MULTI-LEVEL PROJECT WORK; A STUDY IN COLLABORATION

Mats Daniels[1] and Lars Asplund[2]

Abstract — This is a description of our latest effort to find new education forms. We have a long experience with running large projects [1], but wanted to expand the concept into an interdisciplinary setting. By combing three different student groups we have been able to formulate a project aiming at from scratch building robots that will participate in the robot soccer championships.
This complex project resembles a realistic industry development that covers the, for us, usual computer science aspect, as well as interfacing with electronic hardware and mechanical construction.

Index Terms — Industry related, Robot, Team work.

INTRODUCTION

Use of large sized projects with or without cooperation with industries have been part of the educational setting at the department for over 20 years, but the scope of the project set up for the spring 2000 outruns them all (roughly 20 man years). This paper presents this project and a report from the first part of its implementation.

The goal of this project is to win the world championships in soccer for robots (see http://robocup.org). The decision to go for this was based on the success of the 1999-project, where a robot was made to guide visitors at a museum.

The project is a capstone, whole semester, course in the fourth and final year of master students in information technology. The task was first judged to be too large and almost abandoned. The idea was too challenging to let go and the solution was to introduce a second set of students, electrical engineers doing a half-semester project during their third and final year, as well as finding collaboration from industry. As planning went on a third student group was incorporated, the mechanical engineers.

It is clearly a large project, which involves all ingredients of an industrial full-scale project. There is a limited budget (time as well as money) and there is clear goal, and finally there is hard dead line.

PROJECT DESCRIPTION

Goal

The immediate goal is to take four robots to Amsterdam, Holland, and win the European championships. The intention is then to use this victory to attract funding to go to the World championships in Melbourne, Australia.

The Robots

The robots are made from scratch in the project, from AI programming for game strategies down to mechanical construction, including specially designed wheels.

The internal of each robot is a Pentium 266MHz processor on a PC-104 industry card, where the special characteristics are small dimensions and low power consumption. The operating system will be of real time type and communication between the processor and the other components in the robot is done over a CAN bus. The internal parts contain sensors for angles, distance, collision avoidance, tachometer and cameras.

External communication between the different robots and a team leader, a server on the side, is made with Blue-Tooth technology. The communication topology is a star with point to point links between each robot and the server, i.e. the server is the hub in the star net.

The angel sensor calculates the angel between the vector in the front direction and all the other robots in the team. This is based on each robot sending IR signals in all directions. This signal is modulated according to the DTMF protocol, which is used for identification. The IR signal is picked up by a sensor that is placed at the focal point of a mirror, which is made to turn 360 degrees by the use of a stepping motor. This is used to scan the area.

Distance is based on sensing a modulated laser signal from a diode. There are some problems with range with this solution and other methods are tested, e.g. one where the reflection angel is measured. So far none have been good enough to cover the whole playing field.

Collision avoidance is handled by a number of ultrasonic transmitters and sensors that are used to measure short distances. These are working at two frequencies in order to avoid possible confusion between teams.

Tachometers are built with the aid of optical forks that are placed on an internal belt. These signals are part of the control system that controls the motors. This is a completely separate control system, although the computer send required values for speed and direction.

The cameras are the most complex piece of the construction. Each robot has four cameras, each small and inexpensive. They send out signals according to the PAL system. The color signal isn't directly usable, but is feed to a video processor where it is transformed to a 3 by 8 bit RGB signal. This is used to find a value in a table [2 Mbyte] for

[1] Mats Daniels, Uppsala University, Department of Computer Systems, Box 325, 751 05 Uppsala,, Sweden, matsd@docs.uu.se
[2] Lars Asplund, Uppsala University, Department of Computer Systems, Box 325, 751 05 Uppsala,, Sweden, asplund@docs.uu.se

the corresponding modified Hue signal. The purpose of the modification is to be able to also capture very light [white] and very dark [black] signals. The modified Hue signal is then used in another table where different features, up to eight, are coded. This feature signal is sent via a fast connection to a digital signal processor. The streams between cameras and signal processors are controlled with switches connected to the video processors and can for instance be directed to use a single camera.

Motion is done with two wheels. The wheels can be positioned in all possible directions. The turning is controlled via stepping motors and the driving of the wheel is by a DC motor. In an early draft an external company was approached to construct these wheels, but it couldn't be done due to lack of resources.

The ball is handled with a "catcher", where the ball can be pushed ahead of the robot. There is also a "kick" equipment. This is pneumatic and driven by gas controlled by a magnetic vent.

