Managing large projects with changing students — the example of the Roboter Soccer team 'Vienna Cubes'

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Abstract

Roboter Soccer plays an important role in the field of artificial intelligence. RoboCup focuses on the development of robots winning a play of soccer against a human team by 2050. The Vienna Cubes participated in the Roboter Soccer World Championship in 2003, reached the quarter finals in 2004, and qualified again for the World Cup 2005 in Osaka. Again, the quarter finals could be reached. The entire project (except top-level management and financial control) is managed by students. Today, 24 students develop the necessary hard and software. There are numerous problems to overcome. Most important, most students are only engaged in the project for two years, thus meaning special care has to be taken to keep the gained knowledge alive. To overcome the drain of knowledge, the authors developed a rotational concept for the team members, the whole cycle consist of two years of work, followed by a honour phase to further support the working students. The second challenge is to structure the project in a way, which encourages highly motivated students to put all their energy into the project itself, rather then to achieve a good mark on a test. This problem was solved by concentrating on the intrinsic motivation of students. The whole team is organized by the students. Professors only take part in setting the goals and only advice the active students, if they wish. The structure has proven to be very efficient and allowed an excellent performance of the team.

Keywords

roboter soccer, artificial intelligence, motivation, management of knowledge

Introduction

Roboter Soccer has become an important key problem for the development of Artificial Intelligence (AI). The Robot World Cup Initiative (in short: RoboCup) is an international research and education initiative. It is an attempt to foster AI and intelligent robotics research by providing a standard problem where a wide range of technologies can be integrated and examined, while being used for integrated project-oriented education. The RoboCup Organisation focuses on the development of a Roboter Soccer Team that wins a game of soccer against a human soccer team in the year 2050.

Today, around 300 teams in the world are developing hard and software for roboter soccer, most of the teams are found on universities. In 2001 students of the electronic course at the Technikum Wien came up with the idea to develop robots that play soccer. The authors decided to accept the idea as a suitable project to teach information technologies, electronics, telecommunications and embedded systems in our 'Project Based Learning' environment. Most students did very well and at the end the project, the team members came up with the idea to orientate a follow up project on the RoboCup guidelines (http://www.robocup.org) and if they could fulfil the requirements they suggested setting the participation in the RoboCup Games as a medium term goal.

Already in 2002 they participated in the World Championship in Padua, Italy. However, not a single goal could be scored. In 2004 the Vienna Cubes reached the quarter finals in the World Championship in Lisbon, Portugal. In the World Championship 2005 in Osaka, Japan, the Vienna Cubes Team again reached the quarter finals.

Roboter Soccer: An overview

The Vienna Cubes participate in the F180 small system league. Figure 1 shows the overview of the whole system. The Field in the center of the picture shows where the action takes place. Here the robot teams play against each other. The size of the field and the maximum dimensions of the robots are defined by the rules for the F180 Small Size League. Each team consists of four field players and one goalkeeper. Each robot is marked with color dots comparable with soccer shirts in human beings' soccer games.

Above the field two cameras monitor the ongoing game. The cameras are connected to a computer that runs Image Recognition (IR) software. This software finds the positions of all players (own and opponents) by analyzing the picture stream and searching for the colored marks.

