IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AI For Personalized Diet Plan

Using quantum algorithm and linear programming

[1]Yamuna Vasanth

[1]Assistant Professor,

[1]Department of computer science and engineering AI & ML,

[1]Bharath College of Engineering, Badlapur (west), Maharashtra, India

Abstract: Linear Programming was conceived in the period of the second world war to address defense needs. Dantzig, who developed LP modelling and simplex algorithms, tried to use LP for his personal diet plan (meeting his nutritional needs at minimum cost). He could not sustain the approach because of various factors. In the later history of LP modelling, diet problems have been addressed in various settings like hospitals, industries and with additional objectives like environmental impacts, cultural acceptance. One of UN Sustainability goals is meeting nutrition needs of children. In India programs like Akshaya Patra provide midday meals for school going children. Everyday millions of school kids are fed by such programs. Can we do what Dantzig did for himself (diet planning) for every school going kid?

Such goals are now attainable and sustainable with modern developments. Quantum Computing and Artificial Intelligence will help us to realize this. Quantum computers using features of the quantum world (superposition and entanglement) allow us to solve problems which are not practically tractable for classical computers and provide exponential speedup in time. Quantum algorithms (like Quantum Approximation Quantum Algorithm) have been conceived for linear programming and tested.

Artificial Intelligence can now provide user-friendly support for data extraction, model formulation, solution links and interpretation of results for action for various kinds of user settings. The paper develops a road map for Quantum AI Linear Programming decision support for personalized diet plans for members of massive organizations like national midday meals for school kids.

Index Terms - Linear Programming, Diet Plan, Artificial Intelligence, Quantum Computing, Quantum Algorithms, National Midday Meals Scheme.D:Waves System.

I. INTRODUCTION

In the context of AI for sustainability, we identify a socially relevant challenge as opportunity. The focus: Optimal Diet Plan for Every Kid. We address this challenge in this paper. We identify developments in three fields as relevant: Linear Programming, Artificial Intelligence and Quantum Computing.

Linear programming (LP) is an important mathematical optimization technique in management. It has been used in diet plans extensively. Dantzig, who developed linear programming and simplex algorithm to solve it, had tried using LP for his personal diet plan. For various reasons, he could not sustain such an approach. We want to address the goal of providing every school kid with a personalized diet plan. Now, it is realizable because of developments in AI, Data Science and Quantum Computing.

II. LINEAR PROGRAMMING

2.1 BASICS:

Linear programming (LP) is a mathematical optimization technique used to optimise a linear objective function, subject to a set of linear constraints.
Here are some basic pointers on linear programming:
Objective Function: In linear programming, the objective function is a linear equation that represents the quantity to be optimised (e.g., profit, cost, revenue).
Decision Variables: Decision variables are the variables that are used to represent the unknowns in the problem. They are the variables that the LP solver will optimise. The values of decision variables determine the solution to the problem.
Constraints: Constraints are the restrictions that limit the possible values of the decision variables. Constraints are expressed as linear equations or inequalities.
Feasible Region: The feasible region is the set of all possible values of the decision variables that satisfy all the constraints of the problem.
Optimal Solution: The optimal solution is the point in the feasible region that maximises or minimises the objective function.
LP Solver: An LP solver is a computer program that solves linear programming problems by finding the optimal solution.
Sensitivity Analysis: Sensitivity analysis is the study of how the optimal solution changes with changes in the objective function coefficients or constraints of the LP problem.
Duality: Duality is the relationship between the primal (original) LP problem and its corresponding dual problem. The dual problem provides an alternate way to solve the original problem and can also provide useful information about the original problem.

2.2 The Diet Problem

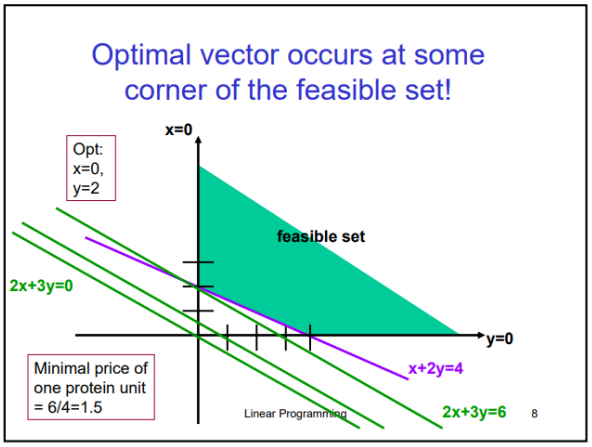
An Example [LP2010]
• A student is trying to decide on lowest cost diet that provides sufficient amount of protein, with two choices:
– steak: 2 units of protein/pound, $3/pound
– peanut butter: 1 unit of protein/pound, $2/pound
• In a proper diet, you need 4 units of protein/day.
Let x = # pounds peanut butter/day in the diet.
Let y = # pounds steak/day in the diet.
Goal: minimise 2x + 3y (total cost)
subject to constraints:

$$x + 2y \geq 4$$

(This is an LP- formulation of our problem)

$$x \geq 0, y \geq 0$$

- This is an optimization problem.
- Any solution meeting the nutritional demands is called a feasible solution
- A feasible solution of minimum cost is called the optimal solution



Acknowledgement -lp.pdf (washington.edu)

The optimal solution in this case (Diet Plan): 2 units of peanut butter

2.3 DANTZIG DIET PLAN EXPERIMENTS:

Dantzig, the founder of linear programming, was always enthusiastic about applying the LP model for diet planning. Both in early research and his textbook "LP AND ITS EXTENSIONS", issues in Diet Planning using LP are discussed.

