

Using Inexpensive Educational Robots to Teach Language Engineering

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1 Goals and Objectives

Language engineering – the theory and practice of building language processors and compilers, have long been recognized as important subject in Computer Science curricula. However, due to lack of resources, in particular, a suitable target system, educators face significant challenges to create relevant and realistic system context and teach the language engineering topics effectively.

In this Academic Technology Grant funded project, leveraging the emerging inexpensive robot devices, we have developed a new approach of using robots as system context to teach language engineering topics. To program the robots, we have designed Chirp, a simple language with both common language constructs and special hardware-control features that target embedded robot controllers. Combined together, Chirp and the robots provide an affordable, engaging and feature-rich platform to explore a wide range of language engineering topics.

This report will discuss the work that has been done and our teaching practice of using robots in undergraduate Computer Science courses at UMass Lowell. I will describe the progress we have made and highlight paper publications in premier Computer Science education conferences resulting from the work of this project.

2 Project Achievements

As proposed in the project, we have made the following achievements and contributions:

- Redesigned the UML 91.204 Computing IV language engineering curriculum to use robots as compiler target. The funding support has been used as summer stipend for PI to design and develop robot-based language engineering modules. In our redesigned curriculum, the Scribbler robots are used to demonstrate the lexing, parsing and code generation topics on compiler design. Sample program modules for building lexer, parser and code generator targeting the robots are used in class for student live experiments to explore related topics in the classroom.

- Designed and developed students project modules to build a real robot compiler. Using robots, we not only teach students the theory and techniques on building language processors, we also designed a 4-module project sequence to guide students to construct a working robot compiler themselves. The Scribbler robots provide an easy to understand system target. In the first project, students experiment with robot hardware controls to study target properties; in the lexer and parser projects, students build the compiler front-end for the robot control language Chirp; in the last project, students create the code generator to emit robot control code from the abstract syntax tree and integrate the modules to realize the complete compiler.
- Conducted exams and surveys to evaluate teaching effectiveness. We have conducted multiple exam tests and student surveys during the Spring'08 semester. We use the results to evaluate teaching effectiveness and gather feedback. The data are compared to previous class which did not use robots as the control group. The test results show the robot based class has majority of students to be able to solve the problems which in previous class, less 20% of students attempted these problems. From students survey, students indicate robots are very helpful tools to understand compilers.
- Publish papers on Computer Science education conferences to promote robots-based teaching approach. We have published two papers on leading Computer Science education technology conferences [Xu08b, Xu08a]. The papers make the results and experiences from this project available to the large CS education community.

3 Future Work

In the coming Fall 2008 semester, we will expand the use of robots to teach the full semester 91.406/534 upper-level undergraduate and graduate class on Compiler Construction. We will use robots as the system target for both compiler basics and advanced subjects, including compiler analysis and optimization. The Scribbler robots provide a suitable target and concrete example for many topics in this course and we expect the robot-based approach to language engineering will help improve teaching and learning for this advanced class.

References

- [Xu08a] Li Xu. A Modular Approach to Language Engineering Using XML and Inexpensive Robots. *Journal of Computing Sciences in Colleges*, 23(5):133–141, 2008.
- [Xu08b] Li Xu. Language engineering in the context of a popular, inexpensive robot platform. In *SIGCSE '08: Proceedings of the 39th SIGCSE technical symposium on Computer science education*, pages 43–47, 2008.