

Robotour - robotika.cz outdoor delivery challenge

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Abstract—In this paper, we present an international contest for autonomous robots: Robotour – robotika.cz outdoor delivery challenge. The main task is a navigation in real-world situations. First three years were held in park Stromovka, Prague, Czech Republic and raised an interest of many teams, media and general public. Last year, the contest started to migrate. To our knowledge, there is no similar European outdoor contest for fully autonomous machines. Note, that there are some common features with American Mini Grand Challenge and a younger Japanese Real World Robot Challenge. The rules of Robotour are described in more detail together with experience gained over the past four years – both from the organizers’ and the participants’ point of view.

Keywords: autonomous robots, outdoor, international competition

I. INTRODUCTION

Competitions such as Eurobot [1] and DARPA Grand Challenge [2] have repeatedly shown that both young students and senior researchers are attracted by competitive research environments. Autonomous robotics is a multidisciplinary domain which offers educational opportunities and interesting real-world research topics.

In 2004, the American Defense Advanced Research Projects Agency (DARPA) organized the first Grand Challenge. The goal of DARPA was to foster a research in fully autonomous vehicles. In the first year, only 11.78 km of the 240 km long route were completed by the best team. Already in the second year of the competition (2005), five vehicles finished the 212 km long route. This shows a tremendous impact the challenge has had on the field of fully autonomous ground vehicles.

Since 1994, the Eurobot competition attracts many young people (more than 2000 in year 2010) [3]. Eurobot has successfully shown how an international competition can be used to teach young people how to cooperate and how to develop complex systems.

In 2006, the Robotour – robotika.cz outdoor delivery challenge has been founded. In our opinion, the large gap in complexity between Eurobot-like competitions (e.g. RobotChallenge [4], Istrobot [5] and other) and competitions like DARPA Grand Challenge needed to be bridged. In about the same time, other organizers felt similar insufficiency and more competitions were born. Since 2003, Field Robot Event focuses on the agricultural automation [6]. Since 2006, European Land Robotic Trial allows research teams and industrial companies

to demonstrate their unmanned outdoor systems in realistic scenarios and terrains [7]. One year after Robotour – in 2007 – Tsukuba Real World Robot Challenge (RWRC) took place in Japan for the first time [8]. Since 2009, a similar straight line outdoor challenge takes place in Písek, Czech Republic [9].

Robotour – robotika.cz outdoor challenge is focused on autonomous ground vehicles and their orientation in the real-world outdoor environment. The robots perform a delivery task in complex environments of city parks. They are not allowed to leave paved roads. Participants of various background are welcome. In the previous years, students from high schools, university researches and hobbyists took part.

In this paper, we describe the Robotour – robotika.cz outdoor delivery challenge. General rules are covered in Section II. In Section III, we share experience obtained from the organizers’ point of view. Reflections of the participants are captured in Section IV.

II. RULES

A. Historical Overview

The rules for each year change slightly and the contest becomes more and more challenging every year. The unified theme of all years is robot’s ability to autonomously navigate in outdoor environments and to move payload from one place to another. The robots have to be fully autonomous, which means that after a task entry they have to control themselves.

Since the first year, the basic requirement is to navigate on paved roads in the park without leaving them – similar to cars not leaving the streets. In the second year, a possibility of robot cooperation was introduced. In the third year, obstacles were added and robots had to deal with them successfully. In the fourth year, robots did not know exactly their start position and had to deal with obstacles more carefully.

The fifth year of this contest should be a next step towards smarter and more autonomous robots. In contrast to the previous years, the robots get only a map and coordinates of the destination. The robots should be able to navigate around the park even if they have never been there before. The map and the destination should be the only information the robots get before the start. Robot successfully solving this task should be able to demonstrate its ability with a corresponding map in any park.



Fig. 1. A simple map of the Lužánky park in Brno given to the participants in 2009.

B. Detailed Rules

1) *Task:* The task for the robots is to deliver payload in a given limit of 30 minutes to a destination as far as 1 km. Robots must be fully autonomous, not leave a road and choose correct path on junctions. The starting place, starting time and the destination will be the same for all the robots.

2) *Map:* Vector map of footpaths in a park will be based on a vectorization of an orthophotomap and teams could improve it further. The basic idea is taken from Open Street Map [10]. A robot is allowed to use only this shared map – all other maps are prohibited!

3) *Robots:* A team can deploy multiple robots this year, but only a single designated one is used to compute a score. Every robot must have an emergency stop button, which stops its motion. The button must be easily accessible, red and must form a fixed part of the robot (aka Big Red Switch), so it could be used in a case of a danger. The team must show that it is easy to manipulate with the robot – two people must be able to carry it several tens of meters. There is also a minimal size – robot has to carry 5l beer barrel (at least an empty one).

4) *Leaving the Road:* The robots are expected to stay “on the road” which means to stay on the paved passage ways. If any robot leaves the road, its trial ends. The team has to take care of their robot and remove it immediately.

