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Effective Dietary Recommendation through a Two-Phase Method

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A B S T R A C T

Information technology (IT) is growing rapidly worldwide these days. The growing IT claims that operations research is used in the development of numerous application systems. The technology is used to solve a human nutrition choice issue using linear programming. The objective of a diet problem is to identify the best foods in terms of nutrients, provided that an individual's daily nutritional needs are met. First, since the diet has the fewest calories, the nutritional content of the menu items that a person typically eats over the course of a day was determined, and the amounts of nutrients were calculated using linear programming techniques. The total number of calories in the suggested meal is the objective function of the mathematical model of the issue, which is constructed as a linear program. To determine the bare minimum of nutrients ingested during the day in terms of calories, protein, total fat, saturated fatty acids, cholesterol, carbohydrates, total dietary fiber, potassium, and salt, the two-phase technique can also be utilized. The system identifies the best diet choice for those who wish to maintain or lose weight and lead healthy lives. The Java programming language is used in the implementation of this system.

1. Introduction

Operations research (OR), artificial intelligence (AI), software engineering (SE), networking, and other disciplines are all included in information technology. Among these domains, the "Optimal Diet Decision Using Two-phase Method" method determines the minimal calorie intake of the diet using the Linear Programming (LP) model of Operations Research (OR) discipline. The scientific technique of operations research gives executive departments a numerical foundation on which to make choices on the activities that they are in charge of. It is an applied science that uses every known scientific method as a tool to address a particular issue. Although it makes use of mathematics, it is not a branch of the subject. It is frequently both an observational and an experimental science. Determining the true issue is frequently the operations research worker's primary contribution [2].

The diet issue is one of the traditional uses of linear programming. One of the earliest optimization issues examined in the 1930s and 1940s was the Diet Problem in Linear Programming. Choosing a group of meals that satisfy certain daily nutritional needs and tastes is the major objective. A useful linear programming model was created and used to a dietary scenario. The process outlined was modified for a diet issue, in which the objective function is the number of calories in the diet, the variables are food items, and the limits are nutritional criteria. The system can offer a quick solution to this diet issue and determine whether a person's daily nutritional needs are met by using the Two-Phase technique.

Choosing a collection of meals that will meet a set of daily nutritional requirements at the lowest possible cost is the aim of the diet problem. The challenge is presented as a linear program, with cost reduction as the goal and meeting the designated nutritional needs as the constraints. Usually, the dietary restrictions control the quantity of calories as well as the vitamins, minerals, fats, cholesterol, and salt that are consumed.

2. Background Theory

Operations research is a modern discipline that models and solves complex problems using mathematical, statistics and algorithms models and determining the optimal solution and allowing, in this way, to choose a decision. It includes great quantity of branches like linear programming, nonlinear programming, queuing theory, inventories' theory, graph theory, dynamic programming, simulation, etc.

Using techniques from other mathematical sciences, such as statistical analysis, mathematical modeling, and mathematical optimization, operations research arrives at optimal or near-optimal solutions to complex decision-making problems. Operations research has overlap with other disciplines, notably industrial engineering and operations management, and draws on psychology and organization science since its emphasis on human-technology interaction and its focus on practical applications.

Operations research is often concerned with defining the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost) of some real-world objective. Originating in military efforts before World War II, its techniques have grown to concern problems in a variety of industries.

OR includes a wide range of problem-solving techniques and methods applied in the pursuit of improved decision-making and efficiency, such as mathematical optimization, simulation, queuing theory and other stochastic-process models, Markov decision processes, econometric methods, data development analysis, neural networks, expert systems, decision analysis, and the analytic hierarchy process. Nearly all of these techniques include the construction of mathematical models that attempt to describe the system. OR also has strong ties to computer science and analytics because of the computational and statistical nature of most of these fields.

Operational researchers faced with a new problem must determine which of these techniques are the most appropriate given nature of the system, the goals for improvement, and constraints on time and computing power. Operations Research (OR) applies scientific method to the management of organized systems in business, industry, government and other enterprises. OR is regularly applied in areas such as: Marketing and revenue management systems, supply chain management, manufacturing plants, financial engineering, telecommunication networks, healthcare management, transportation networks, energy and the environment, service systems, web commerce and military defense.

