MULTIMEDIA COURSEWARE DEVELOPMENT USING INFLUENCE DIAGRAM

Timothy K. Shih, Lun-Ping Hung
Department of Computer Science and Information Engineering
Tamkang University
Taiwan, ROC
E-mail: tshih@cs.tku.edu.tw, robin@mail.mine.tku.edu.tw

ABSTRACT

Web-based distance learning programs are widely available. A few distance education platform and standards were developed or proposed. Among current software systems, it is hard to realize strategic assessment of courseware quality. Since one of the difficulties of distance education is the load that an instructor needs to spend in courseware design, it is worthy to investigate an automatic mechanism to help an instructor to produce effective courseware. Thus, distance learning program can proceed efficiently. In this paper, we develop a mechanism for the construction of courseware structure based on influence diagram. The mechanism can be implemented as a decision support system for the instructor to analyze the relation among course units and test units. The overall value of a courseware can be systematically analyzed.

Key words: distance learning, influence diagram, courseware, virtual university, multimedia presentation

1. INTRODUCTION

Many distance learning platforms, such as WebCT [2], Blackboard [3], and LearningSpace [4] were developed. However, authoring tools of these systems are lack of a systematic analysis mechanism. Contradictively, decision support system is one of the success examples that computer programs can help a manager to make a systematic analysis, and lead to a good decision for overall revenue. Decision problem consists of sub-problems, with influences or dependencies to each other. From a knowledge acquisition prospective, the organization of a distance learning courseware is a decision problem – *how does the courseware benefit students in a maximal learning capacity*. Thus, we consider several approaches on decision science that could benefit our courseware design. Conceptual graph was initially considered. The graphical representation of conceptual graph and influence diagram are similar, but influence diagram has different types of nodes, including decision nodes. Conceptual graph is primitive. It is worthy to consider influence diagram as a base for our proposal, as we should explain the reasons in the following sections.

2. INFLUENCE DIAGRAM AS A TOOL

The most common method to formulate a decision problem is the decision tree. A decision tree contains controllable and uncertain variables. It is easy for the decision maker to explicitly see the value of each possible outcome. Decision tree was used in the construction of decision support systems. However, in spite of its popularity, decision tree has several drawbacks:

- Independent relations are hardly exploited.
- A large decision problem requires a highly redundant tree.
- If redundant sub-trees are eliminated, the tree will lead to losses of information.
- Tree structure forces decision maker to think forward. But, backward reasoning seems to be more attractive.
- Un-experienced practitioners confuse decision with probabilistic expansions. This may lead to a wrong structure of the formulated problem.

Consequently, for large decision problem, a symmetric decision tree is hard to construct and visualize, even with computers. Therefore, decision tree can only be used in smaller decision problems in general. Nevertheless, influence diagram was developed with theoretical and practical advantages over decision trees. Clear and smaller size of the diagram, with a clear distinction between informational and probabilistic nodes, allows exploited independent relations. Influence diagram grows linearly (as opposed to growing exponentially of decision trees) so that larger decision problem can be represented. An influence diagram is a singly connected DAG (directed acyclic graph) without loop. Two types of nodes are used in an influence diagram – the decision nodes and the chance nodes. A decision node is represented by a rectangle or a square, which represents a variable under the decision maker's control. A chance node is represented by an oval or a circle, which denotes a

0-7803-7304-9/02/$17.00 C2002 IEEE

probabilistic variable. Links in an influence diagram are divided into types – the conditioning links and the informational links. A conditioning link always points to a chance node and represents a probabilistic dependence. On the other hand, an informational link always points toward a decision node and denotes available information. In addition to the above definitions, the set of decision nodes bust be fully ordered. This is known as the no-forgetting condition. A decision is made with all outcomes of its direct predecessors. Thus, informational links imply a chronological order. However, conditioning links do not imply a chronological order. Another important issue of conditioning link is its direction. In general, representation of a decision problem is not unique. That is, the chance nodes do not imply orders. A conditioning link between two chance nodes can have a reversed link for the same decision problem. Another important feature of influence diagram is, an influence diagram may have a number of redundant links, which can be deduced from the structure of an influence diagram. Without loss of generality, while representing a decision problem, these redundant links can be omitted. Nodes (decision or chance) with no successors or predecessors are special in the diagram. Typically, an influence diagram has a single sink node, which is called the value node. Links toward the value node are also conditioning. A value node can be represented as an octagon, which represents the decision maker's value on the overall decision outcome. Chance nodes without direct predecessors are called border nodes. A border node usually represents an independent variable and is important in the construction of an influence diagram.