5) *Obstacles:* There could be obstacles on the road. Besides natural obstacles like benches there could also be artificial obstacles. A typical (artificial) obstacle is for example a figurant, a banana paper box or another robot. Robots must not touch an obstacle. Contact with an obstacle means an end of a trial. The robot may stop in front of an obstacle and visually or acoustically give a notice. Note, that the robot has to detect, that the obstacle is no longer present.

6) *Robots Interaction:* Situations, in which a faster robot catches up with a slower one, will not be explicitly handled. The faster robot can handle the slower robot as an obstacle, i.e. avoid it or wait until the “obstacle” disappears. In general, the road rules will be respected: right of way, avoidance

to the right, passing on the left.

7) *Start:* All robots will start from the same park road simultaneously. A minimum width of this road is 3 meters. The starting area for each team will measure approx. 1.5×1.5 meters. Starting areas will follow one after another on one side of the road. Within the starting area, each team can place its robot as they see fit. The order of the robots on the start is given by their results in the previous round (a better robot will be closer to the destination). The order in the first round will be given by the order of successful homologation. Robots start automatically via their internal timers. During the last minute before the start, no interaction with the robot is allowed.

8) *Score:* The team, whose robot manages to proceed along the route best, wins. The aerial distance of the last position of the robot (leaving the road, a collision or a time-out) to the destination is critical. For every meter towards the destination, a team gets one point. If the team carries a payload, its score is doubled (“points for the payload”). Each robot can carry only one “payload”. A 5l beer barrel (full) serves as a payload. In every round, a robot can obtain points at most equal to twice the aerial distance of the start and the destination.

9) *Organization:* The contest will consist of four trials for each team. The start and destination will be different for every trial. The selected destination will be announced to all teams 10 minutes before the start. The speed of the robots is not important (actually, it is limited to 2.5 m/s). All points gained during all trials will be summed together. The trial starts at a specified time and ends after 30 minutes. The robot must leave the starting area within 10 minutes of the start. If the robot does not move for 60 seconds its trial ends. Each team has to arrange for one person familiar with the rules that will be part of the referee team during the competition.

10) *Homologation:* A team can participate in the contest only if it is able to score at least one point. Another necessary condition is an ability to travel along a 10 meters long route fragment without a collision with any obstacle. The starting procedure will be tested (the automatic start) as well as the functionality of the emergency stop button. Usage of liquids, corrosive or pyrotechnic material as well as live beings is strictly prohibited. Every robot has to be accompanied by a team member, older than 18 years, who is fully responsible for the behavior of the robot.

11) *Technical Documentation:* Every team has to provide basic technical documentation about their robot (for presentations, general public and journalists). Three winning teams will be asked for a more detailed description for a website presentation and to make the entry of novices in the following years easier.

III. ORGANIZATION

Robotour is organized as a three-day event (Friday to Sunday). Friday is dedicated to the testing, clarification of rule details and homologation. During the homologation, we want to make sure that robots are not dangerous, have a functional

emergency stop button and are able to gain at least one point in the contest. Saturday is the contest day. Finally, there is a workshop on Sunday. It is after the contest, so the competitors have a fresh experience with their robots and algorithms. They are also not stressed any more and thus this is a good moment for sharing knowledge.

We started to enforce this three-day template after the first competition in 2006. That competition ended on Saturday and most teams left without letting us and other teams know what has worked and what has not. What was even more important was that teams left exhausted from the programming marathon and one team had a car accident on the way home. Since the following year, the workshop is mandatory.

The Robotour contest is relatively self-supporting and the expenses are minimal. There is no special playground – a public park is used instead. There is no need for renting a hall because the event takes place outside. To be precise, some room is necessary as a base for the teams especially in bad weather conditions. It is recommended to have a partner who provides this place, like Planetarium Praha in the first park Stromovka did. A good idea is also a combination with an exhibition of robots and a related technology parallel to the contest.

There is no registration fee, but the teams have to take care of catering and pay an accommodation.¹ Small items remain on the bill: leaflets printing, diplomas, cup for the winners, and a Saturday night dinner. The dinner is usually sponsored and the goal is to unite the teams and give them a chance to relax a little bit after the contest. Note, that prices are rather symbolic, which lowers expenses on one side and also reduces a potential rivalry between the teams.

A. Duties over the Year

The first task of the organizers is a precise specification of rules for the next contest. They are presented on the robotika.cz website in Czech and English languages. The core remains the same (autonomously navigate in a park) and the changes are usually a consequence of a discussion at the workshop and experience gained.

The second task is to ensure an affordable accommodation for a relatively large group of people (50 people needed accommodation in 2009). An agreement with a university dormitory serves well. The reservation must be performed usually a month in advance and that defines a clear deadline for the registration of the teams.

Finally, it is necessary to find an interesting park, manage permission for the contest day and find building with large enough room(s) for team base with many electric outlets.

B. Experience of the Organizers

There were couple lectures we have learnt over the last four years organizing Robotour (and previously several years of organizing Czech Cup of Eurobot). The basic scenario was already mentioned and serves good and is worth a recommendation. What has changed over the years are two major

¹Accommodation is usually partially or fully sponsored.



