Utilizing Optimization Technique as A Decision Making Tool for Modeling Student Comprehension Ability in an Its

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Abstract:

This paper is focused on the utilization of optimization techniques in finding the solution to the appropriate learning style suitable for each student in an Intelligent Tutoring System, (ITS). The quest for this solution in an ITS, was borne out of the need to address the problems associated with learning systems. This major problem concerns the ability to determine the comprehension level of a student being taught before he proceeds to take an examination. Interestingly, there are several researches conducted in the past using several techniques in finding answers to the problems as reported in recent literatures, however, the researchers had not recorded maximum success. Therefore in our paper, we intend to find solution to the best learning style among many that is suitable for each learning student and to perpetually assign it to that student for subsequent learning. This option is chosen because the major problem students face while learning in a particular domain is that of not being able to comprehend or have a grasp on what is taught. In our approach, we are not focusing on the content which is an integral part of the knowledge base of the system but the path with which the tutor agent of the system uses to pass the content in the domain expert of the system down to the student module of the system. We deploy four learning paths which is the learning styles such as Auditory Learners (Through Hearing), Visual Learners (Through seeing), Kinesthetic Learners (Through Touch or practice) and hybrid (Combination of two or more) were used while modeling the student. Optimization technique was then deployed to find out the appropriate learning style suitable for each student. Therefore in this paper, we entirely x-rayed the concept of utilizing optimization technique as a decision making tool in modelling student in a typical learning environment.

KEYWORDS: Optimization concept; Optimization Techniques; Learning styles; ITS; Student modeling; Decision making process.

I. INTRODUCTION

The study of artificial intelligence and student modeling has been a major area of interest by several researchers over the years now but this area of decision making has been sidelined in same area of the research. The problem faced by researchers is not gathering information about any existing problem in this domain of study but how to make a proper decision as to what input among several option that will best give the required output[1]. There are several decision making processes which other authors have tried in their research that brought about some dimension of results. In this paper, we would be using the optimization decision making process as a tool that will help us decide which learning style among the four learning style that we are using to model student in a typical Intelligent

Tutoring System(ITS) is more appropriate. Optimization and constraint based optimization, happens to be the most appropriate for this system because it has to do with choosing the best out of several constraints. The constraints we have in this research are four in number, which connotes the four different learning styles which are used as path to student knowledge. The optimization decision making process will help choose the best learning style that is most appropriate to each student which will now be the student learning style that he/she will be learning with anytime the student learns. The diagram below is used to illustrate the several constraints that are used as in which the decision process works on to give out the best learning style out of which the students will be using to learn.
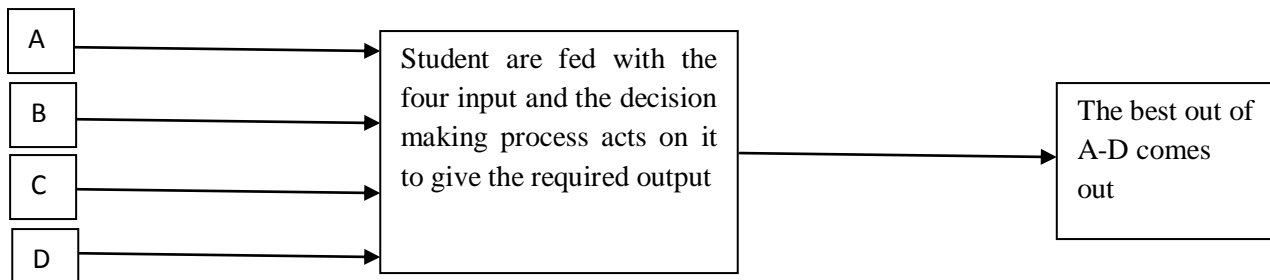

Fig1: Decision making process with four constraints

From the above figure, we have four constraints which serves as input to the decision making process within the ITS, A, B, C and D, which signifies the four different learning styles. Where the decision making process is necessary is in choosing the best out of the four constraints that best suits each students. The idea is to match each student with the learning style that will grant the student understanding of the subject matter being taught. For example, some student may understand a subject matter when they listen to lectures, while other may have a grasp of a subject being taught by practicing in that order. This system should be able to find out the best learning style which each student could learn with and assign it by way of storing it in the student profile for further/subsequent studies. Our output is the best learning style that the student uses to learn.

This research was borne as a result of the mass failure that we experience when student writes examination because most system uses examination as a test of knowledge. This approach is not even the best because this could lead to discouragement on the side of the student, excess waste of money in terms of payment of school fees and other related problem. Therefore, this paper focuses on how a student under tutor could comprehend a subject before facing examination by knowing how best a student could learn. The goal usually as in other researches is to help maximize success in examination and minimize failure in examination[6]. To be able to realize this, we will discuss the mathematical modeling that takes place within the decision process and how it works as well as the techniques involved.

