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Ketchup House – A Promising Robotic Contest

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***Abstract*—In this paper we present a new category Ketchup house, for the international robotics contest Istrobot. The main task is to manipulate ketchup cans and move them to their appropriate positions. The contest had its first run on Istrobot 2012 in Bratislava and gained a well-deserved publicity. We describe origins and rules of this new category as well as results obtained in the first year.**

***Index Terms*—engineering education, mobile robots, robotic contest, Istrobot**

I. Introduction

There is no doubt that robotic contests are great tool to trick students into learning [1]. They are excellent opportunities to reinforce the relationship which math and science have on tangible real-world applications [2]. Competitions can also emulate real life engineering and product development [3]. Large amount of various robotics contests are held all over the world, from local contests supporting the AI or robotics classes at universities to large international multi-discipline events. An overview of robotic contests can be found e.g. in [4] or in [5].

At the Slovak University of Technology in Bratislava, we organize the robotic contest Istrobot since the year 2000. More than 10 years of competitions have given us some great experiences. We started with classic Linefollower category, later the MicroMouse and MiniSumo categories were included. Since the second year, we also have the Freestyle category which attracts the biggest interest of visitors. Unfortunately, it is very difficult to evaluate various types of constructions which vary from simple Lego robots to very complex robotic systems built from scratch. This is rather an exhibition of projects than real competition. Another category – MiniSumo, gains broad interest of visitors and participants since its introduction in 2005. Unfortunately, great expectations of organisers were not met. We assumed clever constructions, focused on various strategies and tactics. Instead, robots converged to one robust construction, participants spent a lot of money and time with embellishing their precise constructions, and most important – they took it too seriously and lost the fun.

Then we started to think about the new category, which would eventually replace the MiniSumo category. Our goal is to have such contest, where cheap, simple robot with brilliant idea can win over the technologically superior and hardware overloaded but dumb robot. Our attempt is to encourage people in *thinking*, not in spending money on additional processors. We tried to identify what makes the contest attractive and challenging both for participants and for visitors:

- Challenging and clear, easy to understand task.
- Clear, well defined environment. Robotic contest should be an example of well-defined engineering problem.
- Problem solution should not require expensive and complex hardware. Participants don't want to spend the time available on fundraising.
- Contest should not require expensive and complex environment and playground. Organizers also don't want to spend the available time on fundraising.
- Robots should be eventually re-usable for other contests.
- Contest should be Lego NXT friendly (regarding dimensions, number of required sensors etc.).
- Contest should involve an opponent robot. The second robot at the playground always brings random moments. As the goal is not to build only simple automatic machines but "intelligent" robots, the way how they cope with changing conditions is a good measure of their quality.

From the beginning, it was clear that we have to include at least two robots into the competition since it is the most attractive element for spectators, and it also brings new and random elements which the robot should be able to cope with.

We have been inspired by the classical computer game *Sokoban* (warehouse keeper – see Fig. 1). It is a transport puzzle, in which the player pushes boxes around in a warehouse, trying to get them to storage locations. The game was created in 1981 by Hiroyuki Imabayashi, and published in 1982 by *Thinking Rabbit*, a Japanese software house [6]. Realistic

