Robot Competition with Teachers

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Abstract. This paper describes the predator and prey robot competition that took place within a robotics class for teachers. The robotics class was part of a degree program that aims at educating upper secondary school teachers of different backgrounds in informatics, a discipline that is not yet a mandatory part of the Swiss school curriculum. The aim of this robot competition was to familiarize the teachers with robotic hardware and software such that they would be able to design their own informatics class syllabus. This paper describes the custom robotic platform used, the competition, its aims and results.

Keywords: educational robotics, robot platforms, robot competition, artificial intelligence, teacher education.

1 Introduction

There has been a rapid development of information and communication technology in the last decades that highly influenced our society. Informatics is seen as the science that drives the progress in these technologies. In order to maintain economical competitiveness, education in this discipline in crucial. Informatics is not yet a part in the curriculum of upper secondary schools in Switzerland. The Swiss school authority has recently identified this and decided to incorporate informatics as an optional discipline in its school curriculum. Consequently, teacher education in Informatics is an urgent requirement. The Swiss Hasler foundation has created a degree program "Master of Advanced Studies Informatics in Upper Secondary Schools" to address this need. This program targets teachers that are willing to teach informatics in addition to their primary discipline. This two-year master study program includes topics such as programming, Internet and multimedia, databases, information systems, theoretical informatics and robotics. Since there is no official syllabus for this optional discipline in informatics provided by the school authority, this broad background of informatics should enable the teachers to to produce the syllabus by themselves.

This paper describes an exemplary predator and prey robot competition project which was conducted in the 'Robotics' course taught by the authors, as part of this teacher education program in January 2010. All of the 15 male teachers were between the age

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of 35 and 54 and familiar with very different disciplines (4 Mathematics, 3 Informatics, 2 Physics, 1 Chemistry, 1 German literature, 1 Biology, 1 Sports, 1 Greek, 1 Economics). The 3 informatics teachers used to teach only applications such as Microsoft Office and how to use the Internet. With that study program they want to broaden their knowledge. In this project, robots were used as a learning tool for the teachers. As robots are often attractive tools for hands-on education of younger students in science and mathematics due to the 'fun' factor, we believe that it is necessary for the teachers to learn and have first-hand experiences with robots themselves. In addition, since the teachers will have to design their future informatics class by themselves the aim was to familiarize them with the "inside" of a robot. They should have some basic knowledge of the components which are necessary to build a robot and how they function. Therefore, we built and provided custom robotic platforms for the class project competition. This knowledge should enable them to evaluate off-the-shelf robot kits in order to choose the right one for their own purposes.

In the rest of this paper, besides the related work, the predator and prey robot competition project, its rules and environmental setup as well as the robot's hardware and software are described. This is followed by results, discussion and conclusion.

2 Related Work

Robots have been used in the last decade to introduce kids and especially girls [1] to science and technology. Class activities with robots range from kindergarten to high secondary school. Following the constructivist/constructionist paradigm, learning through play can contribute to the construction of new knowledge [2][3][4]. Furthermore, robot competitions have been very popular [5]. A competition provides additional extrinsic motivation for the students, it increases the group work skills and encourages the student to identify and evaluate a variety of opinions [6].

3 Predator and Prey Robot Competition

The robotics class duration was in total eight full days excluding homework hours. The class syllabus covered topics in Artificial Intelligence such as Introduction to Artificial Intelligence, Morphological Computation, Neural Networks, Artificial Evolution, Artificial Life as well as topics in robotics (robot hardware, sensors, and actuators). Next to many practical exercises the main group project that was graded was the "Predator and Prey" robot competition. Of course not all of the topics taught in this class were relevant for this group project. The teachers had time to work on this project mostly as homework. A self-made robotic platform built by the authors was used for that purpose. Each group consisting of two people received two robots – one predator (Figure 1a) and one prey (Figure 1b). The robot has two wheels actuated by

