

# COURSEWARE GENERATOR FOR AUTOMATIC CONTROL LEARNING THROUGH INTERNET

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**Abstract:** This paper presents a system that generates automatically coursewares for the learning of Automatic. The developed system, like adaptive hypermedia systems, uses a semantic network that arranges the information on a certain area. From this, it is able to generate coursewares ready to be used by the user or student. The paper shows how the teacher constructs the knowledge domain and how he can set the goals for a specific course and the courses are seen by the students.

**Keywords:** Adaptive, Hypermedia, Education in Internet, Automatic Control.

## 1. INTRODUCTION

Traditionally, a course by Internet is the transcription to electronic format of the course text. In this support, it is included connections to other pages of hypertext and to other materials multimedia (audio, simulations, videos, animations...). The system is complemented with other aid systems, as glossaries, the notes of the students, etc. (Aranda et al. 1998, Aranda et al. 1994, López-Orozco et al. 2000, Sánchez et al. 1998).

The main disadvantage of these courses is that they are a static material, designed for a certain audience and with the criterion of structuring of the teacher who design it. In many occasions, the teacher, both presential and distance education, generates a great amount of material that rarely reuses to give other courses. The material base is reused, but usually the teacher finds that it is easier to redesign a new course than to take advantage of the generated material.

Another problem that education by Internet faces is how to generate content that adapts the user who accedes to the courseware at every moment. A change of audience or to consider other criteria or level of depth of the course suppose, in many cases, almost to have to consider a new project. It would be necessary to have adaptive tools that they adjust to the level and progresses of the student at issue and facilitate the work of the professor as well.

In order to solve the problem, a model has been proposed. This model structures the knowledge

according to the dependences to acquire it. That is to say, it is assumed that a node is a complete explanation (with a certain level of depth) for a certain concept or topic, but, to be able to understand this concept it could be necessary to assimilate some previous concepts. Those concepts are another nodes with their prerequisites and so on. This structure is transparent for the student, but the teacher is aware of it and he uses it to create its own course. From this structure, the system adapts the content of the information shown to the student according to the goal pursued, their level of previous knowledge and the level of depth desired.

The hypermedia systems in education are used to provide to the students a way to guide by the didactic material. In this sense, the adaptive hypermedia systems are necessary to adapt the information at the level of real knowledge of the student and to support navigation in different user levels (Beaumont 1994, Brusilovsky 1998, Brusilovsky et al. 1993), showing or annotating the best links to follow. (Brusilovsky and Pesim 1994, Brusilovsky and Zyranov 1993, de la Passardie and Dufresne 1992, Tang et al. 1990).

The core of an adaptive hypermedia system is a set of topics or concepts. The topics represent elementary pieces of knowledge about a certain material. The size of topics depends on the material. Generally, these topics are connected forming a semantic network. This network (or graph) represents a model of the structure of the material. Most of the adaptive hypermedia systems are based on these types of models, which can be more or less simple. The

simplest models are models of an only level without making a distinction between different types of topics and connections, in advanced models; several classes of topics and connections can be founded. (Boecker et al. 1990, Brusilovsky 1998, Brusilovsky and Pesim 1994, Kobsa et al. 1994, Scott and Ardron 1994).

The relation between hypermedial topics and pages can be more or less complex. Although in almost all the existing systems, the rule that it is used is "each topic has a page like external representation (or several if the amount of information relative to this topic is great)".

The developed system, like adaptive hypermedia systems, consists of a semantic network arranged in a graph where all the information on a certain area is structured. From this, the system is able to generate courses ready to be used by the user or student. The system provides two ways of generation: starting from the student level and from the objectives that the user is looking for, a course and a learning sequence is created in order to obtain the required knowledge; or it generates a course appropriate to the level or levels of knowledge and depth to learn the solicited matter.

However, a question as important as courseware generation is that the system can support teacher to organise, to manage and to use the didactic material efficiently. In the developed system, it has been made a special emphasis on the support to teacher so he can be to take the maximum advantage of his work. Although the effort of elaboration and insertion of necessary material is slightly greater than in a static courseware, will be worth since modification, update and reuse will be direct and simple, saving much work and even allowing to generate courses with different restrictions, studies on efficiency in the form to give a subject, etc.

Moreover, if amount of information and didactic material are great, it is essential to have a tool that allows to structure and to show the information according to different necessities and restrictions. The developed system allows grouping all the information generated in a coherent and structured way and adding and extended sections or subjects without any difficulty.

The generator not only constructs a course based on the requirements of the student, but suits to student interests, constructs the necessary pages of hypertext to show the information that student needs or solicits progressively.

