Educational Features of Malaysian Robot Contest

Amir A. Shafie and Zalinda Baharum

Software and Intelligent System Development Program
Electronics and Computer Applications
SIRIM Berhad, Shah Alam, Selangor
{Akramin,zalinda}@sirim.my

Abstract. The educational experiences from robot contest of entry, junior and advance level are presented based on guided constructionism approach in education that combines hands on guidance with hands-on experience. The aim of the competition as a whole are to allow the student to (i) conceptualise the robot (ii) manage the non-deterministic characteristic of the environment and (iii) manage integrated hardware and software development projects. Indeed with this knowledge the student should be able to win a number of international robot tournaments.

1 Introduction

Technological education in Malaysia is undergoing reform in relation to its status, goals and teaching/learning strategies. This trend in reforming technological teaching/learning strategies is following the worldwide general reform process with the aim of making technology education at all levels more meaningful, intellectual and creative [1]. Real world problems, interdisciplinary approaches, project oriented learning, team cooperation and authentic assessment have become the highlights of recent curriculum innovations. The skills in focus now are used to integrate different competencies an intelligent application to construct hardware objects so that they are governed by intelligent software that continuously interacts with non-deterministic real world [2].

The goal of introducing robot games as a healthy competition in the education system is to accelerate the acquisition of general skills in problem solving and scientific concepts in experimental science domain. Robot competition involves the use of computers to acquire, analyse, control and model different worlds not reduced to screen simulation but with real device control. The educational strategies employed as the impetus for organising robot competitions are those mostly linked to theory of constructionism and refer to active pedagogy [3]. For the past two years the Software and Intelligent System Development Program of SIRIM Berhad has been actively promoting and organizing a number of robot competitions for various level of education. The aim of the competitions is to create awareness in robotic technology among the Malaysian public.

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2 Competition Set-Up

The competitions have been set-up differently according to the participants' level of education. However all the competition set up have an educational purpose based on the guided constructionism approach towards technological education [4]. The set-ups of the competition were designed as a three-step educational process in which they work with imaginary robots followed by robot with modifiable body plan with complex team behaviour and lastly project coordination through robot construction and problem solving. By going through this series of robot competitions it has been the organisers hope that the students through their competitive and dedication will get a thorough understanding of robot concept in relation to the effect that the robot will have on human lives. The student also will have an understanding of the body and brain relationship with regard to the real world applications and an understanding of communication and distributed systems role in real world problem solving. In general the student should learn to manage and understand the non-deterministic characteristics of the real environment and to integrate hardware and software solutions to find the optimal set-up in solving the problem laid out for the competition.

2.1 Robot Drawing Contest

Every year in January invitations are sent through the ministry of education and mass media to invite primary school children to send in their drawings for the national robot-drawing contest. The drawings are based on the current trend of social-robot themes e.g. for the year 2002 the theme is 'Robot Maid' and for the year 2001 is 'My Friend is a Robot'.

The robot drawings are judged mainly on its originality and the ability of the participant to bring the concept in the competition theme into their drawing. The participants are from primary school (7-12 yrs old) thus their exposure to robots at this stage are mainly from televisions and toys, which has somehow hampered their effort in producing the original drawing. Therefore from the judges' observation the robots in the drawing actually depicted how the participant impression of how their favourite robot will effect their lives. Although one of the main purposes of this competition is to encourage the student to concept out an original robot, the organisers feel that their achievement in being able to concept out the theme with their favourite robot is an achievement to note. However it has to be noted that from the organisers interview with the participants, the robot are mainly thought of as the perfect being where as in real life most robots tend to break down regularly!