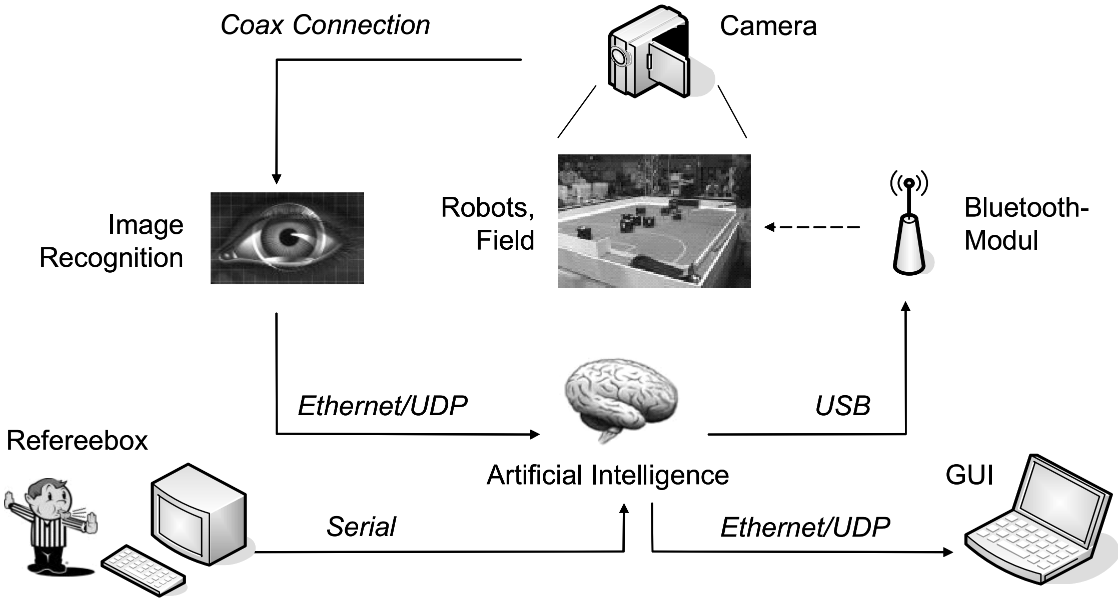

Figure 1: System overview

The calculated coordinates of the robots are sent to a second system performing Artificial Intelligence software. Primarily it analyzes the current situation of the game. Using several algorithms the program determines the best reaction and orders the robots to execute the next playing steps by transmitting commands to the own players.

For example it instructs a robot to go to a new position with a specific speed. Furthermore like in a real soccer game there are a lot of rules that have to be taken into consideration. The commands are sent via radio transmitter. Because of the fact, that actually this is a very complex procedure a separate PC is used. The arrows in Figure 1 show the main dataflow from the cameras through Image Recognition to the Artificial Intelligence system, which generates commands that are then sent to the robots. The robots itself just act on instruction and do not have any own logic or intelligence.

At last the system has to mention the Referee box and the Graphical User Interface (GUI). The serial interface for the Referee box is obligatory because there has to be a referee that keeps an eye on the game and watches out for any infringements. The referee stops the game, i.e. the Referee Box instructs the software of the teams to stop the game and take some special action like penalty, free kick, etc. The Graphical User Interface displays a lot of system parameters and outputs and allows the system's calculations and decisions to be monitored and analyzed. Moves and even whole games can be recorded, reviewed and analyzed using this component. Since the robots have to play autonomously there is no way to control them manually. The main task of the GUI is to get a little bit more insight into the decision processes of the Artificial Intelligence, to find errors in the algorithms and to improve them.

Motivation to join the team

How does the momentum start? What are the reasons for a student to become a member of the Vienna Cubes team? Motivation to do something is widely recognised as one of the key factors for success. The more general question is, where does the motivation of students to study a specific subject deeply or just up to the absolute minimum level come from? Most teaching methods simply rely on external force (=exam) to make students do something, the teacher wants them to do. This method just does not take into account that there exist two different forms of motivation, namely intrinsic and extrinsic motivation, both of them having specific advantages and disadvantages.

Intrinsic vs. extrinsic motivation

The motivation of students to do what teachers want them to do is, in most cases, the simple need to pass an examination. Of course, this leads to the question: 'What do I have to do to pass the exam with the minimum effort and the maximum effect (=grade)?' Or in other words, efficiency from a student's point of view is to find out what a teacher wants to hear. It is quite clear that the main focus now lies on the mark given by the teacher, and not on the subject itself.

In many cases this well-known problem turns out to be rather persistent. The reason for this is our educational system itself, which heavily relies on shifting the focus of the student away from the subject towards the test about the subject (Norman & Schmidt, 1992; Pucher, Wahl, & Mense, 2001; Middleton, 1995; Sprenger, 1995; 2001).

Intrinsic motivation

Intrinsic motivation is the stimulation or drive stemming from within oneself. In relation to studying, one wants to learn by a motive to understand, originating from one's own interests in the result. Intrinsic motivation is associated with intrinsic rewards and the natural rewards of a task are the motivating forces that encourage an individual in the first place.

Extrinsic motivation

Extrinsic motivation is encouragement by an outside force. The behaviour of an individual comes from the expectancy of an outside reward. This can be money, praise or in relation to learning, the mark. Extrinsic rewards are usually necessary to bribe someone into doing something that they would not do on their own. It is a matter of fact that these types of reward systems are the main reward systems used in our universities. Students have to do a specific task, but what is important is not the task itself, but the mark they finally get.

The known problems with these types of extrinsic motivators are numerous. Among the many disadvantages of extrinsic motivation is the fact that it tells students, the task itself is not important, but the reward is the important thing. This is exactly the behaviour we frequently observe in daily teaching routine (Lepper, Greene, & Nisbett, 1973; Deci, 1971; Kohn, 1993; Sprenger, 1995; 2001).