## 2. DYNAMIC COURSE PLANNING SYSTEM

The set of topics or introduced information forms a complete knowledge domain on a certain matter. A course on this matter supposes an arrangement of a

part of these topics and the links to the pages that contain them, so the student can advance in the course without disorientation in navigation and follow a logical structure of study. In a way, the problem is similar to obtain information of a hypertext using dynamic tours guided, although with remarkable differences. The proposal of Guinan and Smeaton (1992) is obtain information in direct answer to a user query, to do that it combine the metaphor of tour guided of Hammond and Allinson (1987) and the techniques of information retrieval of Frisse (1988). The presented proposal is the creation of a new hypertextual structure in which the links mark precedence of study of the corresponding concepts, according to the objectives that are wanted to obtain and the initial level of the student.

In order to create the hypertextual structure, it starts from a knowledge domain in which it's established a relation of order between concepts. This knowledge domain is structured in form of directed graph where nodes are topics or concepts and arcs represent precedence relations between concepts.

The generation of a course is based on the next: given a topic,  $t_i$ , its wanted to give an ordered list of all the nodes necessary to be able to understand and to explain that topic. After selecting the node or nodes that are going to teach, the system extracts the subgraph associated to the course, this subgraph is named *the course structure*. The structure of the obtained course will have superior semireticulum structure and the supreme of the set is the above  $t_i$ .

A network in which the vertices represent tasks (or activities) and the edges represents relations of precedence between the tasks, denominates *activity network*. These networks are used in operation research for projects planning. The proposed graph can also be seen like an activity network. The algorithm that verifies if the digraph is acyclic is going to also generate a linear ordering, that is to say, a *topological sort* of vertices (nodes).

In general, the vertex order produced by a topological sort is not unique. We could reorder the nodes while maintaining the precedence relation. Nevertheless, any generated order guarantees that no concept will be displayed to student before showing necessary knowledge for correct understanding and assimilation.

## 3. COURSE GENERATION.

To show a real example of how the developed generator works, it has been applied to teaching of automatic Control.

The introduced knowledge domain consists of different concepts (nodes) on Automatic Control, where edges indicate concepts that precede to other

concepts, that is, knowledge that student would have to acquire before reaching the following node. For example, in figure 1 it is possible to see how to reach the numbered concept as 1.5, it is necessary to learn topics 1.4 and 1.6 before, and before these topic 1,3, and so on. This relation allows the system to give a suitable order to the contents of the course, for that reason is very important the structure that the teacher constructs while he inserts the nodes.

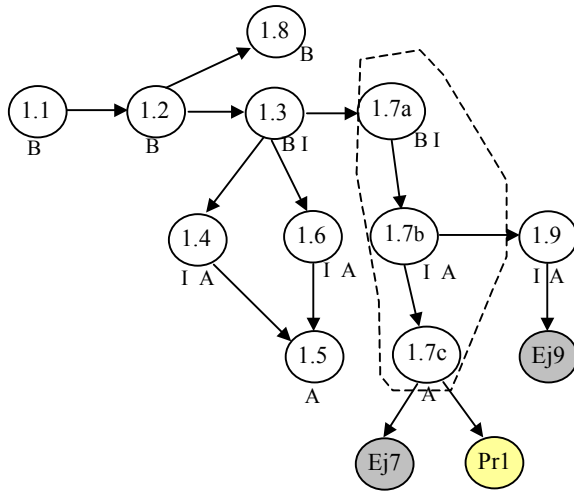


Figure 1: Example of the structure of the knowledge domain

Figure 1 shows an example of a graph that represents the structure of the knowledge base. There are several types of nodes (theory, exercises and practice). Particularly, there are two nodes of type exercise (associate to the theory nodes 1.7c and 1,9) and a practice node associated to the node 1.7c. In addition, it can be observed that each node can have one or more levels (Beginner, Intermediate or Advanced). That classification will allow generating different courses according to the initial level of user or the level that the user wants to reach. Finally, the nodes 1.7 are grouped forming a category. A category is any group of nodes. Table 1 includes different examples of courses obtained from this graph. UI represents the user level and CI the level of depth of the course, levels are beginner B, intermediate I and A advanced. To simplify, the chosen course corresponds to a category that contains all the nodes shown in Figure 1.

The system not only allows the insertion of knowledge domain structured as in figure 1, but also supports to teacher in management and organization of the knowledge domain and in administration and monitoring of students. In the teacher interface, (figure 2), there are a menu with different options that permit management of knowledge domain (pages, categories and courses) and administration of students. That way teacher can modify nodes, edges, to make statistics, register students or courses, etc.