II. DECISION MAKING

Anyone who holds a technical, managerial, or administrative job these days is faced with making decisions daily at work [2,3]. It may involve:
• determining which ingredients and in what quantities to add to a mixture being made so that it will meet specifications on its composition,
• selecting one among a small number of suppliers to order raw materials from,
• determining the quantities of various products to manufacture in the next period,

• allocating available funds among various competing agencies,
• determining how to invest savings among available investment options,
• deciding which route to take to go to a new location in the city,
• allocating available farm land to various crops that can be grown,
• determining how many checkout lanes to staff during a period of stable demand in a grocery store, etc.,

A situation such as one of these requiring some decisions to be made is known as a decision making problem or just decision problem[4]. These problems arise in the operation of some system known as the relevant system for the problem. The person(s) responsible for making these decisions are called the decision maker(s) for the problem. At one extreme, these decision making problems may be quite simple requiring the determination of the values of a small number of controllable variables with only simple conditions to be met; and at the other extreme they may be large scale and quite complex with thousands of variables and many conditions to be met. Decision making always involves making a choice between various possible alternatives[5]. Decision problems can be classified into two categories with very distinct features. It is important to understand the difference between these categories.

III. CATEGORIES OF DECISION MAKING PROBLEM

There are two categories of decision making:

Category 1: This category includes all decision problems for which the set of possible alternatives for the decision is a finite discrete set typically consisting of a small number of elements, in which each alternative is fully known in complete detail, and any one of them can be selected as the decision[7,8]. Even though many authors do not discuss these problems, these are the most common decision problems encountered in daily living, in school, at work,

and almost everywhere. Some examples of this category are:

• A teenage girl knows four boys all of whom she likes, and has to decide who among them to go steady with.
• An automobile manufacturer has to decide whether to use a cast iron engine block, or an aluminum engine block in their new car line.
• A company has received merger offers from three other companies. It has to decide whether to accept any one of these offers, or to continue operating by itself. Since all the alternatives for the decision are fully known in full detail, it is not necessary to construct a mathematical model to identify the set of all alternatives for the decision in this category. Instead, one can begin applying an algorithm for solving these problems directly.

Category 2: This category includes all decision problems for which each possible alternative for the decision is required to satisfy some restrictions and constraints under which the relevant system must operate. Even to identify the set of all possible alternatives for the decision, we need to construct a mathematical model of these restrictions and constraints in this category. An example of a decision problem in this category is discussed in the next section. Even when there are no constraints to be satisfied in a decision problem, if the number of possible alternatives is either infinite, or finite but very large; it becomes necessary to define the decision variables in the problem, and construct the objective function (the one to be optimized) as a mathematical function of the decision variables in order to find the best alternative to implement [9, 10]. Such decision problems also belong to Category 2. So, the essential characteristic of a Category 2 decision problem is that in order to handle it we need to identify the decision variables in the problem and build a mathematical model of the objective function and/or the constraints in terms of the decision

variables. The rest of this paper deals only with this category of problems.

IV. LEARNING STYLES AND STUDENT MODELING IN AN ITS

This is a typical example of category 2 decision making process since this category allow infinite or finite variable and each of the variable can satisfy certain restriction or constraint before the system can work. In this case, our variables are finite since we have chosen four variables which have certain constraints on the learning students. The four variables are the four learning styles used to tutor the student which are Auditory Learners (Through Hearing), Visual Learners (Through seeing), Kinesthetic Learners (Through Touch or practice) and hybrid (Combination of two or more).The constraint is that of not comprehending the subject being taught whenever any of the variables that does not suit the learning student are used. The problem is to find out which of the finite variables will be used to obtain success. This is where we depend on a mathematical function of the decision variables in order to find out the best alternative to implement that will suit each learning students.

V. QUANTITATIVE ANALYSIS FOR SOLVING CATEGORY 2 DECISION PROBLEM

In the past decisions were made exclusively on intuitive judgment based on hunches acquired from past experience[11]. But to survive and thrive in this highly competitive technological world of today it is essential to make decisions on a rational basis. The most rational way for decision making is through quantitative analysis which consists of the following steps.

1. **Get a precise definition of the problem, all relevant data and information on it**: The initial statement of the problem may be vague or imprecise. Study the relevant system and develop an accurate and complete statement of the problem. Quite often the problem undergoes many changes in successive discussions until its final version is agreed upon by all the decision makers involved. Two types of factors or variables may be affecting the system. These are: **Uncontrollable factors**: Factors such as environmental factors which are random variables not under the control of the decision makers.

