

A Fuzzy Control Course on the TED Server

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ABSTRACT: The Training and Education Committee (TED) is a committee under ERUDIT, a Network of Excellence for fuzzy technology and uncertainty in Europe. The main objective of TED is to improve the training and educational possibilities for the nodes of ERUDIT. Since early 1999, TED has set up the TED server, an educational server that serves as a learning central for students and professionals working with fuzzy logic. Through the server, TED offers an online course on fuzzy control. The course concerns automatic control of an inverted pendulum, with a focus on rule based control by means of fuzzy logic. A ball balancer, implemented in a software simulator in Matlab, is used as a case study. The course differs from other distance learning courses in the one-to-one interaction with the teacher, based on e-mail. This paper presents aspects of the use of the course, aiming at students and at teachers.

KEYWORDS: Education, distance learning, automatic control, pendulum, Matlab, ERUDIT.

1. INTRODUCTION

With the advent of the Internet and World Wide Web technologies, distance learning has become rather widespread, most notably in the UK, USA, and Australia. The major motivation for an on-line course is flexibility, but there are other key issues, including costs, technology, and credit unit transfer.

The network ERUDIT (ERUDIT, 1999) has established in 1998 the Training and Education Committee (TED) in order to emphasize training and education (TED, 1999). The TED server, based on Lotus Learning Space, is a computer application that lets students take courses using a Web browser. Through the server, TED offers an online course on fuzzy control (Fuzzy Control, 1999), a modernised version of the fuzzy control course administered on the Internet since late 1995 by the Technical University of Denmark.

The course concerns automatic control of an inverted pendulum problem, with a focus on rule based control by means of fuzzy logic. The course objectives are to teach the basics of fuzzy logic, to show how to use fuzzy logic, and to teach how to design a fuzzy controller. A paper from the on-line WSC2 conference in 1997 describes development aspects and experiences from running the course (Jantzen, 1998a), and a paper from the on-line WSC3 conference in 1998 reports on a fuzzy control tutorial based on the course that was given on the Internet by TED (Dotoli, 1999). Details about the implementation and organisation can also be found in the references (TED, 1999) and (Fuzzy Control, 1999).

This paper presents aspects of the course and aims at students interested in taking it, and at teachers who might want to run a similar one.

2. KEY ISSUES

From the home page of the course (figure 1), the students can access four different sections: the Schedule, the Media Center, the Course Room and the Profiles section. In Schedule students can view the course modules and download them (figure 2), as well as do the self-assessment exercises (figure 3). The Media Center is a library from where students can download software or articles (figure 4). In the course room students and teachers can open discussions and send messages of any kind (figure 5). Finally, in the profiles page participants can edit their profiles and publish photos (figure 6).

The initial development of the course consisted in acquiring the Lotus technology and setting up the existing DTU course on the TED server. This proved rather inexpensive but quite time consuming (the cost of the equipment and software amounts to about 7000 EUR with university discounts).

It was decided to make the course as modular as possible. Each module was then divided into a preparation section, an exercise and an assignment. Also the material for study, originally a textbook, was modularized into several articles and reports, and organized into an on-line library, where keywords searches can be performed and articles can be sorted by author, title, year or name (figure 4).

The on-line modules were then supplemented with survey sheets, evaluation reports and self assessment sheets (figure 3). In the near future, the course will be completed with a final on-line student examination. Students will be graded on the basis of an on-line multiple answer test containing questions randomly extracted by the server from a data base of questions.

The TED server and course were launched and tested in Delft in the course of a tutorial on Fuzzy Control with a hands-on computer session during the summer school on applications of fuzzy control, held in April 1999 at the Delft University of Technology.

3. OUTLINE OF THE COURSE

The case study of the course is widely used for education and benchmarking and is described in a paper from the media center (Jantzen, 1998b). It is an inverted pendulum model of a cart-ball laboratory rig, consisting of a steel ball on a curved bridge on a moving cart. It is fairly easy to control the system such that the ball balances on the top of the bridge, but it is difficult to position the cart at the same time in a pre-specified position (figure 7). Students design a fuzzy controller that balances the ball on top of the bridge (Jantzen, 1998c). The software package PENDULUM (Kvaran, 1998), which runs under the Matlab environment, is used throughout the course as a simulator (figure 8) and can be downloaded from the TED library. To make it as independent as possible, the simulator only requires the student edition of Matlab and no extra toolboxes. If the student does not have access to Matlab, it is necessary to buy the student edition (Matlab SE, 1997). The students use a variety of platforms, and the simulator runs on all (after some initial adjustments to the code).

