USING TOOLBOOK TO DEVELOP A TEACHING PACKAGE FOR CONTROL ENGINEERING LABORATORIES

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ABSTRACT

With the availability of low cost desktop multimedia systems there has been a renewed interest in creating software to supplement the teaching of laboratory experimentation.

The authors will describe a simple to use teaching package incorporating four different teaching approaches into one package using the TOOLBOOK Multimedia Authoring Software. These are Tutorial, Drill and Practice, Simulation and Modelling. The curriculum content of each approach is broadly the same and users are able to select their preferred approach when using the software.

The software is part of a pilot demonstrator for research being undertaken into Computer Simulated Experimentation at Cheltenham & Gloucester College of HE and the University of Brighton. The paper will discuss criteria used for each teaching approach, difficulties encountered in the implementation and will include a short demonstration of the software.

Keywords: Multimedia, Simulation, Computer, Control, Laboratory

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INTRODUCTION

Computer Simulated Experimentation (CSE) is becoming more popular in Engineering Education [1,2] because it enables students to undertake investigations at their own pace and to engage in complex and interesting learning environments without the usual constraints of a traditional laboratory environment.

In previous papers the authors have described a classification framework [5,6,7] for designing and evaluating computer simulated experiments. This paper focuses on the design of a package for the teaching of an introduction to Open & Closed Loop Control Systems. The software is part of a demonstrator for research into CSE currently being undertaken at Cheltenham & Gloucester College of HE and the University of Brighton.

The package was developed using the Asymetrix TOOLBOOK Multimedia Authoring Software and uses embedded Visual Basic Objects to perform animation's and Graph Plotting. The development required extensive use of the OpenScript facility within TOOLBOOK to create the simulation module which forms the background to all the teaching approaches. Formative and Summative evaluation techniques were applied during the development cycle.

USER INTERFACE DESIGN

The challenge when designing interactive multimedia based applications surrounds the conflict between the interaction requirements and the information content you wish to make available to users. Boyle [8] in a recent book highlights the difficulties in designing multimedia learning environments and describes a design model which centres on the conceptual design of interactive multimedia learning environments taking account of content (curriculum design), interaction (pedagogy) and composition (context). Interactive multimedia puts an increased burden on the product quality assurance process as both interaction (functionality) and content (curriculum) correctness need to be thoroughly tested. The software was developed using a commercially available multimedia authoring tool [9]. The different teaching approaches, Tutorial, Drill, Simulation and Modelling are accessed through the main menu shown in Diagram 1. Two underlying analogies are used to enable students to study different applications of control. The first is the analogy of a water tank with a leakage factor proportional to the height of water in the tank. The control goal is to maintain the height of water in the tank by controlling the inflow of water. In the second case the analogy is of a room, heated by an energy source, which loses heat proportional to the difference between the room and the outside temperature. The control goal in this case is to maintain the inside temperature of the room by controlling the flow of energy into the heater.