Controllable inputs: Factors whose levels can be controlled by the decision makers and set at desired values. These factors whose values the decision makers can manipulate are called decision variables in the problem. They may include other ancillary variables that are functions of the decision variables.

If there are no uncontrollable factors, or if the values of all the random variables among the uncontrollable factors are known exactly, the relevant system depends only on the values of the controllable decision variables and there is no uncertainty, i.e., all the relevant data in the decision problem is known with certainty. In this case the decision problem is known as a deterministic decision making problem. When the random variables among the uncontrollable inputs are subject to variation, the decision problem is known as a stochastic or probabilistic decision making problem. Here the outcome of the relevant system is uncertain even when the values of all the decision variables are fixed, because some important variables will not have their values known before the decisions are finalized. This uncertainty must be incorporated into the decision making. To solve a stochastic decision making problem, we need knowledge of the probability distributions of all the random variables among the uncontrollable inputs[12]. Unless the decision problem is a very simple one, exact analysis of it using these probability distributions may become very complex. That's why very often stochastic decision problems are analyzed by studying appropriate deterministic approximations of them. One commonly used hedging strategy to construct a deterministic approximation of a stochastic decision making

problem is to replace each random variable by some location parameter of its probability distribution (mean, median, or some desirable percentile) plus some safety factor to account for the uncertainty in its value. This converts the problem into a deterministic decision making problem. That is why studying techniques for solving deterministic decision making problems is of great importance. In this paper we will discuss only deterministic decision making problems which our system under construction belongs.

2. **Construct a mathematical model of the problem**: Construct a mathematical model that abstracts the essence of the decision problem. The model should express the various quantities in the problem including performance measures if any, in the form of mathematical functions of decision variables, and express the relationships among them using appropriate equations or inequalities, or objective functions to be optimized (maximized, or minimized, as appropriate).

Real world problems are usually too complex to capture all the fine details of them in the form of simple mathematical models that we can analyze. Usually a model is a simplification that provides a sufficiently precise representation of the main features such that the conclusions obtained from it also remain valid to the original problem to a reasonable degree of approximation[17]. Therefore, constructing a mathematical model usually involves making approximations, heuristic adjustments, and quite often ignoring (or putting aside or relaxing) features that are difficult to represent mathematically and handle by known mathematical techniques. When such relaxations are used, it may be necessary to make some manual adjustments to the final conclusions obtained from the model to incorporate the relaxed features[16].

It usually takes great skill to decide which features of the real problem to relax in

constructing a model for it, this skill comes from experience.

3. **Solve the model**: Solve the model to derive the solution, or conclusion for the decision problem. For some of the models we have efficient algorithms and high quality software systems implementing them. For some others we do not yet have efficient algorithms, and when the model is large, existing algorithms might take unduly long to solve it. In this case, one usually obtains approximate solutions using some heuristic approaches.

4. **Implement the solution**: In this final phase, the solution obtained is checked for practical feasibility. If it is found to be impractical for some reason, necessary modifications are carried out in the model and it is solved again; the same process is repeated as needed

Often the output from the model is not implemented as is. It provides insight to the decision maker(s) who combine it with their practical knowledge and transform it into an implementable solution. As an illustration, in the next section we develop a mathematical model for a very simple decision making problem of Category 2.

VI. OPTIMIZATION MODELS

The model of restrictions and constraints for the decision problem as we are discussing in this paper is a single linear equation in one decision variable which has a unique solution. This is quite rare. Such models for most real world decision problems have many solutions. The question that arises then is how to select one of the many solutions of the model to implement. This is usually done so as to optimize an objective function which is a measure of effectiveness of the relevant system [13,14]. Since prehistoric times, humans have had an abiding interest in optimizing the performance of systems that they use. Now-a-days all the decisions that we make at work, and those

