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Diet Generator Based on World Health Organization Recommendations

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Abstract. Scientific advances in the last years have helped to clarify the role of diet in the prevention of premature mortality resulting from non-communicable diseases. In particular chronic diseases, thus like obesity, diabetes mellitus, hypertension between others have become a significant cause of premature death. The World Health Organization (WHO), have a analyzed this problem and elaborated some dietary guidelines to follow, specifically, in WHO technical report #916, establish some ranges for population nutrient intake goals. That consider fats, carbohydrates and proteins as main parameters, but also specify limits for Cholesterol, sodium, fruits and vegetables, and fibre. This paper focuses in automatic diet generation following the rules established in this report, in order to do this a genetic algorithm is developed.

Keywords: Genetic algorithm, machine learning, nutrition systems.

1 Introduction

In the last years, scientific advances and in particular the amount of population-based epidemiological evidence has helped to clarify the role of diet in preventing and controlling morbidity and premature mortality resulting from non communicable diseases (NCDs) [6]. The NCDs includes obesity, diabetes mellitus, cardiovascular disease, hypertension, stroke, and some types of cancer.

Nutrition is coming to the fore as major modifiable determinant of chronic disease, with scientific evidence increasingly supporting the view that alterations in diet have strong effects, both positive and negative, on health throughout life, dietary adjustments may not only influence present health, but may determine whether or not an individual will develop such NCDs [6,18].

Diet and nutrition are important factors in the promotion and maintenance of good health throughout the entire life course. Their role as determinants of chronic NCDs is well established and they therefore occupy a prominent position in prevention activities [17].

But NCDs not is the only one problem derived from a bad diet, hunger and malnutrition remain among the most devastating problems facing the majority of the world's poorest nations. Nearly 30% of humanity are currently suffering from one or more of the multiple forms of malnutrition [16]. This forms of malnutrition includes, but not are limited to, Iodine deficiency, Vitamin A deficiency and iron deficiency anemia.

Food strategies must not merely be directed at ensuring food for all, but must also achieve the consumption adequate quantities of safe and good quality foods that together make up a healthy diet [6].

Population nutrient intake goals represent the population average intake that is judged to be consistent with the maintenance of health in a population [6]. Health, in this context, is marked by a low prevalence of diet-related diseases in the population. consistent with the concept of a safe range of nutrient intakes for individuals, there is often a range of population averages that would be consistent with the maintenance of health [6].

The population nutrient intake goals for consideration by national and regional bodies establishing dietary recommendations for the prevention of diet-related chronic diseases are presented in table 1 [6]. These recommendations are expressed in numerical terms, rather than as increases or decreases in intakes of specific nutrients, because the desirable change will depend upon existing intakes in the particular population, and could be in either direction. This table complements another reports on energy and nutrient requirements issued by FAO and WHO [5,3,4]. In order to translate this goals into a dietary guidelines, due consideration should be given to the process for setting unp national dietary guidelines [15].

The recommendations for total fat are formulated to include countries where the usual fat intake is typically above 30% as well as those where the usual intake may be very low, for example less than 15%. Total fat energy of at least 20% is consistent with good health. Highly active groups with diets rich in vegetables, legumes fruits and wholegrain cereals may, however, sustain a total fat intake of up to 35% without the risk of unhealthy weight gain [6].

It is recognized that higher intakes of free sugars threaten the nutrient quality of diets by providing significant energy without specific nutrients. It is necessary to consider that:

1. Free sugars contribute to the overall energy density of diets.
2. Free sugars promote a positive energy balance. Acute and short-term studies in human volunteers have demonstrated increased total energy intake when the energy density of the diet is increased wheater by free sugars or fat [14,13,12]. Diets that are limited in free sugars have been shown to reduce total energy intake and induce weight loss [10].
3. Drinks that are rich in free sugars increase overall energy intake by reducing appetite control. There is thus a less of a compensatory reduction of food intake after the consumption of high sugars drinks than when additional

Table 1. Ranges of population nutrient intake goals.

Dietary Factor	Goal (% of total energy unless otherwise stated)
1. Total fat	15-30 %
1.1 Satured fatty acids	< 10%
1.2 Polyunsaturated fatty acids (PUFAs)	6-10%
1.2.1 n-6 Polyunsaturated fatty acids (PUFAs)	5-8%
1.2.2 n-3 Polyunsaturatedc fatty acids (PUFAs)	1-2%
1.3 Trans fatty acids	< 1%
1.4 Monounsaturated fatty acids (MUFAs)	By difference
2. Total carbohydrate	55-75%
2.1 Free sugars	< 10%
3. Protein	10-15%
4. Cholesterol	< 300mg per day
5. Sodium Chloride (Sodium)	< 5*g* per day (< 2g per day)
6. Fruits and vegetables	⩾400g per day
7. Total dietary fibre	from foods
8. Non- starch polysaccharides (NSP)	from foods

foods of equivalent energy content are provided [12,8,2,9]. Children with a high consumption of soft drinks rich in free sugars are more likely to be overweight and to gain excess weight [9].

The benefit of fruits and vegetables cannot be ascribed to a single or mix of nutrients and bioactive substances. Therefore, this food category was included rather than the nutrients themselves. Wholegrain cereals, fruits and vegetables are the preferred sources of non-starch polysaccharides (NSP). The best definition of dietary fiber remains to be established, given the potential health benefits of resistant starch. The recommended intake of fruits and vegetables and consumption of wholegrain foods is likely to provide > 20 g per day of NSP (> 25 g per day of total dietary fiber) [6].

