The use of RoboCup (soccer simulation) for an AI programming course

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Abstract

In this paper we present an AI programming organised around RoboCup: a soccer simulation system. The course participants create a number of software agents that form a team, and participate in a tournament at the end of the course. The use of a challenging and interesting task, and the incentive of having a tournament has made the course quite successful, both in term of enthusiasm of the students and of knowledge acquired. In the paper we describe the structure of the course, discuss in what respect we think the course has met its aim, and the opinions of the students about the course.

1 Introduction

During the fall term 1997 we have been responsible for the course on Artificial Intelligence Programming (AIP, described on the home page `http://www.ida.liu.se/~jacma/official/aip.html`) at the Department of Computer Science, University of Linköping in Sweden. The main aim of this course is to let the students learn how to create nontrivial knowledge-based software systems. Students choosing the AIP course are expected to be taking the third year of Computer Science or the fourth year of Computer Engineering programmes. The prerequisites are an introductory artificial intelligence course and the Incremental Programming (read: Common Lisp) course. Credit for this course is given solely on the basis of approved lab assignments, differently from most other courses, where it depends mostly on examination results.

During the recent years the course has fought with bad rumour (was considered boring and time-consuming) and decreasing number of students. In 1996 only five students have chosen it, out of which just two have got all the lab assignments approved.

In order to remedy this situation, we have decided to introduce a challenging task so that the students feel interested in employing AI techniques they have learnt earlier and during the introductory lectures of AIP and are motivated for getting a working system at the end of the course, rather than quitting it in the middle of the term.

We have chosen to use RoboCup (for more information please confront `http://www.RoboCup.org/RoboCup/RoboCup.html`) as the primary lab assignment throughout the course. RoboCup is an initiative [1, 2] to foster AI and intelligent robotics research by providing a standard problem (soccer) where wide range of technologies can be integrated and examined. A number of international conferences and competitions are organized every year using both real robots and a simulated soccer environment. In our course we have used the simulation environment, as the main objective of AIP is to teach programming techniques. The RoboCup tournament organized at the end of the course gave the students an opportunity to present their solutions and confront them with those of others.

In the rest of the paper we describe in more detail the structure of the course, analyse whether the aims of this change have been met, summary the students' opinions and present our own conclusions about this experiment.

2 Structure of the course

The course spans two quarters of the academic year (approximately four months) and consists of 4 lectures 2 hours each, 10 hours of seminars and 52 hours of laboratory sessions.

The lectures are devoted to the introduction of the RoboCup framework and to the basic AI programming techniques we expect the students to use in their designs and implementations. The first lecture is an introduction to RoboCup and to the problem the students are expected to solve. In the second lecture several agent architectures are presented, ranging from Brooks' reactive architecture to the classical AI "sense-think-act" agent architecture. Learning is discussed during the third lecture. The final lecture introduces problems and important practical aspects related to the development of a team of agents. This lecture is given by a person that has actually developed a team for one of the previous competitions.

The seminars are mainly used by the students to discuss the architecture of their agents and to receive feedback from the teachers and from other students about their design. In the beginning of the course the students are given a number of articles describing earlier RoboCup teams to take inspiration for their design.

During the laboratory sessions a student has access to a number of Sun Sparcstation computers and can get help from the teachers about implementation and design issues.

In order to get credit the students are expected to implement agents fulfilling the specifications given in the beginning of the course and capable of taking part in the final competition. Also they have to write two reports: one after the first few weeks that gives a first idea about the agent architecture they intend to implement, and a second after the competition that explains, justifies and critically discusses the used architecture and the implementation.

3 Did the course meet its aims?

While evaluating the success or failure of the course we have to assume some criteria. They may be based on the formal definition of the course (as published in the coursebook of the university), or may take into account satisfaction of the students and analyze whether they have learned something useful by taking the course.

Analysing the goals of the Artificial Intelligence Programming course, we can see that the students taking it are expected to learn a variety of implementation techniques commonly understood as AI-related, so that they can later employ them in whatever (software) system they create. From this point of view, using RoboCup only partially meets this goal, as the students make quite early decision about how their software agents will look like, what implementation techniques they would like to use and what are the system-design solutions (architecture, functionality, representational capabilities, finally the implementation language). On the other hand, in the beginning of the course they learn about various architectures that might be used, about several representation formalisms that might be employed and about different functional possibilities while implementing their agents. A number of papers is read and discussed by the students during this part of the course (all lectures and most seminars, plus a small number of lab sessions). Afterwards they are expected to file a design specification that states their design decisions and motivates them. This way we ensure that the expected amount of background knowledge has been assimilated, before proceeding to the more practical part of the course.