affecting our personal lives, usually have the goal of optimizing some desirable characteristic. If there are some objective functions to optimize in addition to satisfying the requirements on the decision variables, the resulting model is known as an optimization model. Each of the objectives to optimize is typically a measure of effectiveness of performance of the relevant system, and should be expressed as a mathematical function of the decision variables. If higher values of a measure of performance are more desirable (such a measure could be considered as a profit measure) we seek to attain the maximum or highest possible value for it. If lower values of a measure of performance are more desirable (such a measure could be interpreted as a cost measure) we seek to attain the minimum or the lowest possible value for it. The various measures of performance are usually called the objective function(s) in the mathematical model for the system. To optimize an objective function means to either maximize or minimize it as desired [15]. If there is only one measure of performance (such as yearly total profit, or production cost per unit, etc.) the model will be a single objective model. When there are several measures of performance, we get a multi-objective model in which two or more objective functions are required to be optimized simultaneously. In optimization models the requirements come from the relationships that must hold among the decision variables and the various static or dynamic structural elements by the nature of system operation. Each requirement leads to a constraint on the decision variables that will be expressed as a mathematical equation or inequality in the model for the problem. The model also includes any bounds (lower and/or upper) that the decision variables or some functions of them must satisfy in order to account for the physical limitations under which the system must operate. In some problems, in addition to all these requirements, there may be others that specify that the values of some decision variables must come from specified sets

(for example, if the decision variable x1 is the assigned to different learning styles with values 1", or 1.5", 2" or 2.5" only; then the value of x1 must come from the set {1", 1.5", 2" or 2.5"}). In such a way that each value signifies each learning styles. We know that if an objective function is be effective, there must be comprehension through it (Understanding) and if not, there will not be. We would like to minimize (maximize) it. Minimize lack of understanding and maximize comprehension. Fortunately, it is not necessary to consider minimization and maximization problems separately, since any minimization problem can be transformed directly into a maximization problem and vice versa. For example, to maximize a function f(x) of decision variables x, is equivalent to minimizing $-f(x)$ subject to the same system of constraints, and both these problems have the same set of optimum solutions. Also, we can use

$$\left(\begin{array}{c} \text{Maximum value of } f(x) \\ \text{subject to some constraints} \end{array} \right) = - \left(\begin{array}{c} \text{Minimum value of } -f(x) \\ \text{subject to the same constraints} \end{array} \right)$$

For this reason, we will discuss algorithms for minimization only in this paper.

Let $x = (x_1, \ldots, x_n)^T$ denote the vector of decision variables. A typical single objective optimization model has the following form:

$$\text{Minimize} \quad \theta(x) \tag{1.3.1}$$

$$\text{subject to} \quad g_i(x) \quad \begin{cases} = b_i, & i = 1, \ldots, m \\ \leq b_i, & i = m+1, \ldots, m+p \end{cases} \tag{1.3.2}$$

$$\ell_j \leq x_j \leq u_j, \quad j = 1, \ldots, n \tag{1.3.3}$$

$$x_j \in \Delta_j, \quad j \in J \subset \{1, \ldots, n\}. \tag{1.3.4}$$

where all the functions are assumed to be continuous and differentiable, and for each $j \in J$, Δj is a specified set within which the value selected for the variable xj is required to lie. The function gi(x), constant bi are respectively the constraint function, Right Hand Side (RHS) constant respectively for the ith constraint in (1.3.2).

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Any "≥" inequality constraint can be transformed into a "≤" constraint by multiplying both sides of it by −1. That's why we listed all the inequality constraints in the "≤" form. j, uj are the upper and lower bounds on the decision variable xj. In many problems j = 0, uj = ∞ is common (i.e., xj is required to be non-negative) because economic activities can only be carried out at nonnegative levels. But in general j, uj can have any real values satisfying j ≤ uj, in fact we can have j = −∞ and uj = +∞ (in this case xj is called an unrestricted variable. Constraints like those in (1.3.4) mainly arise in discrete problems where some variables are required to assume only values from specified discrete sets. For (1.3.1) − (1.3.4), a numerical vector x is said to be a feasible solution if it satisfies all the constraints (1.3.2) − (1.3.4). A feasible solution ⁻x satisfying θ(⁻x) ≤ θ(x) for all feasible solutions x is said to be an optimum solution or optimum feasible solution for (1.3.1) to (1.3.4), because it has the smallest value for the objective function among all feasible solutions. The typical multi-objective problem is of the form Minimize θi(x);

i = 1 to k simultaneously subject to constraints of form (1.3.2) − (1.3.4). If constraint (1.3.4) is absent, the above models are said to be continuous variable optimization models since each variable can assume any value within its bounds subject to the other constraints. If constraints (1.3.4) are there, and Δj are discrete sets (like the set of integers, or the set {0, 1} etc.) the models are said to be discrete.

VII. CONCLUSION

This paper was centered on using the optimization technique to solve the problem of decision making in a typical ITS with four given alternatives to determine the correct variable that best fits each leaning students and store it against each student for their subsequent studies. This actually demonstrated the cathegory2 problem solving with mathematical model approach using the minimum and maximum techniques of optimization. This ensures that comprehension is on the maximum when the learning student is assigned the learning style that suit him/her learning and comprehension ability and as well minimize the problem of not comprehending a subject matter.

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