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Integrating Matlab with an Authoring Program

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Abstract: A CD-ROM based interactive multimedia instruction in experimental modelling for Danish Engineering School teachers is described. The content is based on a new sensitivity approach for direct estimation of physical parameters in linear and nonlinear dynamic systems. The presentation is inspired by Soloman's inventory of learning styles. To enhance active learning and motivation by real life problems, the simulation tool Matlab is integrated in the authoring program Medi8or.

1. Introduction

The potential advantages of Multimedia and Computer Based Learning (CBL) are enhanced flexibility and effectiveness of the learning process. The flexibility with respect to place and time makes CBL very appropriate for distance learning: the students can work in their own home, on their own time, and at their own pace. The enhanced effectiveness of Multimedia and CBL is mainly due to extensive sensory stimulation using text, graphics, animations, sound, voice and music, and - in particular - to increased interactivity i.e. active learning.

These potential advantages and their implementation in educational software is described in many publications, eg. [1]-[6]. Typical results of CBL is an increased learning speed and retention (up to 50%), lower drop-out (30%), better grades, and a general positive or even enthusiastic acceptance by the students, [3], [7]-[9].

The project described in this paper has two objectives:
- to develop a Multimedia Based Instruction (MBI) in Simulation and Experimental Modelling of dynamic systems, primarily for upgrading of Danish Engineering School teachers in advanced control engineering
- to develop a general concept for flexible multimedia based instructions in the field of Control Engineering

For the sake of the engineering school teachers, a distance learning (self - learning) course on CD-ROM is desirable. Also a simple electronic communication network will be established.

For analysis of dynamic systems, numerical calculations and graphical visualization of the results, Matlab [10] is an excellent tool. As pointed out in [7] , commercial tools for design and simulation, such as Matlab, are extremely important for student problem solving, but they are not designed for the purpose of communicating basic concepts. Consequently, it is an obvious idea to integrate Matlab into a computer based instruction, created by an appropriate authoring

program.

In the following, the presentation of the subject and the corresponding pedagogical concepts are discussed. Next, the applied software, Matlab and the authoring program Medi8or, is briefly presented, the content of the instruction is described, and finally some examples of the implementations of the concepts into the MBI are given.

2. Presentation And Pedagogical Concepts

Though content is the foremost concern of any educational product, good presentation is vital to convey the content to the student. The multimedia offers some new possibilities for presentation, and for optimal utilization of these possibilities, known pedagogical principles must be applied and new developed. The keywords for the design of this MBI are: learning styles, active learning, and understanding.

Learning styles.

Soloman's four dimensions of learning styles [5] are described in Table 1. The numbers in brackets are results of a survey of an introductory material and energy class reported in [5]. They are very similar to other observations.

Processing: Active/Reflective (67%/32%)
Active learners learn best by doing something physical with the information, while reflective learners do the processing in their heads.

Perception: Sensing/Intuitive (57%/42%)
Sensors prefer data and facts. Intuitors prefer theories and interpretations of factual information.

Input: Visual/Verbal (69%/30%)
Visual learners prefer charts, diagrams and pictures, while verbal learners prefer the spoken or written word.

Understanding: Sequential/Global (71%/28%)
Sequential learners make linear connections between individual steps easily, while global learners must get the 'big picture' before the individual pieces fall into place.

Table 1: Learning styles

These results are used to meet the needs of the students in two ways: by generally emphasizing presentations appropriate for the most common learning styles (active, sensing, visual, sequential), and by utilizing the flexibility of computer based learning to let the student choose, e.g. between examples and proofs of formulas.

Active learning.

Active learning "involves providing opportunities for students to meaningfully talk and listen, write, read, and reflect on the content, ideas, issues and concerns of an academic subject" [2]. At Aalborg University this has very successfully been implemented as group- and project-organized studies [11]. The question is now: how and to what extent can the computer in self-learning take over the interactivity between students in groups and between student and teacher ?

With this MBI the student is constantly activated by selecting the segment of text to be read and a corresponding speak, by selecting hyper links, by interactive examples and demonstrations, and by problems and exercises to be carried out. Hopefully, this will also make the student reflect on the results and the basic concepts.

Understanding.

The purpose of the learning process is to obtain an understanding of the subject, and for an academic subject this is definitely more than the ability to use it for doing simple exercises. Generally, an understanding is best obtained by a combination of learning styles, but often, intuitive understanding is associated with visualization skills and perceiving connections [7]. In particular, for understanding the behaviour of various dynamic systems in circuit analysis, modelling and control theory, graphs are very beneficial, for example a combined graphical representation of step response, Bode plots, and pole-zero location in the complex plane. This is a good reason for integrating Matlab in the MBI.