Table 1: Generation of different courses

UIP - CIP	UIP - CIPI	UII - CIIA
1.1	1.1	1.3
1.2	1.2	1.7a
1.3	1.3	1.4
1.7a	1.7a	1.6
1.8	1.8	1.7b
	1.4	1.9
	1.6	1.5
	1.7b	1.7c
	1.9	

#### 4. INTRODUCTION OF TOPICS

In order to introduce a graph like in figure 1, it is necessary teacher introduces some information about the node.

1. - General information on the topic: Title, URL, type (theory, practices, exercise) and Level of the displayed concept (beginner, intermediate, advanced).

2. - The situation of that concept within the knowledge domain, that means, the preceding pages or concepts that are necessary to know before showing this one and the category or categories to which it belongs.

Figure 2 illustrate an example of the screen showed to teacher to modify a node or concept. First there are the information on the topic and next some lists box to indicate the preceding pages and categories to the node at issue. The first two lists display all the existing topics in the knowledge domain (the one of the left) and what topics are prerequisites to the node selected (the list of the right). This will constitutes the edges of the graph of knowledge domain.



Figure 2: Option *Modify node*

The introduced nodes can be documents in format HTML, XML, pdf or in any other format visible by the navigator. In fact, information is not introduced, but only the link or URL where this information is allocated. This fact allows teacher uses his own

information or adds to the knowledge domain any page available in Internet.

A category is a group of pages (or topics) that has a certain relation each other or they can be grouped together under some type of interpretation. In addition, categories of categories can be made. Categories allow giving a hierarchical structure to the knowledge domain, structuring and classifying the introduced information. In addition, it allows that access to a set of information, subject or module be simple and direct.

For example, on Figure 2 there are two list boxes at the bottom, the left one indicates the categories existing or available and the right one shows to what of the existing categories the node belongs.

## 5. PRACTICE AND EXERCISE NODES

They are nodes that can be associated to theory nodes. They are introduced just as theory nodes, but they are not within the table of content of the course shown to students, unless user wishes to study a certain exercise or practice: In this case the system will show all the theory that he needs to make and to understand this practice suitably.

The exercise and practice nodes are associated to theory nodes. In a couserware, they appear if the theory node forms part of the course. Figure 3 shows the exercise nodes associated to a theory node. These exercises are only visible if user actives the link denominated *exercises*. Then, a menu expands. This menu shows all exercises associated to that theory node and adjusted to user level.

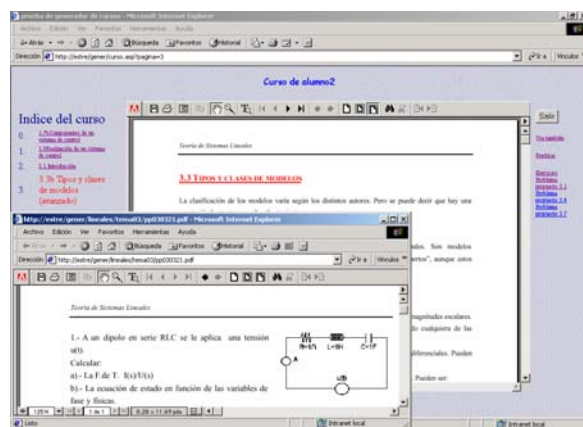


Figure 3: Exercises associated to a theory node

It would be interesting to remember that construction of the knowledge domain does not imply to generate new documentation, but only to structure the already existing one. Thus, existing examples, exercises or practices in other Internet location can be used as if they were physically in the server where the tool is. The only thing it can be made is to indicate the

corresponding URL. An example of this can be observed in Figure 4, where there are a practice made with *Matlab Web Server* available in a server that is different from the server where the course generator is installed.

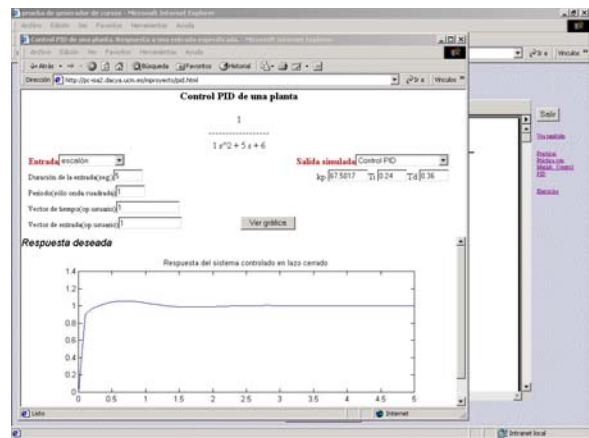


Figure 4: Example of a practice made with MatLab Web Server

## 6. COURSE CREATION

The creation of a concrete course is reserved to the teacher, but the course will be available for all the students who are registered to follow it.