The mathematical model of influence diagram is similar to the one of conceptual graph. An influence diagram is a directed acyclic graph (DAG) with no loops, $G = (N, L)$, where N is partitioned into D, C, and V. The set of decision nodes, D, and the set of chance nodes, C, contains zero or more members. And, the set of value nodes, V, is an atomic set (only contains one member, v). The link set, L, is also partitioned to CL and IL for conditioning links and informational links, respectively. The following conditions hold:

$$N = D \cup C \cup V \wedge D \cap C = \phi \wedge C \cap V = \phi \wedge V \cap D = \phi$$
$$L = CL \cup IL \wedge CL \cap IL = \phi$$
$$\forall l_{ij} \in L \bullet l_{ij} = \{ n_i n_j \mid \forall n_i, n_j \in N, i \neq j \}$$
$$\forall cl_{ij} \in CL \bullet cl_{ij} = \{ n_i n_j \mid n_j \in C \vee n_j \in V \}$$
$$\forall il_{ij} \in IL \bullet il_{ij} = \{ n_i n_j \mid n_j \in D \}$$
$$V = \{ v \}$$

The formal definition of an influence diagram precisely defines the diagram. The first and the second expressions state that the nodes and links are partitioned accordingly. The third expression restricts the graph from loops. The rests denote the definition of conditioning links and informational links, as well as the atomic set of the unique value node. However, influence diagram is not completely suitable for the modeling of a distance learning courseware, as we should discuss the differences in a revised diagramming technique in the next section.

3. A NEW COURSEWARE DIAGRAM

As we discussed before, the design of a courseware will benefit to the students to receive a maximal learning efficiency. This design can be regarded as a decision problem. Thus, the use of influence diagram in courseware design is natural. However, proper alternation to the diagram is required. We argue that, the following two propositions hold:

- **Decision nodes can be used to represent test units**: In a typical instruction procedure, tests such as quizzes and exams will be given to students to monitor learning performance. According to the outcomes, an instructor needs to suggest appropriate course units for the next lecture, or to design a remedial lecture. Thus, the topology of a courseware can be designed to fit multiple needs, which depend on the decision the instructor makes after a test. Therefore, we believe decision node can be used to represent a test and its evaluation event, before the next step of instruction can be proceeded.
- **Chance nodes can be used to represent course units**: A chance node is associated with a probabilistic variable, which represents the possible influence of the node. When a course unit is learned by a student, there is a degree of understanding associated with the unit, as the probabilistic variable. Therefore, chance nodes can be used to represent course units.

Conclusively, we have two types of nodes, the course units and the test units in the diagram. We call the new definition the courseware diagram. In addition to the two types of nodes, the value node (call the final unit in courseware diagram) can be treated as a summative evaluation reference. Summative evaluation gives the semester grade to a student, which justify the learning performance of an individual based on the courseware. Nodes are connected by different links in the courseware diagram. There are six types of connections:

- From course unit to course unit: accumulation link
- From course unit to test unit: knowledge link
- From course unit to final unit: knowledge link
- From test unit to course unit: conditioning link
- From test unit to test unit: prohibited
- From test unit to final unit: prohibited

Note that, the final unit is a sink node. There is no out-going link from the final unit. In addition, we forbid the uses of the last two kinds of connections, to satisfy the need of courseware design. Moreover, it is strange to have two consecutive tests in a sequence of instruction units even it is possible in the classroom. Thus, the last two types of links are not recommended. Consecutive course units will accumulate degree of understanding (via accumulation links). Links from a course unit to a test unit or the final unit will be regarded as knowledge information (knowledge links) required for the test. Links from a test unit to a course unit will be a conditioning link. Course units are represented as ellipses or circles. Test units are represented as rectangles or squares. And, the final unit is represented as an octagon. These shapes are following the convention of influence diagram. However, it is different from the conceptual graph. In a conceptual graph, concept or course nodes are represented as a box. But, course units in a courseware diagram are ellipses. Knowledge links are represented as solid lines with arrowhead. Accumulation links and conditioning links are denoted as dash lines with arrowhead. As an example, figure 1 illustrates a courseware to teach students how to write a word process application program. Note that, course units are enumerated as numbers while test units are enumerated as alphabet characters.