2.1 Two-Phase Method

In Two Phase Method, phase one of the simplex method deals with the computation of an initial feasible basis, which is then handed over to phase two, the simplex method is described [1].

Phase 1: Replacing the original objective problem by the sum of the artificial variables to formulate a new problem. Then this new objective function is then minimized subject to the constraints of the original problem. If the problem has a feasible solution, the minimum value of the objective function will be zero which shows that all the artificial variables are zero. Then proceeding to phase II. Otherwise, if the minimum value is greater than zero, the problem has no feasible solution.

Phase II: Using the optimum basic solution of phase I as a starting solution for the original problem. Now the original objective function has to be expressed in terms of the non-basic variables only. This can be achieved by adding suitable multiples of the constraint equations involving artificial variables.

In Two Phase Method, the whole procedure of solving a linear programming problem (LPP) involving artificial variables is divided into two phases. In phase I, a new objective function is formed by assigning zero to every original variable (including slack and surplus variables) and -1 to each of the artificial variables and eliminates the artificial variables from the basis. The solution at the end of phase I serves as a basic feasible solution for phase II. In phase II, the original objective function is introduced and the usual simplex algorithm is used to find an optimal solution.

3. System Design and Implementation

The system focuses on solving the diet problem using Two-phase method. The diet problem is one of the most well-known minimization problems. It involves the establishment of a diet plan for adults.

3.1 System Design

System design is commonly used for displaying software systems. The system design diagram of optimal diet decision using two-phase method. The input of the system is nutrients of foods that a person consumes a day. The system calculates the minimum amount of calories that should be eaten for a person using two-phase method. The output of the system is amount of foods that a person should eat.

3.2 System Flow

A linear programming problem can be defined as a problem of optimizing (maximizing or minimizing) a linear function subject to linear constraints. A feasible vector which the objective function gets the value is called optimal. A feasible optimal problem is said to be unbounded if the objective function can assume arbitrarily large positive (resp. negative) values at feasible vectors; otherwise, it is said to be bounded. The value of a bounded feasible minimum (resp, maximum) problem is the minimum (resp. maximum) value of the objective function as the variables range over the constraint set. Any linear program consists of four parts: a set of decision variables, the parameters, the objective function, and a set of constraints. To solve a linear programming problem, the system must find an objective function that minimizes, maximizes or achieves a specific goal (a feasibility problem), respectively, while variables satisfy the constraints of the model [3].

A classical diet problem has to supply the required nutrients at minimum cost, for different types of food, that supply varying quantities of the nutrients that are essential to good health. The user can choose the foods from seven food types that should be eaten for a person throughout an entire day. The mathematical model of the problem is formulated as a linear program where the objective function corresponds to the total amount of calories. At the daily-menu level, there are constraints that need to be satisfied, regarding the amounts of protein, vitamins, minerals, fats, dietary fiber, etc. And then the system calculates amount of nutrients of selected foods by using two-phase method. Firstly, the system changes the equation forms of the constraints of the problem and then calculate phase I. The system checks that if the r values is zero or negative, it will go to phase II. Otherwise, it will terminate in phase I. The output of the system is minimum amount of calories and number of units of foods that the person eats.

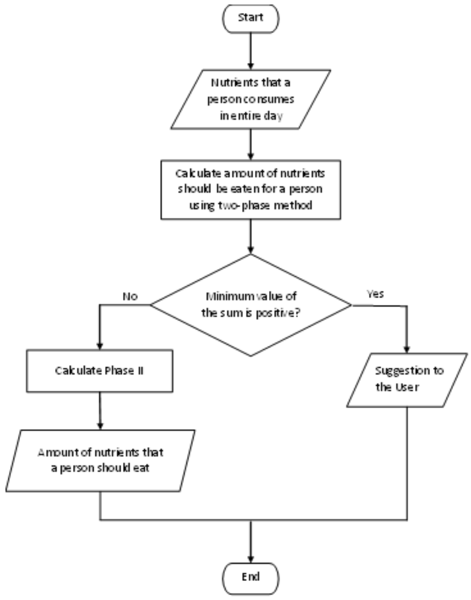

Fig. 1 – system flow diagram.