Students often analyse the specific way a teacher asks questions. Statistics on the occurrences of questions are available among students for many subjects, which allow more efficient study from the student's point of view by just reducing the amount to be remembered. If students work on projects in the field of computer science, often it is very hard to find out the contribution of an individual student to the project. In some cases, students can get away by copying and slightly modifying work that originates from other students. Only if students are interested in the outcome of the project itself and not in getting a mark will they give their best.

Intrinsic motivation in the RoboCup project

In the RoboCup project intrinsic motivation is high, mainly because only those students are allowed to participate who prove interest in the project. Not teachers but students themselves decide if a specific person is allowed to become a junior member of the team. The whole responsibility lies in the hands of the students themselves. There simply is no teacher who will accept excuses why something dit not work. Students who participate want to achieve a high rank in the competitions. Continuous interest of Austrian TV and newspapers is one of the feedbacks that prove students that they do the right thing right.

Teachers do not teach; they coach the students. The knowledge of the teacher is not the key success factor, but her/his ability to assist students in their own way of finding relevant information themselves and to assist students in the process of transforming the information into a working project. For the students it often turns out to be very difficult to accept that there is no one who knows all the answers. It is a key element in learning that the only ones who can solve the problem are the students themselves by walking a creative innovative path.

Keeping knowledge alive

Students are not employees. Students join the team for two years only. A huge drain of knowledge is the result of this short time of engagement unless measures are taken to prevent that. The authors introduced a rotation concept, consisting of three stages, namely 'Junior', 'Core' and 'Senior'. Students who join the team start as juniors first and advance after one year to core team members. The specific responsibilities of each phase are detailed.

	Motivation	Knowledge	Recruit	Research	Build robots	Marketing	German Open	World Championships	Find sponsors
Junior	Receive	Build up			Do		Take part		
Core	Do/Receive	Teach	Do	Do	Do	Do	Take part	Take part	Do
Senior	Do	Teach				Do			Do

Figure 2: Team structure

Juniors are organized by 'Core' team members. Core team members do all the actual programming and development. Senor team members can participate in actual work if they wish so. However, most senior team members already left university and do not have sufficient time to participate in daily routine work.

The most important element is the teaching of junior team members by core team members. Because core team members need the skills of the juniors they are willing to teach them all necessary knowledge to get help from them. On the other hand, juniors are allowed to develop their own ideas and maybe to implement them in the active robots, once they became core team members.

Junior or core team phase usually last for one year. After one year of being core team member, students advance to the senior phase, the juniors become core members and new juniors are recruited by the core members. The most productive phase is the core phase. These students do most actual work. The students themselves carry the responsibility to achieve a planned rank in the European, National or World Championship Games (see Figure 3).

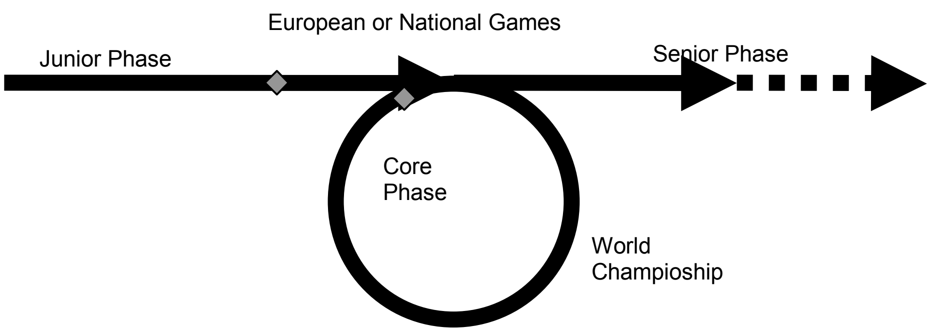

Figure 3: Team phases

Setting of goals

For a period of two years the authors believed that even setting of global goals, like where we want to be in three years, etc. should be set by students. However, we learned that the students couldn't set these global goals. The reason for this is now obvious. Students just do not see goals that they themselves cannot achieve in the time they join the project. There is simply no motivation to plan something you do not gain profit from.

Therefore, the authors decided to set long term goals themselves, such as a specific rank in the World Championship in three years themselves. We defined a staff member of the department of computer science who takes this responsibility along with the responsibility for financial control.

All other goals are set by the students themselves. This is a very important issue. The authors point out that best results are achieved when students themselves carry as much responsibility as possible, leaving only the absolute minimum responsibility with the teachers. Teachers (in general) do not interfere in decisions taken by core team members. However, specialists in the fields of IT, telecommunications and embedded systems are always open to be asked for their opinion on specific questions students have.