Another objection that might be raised against RoboCup as the practical task for AI Programming is that it requires a substantial amount of knowledge not related to AI, like real-time and process programming (there is a course on Process Programming given by our department, but we cannot expect that students choosing AIP have already taken it). Actually, this was the major complaint from the students - that they had to devote a lot of time to learning other things while creating their systems. Some of them have spent a substantial number of hours finding out how to make their agents communicate with the server via a socket. The fact that some of them used Lisp didn't make it easier.

However, the students were very enthusiastic until the very end of the course. We have received a number of evaluation questionaires; all of the participating students thought that RoboCup was a good idea to follow in this course. Moreover, we have managed to revert the decrease of the number of students taking the course: the lectures have been attended by eight participants and five teams have been presented at the final tournament. So from this point of view we consider this year's AI Programming course a success, too.

If we analyse intead the knowledge that the students have gathered during the course, then definitely the evaluation of the course must be positive. Besides learning some classical AI implementation techniques, they were forced to learn about reactivness vs. deliberativeness in complex autonomous systems, about multi-agent systems, agent cooperation and coordination (actually, the latter two topics are not covered during the basic course on Artificial Intelligence), last but not least about real-time programming and multi-language system implementations.

Thinking about the future of the course we might imagine two possible ways of proceeding: either keeping the AI Programming as the major focus, or shifting it towards agent-based programming. In the first case the course should be prolonged to three quarters of the year — the students feel that the time available for developping their systems is not sufficient. The first part of the course, lasting one quarter, would focus on general AI programming paradigms, while the next two quarters would give the opportunity to thoroughly design, implement and test a multi-agent team capable of participating in a RoboCup contest.

In the latter case, more information should be provided about the multi-agent systems, including theoretical foundations of cooperation and coordination, on the expense of techniques that are not relevant in this context. The course could then be given under the title "Agent programming" or similar.

4 Student opinions

We have asked the students a number of questions about the course. What follows is a summary of their answers.

The students were very happy about the course and felt that it was corresponding to their expectations. They found it stimulating to implement a "real system", and to see how it actually worked in practice, although they thought that implementing it was time-consuming. All students though that using RoboCup was a good idea. The main suggestions for improvement were in the direction of giving to the students more help in overcoming the practical problems related to the soccer simulator and in particular socket communication and multiprocessing. Also in order to run a team efficiently it could be necessary to use several Sparcstations and this can be impractical during the development of the team. A possible solution would be to slow down the simulator instead. The course was considered quite time consuming and this has been the main reason for the few drop-outs we had from the course.

5 Lesson learned and improvement of the course

The main lesson learned is that it is possible to have students design and develop quite a large system if the task is sufficiently interesting and appealing. During the course the learning process was mainly based on solving a specific problem. This has the disadvantage that the students learn less general knowledge about the subject, but on the other hand they practice their capability of actually solving a problem and assimilate much better the part of the knowledge directly related to the problem. As this course is taken by students that already have a basic knowledge in AI we think that the advantages of the problem-based learning (PBL) approach overcome the disadvantages.

For the future we intend to provide skeleton agents in several languages to help the students starting off their implementations. The soccer simulator could also be made run slower so that a number of practical problems could be removed. We have noticed that the team's performance was improving during the competition due to small changes made by the students. We think that it could be a good idea to have a pre-competition where the team could be tried out, and the real competition should happen some week after it. This way the student's satisfaction of their teams could be even larger.

6 Conclusions

We have described a course on Artificial Intelligence Programming given at the Department of Computer Science, University of Linköping. The course has much benefitted from incorporating the RoboCup challenge as the main laboratory task. Although the amount of knowledge students gathered during the course is hard to measure quantitatively, it is our firm belief that they have learned more than during previous years the course was given. The students' satisfaction is also a factor that shouldn't be neglected in this context.

We hope that our experience can help in preparing similar courses at other universities. All the information about AIP course is available at its home page (`http://www.ida.liu.se/~jacma/official/aip.html`), more data can be obtained form the authors.

References

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