2.2 Learning to Manage the Non-deterministic Characteristics of the Real Environment (RoboCup Junior Soccer)

This event is adapted from the RoboCup (World Cup of Robot Soccer) and has been the penultimate event for the yearlong RoboFest Malaysia. The RoboCup is an international tournament where teams of autonomous intelligent robot compete in soccer-like games [5]. It is a serious educational event where the main purpose of the events is to give the student a hands-on experience in managing the non-deterministic characteristic of a real environment. The RoboCup Junior Soccer is a two-on-two competition i.e. there are two robots on each team. By having two robots in each team it is hoped that this rule will encourage team play because it is obvious that the match will be advantageous for the team that can develop team play. Each team has to develop the robot soccer player with the Elekit Robot Soccer M195 kit. The M195 is a miniature robot kit that includes infrared, ambient-light, touch sensors and two independent motors. The OOPic system can be programmed using a java based simulator known as 'Tile Designer' which provides the user with a graphical user interface to program the robot. The simplistic robot sensory system coupled with the low processing power of the OOPic due to high overhead caused by the java based simulator means that the robot soccer behaviour will be limited at all times.

The simplistic sensory system defines the environmental characteristic that the students have to contend with, where the ambient light and infrared strength are not uniform over different areas of the fields. Even though the students are told about the effect of the limited sensory system with regard to the information that they received several times during the training sessions, they are always amazed by changes in environmental conditions during the robot soccer player building process.

The two goal markers are equipped with different infrared signal frequency to differentiate between their own goal and the opponent goal. However the students very seldom reach the point where they have to consider the goals as they grappled with the problem of getting the robot to recognize the ball. Therefore, so far in the Malaysia RoboCup competitions the incident of own goals are frequent but it is believe that in future after the student have mastered the sensory systems the robot behaviours will be more complex.

The organisers also experienced many periods ended with the robot(s) pushing the ball into one of the four corners of the playing field. The robot(s) was unable to move the ball out from the corner, partly because of the shape of the robot. However in the second year of the competition some student tried a number of different strategies to move the ball out from the corner, e.g. turning very fast around itself while having contact with the ball, but these strategies were only successful in some particular cases with the right placement of the touch sensor.

The above situations showed that a lot of empirical tests are necessary in order for the students to make the environment suitable for the purpose that they have in mind. Often one has to manipulate the light, colours and shape of the playing field based on this many empirical tests. In this case, the interest is in teaching the future scientist about real-world application and therefore the set-up was biased by the educational purpose. For instance we chose to allow only the same kind of robot on each team. In other RoboCup and FIRA competitions, different teams are allowed to use any kind of robot that they build or buy within a specific size. Therefore as they are using one specific robot, the focus is on improving the robot behaviour through programming and creative tinkering. All teams start with the same motor characteristics, the same sensory system etc. to work with and therefore the performance can directly be compared to the properties of different robot controllers and different development process.

In a sense at this level of education, the secondary school (13-17 yrs old) there is a limit on the number of free parameters available for the students as they are using the same hardware platform for all robot soccer players. This is made as such so that the students have better focus towards solving the problem and learning how to manage real-world applications.

2.3 Learning to Integrate Hardware and Software in Distributed Systems (RoboCon)

In the RoboCon tournament the students are again given the task of making the robots, but this time they need to develop both the controller and the morphology of the robot to suit the task given. However, in this case they are confined to the budget given to them by their college and universities. This limitation requires the student to 'shop around' and opening their option to various possibilities.

The arena for this competition are large at 20m x 20 m and had different kind of colour and lines on the floor in different areas, so one could make a robot navigate around on the floor in different areas according to the colours perceived with the chosen sensor. Even though the student was able to manipulate the characteristics of the arena, it was difficult for the student to design robots that would satisfy the task requirement. The successful team however managed to use the sensor through rigorous testing phase. However more importantly the student obtained new knowledge on top of what was experienced with their entry into the competitions. At this level the knowledge is more complete as the student experience the principles for the development of controllers, mechanical aspect of the robots and integrating them through programming whilst at all time managing the project as a whole.