In a 1990 summary paper [DAN 1990] , he discussed his personal diet plans and experiments. *His colleague Ray Fulkerson (famous for his contributions to network flow and matroid theory) was skeptical. "You're crazy or something? We solve models to obtain optimal schedules of activities for others to follow, not for ourselves/' Nevertheless I was determined to do just that".* Dantzig had 500 food data on punched cards and used Computer IBM 701. Anne, his wife, was asked to cook according to the diet plan given by the computer. His objective was to "Maximize feeling of being full". He used the weight (per unit amount) of a food minus the weight of its water content. Computer Suggestions were weird such as: First day's diet plan included 500 gallons of Vinegar. Because the water content of Vinegar is zero, the more vinegar you drink the greater your feeling of feeling full. Then he removed Vinegar as a food item. The next day the diet plan of the computer included 200 bouillon cubes. Upper bounds on variables in linear programming were introduced for the first time. The next day's plan included 2 pounds of bran. Anne got tired of the whole game and said "I'll put you on MY diet". She did and Dantzig lost 22 pounds.

Even Though, Dantzig was keen to use LP for diet plans, he could not sustain the approach. Main issue might be that he was not engaging his decision maker (Wife) in modelling his cycle. She felt threatened and uninvolved.

2.4 Modern Diet Apps using LP

Comparing the times of Dantzig's diet experiments, now we have many personal diet plans apps using LP [AIDiet.]

For example,

- ➔ Nutrino: uses Machine Learning. It is a smart nutrition app that provides you with the best knowledge currently available in nutrition.
- ➔ Mealime: creates personalised eating plans for the entire week, and get automatically generated shopping lists.
- ➔ Noom: encourages people to make behavioural changes to live healthier.
- ➔ Myfitness: It can be used as a calories tracker and calorie counter to log their foods, and take advantage of the app's food database that contains over 14 million foods.

III. QUANTUM COMPUTING

3.1 Basics

Quantum computing is computing using special features of the quantum world. Quantum computers can be used to solve problems intractable for classic computers. There are two features relevant here: Superposition and entanglement. Classical computers are based on classical bits which can hold one of the values 0 or 1 at a time. Quantum bits allow superposition of both states 0 and 1 at the same time.
Consider an example [QUAC]:
We have three tennis players and two tournaments. We have to make assignments of team members to the two tournaments. Let's represent tournament one as 0 and tournament two as
1.The total options of assignments:
Every player has two options
2.There are three players. The total number of assignments is 2^3=8
They are: 000,100,010,001,110,101,011,111
We may have a scoring function and by applying it to each assignment, we can find the score for each assignment and compare the scores and choose an assignment. In classical computing, we need 3 bits to represent one assignment. In a quantum computer 3 qubit holds all 8 assignments in a superposition. One can apply a scoring function to all 8 options at the same time. This way quantum computers provide a kind of parallel computing. The parallelism is a form of probabilistic parallelism. When you measure the system for the results, you cannot get results for all assignments, but one of them, chosen randomly. Entanglement is used wisely to get the desired result. If two quantum particles are entangled, by measuring the state of one particle, one can deduce the state of the other particle without measuring the other particle. It can even be far off.
Some of the popular quantum algorithms are [JA2022]:
Simon's algorithm introduced the concept of supremacy of quantum algorithms.
Shor's algorithm is a quantum algorithm to factor integers in polynomial time.
3. Deutsch-Jozsa Algorithm proved exponential speedup of quantum algorithms over any deterministic classical algorithms.
4.Les Grover's algorithm solves the problem of unstructured search.
5.Bernstein-Vazirani Algorithm
Quantum Algorithm to find a secret number, in one try.

3.2 Quantum Algorithms for linear programming:

Quantum algorithms for linear programming [MSVE2017] have been developed. One approach is to use the quantum algorithms developed for solving linear systems AX=B. HHL algorithm is such one. Another approach is to modify Primal-Dual methods for quantum computing. Quantum Interior Point Method is the adoption of interior point methods for quantum computing.

3.3 Quantum Computing Cloud Services:

Presently various organizations like IBM, Amazon, D: Waves systems provide open access to the public to try to experiment with quantum computing. For example, LEAP™ of D-Wave systems is real time cloud service giving access to the Advantage Quantum Computer and quantum hybrid solver service. The platform gives an example of a diet88 plan problem [DWAVE]. One can submit problems to any of the solvers: Quantum, hybrid and classical.