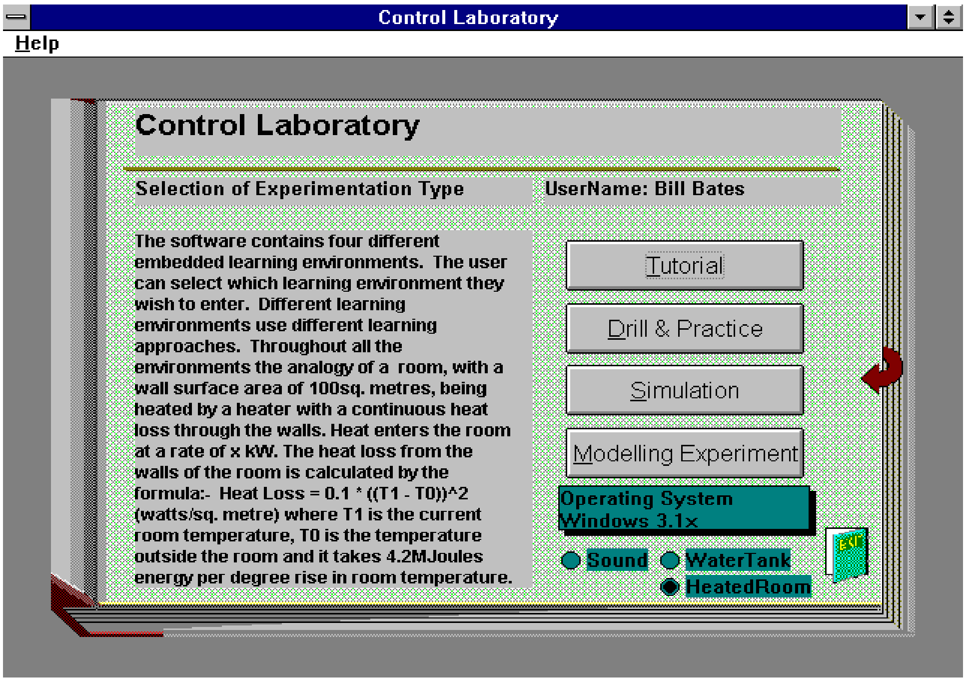

Diagram 1 - Control Laboratory 'Main Menu'

The first teaching approach to be developed was the Drill and Practice part. The goal of this particular part was to create an environment whereby the users could assess their knowledge in the area of control schematic diagrams, basic controller performance, modes of control and explore the relationships between controlled and manipulated variables in a control algorithm. Diagram 2 shows the first of 5 drills included in the Drill & Practice part.

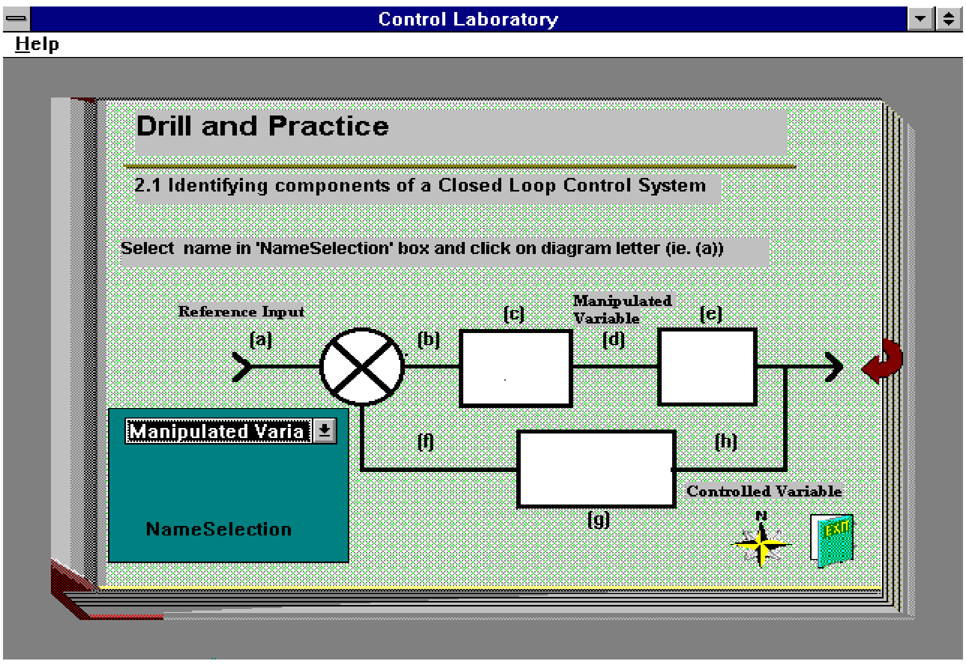

Diagram 2 - Control Laboratory '2.1 Drill'

The second teaching approach developed was the Tutorial part. This required substantial content development and production but the interaction was relatively simple. Navigation was limited to forward or backward pages, jump to next section or skip to Self Assessed Questions (SAQs). SAQ's were provided for each section of the tutorial. The only numerical user data interaction occurred in the SAQ's where users were asked questions about their understanding of the current section they were investigating. There were four sections developed; Principles of Control, Designing Control Systems, Systems to be Controlled and Methods or Modes for Control of Closed Loop Control Systems In each SAQ the user was advised of their current progress and could repeat tests as they considered necessary.