Each on-line module or lesson is divided into three steps: a preparation section, an exercise and an assignment. These are increasingly activating for the student. In the first step the student reads the text material offline. The exercises are related to the simulator and must be done on a PC or workstation; the student does not answer any questions in this step, but only has to observe and explore. The third step is a matter of solving specific design problems related to the case study.

For each assignment, students download it as a text file, include it inside an e-mail, work with it, make notes about results and comments they want to pass to the instructor, write their answers directly into the file, and e-mail this to the instructor. The instructor will comment on their solution and return the e-mail note. The instructor may then urge the student to proceed with new questions related to the topics in the lesson. Drawbacks in this kind of procedure are traffic on the Internet and break downs of connections.

The delivery of the course promotes a deeper learning compared to lectures. An online lesson forces the student to be active and alert. Student responses are written, so they have to be precise and well thought through. The teaching style is like tutoring, because the communication sessions are iterative. Compared to a three-days crash course, the learning is deeper, because it is extended over a longer period and the student-teacher interaction is one-to-one.

The course has eleven modules, which have been changed and reorganised as a result of student feedback:

1. Install simulator software
2. Cart-ball model
3. Linear controller design (optional)
4. Controller test (optional)
5. Fuzzy set theory
6. Fuzzy logic
7. Fuzzy controller design
8. Fuzzy linear controller
9. Fuzzy non linear controller
10. Self-organizing controller
11. Course evaluation

4. CONCLUSIONS AND RECOMMENDATIONS

The objective of the fuzzy control course on the TED server is to achieve flexibility. From the teacher's point of view, the course can be taught anywhere (provided an e-mail access) and there is 48 hours slack in the deadline for answering assignments. With many students, however, the flexibility is decreasing since the amount of work per student is constant. At the moment about 50 students from 20 countries follow the course. From the student's point of view, the course provides flexibility in pace and space; the only deadline is a requirement to finish the course within six months.

To achieve a greater degree of flexibility for the teacher, the easiest way is to include some self-study modules, with self-assessments instead of e-mail assignments.

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Figure 1: Fuzzy control internet course homepage.

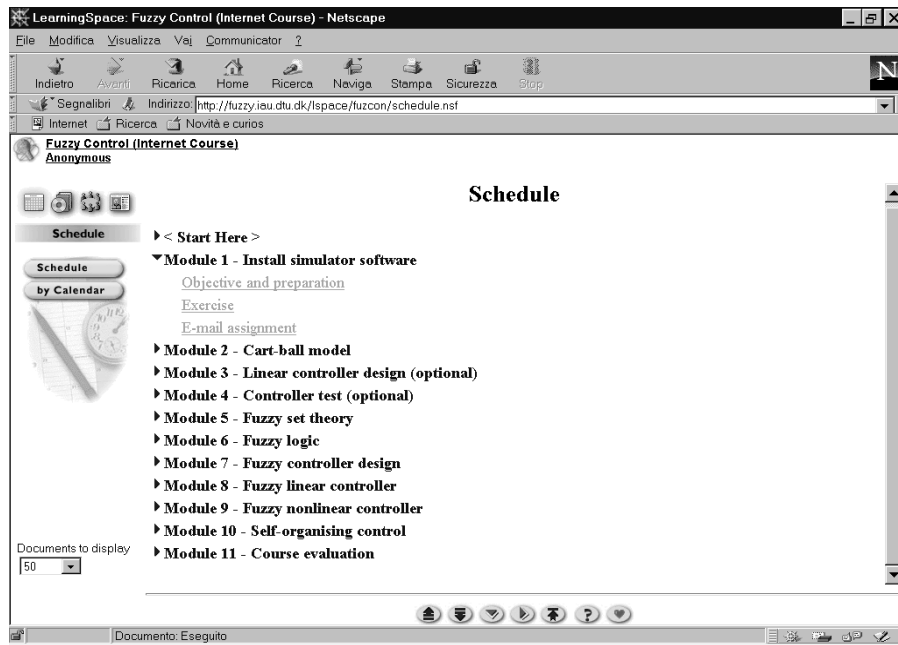


Figure 2: Fuzzy control internet course schedule.