Fig. 2. Robot of the R-team (left) leading the allied robot of RobSys (right).

trends: the number of teams is increasing and the task is getting more difficult. In the first case, we tried to find some optimal timetable of the rounds and we are still not satisfied. What suits the teams does not suit a general audience and vice versa. This year, we will start all the robots from one place simultaneously, which could be attractive for spectators, but may cause problems to many teams.

The task complexity is another issue. Beginners have a harder position to enter the contest every year. For 2010, we discussed a new category (WagonOpen), but we will probably cancel it. The reason is a new, for the beginners with outdoor robots highly recommended contest “Robotem rovně” (Robot, go straight!) in Písek. In Písek, the task is to navigate as far as possible on a 3 meters wide and 300 meters long park road. This is exactly the first stage which is necessary to enter the Robotour contest.

IV. REFLECTIONS

A. Questions

To reflect an influence the competition has had on its participants, we have asked some of the past successful teams few questions:

- 1) What did you expect from the competition?
- 2) What did the competition give you?
- 3) What were you disappointed with?

B. Asked Teams

The following teams were asked:

- **Propeler-team**, Opava: A group of high school students, who placed 2nd in 2006.
- **LEE**, Prague: Researchers and students from Czech Technical University in Prague. Winners of the year 2008 and the year 2009.
- **R-team**, Rychnov nad Kněžnou: A team of a high school teacher. Since 2010, he organizes *RobotOrienteering* in Rychnov nad Kněžnou. R-team finished 2nd in 2008 (in a coalition with the RobSys team, see Figure 2).
- **Roboauto**, Brno: A self-funded group of researchers, which ranked 2nd in 2009.

- **Radioklub Písek**, Písek: Hobbyists and professionals, who also teach electronics in a club. Radioklub Písek got a 3rd place in 2009. Since 2009, the club organizes *Robotem rovně* (mentioned in Section III).

C. Answers

1) What did you expect from the competition?:

- Propeler-team:
 - The competition motivated us to build our first robot.
 - Having almost no restriction on the dimensions of the robot allowed for a simple construction – We could use a notebook, get an image from a camera and use a bought chip to control the motor and the servo (we did not understand microchips and servos at that time).
- LEE:
 - We wanted to see a comparison of several approaches to the mobile robotics.
 - The competition gives us an opportunity to have our solution judged in an unbiased fashion.
- R-team:
 - After Istrobot and Eurobot, I wanted to try something new.
- Roboauto:
 - The competition served as a motivation to finish a functional version of algorithms and of the robot.
 - We wanted to present our results to a general public.
 - We expected to meet with a like-minded community.
- Radioklub Písek:
 - After seeing the robots in 2007, we believed we could do better.

2) What did the competition give you?:

- Propeler-team:
 - We met people in the same domain of interest, saw their approach and other technology.
 - Every year, we have a motivation to catch up with our first result.
- LEE:
 - We have seen, how a relatively simple solution (by R-team) can solve a given task.
 - We realized that the increasing accuracy of hardware and sensors can have a huge impact on the accuracy of simultaneous localization and mapping.
 - We have been shown, how important it is to deal with the technical details and with the reliability of the robots.
- R-team:
 - I have learned that even the hardware is not fully reliable. Indoor robots do not suffer from such problems.
 - I realized how difficult the task is, even though I have expected some difficulties even beforehand.
- Roboauto:

- It has fulfilled our expectation.
- The competition gave us a practical experience with deploying a robot.
- We have got an inspiration for further improvements of the hardware and algorithms.
- We feel in touch with people with similar interests.

- Radioklub Písek:

- We realized the competition is not as simple as it seemed for the first look and few others.

3) What were you disappointed with?:

- Propeler-team:

- We are not really disappointed: When the robot works, everything is fine.
- Answering the question “What does the robot do?” is difficult, when the task difficulty is not obvious.

- LEE:

- Although there is a lot written by the competitors at robotika.cz, every year someone new comes and repeats previous mistakes.

- R-team:

- In my opinion, the competition has become too difficult. Only one or two best teams can fully cope with the rules.

- Roboauto:

- Problems with a reliability and with a robustness are bigger than we have expected.
- We are disappointed with only a small media attention.
- We hoped to get an attention of potential sponsors or future team members, which has not happened so far.

- Radioklub Písek:

- We are sad that the cooperation of multiple robots is not encouraged any more. We have learned several interesting things doing that. On the other hand, as the competition evolves, it does not suffice to copy a solution from the previous year.

V. SUMMARY

We have introduced Robotour – robotika.cz outdoor delivery challenge, its rules and their evolution over the time. We share experience gained while organizing several years of the competition and show several patterns worth following. The competition has been successful in attracting people to robotics and giving them an opportunity to learn. The contestants enjoy a chance to meet others, exchange ideas and compare their approaches in an independent manner. As the competitors note, while seemingly simple, the competition became difficult to participate in. This in turn led to a creation of two new robotic competitions in Czech Republic, which differ in the level of difficulty. Currently, there exists an evolutionary path for a person interested in robotics through these outdoor competitions up to Robotour and possibly even further.

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