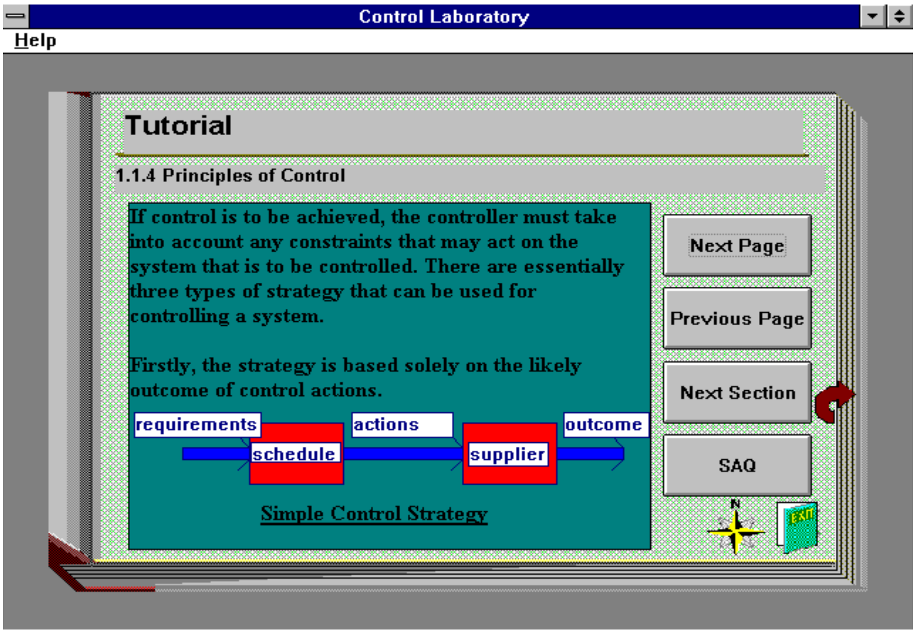

Diagram 3 - Control Laboratory 'Tutorial 1.1.4'

The third teaching approach developed was the Simulation part. This required the user to set up parameters and execute the simulator for a set number of simulation time periods. Users were able to change the control algorithm from Open Loop to full PID control. In the case of the room heating analogy users could also set the outside room temperature. During the simulation run a simple visible cue (showing water height or room temperature depending on active control analogy) was provided to let them know the simulation was producing results. A gauge was also shown which indicated where in the current run the simulation had progressed to. When the simulations were completed the results were plotted on a graph which the users could get a hard copy of if required. By performing a series of runs users could investigate the performance of a particular control algorithm for a range of parameter values. Diagram 4 shows an example of the software being used to investigate the performance of a controller using the heatied room analogy.

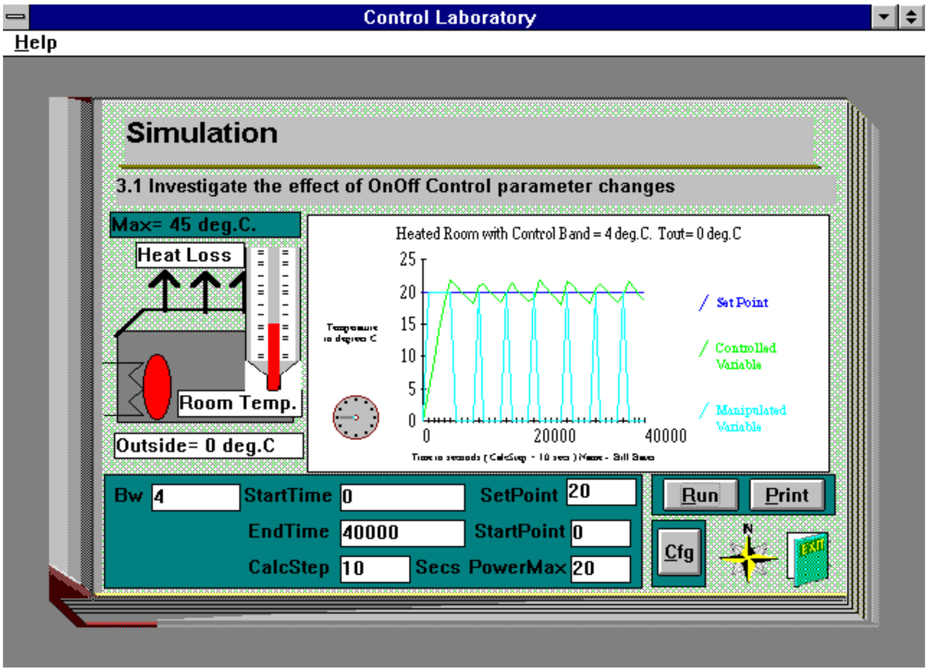

Diagram 4 - Control Laboratory 'Simulation Menu'

The fourth teaching approach developed was the Modelling part. This approach allows users to perform simulations and transfer the run-time parameters to a Dynamic Data Exchange (DDE) linked spread sheet and compare their own developed model with the one embedded in the Control Laboratory software. Diagram 5 shows the system simulating a water tank analogy model in On-Off control mode with a control gap bandwidth of 1 metre.