In order to create a course it is only necessary to set the nodes and categories that teacher desires to be within that course. Nodes can be theory, exercise and practice. These nodes can be documents in HTML, XML, pdf or any other format visible by the navigator. The generator will include automatically all those topics necessary to correctly understand the concepts of the nodes and categories marked by the teacher. It is advisable to notice that topics can be including in different courses, but this fact does not imply duplication of information, since the system only constructs the navigation structure of the course.

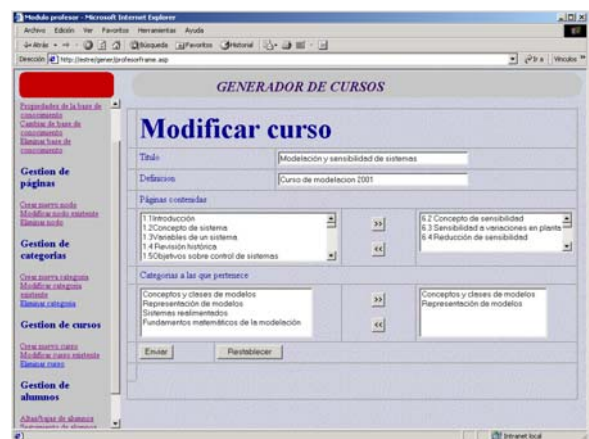


Figure 5: Creation of a course

Figure 5 shows the screen where a teacher can define a course. He only has to indicate what topics and/or categories belong to the course. Figure 6, illustrates how that course is presented to user. It is interesting to notice that nodes that have not been introduced directly in the generation of the course appear because they are necessary to understand some of the concept or category that has been marked like belonging to the course. This is due to the scheme made by the teacher when he introduces the nodes and creates dependencies.

## 7. COURSES SEEN BY THE STUDENT

Students can't create courses. The system asked him for an objective (to follow a course or to understand a concept, exercise or practice) and his user level, from this, the tool constructs the necessary links for the correct study of the topic or course that he has selected.

Firstly, student indicates his level of previous knowledge this avoid him presenting information inappropriate, too difficult or irrelevant information???

Next, student must indicate what depth level of knowledge wishes to reach. This level must be equal or superior to the student level

Finally, it must select the objective that he wishes to reach. He has three options:

1. Choosing a specific course from those teacher has constructed to him
2. Choosing a concrete node. In this case, student is indicating that he wishes to learn or to review a single topic. This topic can be a theory node, a practice or an exercise. From this, the system construct all the links to concepts that user has to revise and in what order before to see the objective node.
3. Choosing a category. In that case, student is choosing one of the groups of nodes that teacher constructed. It can be a chapter, a subject, a module or any other grouping of concepts. In this case, system shows to student all the nodes necessities to learn that category.

After choosing an objective and a user level, system generates the course. Figure 6 shows an example. On the left, a table of contents is displayed, this table shows the topics that student must learn and in what order. In order to guide student through the course, there are at the bottom on the screen two buttons *back* and *next*. On the right, student has some menus available *practices*, *exercises* that student can consult at any moment. Those menus expand to show links to practice and exercise nodes associated to the node displayed. The option *see also* permit that student consult other explanations or nodes of a higher level

if he wants to increase his knowledge about presented node.



Figure 6: Generated course

Figure 7 shows the same course that Figure 6 but to a beginner level, so some of the nodes of higher level have been hiding.

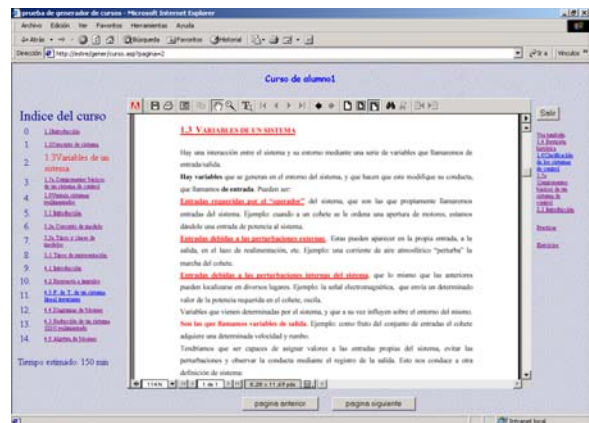


Figure 7: Curso a nivel principiante

## CONCLUSIONS

It is developed a courseware generator as a hypermedia adaptative system applied to technical teaching. With this system a course for teaching of Automatic Control through Internet is implemented.

The system is very versatil and easy to use. The teacher can generate different course for different levels of students and for different targets. The student can choose a specific course, a concrete node or a category. The system asked to student for an objeive and his user level, the tool constructs the necessary links for the correct study of the topic or course that he has selected.

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