Design Workshop on Intelligent Toys and Fuzzy Logic

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Abstract

This paper describes the academic experiences obtained during a Design Workshop course offered at the Electrical and Computer Engineering Department (ECE) at the University of Minnesota Duluth (UMD). This workshop course is one mechanism by which students completing the ECE program at UMD can satisfy the requirement for a senior design project. The design workshop topic for the spring 2003 was the use of fuzzy logic to implement an intelligent toy. In this workshop, students worked in small groups and were required to propose, design, build, and program an intelligent toy with intelligent behaviors using fuzzy logic. During the workshop time frame no formal lectures were taught, however the students received an intensive review covering the topics of the 68HC12 microcontroller, principles of intelligent toys, sensors, and fuzzy logic.

Introduction

In the last years, the topic of intelligent toys has become very attractive to engineering schools [3]. It has been shown that students working in this topic show more interest in learning digital systems, microcontrollers, and electronic circuits in general. This is because they see an immediate application of the subjects they are learning.

On other hand, fuzzy logic has been used extensively to design intelligent systems, and has been used successfully as a practical alternative in adaptive control systems because it provides a convenient method to implement nonlinear controllers. Fuzzy controllers work differently than conventional controllers; expert knowledge is used instead of differential equations to describe a system. This knowledge can be expressed in a very natural way using linguistic variables, which are described by fuzzy sets. Fuzzy logic has been used primarily on large-scale computing systems and personal computers. The introduction of Motorola's MC68HC12 microcontroller, which incorporates several fuzzy logic primitives in its instruction set, has made possible the implementation of fuzzy controllers in microprocessor-based systems.

In the next lines we describe the characteristics of the Design Workshop, present our academic experiences, show some of the projects implemented, and finally make an evaluation of the results and present our conclusions.

Setting

All the students that took this workshop had previous experience working with the 68HC11 microcontroller. They completed the introductory microprocessor class, in which they learned the 68HC11 architecture and the assembly language. Therefore all the students had the necessary background to start using the 68HC12. In relation to the design and implementation of their projects, all the students had a basic background in digital design and analog systems, so that to be able to understand and learn by themselves the basic principles of intelligent toys and sensors, and to design and build the required interfaces to connect the sensors to the 68HC12. In relation to fuzzy logic, some of the students took the elective course "Fuzzy Set Theory and Its Applications", and they were familiar with this subject. However, most of the students were not familiar with fuzzy logic and they had to learn it during the intensive review of the topic and by self-learning. During the review period, students were assigned individual experiments and homework using the Fuzzy Logic Package [1] for Mathematica from Wolfram Research Inc. For the integration of the groups, the students chose their partners, with the restrictions of having three persons per group, and at least one member of the group should have taken the Fuzzy Set Theory course. With this, we ensured some homogeneity in the groups and the success of the projects.

Since students worked in teams, each team was responsible for their own designs and the proper functioning of their project. However, in order to keep a close contact among the students taking the workshop, we kept a class environment during all the semester, having weekly meetings where students presented and talked about the progress and problems that they were having in their projects. This setting made an ideal environment for a class to learn together and learn from each other and benefit from experiences of other students.

Objectives and Organization of the Course

The students had fifteen weeks to do all the work, from the definition of the project to the development and completion of the project. To achieve the goals, the activities were planned as follows. During the first three weeks, an intensive review covering the topics of the 68HC12 microcontroller, principles of intelligent toys, sensors, and fuzzy set theory was given. During this time the students also learned the use of the Fuzzy Logic Package. In the weeks four and five the groups were formed, and the groups started to define the objectives of their projects. For the definition of the projects, the instructors gave several suggestions for possible projects, but it was strongly recommended that each group developed ideas of its own. Also several papers related to the application of fuzzy logic to intelligent toys were given as references. During week six, each group presented a written and oral proposal of its project. Feedback from faculty and peers was given in order to ensure an even set of projects with the same complexity level. During weeks seven and eight students worked in the simulation part of their projects. This means that before starting to build their real toys, students simulated their intelligent behaviors using the Fuzzy Logic Package. During week nine, written reports and oral presentations were given by each group, in which they presented the results of their simulations. Starting week ten, students began to build their intelligent toys and to write the programs to implement the fuzzy logic algorithm in the 68HC12 microcontroller. Some interfaces were designed and built to connect different sensors to the 68HC12 microcontroller. On the last week of the semester, week fifteen, each group presented to the class instructors a formal and complete written technical report. Also each group gave a formal oral presentation, open to the student body and faculty. The written report and oral presentation had to follow the specifications given in the Senior Project guide of the ECE department at UMD.