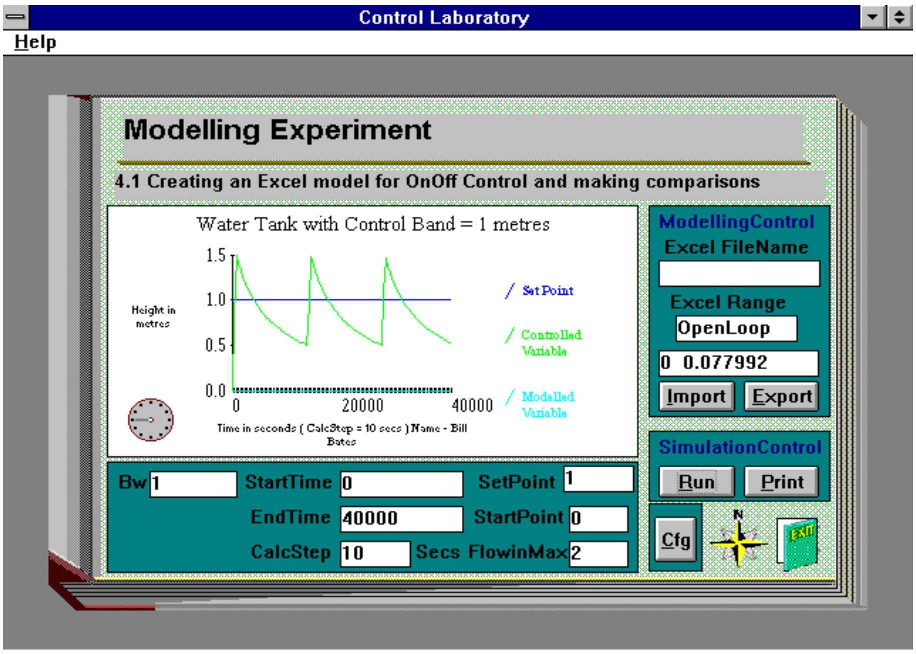

Table 5 - Control Laboratory 'Modelling Menu'

This particular environment is the most sophisticated learning environment supported by the system. The results are imported from the spreadsheet and plotted on a composite graph.

SOFTWARE DEVELOPMENT & EVALUATION

The software was developed using the TOOLBOOK OpenScript Language. Each Teaching approach was defined by a set of classification criteria reported on in previous papers [5,6,7]. For each screen a layout was defined using storyboard techniques and constructed using the user interface development tools available. A prototyping development model was used as suggested by Phillips [10]. Objects for such tasks as animation, indication and graph plotting were imported as Visual Basic VBX objects. The simulation algorithms were implemented using the OpenScript Language and attached to the user interface by TOOLBOOK Button Handler Routines.

During the development phase formative evaluation techniques were used to modify the interaction and some functionality as the system was tested with an expert user. The sytem took about 3 man months to design and implement and was summatively evaluated by 20 users over a 5 week period of laboratory sessions at a UK Educational Institution using a written questionnaire.

CONCLUSIONS

This paper has attempted to describe the rationale behind the design of a multimedia based software package for teaching an introduction to Open and Closed Loop Control Systems. The objective behind the design was to provide a series of learning environments with broadly the same learning objectives based on clearly defined series of characteristics.

The system was developed using formative and summative evaluation mechanisms using a prototyping approach to design and implementation. The system forms part of a pilot demonstrator research programme into Computer Simulated Experimentation currently being undertaken by the authors. It was developed using the commercially available Asymetrix TOOLBOOK Multimedia Authoring software package. The completed application has been used in Engineering Laboratory sessions at a UK Educational Institution. Work is currently taking place to further evaluate the underlying classification system at several UK Educational Institutions.

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