3.3 Food Dataset

There are 100 foods in this system and seven types of food that are cake and bread, cold & drink, fast food, fruit, rice and curry, snack. The following tables show the nutrients of food data. The food dataset gets from the website www.myfitnesspal.com [4]. The system can calculate optimal diet problem based on two-phase method by using these interfaces. The one hundred of foods that contain amounts of protein, vitamins, minerals, fats, dietary fiber are used as dataset of the system. There are seven food type in this system. The system implementation includes representation of user interface. It includes title of the system, supervisor name and developer name. There are two menu items: File and Edit. In the file menu, there is one menu item named 'calculate' menu item. There is 'view food data' menu item in the edit menu.

When the user clicks the calculate menu item from the main page of the system, figure 3.4 will be shown. There are seven tab in this page for choosing food type. When the user can choose the food from this figure, the selected food and number are displayed in two list box. If the user want to eat more a lot of foods, the user can select the count combo box and choose, and then click the ADD button. There are three buttons named remove selected food, calculate optimal diet and remove all button. Remove selected food button can remove the food that the user does not want to eat. Remove all button will remove all items from the selected food list box. If the user finish all food item for the whole day, he/she can click the calculate optimal diet button that will start the calculation.

The mathematical model of the problem is formulated as a linear program where the objective function is the total amount of calories for the selected foods, on the condition that the constraints regarding the amounts of protein, vitamins, minerals, fats, dietary fiber consumed throughout an entire day are satisfied. The system is implemented using Java programming language.

3.4 Example Calculation

Let $x1$ = Chicken stir fry

$x2$ = Kimbab

$x3$ = Kyay-oh

$x4$ = Burmese coconut rice

$x5$ = Homemade chocolate cookie

$x6$ = Hot milo

$x7$ = Chinese-steamed pork dumpling

$x8$ = Burger

$x9$ = Apple

$x10$ = Chocolate cake

Minimize $z = 150x1 + 485x2 + 1588x3 + 160x4 + 265x5 + 120x6 + 55x7 + 160x8 + 65x9 + 186x10$