Design Projects

One of the projects was to create an intelligent hovercraft mobile toy that will navigate by itself without bumping into obstacles and searching for a specific goal. The fuzzy control was used to create a rule-based controller to select the proper fan speed and steering angle using the input distances. In another project the goal was to implement a fuzzy radio controlled system to control and coordinate task to be carried out by a set of radio controlled model construction vehicles. Another team worked in the design and implementation of an intelligent shower. In this project fuzzy control was used to control temperature and water pressure. Figures 1 & 2 show two of the projects implemented.

Evaluation Scheme

The projects were evaluated in several stages, in a gradual and continuous way. In the weekly meetings, each team presented the evolution of their projects and received orientation from the instructors. The objectives of these weekly meetings were also to have a close observation of the teams' progress and assure that each team member contributed to the teamwork because for the final grade, all the members of each team obtained the same grade. During the ninth week, 40% of the final grade was assigned, after the students presented a written report and oral presentation of the results of their simulations. Another 40% of the final grade was assigned to the students during week fifteen when they demonstrated that their project was working in accordance to the specifications. The last 20% of the final grade was assigned based on the final oral presentation, taking into account the quality and clarity of the presentation, and the completeness of the final written report.

Conclusions

In this workshop it was found that students were more motivated in their projects, and in learning fuzzy logic theory and microcontroller programming, by applying them to the design and implementation of intelligent toys. Students gained an excellent understanding in both disciplines: microcontrollers and fuzzy logic. In particular they learned how to apply this knowledge to design, implement, and program a complex system with intelligent behaviors. Students were also exposed to team-learning experience and team-based design, and had the opportunity to exercise and improve their written and oral communication skills.

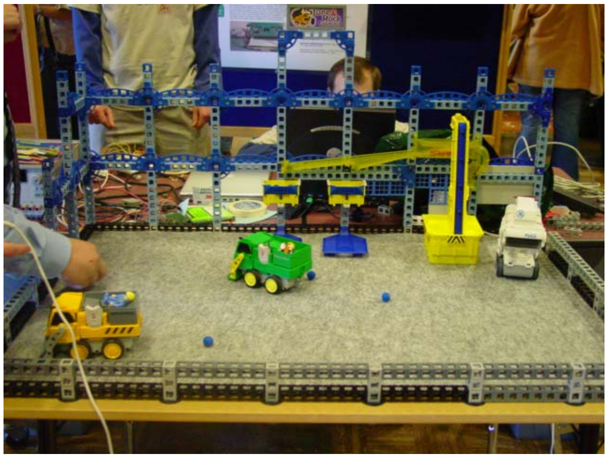

Fig. 1 Fuzzy Radio Controlled System

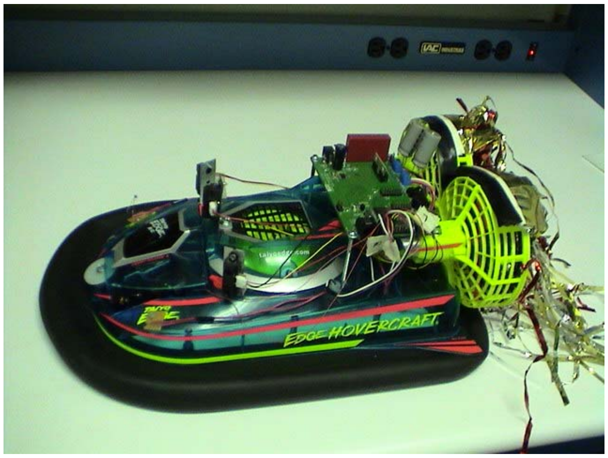

Fig. 2 Intelligent Hovercraft Mobile Toy

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