Sponsors

The budget for this project is based on the normal course budget and sponsoring from industry. Six companies are each sponsoring a robot. In the game only four can participate, but having six is important in the development process. Practice can for instance be done between two teams of three robots. There are also a number of other sponsors that have donated different components.

THE STUDENT GROUPS

The courses officially start mid-January and run till end of May and end of March respectively. All classes have roughly 30 students and both have started preparations for the project during the fall semester. The electrical engineers have been using components that will be part of the robots in a course covering real-time and distributed systems and the information technology students have formed subgroups with different responsibilities and have started to gather information and also meet with their corresponding subgroups among the electrical engineers. The mechanical engineers came in relatively late in the planning, but have proven to be very useful.

The IT engineers

The IT engineers are divided into two groups. One group will handle sensor fusion, i.e. to gather a uniform view of the current situation, and the other will do the AI-part, i.e. to play the game given the unified view from the current situation.

The Electrical engineers

The electrical engineering students are split into six groups and each will use a small sized management tool for specifying the requirements, given by the information technology students. The six groups will deal with:

- Measuring of distance
- Camera subsystem
- Internal communication using the CAN-bus
- External communication using Blue Tooth
- Measurements of angles between robots in the own team
- Kick-subsystem
- Motor and tachometer
- Collision avoidance

The Mechanical engineers

The mechanical engineering students are the ones with the most concrete task and also the least time. They do their contribution as part of a three credit course. The specific tasks for them has been

- The kicker
- The wheels
- The chassis

Time line

The electrical and the mechanical engineers only work with the project for the first half of the semester, whereas the IT engineers work throughout the whole semester. We do anticipate that several of the Electrical and Mechanical engineers will continue in the project by doing thesis work during the second half of the semester.

The IT engineers have set up three major deadlines. The first is when the other groups leave the project in mid March, and the second is late April and the third and final at the end of the semester in late May. Much of the preparations started already in the fall semester, when feasibility studies were conducted.

INTEGRATION BENEFITS

It has been educational and interesting to follow how the different student groups approached each other. There were not much prior knowledge about the other groups and especially their respective competence. One issue has been to settle on the level of the assignment. It is interesting to note that even if there is a clear "us" and "them" environment there doesn't seem to be a hierarchy.

There is a mutual respect between all three groups. The relatively high difference between the groups is probably contributing to this respect, since all groups have a need for each other. The spread has also made it possible to run a project with a reality touch that goes beyond what we have previously been able to do. The project addresses AI issues that rely on underlying functions taking in dealing with the information from the environment, which is taken in by sensors, and all being made possible by mechanical design. There is interdependency and a need for understandable communication between all involved, e.g. students dealing with the mechanics need to understand the expectations and assumptions made at the AI level, like maximum speed, acceleration etc.

This is with industry standards a small project, but in academic terms it is of major size. There are several possibilities to extend the project, but the late addition of students capable of mechanical construction was for us very interesting in that it made the project "complete".

Mosiman and Hiemcke give in [2], where a combination of two project-based courses at the senior level is described, reasons for interdisciplinary projects that are similar to our view. They realized that there were a lack of competence in building hardware in their cohorts and decided to use a ready-made environment. Their conclusion is that their combined project adds to the value of the learning experience, and the indications at our site so far show that expanding the experience into also building hardware and pure mechanics even strengthen this conclusion.

GRADING ISSUES

The work in this project is for the three groups evaluated against a Pass/Fail scale. This makes handling courses like this easier, since they usually contain a wide variety of assignments, which are difficult to compare if more differentiated grading is done on an individual basis.

CONCLUSIONS

The project is extremely fun to work in and have a tendency to engage the students at a probably too high time quota. The students are doing this at full time, i.e. no other courses in parallel, but consideration on the time investment will be taken for future instances. There is a demand for equipment that is different than our normal situation and it has been slightly problematic to get our hands on suitable equipment.

Early observations indicate that having a concrete and exciting goal with firm deadlines is successful. The fact that the project has a touch of "put a man on the moon" type and that it is run in a realistic setting with a wide range of competence required also seem to be of high value for the spirit in which work is done. It is our belief that the setting promotes professional skills and exposes the students to a situation where learning to learn is a natural component.

Other observed benefits are training in communication between interdisciplinary experts, as well as being a positive factor in forming, or rather adding to, an identity for the students groups.

REFERENCES

[1] Daniels, M. & Asplund, L., Full Scale Industrial Project Work, a one semester course, Proc. IEEE Frontiers in Education, San Juan, 1999.

[2] Mosiman, S. & Hiemcke, C., Interdisciplinary Capstone Group Project Designing Autonomous Race Vehicles, Proc. ACM SIGCSE Technical Symposium on Computer Science Education, Austin, 2000.