Another important prerequisite for deep learning and understanding is motivation, and one of the strongest motivators in engineering education appears to be practical real world problem solving [6]. At Aalborg University the students devote half of their time on project work, often in connection with industry or research projects [11]. This is a tremendous motivation factor. Also in courses, inclusion of realistic problems is now possible thanks to the calculation power offered by computers and programs like Matlab. In the MBI, models of various dynamic processes, such as DC-motors and loudspeakers, are obtained from real measurement data.

3. Software Tools

The production of an MBI is an enormously time-consuming process, in particular when it is done by a lecturer with little professional assistance. Ideally, the lecturer should be able to concentrate on the content and the presentation, but there are numerous technical and practical problems to be solved. It is important to utilize good and compatible software tools, and the choice of authoring program is crucial.

Medi8or

The authoring program Medi8or was chosen, mainly for the following reasons:
- It meets the requirement for the specific purpose just as well as most of the possible alternative products
- It is very user friendly and simple to learn, as it is icon based and requires no programming
- The produced run-time version is a stand-alone program to run on a PC with Windows

The creation of multimedia products with Medi8or is object based. Different objects, such as text, lines, buttons, input fields, coloured rectangles, pictures, animation and video can be reached or created from a toolbar

Basically, Medi8or programs consist of *events* causing *actions.* An event may be a mouse click on a button, movement of the curser into or out of a specific object, or a page being ready. An action may be show or hide an object, play a wave file or turn page. The actions may be controlled by if-statements or a timer. The events/actions are easily edited by an Event Dialogue, dragging and dropping corresponding icons.

Medi8or and Matlab

Matlab offers numerical computations based on matrices and graphical presentations [10]. A large number of special functions and toolboxes for various applications reduce the programming to a minimum. Commands and input/output of numerical data can be achieved from files or from a command window.

When using Matlab together with a Medi8or program, the Matlab command window and a graphical window must appear on the Medi8or page. The Medi8or program can start Matlab, and the control can be transferred between the two programs via a file. The principle is [9]:
1) Start Matlab from the Medi8or program
2) Make it run in a loop, checking for input through files
3) Execute commands and pause
4) Continue loop, while control is back to the Medi8or program
5) On a give cue, quit Matlab from within Matlab thus returning to the Medi8or program

This way, prepared simulations can be demonstrated, or the student can try out his own experiments and solve exercise problems, still in the environment of the Medi8or program. In particular, important graphical results can currently be emphasised and commented by speaks.

4. Content Of The Instruction

The basis of the content is a method for direct estimation of physical parameters of dynamic systems, from measured sequences of input-output signals [12],[13]. The method uses a sensitivity approach for design of input signals and for evaluation of the accuracy of the parameter estimates. Compared to classical system identification, [14] the sensitivity approach has the following advantages:
- it is very easy to understand, and compatible with physical insight
- it is applicable for nonlinear systems, distributed parameter systems, multi variable systems, and systems with time delay
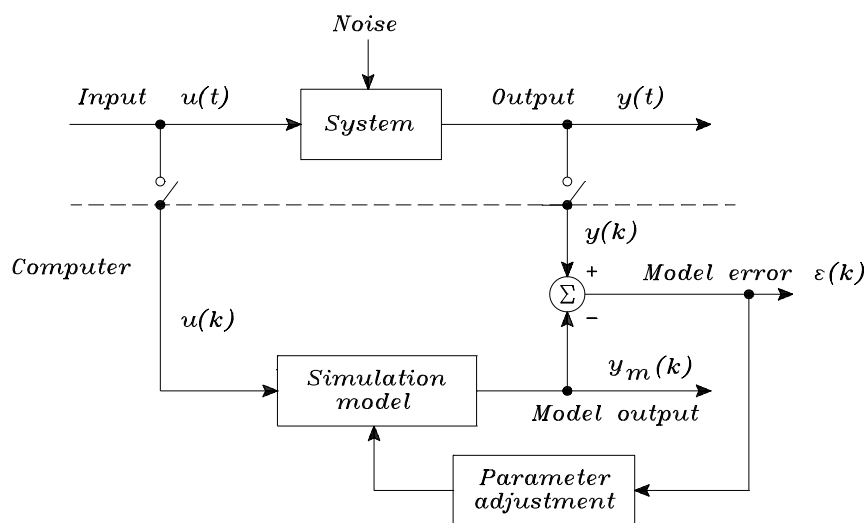- it is robust to violation of theoretical assumptions and approximations

Fig.1 Parameter estimation principle.