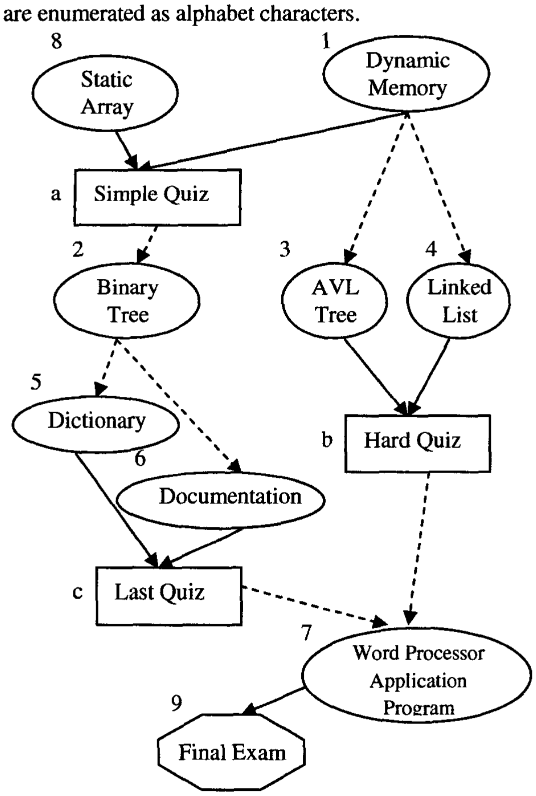

Figure 1: A courseware diagram example

Some features from influence diagram appear in courseware diagram as well. For instance, in an influence diagram, redundant links that can be deduced from the structure can be omitted. Thus, the courseware diagram shown in figure 1 has some links omitted. The elimination of these links will not affect the evaluation of the final assessment. In the courseware diagram (figure 1), each test only has an out-going link. However, it is possible to design a multi-purpose courseware diagram. Depending on the outcome of a test, the instructor may decide whether to give a *remedial lecture*, which is followed by another test. This process is a part of *mastery learning* strategy. The strategy enforces repeated training, until a test is passed by the student. However, loops (or repeated training) are not allowed in influence diagram. Neither does the courseware diagram. Thus, repeated training can be defined as a limited number of remedial lecture and re-test combinations. For instance, a portion of figure 1 is shown in figure 2. Remedial lectures can be arranged, with extra quizzes. The number of lecture-quiz pairs will depend on the content and the need of students.

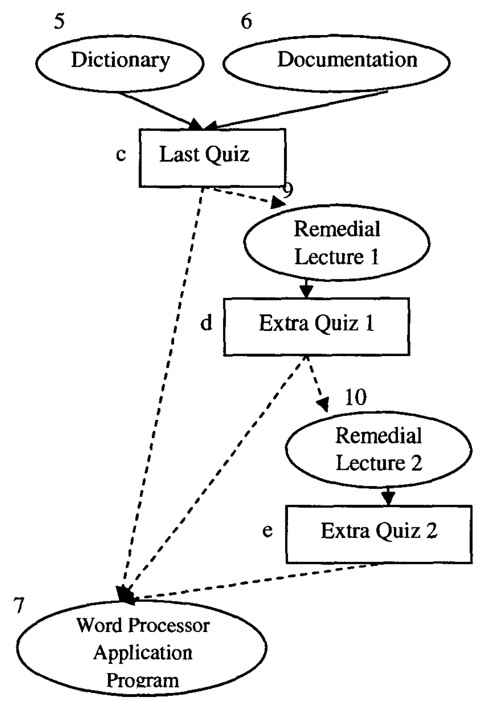

Figure 2: A partial diagram shows usages of tests

The mathematical model of courseware diagram needs to be redefined. A courseware diagram is also a directed acyclic graph (DAG) with no loops, $G = (N, L)$, where N is partitioned into T, C, and F. The set of test units, T, and the set of course units, C, contains zero or more members. And, the set of final unit, F, is an atomic set (only contains one member, *f*). The link set, *L*, is also partitioned to *AL*, *KL* and *CL* for accumulation links, knowledge links, and conditioning links, respectively. The following conditions hold:

$$N = T \cup C \cup F \wedge T \cap C = \phi \wedge C \cap F = \phi \wedge F \cap T = \phi$$

$$L = AL \cup KL \cup CL \wedge AL \cap KL = \phi \wedge KL \cap CL = \phi \wedge CL \cap AL = \phi$$