3.4 National Mission on Quantum Technologies and Applications:

In the field of quantum computing, China is the world leader. India lags behind other developed nations, like the USA, Japan, and Germany. To address this gap, in 2020, India has launched a National Mission on Quantum Technologies and Applications. It is poised to invest $8000 cr for this initiative.

IV. INDIA's National Nutritional Health:

Nation is built on its citizens. If India has to become a developed nation by 2047, like stated by our honorable Prime Minister, addressing an optimal diet according to the needs of the child is of paramount importance. For a moment it might sound difficult: how are we going to understand the needs of every kid, how are we going to arrange our kitchen, how are we going to reach the right food to the right kid at the right time. Thanks to digital technology which already solved organizing the wished food to right customer e.g., Uber eats, Zomato, food panda. The question that's still unsolved is: how do we know which kid need which type of diet. Here, we believe AI based analysis on a child's health parameters can help to design a specific diet for every kid.
We will focus on the national midday meals scheme.

4.1 PM-POSHAN: (Prime Minister - Pradhan Mantri Poshan Shakti Nirman) Scheme

National school midday meals scheme [MDMS]:
In India, a national level school midday meal scheme is implemented. 12 million students are fed daily in 1.27 million schools. It is one of largest projects of its kind in the world. It is primarily funded by the central government and administered by state governments with the support of NGOs. For example, Akshaya Patra Foundation based in Bangalore feeds 10 lakh students every day. The institution has been awarded at the Asian level for its level of service. The scheme is important and it attracts various committed people from different fields to contribute.

4.2 Diet Plans: A Road Map

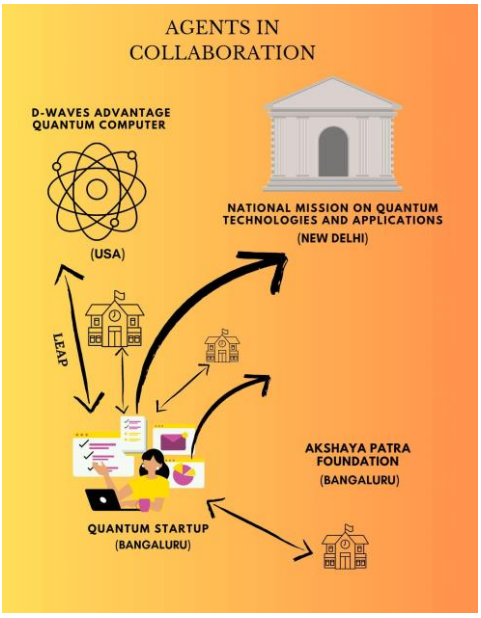
Presently diet plans are made based on average nutrition needs of school going kids. Local in charges take care of the special needs of individual kids to the extent possible. The ideal of "Diet plan for every school kid" has to be achieved in phases. First the centralized system should address the question of food allergies. They should be given special alternatives. In the second phase, it should accommodate the special needs of kids participating in sports. In the third phase, it should take into account the taste preferences of kids. The kids will be asked to give their preferences among suggested healthy food items and they should get a diet taking into account their preferences. This would boost the enthusiasm of the kids. The system should gain the trust of the kids.
In the final phase, the nutrition needs of every kid should be collected. Diet plan can be made in two kinds: food items mix without reference to cost and food items mix taking into account the cost aspects. (cost aspects will vary depending upon the procurement plans).

4.3 AI Based LP formulator

AI based systems can help in mathematical modelling [MUST1986]. AI systems can collect details from student records or student's in charge and formulate the LP model for every kid for a diet plan, submit the problem for suitable LP solver, collect the result and provide it to policy makers in suitable form for further action.

4.4 Implementation Possibility:

We can conceive an implementation possibility. Bengaluru has many startups exploring quantum technologies. One such startup may propose to create optimal diet plans for kids of schools covered by Akshaya Patra Foundation and may get funding from National Mission on Quantum Technologies and applications. It will interact with schools in various states, collect details, formulate LP models and get them solved by using of LEAP™ provided by D: Waves systems (Advantage Quantum Computer at USA) and provide necessary details to Akshaya Patra Foundation and also report to National Mission on Quantum at New Delhi.



V. BEST PRACTICES: Machine vs. Kid

When you look into manufacturing industries, we have several AI based solutions that help machine maintenance activity advance from planned maintenance to predictive maintenance and even beyond to prescriptive maintenance. What does prescriptive maintenance mean? [PM2022], it means that based on machine operating parameters, AI based analysis can prescribe which maintenance course needs to be done before a failure could occur. This helps the industry to run their machines in the most cost optimal way. It is becoming evident that Prescriptive maintenance shall become order of the future without a doubt.

In similar lines, the nutrition needs of a child is not any less than that of the machines in the industry. Hence, we are convinced that **OPTIMAL DIET PLAN FOR EVERY KID** shall become **Order of the Future!**

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