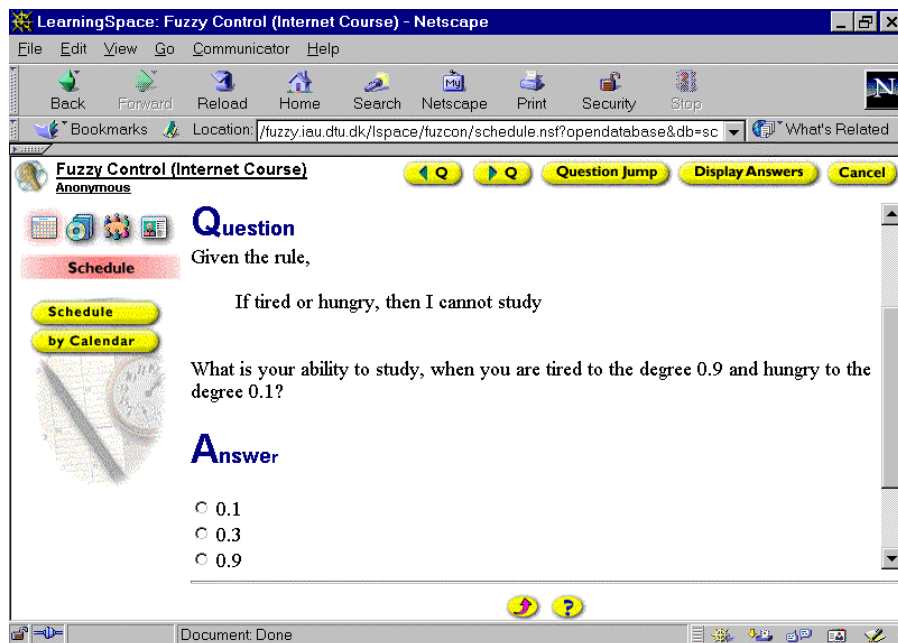


Figure 3: Example of self-assessment exercise.

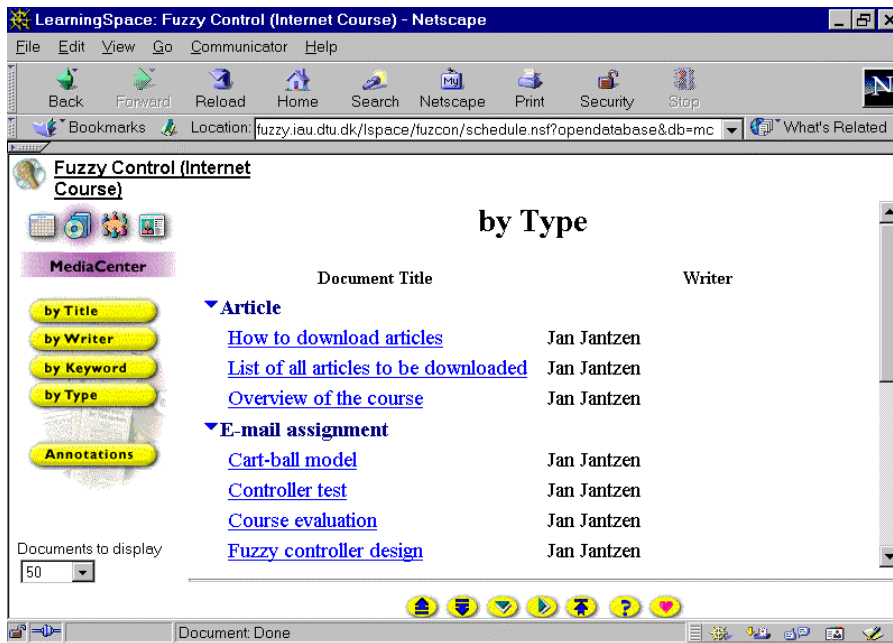


Figure 4: Fuzzy control internet course media center.