$$\forall l_{ij} \in L \bullet l_{ij} = \{ n_i n_j \mid \forall n_i, n_j \in N, i \neq j \}$$

$$\forall al_{ij} \in AL \bullet al_{ij} = \{ n_i n_j \mid n_i \in C \wedge n_j \in C \}$$

$$\forall kl_{ij} \in KL \bullet kl_{ij} = \{ n_i n_j \mid (n_i \in C \wedge n_j \in T) \vee (n_i \in C \wedge n_j \in F) \}$$

$$\forall cl_{ij} \in CL \bullet cl_{ij} = \{ n_i n_j \mid n_i \in T \wedge n_j \in C \}$$

$$F = \{f\}$$

The definition above is similar to the one of influence diagram, except that different nodes and links are used, with different restrictions. The evaluation of the overall value of a courseware diagram is similar to the one used to evaluate influence diagram [1]. Based on the method, we designed an authoring system, which allows the instructor to design distance learning courseware following the method of courseware diagram. In the next section, we should present our system.

4. THE PROTOTYPE SYSTEM

Recent software architecture uses a three-tier approach. We take this approach so that all courseware materials are accessible by students on the Web. However, for the instructor, to implement drag-and-drop user interface, which is a basic function to design a courseware diagram, is hard to be implemented on the Web. Even it is possible to use mobile agent technology, to embed these editing functions in Applets, such that course editing is enabled on the Web, it is still difficult for the instructors to operate the system in a efficient manner since mobile agents need to be downloaded to individual computers. Thus, the software system that we designed uses a sophisticated window programming mechanism. The authoring tool for the courseware diagrams, the course units, and the test units is a traditional window program. However, the courseware produced is automatically uploaded to a distance learning Web site, which is accessed by conventional Web browsers. Figure 3 shows the tool for creating and editing courseware diagram. On the top of the interface, the Content button allows the instructor to design course units, the Quiz button is for test units, the Structure button is for courseware diagram (the structure of the course), and finally, the Assessment button is to evaluate the value of a courseware design. At the bottom, there are several buttons for creating course unit, test unit, final unit, knowledge kink, accumulation or conditioning link, and for the undo action. Figure 3 also shows an interface for the layout design of course units. Typical media such as video and audio, etc., are allowed. Figure 3 also contains a popup quiz window. Several types of quizzes, such as multiple choice, fill-in-blank, etc., are allowed. We have developed a data structure course for undergraduate students using this system.

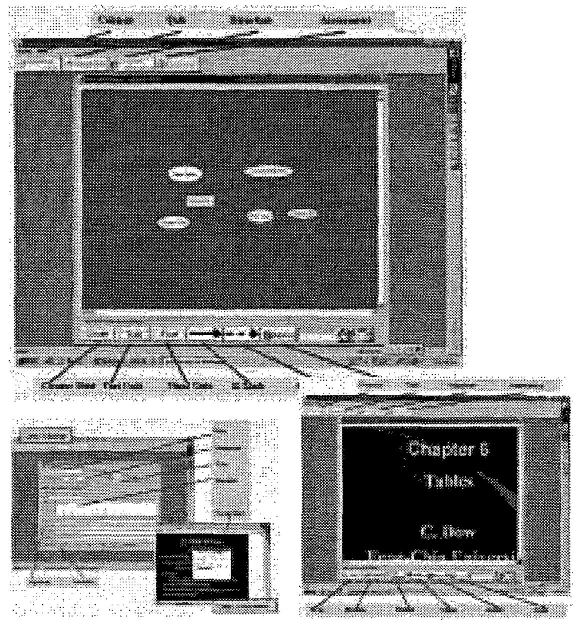

Figure 3: Interface of the Authoring Tool

5. CONCLUSIONS

We think of courseware design as a decision problem. We proposed a courseware diagram, which can be used in a software system, to allow an instructor to design a courseware as making a decision. Assessment of distance learning did not get much attention in the past, especially the systematic mechanisms to evaluate the quality of a courseware. We hope that, the assessment criteria, or standard, can be realized by educators, engineers, and policy makers. Thus, future distance learning will provide better courseware and a more accurate control of education quality.

REFERENCES

[1] Shachter, Ross D., "Evaluating Influence Diagrams," in Operatings Research, Vol. 34, No. 6, November – December 1986, pp. 871 – 882.
[2] http://www.webct.com/
[3] http://www.blackboard.com/
[4] http://www.lotus.com/home.nsf/welcome/learnspace