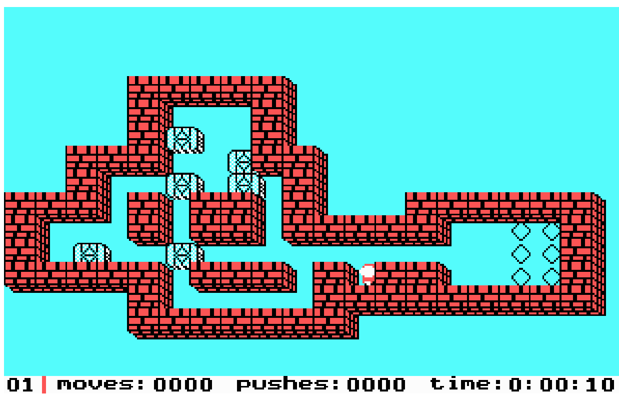

Fig. 1. Classic Sokoban game

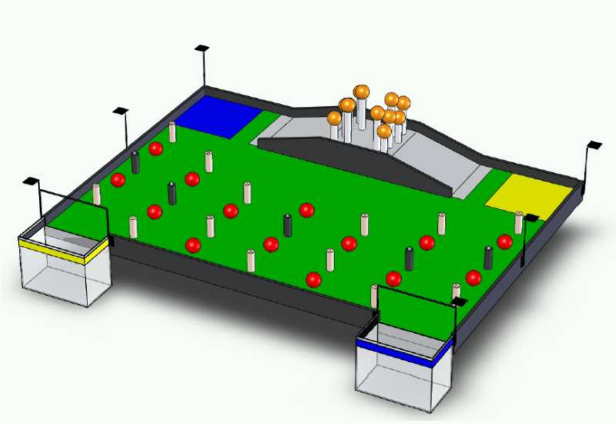

Fig. 2. Playing arena for the Eurobot 2010 contest [7].

implementation of this puzzle was used in AI course at the University in Odense during the year 2011. We analyzed the course constructions and they seem to be too complicated for amateurs; the task takes long time which is counterproductive for our type of the contest.

There are some similar contests, where the task is to collect some objects from the playground. Just to mention some, let us look at the Eurobot[1] contest in 2007 – Robot Recycling Rally. Robots collected cans, PET bottles and batteries. Their task was to sort them properly into the predefined locations. In 2010, the Eurobot contest topic was *Feed the world*. The robot which collected the most of fruits, vegetable and seeds became the winner [7] (see also a playground on Fig. 2). The matches involved two teams and they last 90 seconds. The playing elements were placed in different places on the table, either on the ground in predefined and random positions or in elevated positions. Collected elements had to be put in the containers in front of the table.

Eurobot contests are very succesfull, but we see the problem connected with this type of contest: a relatively complicated setup requiring large playfield with many additional features which make it more complicated both for organizers and for participants.

After many discussions we found a solution – competition slightly inspired by the Sokoban game, modified for two players. Navigation of the robot is simplified by the network of black lines taken from the Linefollower category. This contest is considered to be a follow-up for people already saturated with linefollowing robots, gives them an opportunity to reuse their hardware and add more complicated behaviour to their robots. The contest is also considered to replace the popular MiniSumo category. Name of the game – Ketchup House – came from the main task: to move the cans with ketchup[2] to their appropriate positions in the warehouse.

[1]http://www.eurobot.org/eng/archives.php

[2]To be precise, the can content is tomato puree, not the ketchup.

II. Ketchup House – Rules

A. Task

The task is to design and build an autonomous, microcontroller controlled mobile robot, which will move the ketchup cans into their stock. Two robots compete at the same time. The robot which faster and better fulfills its task wins.

B. Ketchup Can

The robot task is to move as much ketchup cans as possible to its home line.

Ketchup is stored in a steel tinned can with diameter 53 mm (± 1 mm) and height 74 mm (± 1 mm). The mass of the full can (with the content) is approximately 163 grams (± 5 g).

Fig. 3. Tomato puree in can. Available in regular groceries.

C. Stock

The stock is represented by the network of 5 horizontal and 5 vertical lines with the distance 30 cm (± 1cm). This dimension is sufficient also for the Lego Mindstorms robot constructions. Horizontal lines are numbered 1-5, vertical are labeled A-E. Lines are black, their width is 15 mm (± 1mm). Lines are meant as a navigational aid, it is not necessary to move along them.

There is a free area min. 30 cm around the stock from each side. Overall dimensions of the playing field is minimum 180 × 180 cm (i.e. 30 + 4x30 +30).

The base is horizontal and white. It is made of plastic, rubberized fibre, paper or similar material. When the base is not made of a single piece, then the connections shouldn't create steps larger than 1 mm. Slope changes shouldn't exceed 4 degrees.