3 Educational Experience

In this section the use of guided constructionism will be discussed. Emphasis is put on the observation of how students learn to manage non-deterministic characteristics of real-world systems. The observation is based on our assumptions that the students' knowledge on real-world application with control of devices is minimal and in the earlier competition is none. Therefore the students have a number of ungrounded expectations of the performance of such systems. Often these expectations are based on students' previous experience with programming in deterministic environment in the computer. Also it partly arises from the whole natural science approach in which we have profound belief that the systems can be broken down into smaller systems and each of them has a deterministic functionality. Therefore, the students must go through a number of empirical experiments before they are convinced to change their unrealistic view of real-world applications [6]. The student belief in a deterministic reality can be observed mainly in their robot soccer project and from our observation that the student change this view by going through the process of building robot soccer players. Some of these experiences are documented by taking note of their questions while robot workshop are conducted.

First of all, when starting the educational process, the students have totally unrealistic beliefs of the capabilities of the robots. For the two-on-two robot soccer project with M195 robot, one of the members in the robot soccer team laid out their plan for the game as locate the ball by turning side to side and guide the ball to the opponent goal. Obviously these students had no idea about the capabilities of the simple sensory system available at their disposal. Their general idea was that they would be able to translate the human soccer player skills to the robots. After many failed experiments they admitted that the robot capabilities have to be built from the robot ability and not the ideal soccer player condition. In general most students go through the process of having to change their ideal general strategy when they achieved more experience working with the real robots in the real environment.

On the more advance level of competition (RoboCon) is that almost all students believe that they can incorporate a very precise global positioning system in order to solve the problem. The sense of locality are then established based on this global positioning system so that a relationship between the robot and the goals (the tubes). The implementations are based on a counter that keep track of how much the wheel has moved. Apparently at this stage these students do not have an idea on the role of friction, spinning etc. At the tournament many students found out that with very little interference the robot lose its orientation quickly and the method failed miserably.

Many groups realised the difficulties in making a global positioning system work in reality and teams that consider the use of environmental feedback to approximate the robot position fares much better. Obviously the students are used to having all information available in pure form in the simulation work that they performed in their study. However the experience from this competition makes many realise that this information will not be available in a pure form in real-world applications. They change their view and start to think about how to make use of little knowledge that they might obtain via feedback from the environment. However, they also experience difficulties when trying to obtain feedback from the environment, because the more affordable sensors are almost much more primitive than the student expect.

The students initially believe that sensors give a clear and unambiguous input and that they can use abstraction. The abstraction and pseudocode is used instead of experimentation in order to overcome software complexity and only later through experimentation do the students realize the true nature of the sensors. In a sense this resemble the discussion about the classical approach to robotics in which the hardware and software tasks were believed to be distinguishable, so that the engineers could work on the hardware while AI researchers could make abstractions and work on the software only in order to create an intelligent system (robot). Nowadays the newer AI approaches on robotics begin to reject this division and focus on embodied AI.

The students found out during the test period and competition in the real field that the sensory information cannot be interpreted in a straightforward manner using fixed threshold to classify the inputs. They experience that the approach works one day but fails miserably the next day when for example it is no longer sunny weather outside of the arena. Initially the student became frustrated and blamed the hardware. However, the long process of experimentation makes the student realize that the adaptive approaches can be used to overcome this problem. In fact the winning robot in all competitions has a version of adaptive systems in their logic to overcome the changes during play. It is strongly believe that simplistic approaches in suppressing the arena information will lose out in the latter stage of the competition where the teams have better integration between hardware and software. At this stage the adaptive aspect of the robot in determining its behaviour will hold the key between winning and losing. At any level of competitions the students learn the importance of the power supply to the robots. Here they found that the due to battery power levels the logic and abstraction that they chose initially will not work as usual because the abstraction are based on ideal condition. Again the problems arise because the students believe in being able to make abstractions for example classify sensory data with fixed, pre-defined thresholds.

Therefore from an educational perspective the robot competitions put forth the importance of hands-on experiments on real world systems. This is because the students will have difficulties in believing in another view on the real world with deterministic characteristics in which abstraction is feasible. It seems like the students are only able to change this view when they are actually experiencing themselves a lot of times, that their robot will fails with a control program that depends on the abstraction. Then the student start changing their view and implement the more adaptive solutions based on their experimentations.