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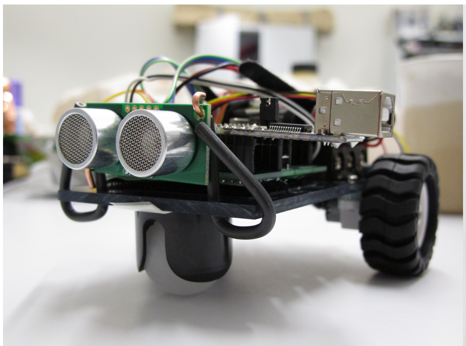
two DC motors that can turn individually forwards and backwards with different speeds. Furthermore it was equipped with odometry, ultra sonic, light and touch sensors. The prey had in addition an infra red sensor for object detection. Figure 1a and 1b show the default robot configuration of the predator and prey as the teachers received it. The teachers were free to form the groups by themselves. Since they had been studying together in this masters study program already for a year, they knew each other very well and therefore the groups were already established. Interestingly the groups in general consisted of teachers from different backgrounds, so it was not at all the case that for example all the Mathematics or Physics teachers formed groups together.



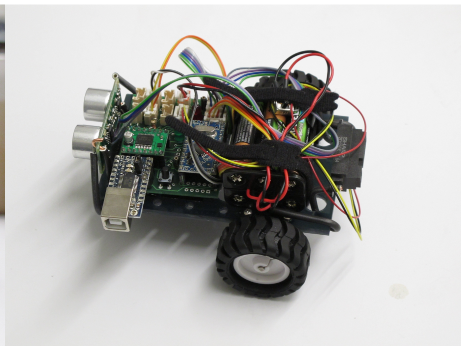


Fig. 1a. Predator robot has to catch the prey. It is equipped with odometry, ultra sonic, light and touch sensors

Fig. 1b. Prey robot has to escape and hide from the predator. It is equipped with odometry, ultra sonic, light, touch and infra red sensors.

3.1 The competition rules

The competition starts when predator and prey are exposed to an random, unknown environment bordered by walls. Figure 2 shows a sample environment. The walls and the obstacles of the environment can be detected by the robot's ultra sonic, infra red or touch sensors. The hideout, i.e. the place where the prey has to escape to, can be detected by the light sensors, if they are pointing to the ground. The obstacles can have any shape, such as round or squared. The robots can detect each other by using their ultra sonic, infra red or touch sensors. Table 1 lists the main nine rules of the competition. These rules define how the predator and prey robot have to indicate in which state of the game they are, such as hunting, hiding or escaping. Furthermore, they define what a robot is not allowed to do and under which circumstances it has won the game. The teachers are allowed to add custom rules as well. The default robot

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bodies in Figure 1a and 1b are provided but not fixed. Every group was encouraged to change the robots default shapes to their needs and strategies. They could relocate sensors wherever they wanted, body material could be removed or additional material could be attached. The goal was to show the importance of the body configuration of the robot. The body shape and location of the sensors play a crucial part in increasing performance of their robots as well as reducing control effort.