At the start, robots are placed on intersections A3 and E3 (see Fig. 4). Vertical line A is a home line for the first robot, vertical line E is a home line for the second robot.

There are four cans in the game. At the beginning, two ketchups are at fixed positions C2 and C4. Other two cans will be placed at symmetric positions B2-D4, B3-D3 resp. B4-D2 which are chosen randomly before each run.

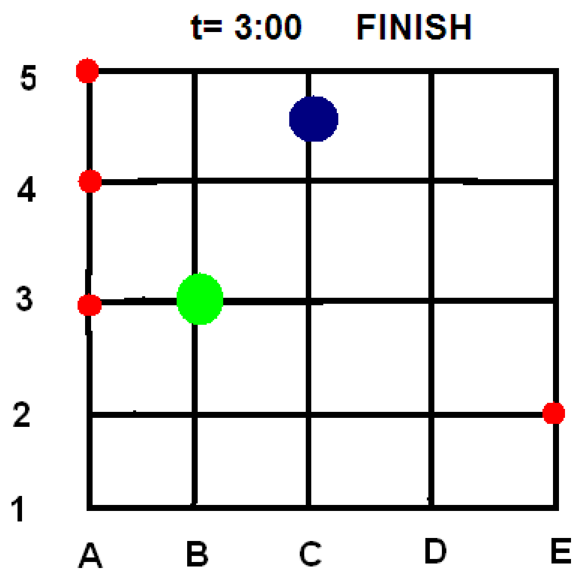

Fig. 5. Green robot wins – it has 3 cans at his home line, while the blue robot only 1. After the finish the robot can stop anywhere, not necessarily at his home line.

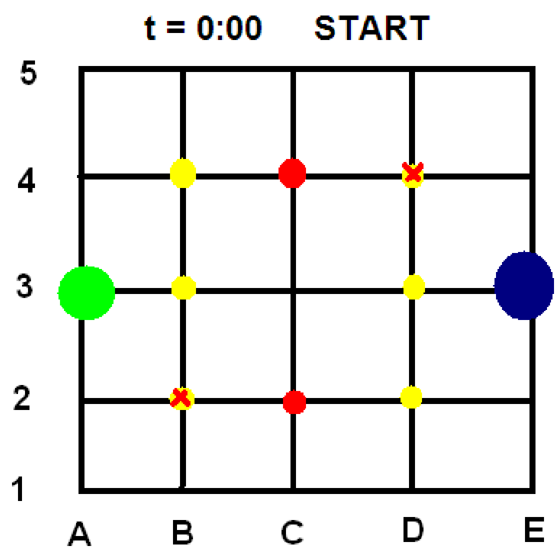

Fig. 4. Robots are at positions A3, E3. Two cans are always at C2 and C4. Other two are placed at two circles marked yellow, e.g. B2 and D4.

D. Robot – storeholder

Robot has to be autonomous. During the contest, no external influence is allowed.

The length and width of the robot have to be less than 30 cm. When the robot changes its dimensions during the contest, in any moment the dimensions can't exceed 30×30 cm. Height of the robot is not limited. Cans are not counted to the robot dimensions.

It is allowed to move also apart from lines, they are considered just as a means for navigation. During the movement, robots are not allowed to place any traces or markings. No part of the robot may stay on the base.

E. Activity of the robot

The basic task is to identify cans in the stock and to move them onto its home line. Is is allowed to move also the opponents cans. Damaging of the opponent robot is strictly forbidden.

Before the start, robots are placed at their initial positions. On the referee signal, they are activated by the team members who then immediately move back and no more interact with the robots. After the time limit, robots are immediately deactivated by their owners.

Cans may be moved using any technique (push, pull, roll,...). This is the difference comparing to the original Sokoban game, where only pushing is allowed. We considered it as a pointless limitation and we were really curious which types of movement will be really adapted. Also more than one can at the time can be moved. Robot may move in any direction, as the lines are meant just as a navigational aid.

