Assignment 1: The Diet Problem

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1 Introduction

The objective of the diet problem, introduced by Stigler (1945) and deepened by Dantzig (1990), is to select a set of foods that will satisfy a set of daily nutritional requirements at minimum cost. It is a classic problem used to introduce linear programming concepts and studied extensively through the years. This assignment applied my personal diet to the diet problem and analyzes my menu that satisfies the specific constraints.

2 Diet Overview

I prefer to cook for myself; consequently, more work was required to set up the diet problem with my personal diet. My diet consists of the following: a protein shake (with added nutrients and vitamins), salad with chicken, chicken with rice and broccoli, mac n cheese with broccoli, and cauliflower gnocchi with chicken sausage and spinach in vodka sauce. Each meal nutritional breakdown was aggregated from Trader Joe's packaging and nutrition site nutritionix.

3 Standard Form LP

After researching the nutritional facts of the ingredients for each meal, the linear programming model was set up. The standard form is shown in the appendix section. Each nutritional element is used as a constraint. The objective function to minimize the total cost uses the estimated single serving cost for each meal. Last, each meal must have a non negative value.

4 Solution to the Diet Problem

The below table shows the output of the initial solution to the Diet Problem using my specific diet. The total cost for the week would be 69.94. Chicken, broccoli, and rice, and the mac n cheese meal are the majority of the diet from the linear programming model. These appear to be due to lower cost and

enough nutritional content from each meal. The protein shake is needed as well to satisfy the Vitamin D component.

Meal	Servings
Protein Shake	6.95
Salad with Chicken	0
Mac n Cheese	16.72
Chicken, Broccoli, Rice	18.19
Gnocchi Chicken Sausage	0

Table 1: Solution to Diet Problem

The initial diet would be too restrictive. To try and remedy this, the linear programming model was adjusted to force each meal to have at least one serving. With the new model, the total cost for the week would be 73.72. Protein shake is still featured around the same amount due to the need for Vitamin D. Chicken, broccoli, and rice meal is featured less.

Additional revisions could be made to further increase variety. These include increasing the minimum number of servings for each meal, using different, less costly ingredients, or adjusting for other nutritional requirements. In other words, by adjusting the constraints of the model, the output can be adjusted.

Meal	Servings
Protein Shake	6.72
Salad with Chicken	1
Mac n Cheese	15.80
Chicken, Broccoli, Rice	15.73
Gnocchi Chicken Sausage	1

Table 2: Solution to Diet Problem

5   LLMs and Generative AI

Large Language Models (LLMs) are increasingly a useful tool in a Data Scientist's toolkit. To see the extent to which LLMs are useful in this context, I attempted to solve this specific Diet Problem using ChatGPT-3.5. The initial prompt used was the following:

This prompt was used to try to give the LLM as much context as possible to solve the problem. Stating that it was a Data Scientist also help provide context and suggest there are solutions within Data Science. While the LLM quickly was able to figure out linear programming was needed to solve the problem, it only provided a very loose outline. The nutritional values and cost for each meal was then provided to the LLM, though the LLM did not then solve the problem. The LLM was specifically asked to solve the problem using code. While it was able to produce working code that utilized PuLP, it did not run

the code. Running the code in Python did produce the correct total cost, but daily servings instead of weekly.

From this addition, LLMs can be a powerful tool to aid in solving problems. However, it needs to be aided in framing the problem correctly and cannot gather data on its own. Iterating on an initial prompt helps the LLM come closer to the solution, though without being able to run code it could not solve the problem.

6 Conclusion

This paper was able to construct a personalized diet using current dietary allowances based on my current food consumption. While this is a start, further research would be needed to solve the Diet Problem for my specific goals (e.g. consuming enough protein to build muscle). Further, this does not account for all the nutrients the US FDA recommends or for other snacks consumed throughout the day. This would be another area for further study.

Lastly, the Diet Problem can be used to compare and contrast each new LLM released, providing a benchmark to compare capabilities.

7 Appendix

Linear Programming Model in Standard Form where

$X_1 = protein shake$

$X_2 = salad with chicken$

$X_3 = chicken, broccoli, rice$

$X_4 = Mac n Cheese$

$X_5 = Cauliflower gnocchi with chicken sausage in vodka sauce$

$$minimize \quad Z = 1.85 * X_1 + 4.32 * X_2 + 1.75 * X_3 + 1.51 * X_4 + 5.59 X_5$$

subject to

$90 * X_1 + 1118 * X_2 + 450.6 * X_3 + 636 * X_4 + 1536 * X_5 \leq 35,000$

$195 * X_1 + 598 * X_2 + 528 * X_3 + 319 * X_4 + 371 * X_5 \geq 14,000$

$34 * X_1 + 69.92 * X_2 + 63.87 * X_3 + 17.57 * X_4 + 21.3 * X_5 \geq 350$

$25 * X_1 + 1.1 * X_2 + 2 * X_4 a \geq b 140$

$567 * X_1 + 147.9 * X_2 + 74 * X_3 + 228 * X_4 + 378.19 * X_5 \geq 9,100$

$0.38 * X_1 + 3.54 * X_2 + 3.39 * X_3 + 3.69 * X_4 + 8.29 * X_5 \geq 126$

$170 * X_1 + 1697 * X_2 + 1164.7 * X_3 + 630 * X_4 + 1788.8 * X_5 \geq 32,900$

$X_1 \geq 0$

$X_2 \geq 0$

$X_3 \geq 0$

$X_4 \geq 0$

$X_5 \geq 0$

(1)

Initial Prompt for ChatGPT:

"You are a graduate student in Data Science working on the Diet Problem for your specific diet. The constraints should consider seven components of nutrition and their daily values, as shown in the following table:

Component
Max/Min
Daily Amount and measure
Sodium
Maximum
5,000 milligrams (mg)
Energy
Minimum
2,000 Calories (kilocalories, kcal)
Protein
Minimum
50 grams (g)
Vitamin D
Minimum
20 micrograms (mcg)
Calcium
Minimum
1,300 milligrams (mg)
Iron
Minimum
18 milligrams (mg)
Potassium
Minimum
4,700 milligrams (mg)

The specific meals to be used are a protein shake, salad with chicken, mac n cheese with broccoli, chicken, broccoli and rive, and cauliflower gnocchi with chicken sausage."

8   References

Dantzig, George B. 1990. "The Diet Problem." Informs. 20:4, 43–47

Food and Drug Administration, Department of Health and Human Services. 2016. Food Labeling: Revision of the Nutrition and Supplemental Facts Labels.

Stigler, George. 1945. "The Cost of Subsistence." Journal of Farm Economics, 25:2, 303–314.