subject to,

25x1 + 20x2 + 44x3 + 7x4 + 3x5 + 3x6 + 4x7 + 6x8 + 0x9 + 3x10 >= 50

25x1 + 20x2 + 44x3 + 7x4 + 3x5 + 3x6 + 4x7 + 6x8 + 0x9 + 3x10 <= 65

2x1 + 17x2 + 69x3 + 8x4 + 9x5 + 3x6 + 4x7 + 1x8 + 0x9 + 15x10 >= 73

2x1 + 17x2 + 69x3 + 8x4 + 9x5 + 3x6 + 4x7 + 1x8 + 0x9 + 15x10 <= 80

0x1 + 0x2 + 0x3 + 2x4 + 5x5 + 2x6 + 0x7 + 0x8 + 0x9 + 4x10 >= 22

0x1 + 0x2 + 0x3 + 2x4 + 5x5 + 2x6 + 0x7 + 0x8 + 0x9 + 4x10 <= 25

50x1 + 0x2 + 0x3 + 85x4 + 3x5 + 0x6 + 18x7 + 0x8 + 0x9 + 0x10 <= 300

6x1 + 60x2 + 198x3 + 16x4 + 40x5 + 20x6 + 15x7 + 23x8 + 17x9 + 34x10 >= 300

6x1 + 60x2 + 198x3 + 16x4 + 40x5 + 20x6 + 15x7 + 23x8 + 17x9 + 34x10 <= 375

2x1 + 0x2 + 0x3 + 1x4 + 3x5 + 2x6 + 0x7 + 1x8 + 3x9 + 0x10 >= 27

2x1 + 0x2 + 0x3 + 1x4 + 3x5 + 2x6 + 0x7 + 1x8 + 3x9 + 0x10 <= 30

0x1 + 0x2 + 0x3 + 0x4 + 40x5 + 0x6 + 70x7 + 50x8 + 0x9 + 0x10 <= 3500

65x1 + 0x2 + 0x3 + 830x4 + 198x5 + 40x6 + 25x7 + 220x8 + 1x9 + 0x10 <= 2400

Phase I

Minimize r = R1 + R2 + R3 + R4 + R5

subject to,

25x1 + 20x2 + 44x3 + 7x4 + 3x5 + 3x6 + 4x7 + 6x8 + 0x9 + 3x10 - s1 + R1 = 50

25x1 + 20x2 + 44x3 + 7x4 + 3x5 + 3x6 + 4x7 + 6x8 + 0x9 + 3x10 + s2 = 65

2x1 + 17x2 + 69x3 + 8x4 + 9x5 + 3x6 + 4x7 + 1x8 + 0x9 + 15x10 - s3 + R2 = 73

2x1 + 17x2 + 69x3 + 8x4 + 9x5 + 3x6 + 4x7 + 1x8 + 0x9 + 15x10 + s4 = 80

0x1 + 0x2 + 0x3 + 2x4 + 5x5 + 2x6 + 0x7 + 0x8 + 0x9 + 4x10 - s5 + R3 = 22

0x1 + 0x2 + 0x3 + 2x4 + 5x5 + 2x6 + 0x7 + 0x8 + 0x9 + 4x10 + s6 = 25

50x1 + 0x2 + 0x3 + 85x4 + 3x5 + 0x6 + 18x7 + 0x8 + 0x9 + 0x10 + s7 = 300

6x1 + 60x2 + 198x3 + 16x4 + 40x5 + 20x6 + 15x7 + 23x8 + 17x9 + 34x10 - s8 + R4 = 300

6x1 + 60x2 + 198x3 + 16x4 + 40x5 + 20x6 + 15x7 + 23x8 + 17x9 + 34x10 + s9 = 375

2x1 + 0x2 + 0x3 + 1x4 + 3x5 + 2x6 + 0x7 + 1x8 + 3x9 + 0x10 - s10 + R5 = 27

2x1 + 0x2 + 0x3 + 1x4 + 3x5 + 2x6 + 0x7 + 1x8 + 3x9 + 0x10 + s11 = 30

0x1 + 0x2 + 0x3 + 0x4 + 40x5 + 0x6 + 70x7 + 50x8 + 0x9 + 0x10 + s12 = 3500

65x1 + 0x2 + 0x3 + 830x4 + 198x5 + 40x6 + 25x7 + 220x8 + 1x9 + 0x10 + s13 = 2400

The problem is solved by using this system.

The optimal solution is 1725.5 calories.

Chicken stir fry (x1) = 0.11 (0)

Burmese coconut rice (x4) = 2.71 (3)

Hot milo (x6) = 3.18 (3)

Apple (x9) = 5.83 (6)

Chocolate cake (x10) = 2.56 (3)

Kimbab(x2) = 0

Kyay-oh(x3) = 0

Homemade chocolate cookie (x5) = 0

Chinese-steamed pork dumpling (x7) = 0

Burger (x8) = 0

4. Conclusion

The linear programming model provides rich and meaningful solutions to optimization problems. The mathematics generated by these theories is consistent. Two-phase method is depending on the constraints and objective forms. The system should be researched with more expert knowledge and other results to create the real application for decision making. A practical model of a linear programming applied to a dietary situation was constructed. The procedure described was adapted to a diet problem, where the variables are food items, the restrictions are nutritional requirements and the objective function is the amount of calories of the diet. The system can provide a fast way to solve this diet problem and to observe if the daily nutritional requirements of a person are satisfied.

This system could be helpful to support development of dietary guidelines that fulfill all nutritional requirements. It also demonstrated to be an applicable system to conscientiously convert predefined nutrient constraints into diets with food combinations. Most studies have used nutritional constraints and cost constraints in the analysis of dietary problems and solutions. LP is clearly a very helpful mechanism for finding solutions to a variety of very complex diet problems. In this system, food information such as food name, calories, protein, total fat, saturated fatty acids, cholesterol, carbohydrate, total dietary fiber, potassium, sodium are used in this system. This system can only support for one hundred food items that are stored in this system. In this system, two-phase method is used for minimization calories. The graphical method, simplex method and M-method can be further developed. This system can be added more variety and more meal options. And it can be extended to calculate over the other point of nutrient values.

5. References

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