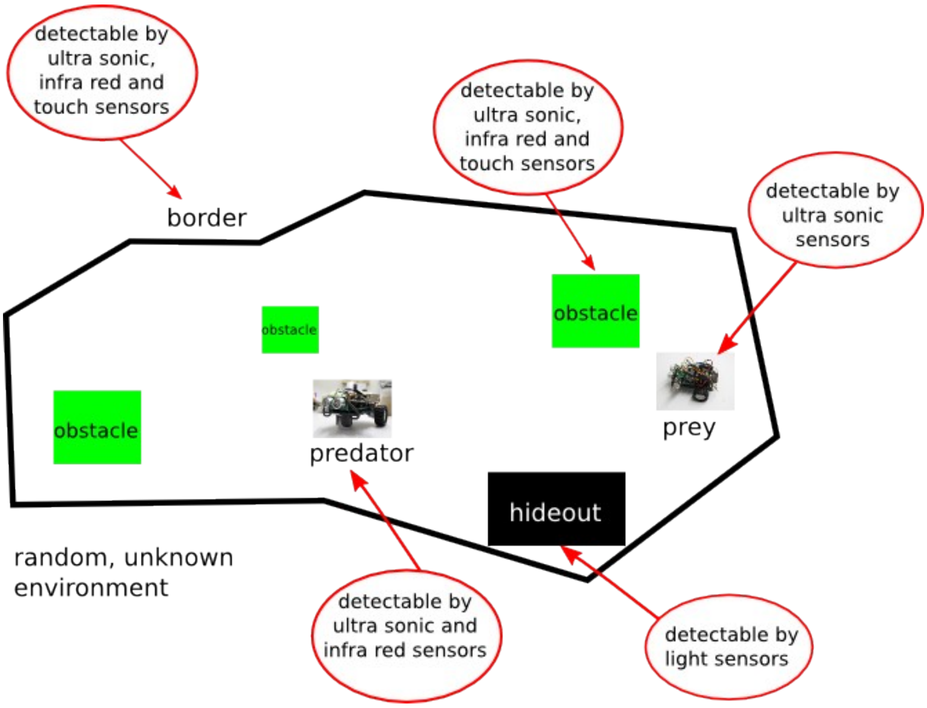

Fig. 2. Random, unknown environment surrounded by walls. The walls and the obstacles of the environment can be detected by the robot's ultra sonic, infra red or touch sensors. The hideout, the place where the prey has to escape to, can be detected by the light sensors, if they are pointing to the ground. The obstacles can have any shape such as round or squared. The robots can detect each other by using their ultra sonic, infra red or touch sensors.

Table 1. The competition rules define among other things how the predator and prey robot have to indicate in which state of the game they are (states such as hunting, hiding or escaping). Furthermore, they define what a robot is not allowed to do and under which circumstances it has won the game. The teachers were allowed to add custom rules as well.

Rule number	Rule
1	While the predator is looking for a prey, it has to be indicated by a green LED
2	When the predator detects a prey, it starts hunting and tries to catch it. This has to be indicated by a red LED

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3	Predator has caught the prey, if one of its touch sensors detected the prey robot (predator should stop and blink with red and green LED, winner of the game).
4	The predator is not allowed to enter the hideout area. If it does so, the predator loses the game .
5	The prey has to move around in the environment (indicated by a green LED). It is allowed to act „dead“, but it has to move on after 10 seconds.
6	If the prey detects the predator (indicated by a red LED), it has to escape to the hideout.
7	When the prey gets to the hideout, it stays there and is blinking with red and green LED (winner of the game)
8	The hideout is always located a the border of the environment.
9	It is allowed to add custom rules (e.g. speed limits for predator and prey).

3.2 The robot hardware and software

As mentioned above, the robot was built by the authors. While designing this robotic platform, the focus was on using cheap, commercial available parts and open-source software. For the control board an Arduino Mini was used. The Arduino platform [7] is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. The teachers should have the opportunity to rebuilt the robot by themselves in case they want to use it in their class. A detailed assembly plan and part list including links where to order each part of the robot was distributed by the end of the class. The total material costs of one robot is about 230 EUR.

The decision why to build a custom robotic platform and not to use an off-the-shelf robot kit such as LEGO was, besides the price, the need to have a flexible platform to which good sensors and motors can be attached. Teachers that are interested in topics such as robotics are usually already familiar with the LEGO platform. It was thought that LEGO is more useful for other applications since it hides more or less the technical “inside” of a robot (neat, standardized connections, no electrical components and PCB visible) and simplifies the programming significantly. Here, the aim was to give the teachers the feeling of working with “real robots” and to give them the opportunity to program it with the programming language C (easy to use libraries were provided). The fact that they could see all the components (such as the controller board, H-bridge, motors, sensors and communication devices) necessary to run and program the robot, and to experience why things do not work anymore if cables are disconnected, helped to teach them what's inside a robot.