The basic principle for any parameter estimation method is illustrated in Fig.1:
i) Sequences of system input-output signals are measured and stored in the computer. ii) A simulation model is given the measured system input, and the difference between the system output and the model output, the model error, is calculated. iii) The parameters of the simulation model are adjusted to minimize the model error.

Different methods may be characterized by the simulation model applied:
1) A linear discrete-time model, often including a stochastic noise model, leads to classical system identification. This requires only little knowledge of the system, except that it is approximately linear.
2) A general continuos-time simulation model leads to the direct, sensitivity based method. It requires a reliable physical model structure.
3) A Neural Network model is appropriate for complex nonlinear systems, where a reliable physical model structure cannot be obtained.

The MBI covers methods 1 and 2; method 3 will later be included.
For the direct, sensitivity based method, 2, a Matlab toolkit, SENSTOOLS [13], with graphical user interface has been developed. The only programming effort required by the user is construction of the simulation program.

5. The Multimedia Based Instruction

In this section some of the main issues in design of the MBI vil be discussed and exemplified. At present only the classical system identification method has been implemented.

The structure: experience show [15] that for technical subjects most students prefer a sequential main structure, with simple sequential sub structures as hyper links. The MBI is structured accordingly, Fig.2. The compulsory pages are sequentially organized as P1....PN. Structurally these are linked roots in a forest of trees, where the descendants of the roots contain illustrating examples, basic theory, mathematical proofs etc.
Each node in Fig.2 consists of one screen page, each with a header field in the upper left corner, a text field, and a button field in the lower right corner. Fig.3 shows an example of a P-page. Clicking on previous/next gives a jump to previous/next P-page. This feature supports the sequential structure of the compulsory part of the lecture. Clicking on links in the text field calls pop-up windows or gives a transfer to an S-page. The S-pages do not have the previous/next buttons, but a return button giving a return to the root of the current tree.
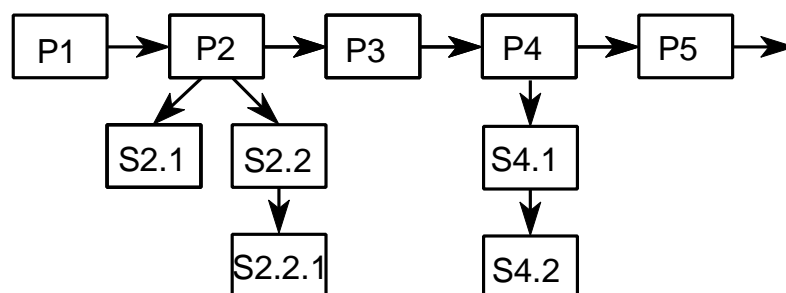

Fig.2 Structure principle of the instruction. Main structure P1...P5...

An alternative way of navigation is by means of the content button. Clicking on that puts Fig.2 on the screen with the current node highlighted. Clicking on another node in Fig.2 gives a direct jump to the screen page.

Text and speaks: to alleviate the problem of reading text on the screen, the student can highlight a segment of text with the cursor. At the same time the corresponding speak will be activated. When the speak is terminated, the yellow highlight will disappear. We hope, that this will also increase the sense of interaction, and help deter passive electronic page turning.
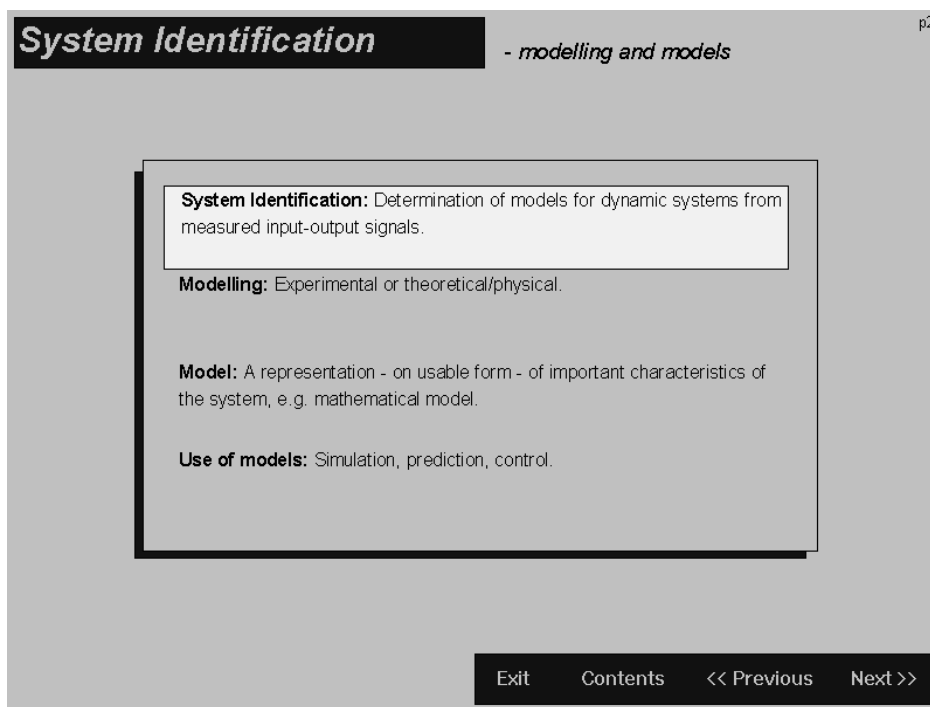