It is very important that the interference of teachers is kept to an absolute minimum. The whole issue of robot soccer is a very complex one. Most teachers do have excellent knowledge in their field. But the application of the knowledge in robot soccer is an entirely different story. In many cases teachers think that the students cannot solve difficult technical problems. The contrary turned out to be true. In most cases the students found simple, elegant solutions where teachers did not have enough insight into the specific problem. One example is the mechanism for omnidirectional moves (see Figure 4).

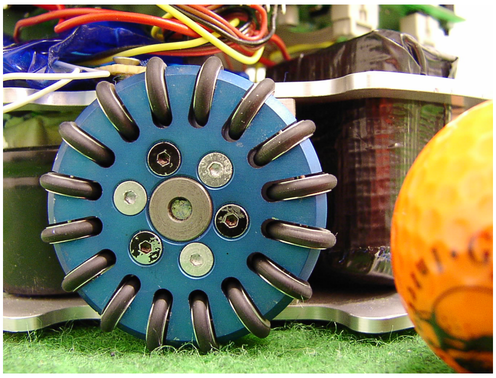

Figure 4: Wheels for omnidirectional moves

Omnidirectional moves allow robots to accelerate from any direction into any direction without prior adjustment of the heading of the device, thus gaining significant advantages in catching a ball. The conventional wheelchair systems have a much lower performance. The system for omnidirectional moves was developed by NASA and adopted by the students of the team.

By placing students in the active role of problem-solvers confronted with an ill-structured problem that mirrors real-world problems they learn a new way of problem-oriented thinking. Therefore, direct teaching is avoided. Students are coached and no prepared answers or solutions (if there are any) are given. Intrinsic motivation seems to be high if three factors can be combined in a single person.

1. Planning of the project.
2. Doing the project.
3. Looking at the results and being proud of them.

If these three factors can be realised by all of the group members, the motivation to really solve the problem will remain high throughout the whole project (Sprenger, 1995; 2001; Boyett & Boyett, 1998). That means that one never answers direct questions of how something can be done. It is better to show ways how to obtain the necessary knowledge and allow the students to do that in their individual way.

Benefits for teaching

The RoboCup environment is an ideal learning platform for our students. Since 2001 the department of Computer Science uses various methods of 'problem based learning' (PBL). Our PBL approach stems from the University of Maastricht and was adopted to suit our needs in projects in our Computer Science course (Pucher, Wahl, & Mense, 2001). The main focus was to find suitable projects where students are able to learn in a way modern society needs. The half time of knowledge in Computer Science today is found to be in the range of years, thus meaning that there never will be an end of learning. Successful people have to realize that the only useful knowledge is knowledge that helps to solve a given problem now. In the RoboCup environment students learn to work in teams, to combine knowledge in the field of Telecommunications, Computer Science, Mechanics, Embedded Systems to reach an abstract goal, namely to achieve a rank in a game of soccer.

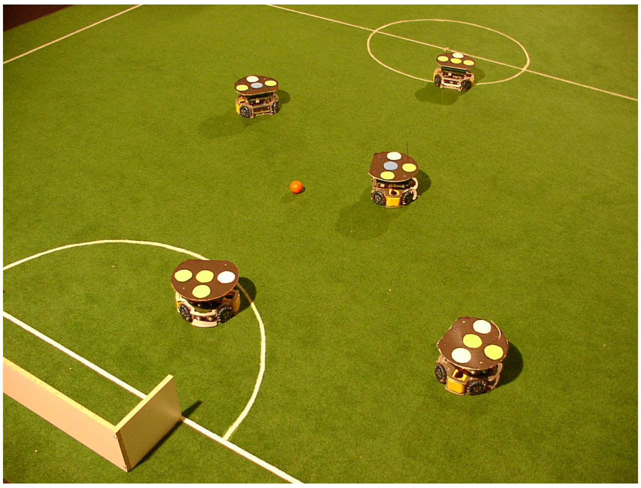

Figure 5: Robots playing soccer

In this way PBL simultaneously develops problem solving strategies, disciplinary knowledge bases, and skills (Pucher, Wahl, & Mense, 2001; Wahl et al., 2004; Pucher et al, 2004).

Conclusion

Motivation of doing something is the key success factor for students in large projects. Only if they feel that what they are doing makes sense will they be willing to give of their best. Intrinsic motivation, which is always inside human beings, is the most valuable resource in teaching. Placing students in a role where they can give their best in planing, doing the work and enjoying the results, changes the way students approach learning: learning becomes a pleasure.

The second issue of high importance is to setup a structure to prevent the knowledge drain, when students leave the team after a period of two years. The authors introduced a rotational concept where students themselves teach juniors to prevent a loss of already gained knowledge. By doing so, our team twice reached the quarter finals in the Roboter Soccer World Championship. These results show the usability of the concept.

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