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4 Results

The teachers were very motivated to work in this robot competition project. They enjoyed both changing the robot's body and programming its controller. Some examples of predator and prey robots built by the teachers are shown in Figure 3. Most of the groups changed the default robot configuration completely. Sensors were relocated, additional features such as tentacles, bumpers, stable cases or covers for the light sensors were added by using materials such as LEGO, wood, plastic and metal.

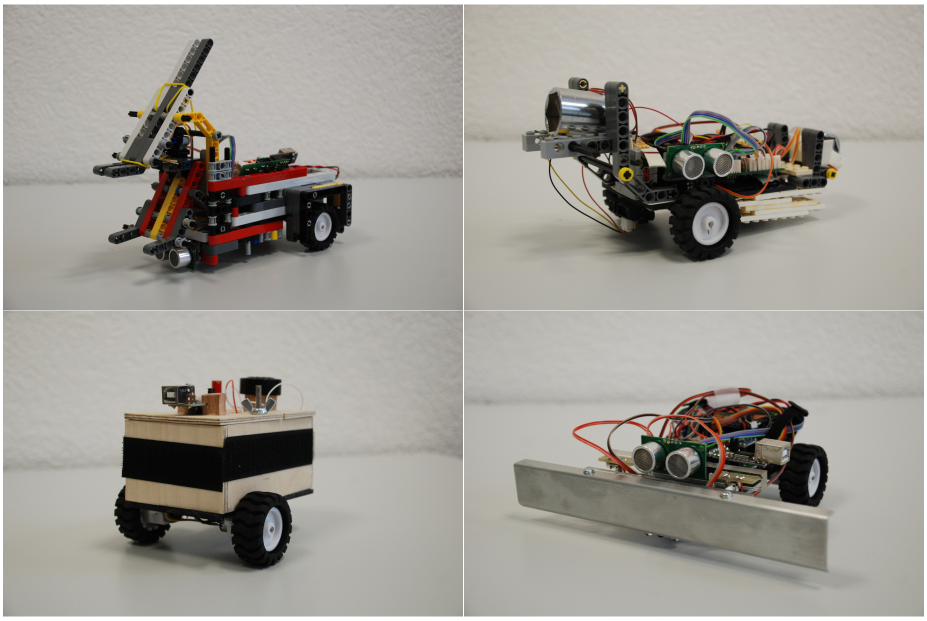

Fig. 3. A selection of four different predator and prey robots built by the teachers. The robots were extended with LEGO, wood, plastic and metal parts. The teachers build additional features such as tentacles, bumpers, stable cases or filter covers for the light sensors.

Each group had to present their predator and prey robots and the implementation details followed by a live demonstration of the competition. Each competition had one predator and one prey robot. After the group presentations and their individual competitions all robots were put in the environment, informally, just for fun. Figure 4 shows this competition run. The performance of the robots differed but the range was not too big. The teachers with prior knowledge in programming had less difficulties to familiarize themselves with the C programming language. Since the Arduino C library and the custom libraries provided by us are very easy to use, no one had real difficulties to program the robot. However, some groups came up with sophisticated control strategies whereas others only managed to implement some basic obstacle avoidance behavior. There was no correlation between the background of the teachers

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and the performance of their robots. Some teachers from non-technical backgrounds were among the best ones due to their motivation and general interest in this topic.