After the time limit, the number of cans at each home line is evaluated. The can is scored when at least its small part touches the home line, not necessarily in the cross-section.

Number of cans at the home line represents score of the robot in the given lap. The contest will run in a round robin tournament. In the case of large amount of participants, the robots will be divided into the smaller groups.

Ketchups are counted after the finish. Until then, robots can steal away them from their positions.

F. Contest

Sequence of matches is determined randomly immediately before the contest. Throughout the contest, the algorithms, settings and components of the robot can be modified or configured differently for facing each opponent.

The robot must be ready within 1 minute after the call, otherwise its match is lost. Each match takes 3 minutes. If both contestants agree, the match can be stopped also sooner.

Winner of the tournament is the robot with the highest score. If during the tournament no points are scored, jury determines the winner consodering its overall success - e.g. how close the can was to the home line, whether the movement was coordinated or just random etc.

G. Results and users acceptance

Surprisingly, even the rules were published just 3 months before the competition, this category registered 12 robots and 11 of them really competed. This is not obvious for other, even mature, categories. During the contest we started with a qualification, where each robot has to show its ability to collect at least one can on the playground. Even though during the qualification more than half of robots didn't succeed, real matches were more succesfull. We split them into the two groups, based on results of the qualification, then performed round robin tournament. Six robots qualified for the finals and three of them were awarded as they gained the same amount of points – 9.

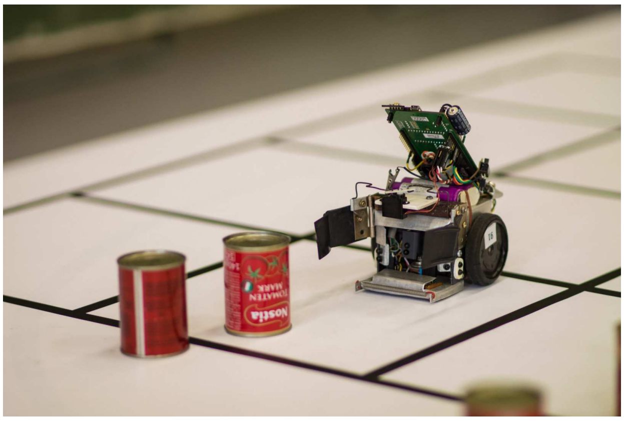

Fig. 7. Robot Missile ARM on Istrobot 2012 (author: Ján Hudec, photo: Andrej Lenčucha)

TABLE II
KETCHUP HOUSE 2012 RESULTS.

Place	Team	Veterobot	Frankie	Franta	ARMtank	PICtank	MissileARM	Score
1	Veterobot	–	2	0	2	3	2	**9**
1	Frankie	2	–	1	2	2	2	**9**
1	Franta	3	0	–	2	0	4	**9**
4	ARMtank	2	2	0	–	2	2	**8**
5	PICtank	0	1	1	1	–	2	**5**
6	MissileARM	0	0	0	1	0	–	**1**

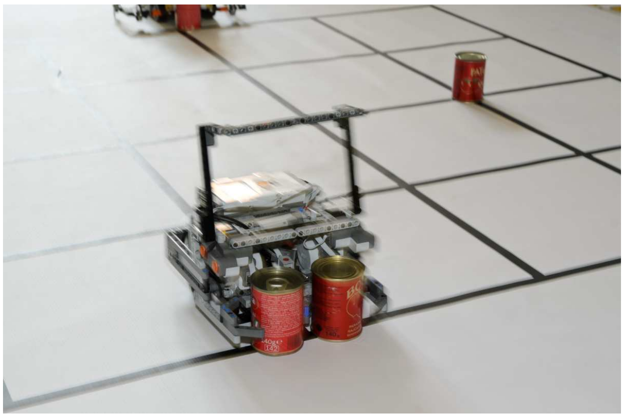

Fig. 6. Istrobot 2012 tournament (photo: Zoltán Janík)