4 Related Work and Discussion

There exist a number of open robot competitions such as Micro Mouse and FIRST (For Inspiration and Recognition of Science and Technology) competitions. Micro Mouse has been running since the late 1970's and it consists of designing an autonomous robot known as mouse, which should navigate its way through a maze. The robot mouse has no prior knowledge of the maze configuration before its release in the maze. During the runs the robot mouse should travel from the starting point to the centre of the maze. The first two runs are used for data gathering and the final is meant for a high-speed run to obtain the fastest handicapped time. FIRST competition is an engineering contest in which high school students team up with engineers from businesses and universities. In six intense weeks students and engineers work together to brainstorm, design, construct and test their robot. The aim of the FIRST competition is to bring together businesses, schools and universities and thereby provide an exchange of resources and talent highlighting mutual needs, building cooperation and exposing students to new career choices. The similarities on the educational perspective have clear resemblance everywhere, which include the MIT series of competitions [7]. The competitions at MIT are part of hands-on, workshop like courses for undergraduates, which usually run as part of their summer course. The conclusions from these series of programs resembles our observations reported in section 3 where most of the students tend to build robots that perform only in ideal conditions. The approach taken by the Malaysian series of robot competitions is based on theoretical considerations put forward by Seymour [8], in what he terms as constructionism. Constructionism suggests that learning is achieved most effectively by participation in the construction of artefacts. The artefacts become an 'object to think with' which can be used to explore and express ideas such as In the robot competitions, the students are allowed to construct their own robots and learn about real-world applications by going through the building process.

The Malaysian RoboFest committee choose to have robotic competitions at different levels because the organizers believe that the educational process to be slightly more complex than what is often suggested in constructionism. In its most pure form constructionism theory seems to suggest that children should be allowed to play in what they find fun and they will learn by this play. However in many subject areas the students need guidance and that there exists subjects that are profound for scientific knowledge which do not lend themselves to a constructionism approach but will have to be thought in a more traditional manner especially the case when educating students with the fundamental knowledge of the subjects. Constructionism then at a higher level can be combined with other pedagogical methods to ensure that the students obtain a profound knowledge about the subject under study.

Therefore, the idea of guided constructionism uses a three step process with (i) imaginary robots, (ii) robots with modifiable body plan and team behaviour and (iii) construction of robots and complex team behaviour. Constructionism is the core of (ii) and more at (iii) while it plays a minor role in (i). With the three-step process the organizers try to ensure that the students first get the knowledge about programming in the real world and a tool to compare their different approaches. The comparison of how the robot should work is achieved at the level where the students are given the knowledge on how to modify the robot body. The students then obtain an essential knowledge about robot programming by working with the robot projects outlined in the competitions where they learn the relationship between controller and robot body plan to manipulate the environment. Hence our approaches stress on the case where the constructionism approach should be combined with other methods and that there exist essential arguments that are better acquired by the student with another approaches. However hands on experience must remain as the major role in technology education and it often facilitates the student acquisition of knowledge about an artefact.

5 Conclusions and Future Work

In this paper the Malaysia Robot Competition Program is outlined in relation to the guided constructionism ideas and the observation from it has been outlined. The test case, used now is the three-step process (i) the conceptual aspect of the artefact, (ii) the manipulation of robot behaviour in Relation to Real World Environment and (iii) the management of the integrated hardware and software project. Further, the idea can be very useful in education for a number of other objects. For instance, robot can be used as an educational tool for artificial life and biological investigation as described by Miglinio [9]. Also in this context the robot competition might be a test platform since one can for instance imagine studying the evolution of robot controllers, the evolution of communication, the evolution of suitable bodies etc. In future the difference between guided constructionism and unguided constructionism should be investigated more thoroughly in order to verify the indications presented in this paper.

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