Teaching New Artificial Intelligence using Constructionist Edutainment Robots

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1 Introduction

As computational technologies infiltrate our everyday lives, it is becoming increasingly important that the future generation are not alienated from these technologies. Specifically, the field of applied Artificial Intelligence (AI) is slowly and inconspicuously becoming more and more embedded in our lives. In order to empower the future generations to not only understand, but to successfully control and develop the myriads of Applied and Embedded AI systems which will be commonplace in their everyday environment, it is essential that they learn about AI and Artificial Life (ALife), rather than merely acquiring vague and unrealistic notions through science fiction fantasy. This will enable them to intelligently interact and influence the further development of these technologies.

Recognizing the need for the dissemination of these concepts to students at an early age, the AI Lab at the University of Zurich decided to pilot a test course in Artificial Intelligence for teenagers, which could serve as a model for school curriculums. The goal of the course was to enhance the students' knowledge of the underlying philosophy and concepts involved in AI and ALife, and introduce them to the technologies and methods used.

One reason that the abstract set of concepts related to AI and ALife remain confined to a particular scientific community is because they are inherently difficult concepts to convey, and even its practitioners often cannot agree on a way to present them. While the general public is impressed and awed by the products of applied AI, there is little understanding of the internal workings and limitations of these systems. Although the students we were working with were highly motivated and intelligent, their young age (13 to 18 years) made it difficult to convey the concepts solely through lectures and discussion. Thus it was decided to test Constructionist Edutainment Robots as a possible method for providing a natural and positive foundation for acquiring these concepts.

2 The Teaching Philosophy

With the increased availability of computing power in homes, industry has placed a strong focus on providing computing-based, multimedia interactive toys and games for children, collectively termed Edutainment. These products offer the allure of high quality sights, sounds and interactivity to entertain children, but also attempt to integrate educational content. These toys and games prove highly successful with children, who are able to express their natural curiosity and willingness to learn with interesting and user-friendly tools. Recognizing both the challenge of imparting many abstract concepts to the students and the need for them to maintain a positive attitude towards absorbing them, the philosophy of Edutainment seemed to provide the perfect foundation for the course.

Our second main concern was that the students should not merely be the passive recipients of knowledge but should "construct" the knowledge themselves. This philosophy, known as Constructionism (Resnick, 1996), is derived from the Piagetian concept of Constructivism, which states that children are not born with an innate knowledge of reality, but rather "construct" the model through physical interactions with the real world. Constructionism, which combines this general philosophy into an active educational method, was our method of choice for this course.

We used the LEGO Mindstorms Robot Construction Set to convey the concepts we wished to teach. While providing a playful and interactive platform that engaged the students' interest, the students were able to iteratively construct robots that illustrated the concepts as they were introduced.

3 Teaching Concepts through Construction

The curriculum of concepts included selected ideas from the philosophy and technical methods of AI and ALife, which collectively define the field of *New Artificial Intelligence* (Pfeifer, 1999). Some of the key concepts are reactivity, embodiment, adaptivity, emergence, intelligence and and cheap design. Some of the main technical methods used in New AI include neural networks, evolutionary algorithms, sensory-motor coupling, distributed computation and behavior-based algorithms. These concepts were initially introduced through lectures, but were then reinforced through construction activities. Many of the activites were geared towards illustrating a specific concept.

For example, the central importance of morphology in New AI became apparent to the students during the construction of a line following robot. One group achieved this by building a robot with two light sensors pointing towards the floor. They discovered that if those sensors were placed too close together, the robot's performance decreased. A later project challenged students to build a robot that could traverse through a tunnel with different widths and heights, which implicitly required that the robot change its morphology to solve the task.

Another robot construction exercise provided a concrete example of emergence. At first, each student group built a light following Braitenberg vehicle. Then, each group attached a torch to the robot, and all robots were placed in the arena. Students were surprised by the complex interactions of the robots approaching and retreating from each other. These behaviors were then identified as examples of emergence.

Cheap design implies that the internal complexity of a robot can be greatly reduced when its prospective environment and task are taken into account. The need for using cheap design for the robot building arose when students were asked to build a robot that used an "inclination sensor". The students were thus motivated to devise a clever way to generate interesting behavior using a combination of simple sensors, rather than using a ready-made sensor for the specific task. One student group achieved this by using touch sensors to detect the sliding of the robot's central brick. Not only for this specific task, but for all robot building tasks, the sensor and programming limitations of LEGO Mindstorms motivated students to understand and use cheap design during construction.

4 Conclusion

In the Artificial Intelligence and Robots course conducted by the AI Lab, University of Zurich, the philosophies of Edutainment and Constructionism were employed to impart the abstract concepts of AI and ALife to young students. The course was structured using group construction activities and projects with the LEGO Mindstorms platform, in such a way that would inherently encourage the students to construct examples of these concepts. Through the use of repeated and more challenging constructions, students not only learned to understand and identify the ideas we wanted to teach, but more importantly incorporated them in their own thought process as tools and building blocks, which could be used in future designs. While anecdotal, the only negative aspect of the course, according to the students was that "It should have been longer" which coming from a group of young teenagers after a 40 hour week of non-stop teaching, came as a pleasant surprise. Another student said that "school should be more like this"; we hope that as more such positive evidence as to the effectiveness of this teaching philosophy accrues, one day it will.

References

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