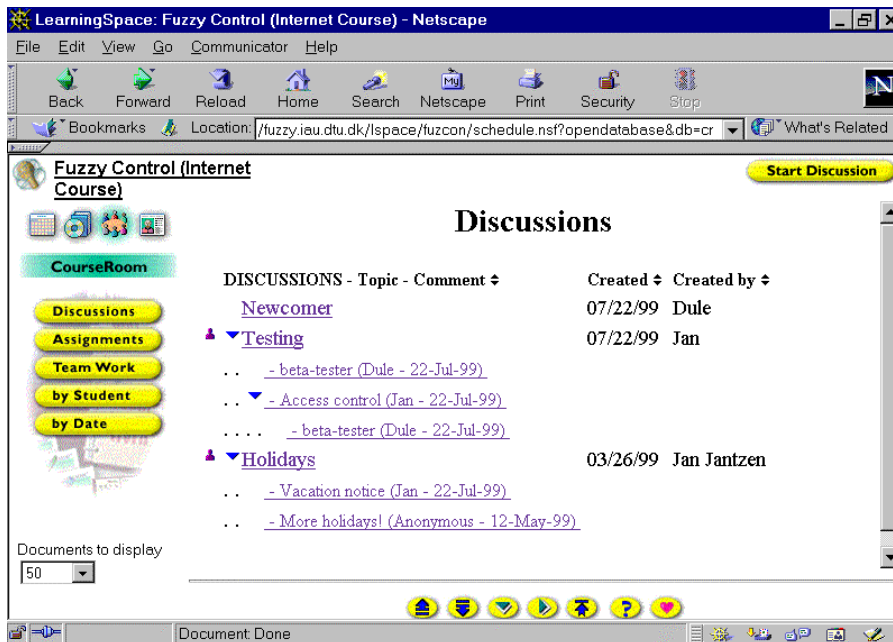


Figure 5: Fuzzy control internet course discussions page.



Figure 6: Fuzzy control internet course profiles page.

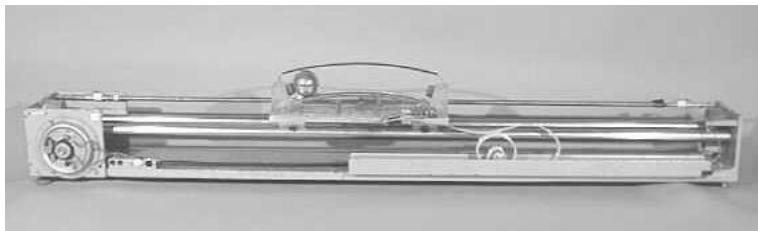


Figure 7: Cart-ball system.

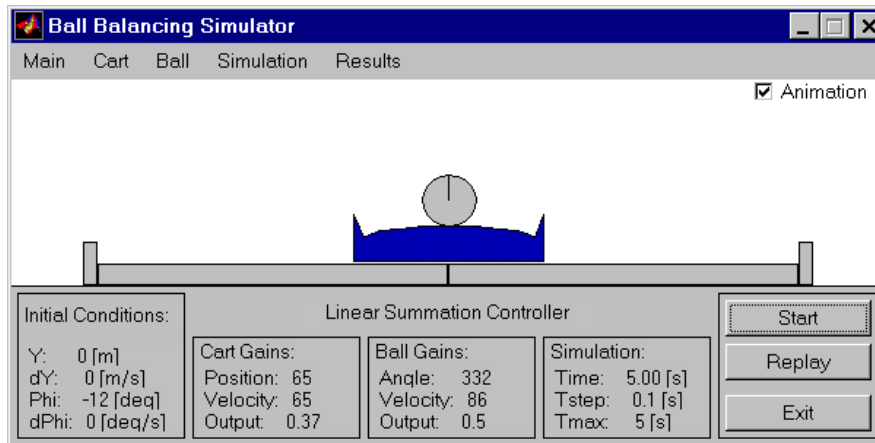


Figure 8: Cart-ball simulator.