TABLE I
LIST OF PARTICIPANTS

Team	Age	Kit?	Processor	Language	Score
Veterobot	14 – 42	Yes	NXT	NXT-G	9
ARMtank	14, 15	No	ARM	C	8
Frankie	14	Yes	NXT	NXC	6
PICtank	15, 15	No	PIC18F4550	picC	4
Franta	21, 22	Yes	ATmega328	Arduino	4
MissileARM	22	No	STM32 Arm	C	3
Omocha	32	Yes	NXT	NXC	1
Bobinator	16	No	ATmega16	C	0
Lugge	22, 27	No	STM32 Arm	C	0
Tomato LM1	13, 13	Yes	NXT	BrixCC	0
Tomato LM2	12	Yes	NXT	BrixCC	0

Only one robot was able to score full amount of 4 points (i.e. 4 cans collected). This robot – *Franta* [8][3] – was built around the Acrob [9] robot with an ATmega328 processor and one line sensor plus two additional for cross detection. For a better navigation a Hitachi HM55B compass sensor was used. For can detection, single Sharp distance sensor was used. The robot was programmed in Arduino language and environment.

We also caught some responses from visitors reflecting the motivational potential of this category:

Ketchup was great discipline and my students get motivated to learn programming... (Václav Králik)

Some others also declared an attempt to build a robot for the next year:

New category capture my attention. I assume to participate the next year... (Juraj Fojtík)

An overview of all participants with characteristics of teams (age) and their robots (kit or proprietary construction, processor and used programming language) is given in Tab. I. Last column contains number of points obtained in qualification, i.e. with no opponent robot at the playfield.

In table II, there are listed results of the final matches between six finalists. There were three teams with the same score, so we decided to award them all as the winners of the contest.

[3]see video at http://youtu.be/rqoO1gnbeUE

III. POSSIBLE DEVELOPMENT

Our new contest is also a good example of a contest which can develop over the years. It is probably too soon to change the rules after the first, pilot year. But we can see some directions in which the contest can develop in the future. First, we can increase the size of the playground and the number of cans. Also we can change the shape of the warehouse. Instead of square it might be more complicated, L-shaped or T-shaped or even very complicated shape more resembling the original Sokoban game with pre-defined final positions of the cans. More complicated shapes will focus the effort on better navigation methods and algorithms.

Another possibility to make the competition more difficult is to use coloured cans placed at predefined final positions. This will focus on different sensors and data processing.

We can also allow the ”fight” of the robots for limited amount of cans and thus the contest shift to resemble the MiniSumo contest, but this is not in the line with our ideas of development.

Another very promising possibility is to change the view of robots from competitors to co-operators. We can evaluate how robot will cooperate with each of the ”opponents” on the common goal - to collect as much cans as possible. Robot obtaining best results with all robots will be awarded as ”the best cooperating robot”. We can also consider the possibility to open a communication link between the robots to support the cooperation between randomly chosen robots.

If we would like people to focus on mechanics and construction of robots, we can introduce additional ”floors”, so cans should be manipulated in 3D and stored, for instance, to an elevated ramp.

IV. Conclusion

After the first year of this competition we consider the idea to be successful. Relatively large amount of registered (and really participating) robots gives us a great chance that the next year it will be really interesting category. We plan to include the partial tasks from this competition into the Robotics course laboratory exercises to attract students of this course to do more than in syllabus. We await also more newcomers from secondary schools hoping they will also be attracted to study at our university later.

Advantage of this contest is relatively easy and cheap playground, low requirements on robots hardware and challenging task. When used in conjunction with robotics courses, it can focus students on the problems of navigation, sensing and precise motion control. Random elements resulting from the movements of the opponent robot increase demands on more intelligence built into the robots.

We would like to encourage other organizers to include this category into their robotic contests and festivals. We would be pleased to hear about experiences from such implementations.

Acknowledgment

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