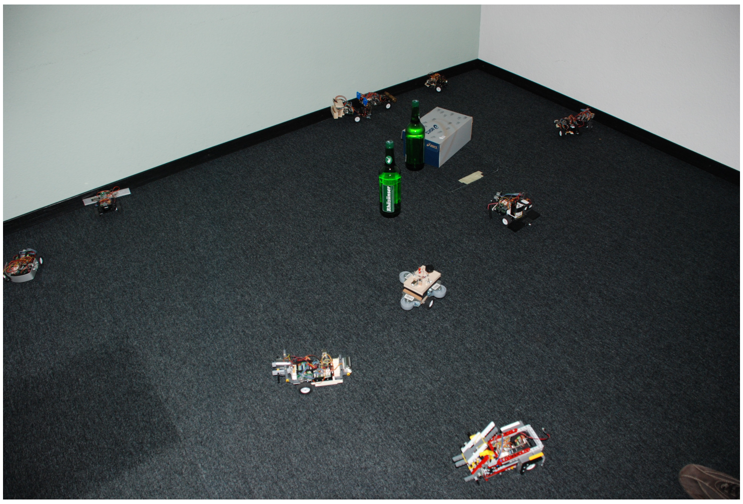

Fig. 4. The environment with all the predator and prey robots together. The green bottles and the card box are the obstacles. The ground had dark color and the hideout was a white paper (not seen in this picture).

5 Discussion

The class evaluation survey was optional and therefore only half of the evaluation sheets have been returned. The feedback that we describe here was received mostly on personal discussions with the teachers and was overall very positive. The teachers enjoyed the hands-on approach of this class and the fact that they could work on a practical project rather than having to write a theoretical exam by the end of the semester. Furthermore, they enjoyed the group work and the competition as a game. The fact that for each group two robots – one predator and one prey – have been distributed simplified the group work. Mostly the groups could work together at the dedicated hours during class time. Some met additionally at homework time but this was difficult since many teachers lived in different cities. There were two main improvement suggestions mentioned by the teachers. Firstly, they would have wished more dedicated group work time during class. Secondly, the robot's hardware should have been built more stable. Problems occurred with cables that came off during the use of the robot and solder connections broke. Since the teachers have little experience to tackle these kinds of technical problems, valuable homework time was wasted due to these problems. Furthermore, the use of a custom robotic platform that looked like a “real” robot was appreciated since many of the teachers were already familiar with LEGO. Many of them had the feeling to have learned a lot about robots

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and felt confident to be able to evaluate robot kits in the future. However, for their own class most of the teachers would not choose a custom robotic platform. The effort would be too big because, as mentioned above, connections come off easily and the following debugging would take too long. For their students they would rather choose a more stable platform such as LEGO. At this stage the teachers could not yet determine how they will design their informatics class syllabus and whether robotics will be a definitive part of it. Nevertheless, most of them would consider using robot kits for their class activities.

6 Conclusion and Outlook

Overall, the robotics class for teachers was successful. The feedback was very positive and the educational objective was met. Most of the teachers saw robots as a suitable tool for teaching science and technology. The approach to use a custom robotics platform for teacher education was a suitable one. For the next class that will take place January 2011, a number of improvements have been planned, which include better robot hardware and more dedicated group work time during class time. The number of attendees will be 21, including male and female teachers from disciplines such as Chemistry, Mathematics, Sports, Physics, Geography, Biology, Economics and Design. A formal and mandatory evaluation survey has been planned as well.

7 References

1. The Initiative "Roberta - Learning with Robots", http://www.roberta-home.de/en
2. Atmatzidou, S., Markelis, I., Dimitriadis, S.: The use of LEGO Mindstorms in elementary and secondary education: game as a way of triggering learning. In: Workshop Proceedings of SIMPAR 2008 Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS, pp. 22-30
3. Arlegui, J., Menegatti, E., Moro, M., Pina, A.: Robotics, Computer Science curricula and Interdisciplinary activities. In: Workshop Proceedings of SIMPAR 2008 Intl. Conf. On SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS, pp. 10-21
4. Savage, T., Sánchez, A., I., O’Donnell, F., Tangney, B.: Using Robotic Technology as a Constructionist Mindtool in Knowledge Construction. In: Proceedings of the The 3rd IEEE International Conference on Advanced Learning Technologies (ICALT’03) 2003
5. FIRST LEGO League, http://www.firstlegoleague.org/
6. Pisciotta, M., Vello, B., Bordo, C., Morgavi, G.: Robotic Competition: A Classroom Experience in a Vocational School. In: 6th WSEAS/IASME International Conference on EDUCATIONAL TECHNOLOGIES (EDUTE '10) 2010, pp. 151-156
7. ARDUINO, http://www.arduino.cc/