Fig. 3 A typical text page. The white field is highlighted (yellow) by the cursor.

Integrating Matlab: Fig. 4 shows a page with a Matlab command window and graph window. This is used to demonstrate how a Gauss-Newton algorithm iteratively determines better parameter values. The command window shows the number of iterations and the current parameter estimates. The graph window shows the measured system output and the model output.; for each iteration the model output approach the system output. This development is commented by speaks.

Tests and exercises: An example of a multiple choice test page is shown Fig. 5. The purpose of this kind of test is to rehearse important concepts and mathematical tools. If the result of the test is inadequate, the student is urged to redo the preceding pages.
The Exercises consist of realistic or real life problems, often using Matlab, where the students are encouraged to reflect on ideas and methods, and evaluate and comment the results. If possible, the program will give feedback on the results.
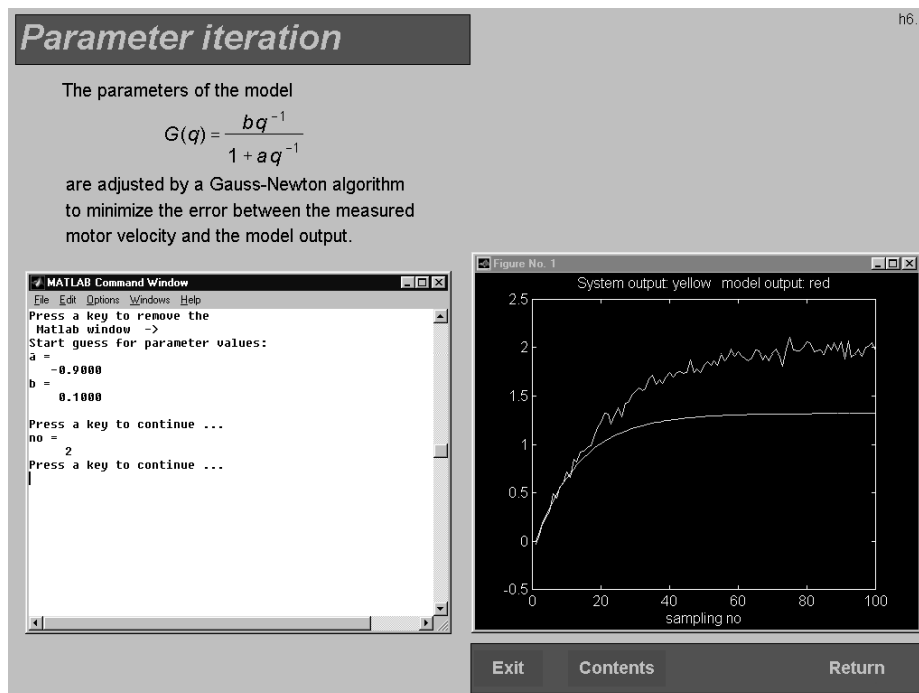
Fig.4 Medi8or program page with Matlab command window and graph window.

Fig.5 Multiple choice test. The correct answer has been given.

Evaluation: The initial evaluation of the MBI will be performed by colleagues and, in particular, the pedagogical experience of the engineering school teachers, for whom it is intended, will be utilized.

6. Summary

A Multimedia Based Instruction in Experimental Modelling was implemented, using the authoring program Medi8or. The simulation tool Matlab was integrated and used for numerical calculations and graphical display. The presentation emphasises flexibility w.r.t. learning styles, interactivity to enhance active learning, and motivation from real life problems.

When the MBI is completed and evaluated, it will be distributed on CD-ROM and probably on www.

Acknowledgment

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