processed and should not be removed. An RGB LED indicates that the machine is able to accept parts (light green), the machine is processing a part (yellow light), the part in this machine is already processed (white light) or that the machine is broken (blink red light).

2.4 The part materials

The materials to be transported by the robots should respect standard dimensions, width and length corresponding to an Europallete 80 x 120 mm (1:10 scale), the height should have a value between 30 mm and 50 mm. Each piece has an LED showing an RGB color that identifies the type of material. When a part arrives to a machine, it can be processed and its color is changed in order to illustrate a different type of part.

2.5 Solving problems in the competition

Team responsible can access the robot up to four times, if one of the robots is not expected to be able to recover. While robot comes out from the arena the time scheduling continues unchangeable.

2.6 Competition starting

The robots must be placed in the closed park one hour before the start of each competition. Teams should not to have access to the robot until about 10 minutes before the start of their competition. There, the referees indicate the teams that should prepare the robot to start their competition.

2.7 Competition rounds

Since this is a competition that can accept participants with different background, it must be differentiated in three rounds. Event organization can provide, for some rounds, an external localization system for robots. This system will identify the robots using a pattern that must be placed on top of each robot and can provide the position and orientation of the robot.

First round The main purpose of the first round is to collect the pieces of the raw material warehouse and transport them to the end warehouse. The robot should transport the most parts it can from the warehouses.

Second round The main purpose of the second round is to process some parts of the raw material. The raw material should be transported from the initial warehouse to the machinery, in order to be processed. When the processing task is ended, the parts should be transported to the final warehouse.

Third round The main purpose of the third round is to sequentially distribute the parts through several machinery. Some parts collected from the raw material warehouse should be placed sequentially in more than one machine to process. Only after the completion of this operation the parts should be transported to the final warehouse. There will be three types of parts in operation. During this round some tracks may be partially or totally blocked. In this round teams are authorized to use two robot at the same time, the used robots must cooperate to perform its tasks.

3. MICROFACTORY COMPETITION

The introduction of a downsized version of the standard Robot@Factory competition is intended to help junior competitors to make the transition from the Junior Leagues to the senior competition Robot@Factory. The downsized version of the Robot@Factory competition, the MicroFactory, reduces significantly costs for the competitors and also for the organization, when compared with the standard competition. The main differences from the Robot@Factory competition, when compared to its downsize proposal, are essentially the following items:

- The dimensions reduce (both in the Arena as well as in robot).
- In order to reduce complexity, for the organizers and competitors, the machines and part materials do not have leds to provide the robots information about their status.
- Passive elements are used to indicate the status of the part materials, as described in subsection 3.2.