The basis of this problem is to establish a diet that fulfill the previous requisites, thus is find a set of appropriate combination of aliments. The aliment database should contain one hundred or one million of aliments, but is necessary to consider most of them when the diet is generated to add versatility.

Genetic algorithms already has been utilized in order to generate diets, for example, Catalan et al. developed one, which generates a diet considering the lipid, carbohydrate and lipid distribution [1].

In similar way in this paper we show a way to generate the diet using genetic algorithms, not for complexity nor the existence of high search space, simple for the ability of find different possible solution in any part of the search space, that is traduced in find different available diets.

Anyway the diet generated must be approved by one specialist, this algorithm does not replace them, is only a tool to help them.

2 Materials and Methods

A genetic algorithm emulates the biological evolutionary process in intelligent search, operates through a cycle of the following stages [7,11]:

1. Creation of a population of strings, representing possible solutions.
2. Evaluation of each string.
3. Selection of best strings.
4. Genetic manipulation to create a new population of strings.

We consider as an aliment as any food stored in the aliment database, for which one we have the measure of kilocalorie, carbohydrate, protein and lipid for each 100gr.

In our database all kind of fats are referred as lipids, for this reason we only use the total fat income range specified in table 1. Also the value specified is Sodium in place of Sodium Chloride. The NSP and free sugar values also are not specified and not would be considered. First of all is necessary to make the following definitions:

r is the goal of total energy intake per day,

a is an aliment stored in a database for which one we have the data of lipids, carbohydrate, protein, cholesterol, sodium, aliment type (from which one we can know if it is a fruit or vegetable), and fiber amount,

d is a diet defined as a vector of n aliments a

$$d = [a_1, ..., a_n],$$

$k(d)$ is a function that returns the total energy intake of the aliments a that compound diet d

$$k(d) = \sum_{i=1}^{n} k(a_i).$$

Following the same notation for others dietary factors and considering their constrains, we can stablish the set of functions and constraints that we use in this paper as shown in table 2.

2.1 Chromosome Representation

As we already said, a diet d is a collection of n aliments a per day, so our chromosome representation is a vector as follows:

$$d = [a_1, .., a_{i,...}a_{15}],$$

where:

$a_1 ... a_3$ are drinks to be consumed,

$a_4 ... a_1 5$ are aliments to be consumed, is necessary to say that we use a zero value to indicate the ausence of an aliment in that position.

The order and time in which the aliments are consumed are delegated to the user.

Table 2. Dietaries factors, symbology and constraints.

Dietary Factor	Function	Constraints
1. Total fat	$l(d)$	$.15r <= l(d) <= .30r$
2. Total carbohydrate	$c(d)$	$.55r <= c(d) <= .75r$
2.1 Free sugars	s(d)	$s(d) < .10r$
3. Protein	$p(d)$	$.10r <= p(d) <= .15r$
4. Cholesterol	$h(d)$	$h(d) <$ 300mg per day
5. Sodium	$m(d)$	$m(d) < 2g$ per day)
6. Fruits and vegetables	v(d)	$v(d) \geqslant$400g per day
7. Total dietary fibre	f(d)	$f(d) > 25g$

2.2 Fitness Evaluation

In order to get the fitness evaluation e, we consider that for each constraint accomplished we add a point and for each not accomplished we subtract point

$$e(d) = \begin{cases} +1 & \text{for each constraint accomplished,} \\ -1 & \text{for each constraint not accomplished,} \\ +2 & \text{in case that } 0.15r <= l(d) <= 0.35r \text{ and } v(d) \geqslant 400g, \\ -1 & \text{per each drink rich in free sugar,} \\ +1 & \text{per each drink rich in free sugar.} \end{cases}$$

2.3 Selection

According with the evaluation we order the population from best fitness (higher evaluation) to lower fitness, we select half of the population that corresponds to the best evaluated chromosomes in order to survive and be reproduced.

2.4 Crossover

Being C^1 and C^2 two chromosomes of the same dimension as follows:

$$\mathbf{C}^1 = [a_1, ..., a_n],$$
$$\mathbf{C}^2 = [b_1, ..., b_n].$$

A single point crossover between this two chromosomes is used in order to generate another two chromosomes, being p the cross point position we have:

$$\mathbf{C} = [a_1, ..., a_p, ..., b_{p+1}, b_n],$$

$$\mathbf{C} = [b_1, ..., b_p, ..., a_{p+1}, a_n].$$

In order to avoid premature convergence and add diversity to population, the parents chosen for reproduction are selected aleatory, and we repeat this process half of the population size, due that is amount needed to be replaced.

2.5 Mutation

Mutation only select one child chromosome and one position randomly and change its value, in meaningful terms it is equivalent to exchange one aliment for another.

3 Results and Discussion

We test our algorithm using the following parameters:

- Population size: 20,
- Generations: 100,
- Crossover position: Random per child created,
- Mutation frequency: each 3 generations each child created is mutated.

We run several test in order to find a diet for a 800 KCal, 1,000 KCal, 1,200 KCal, and 1,500 Kcal. In all of this experiments, the algorithm converges around the 60 generation, arriving to a good solution. We have detected that between bigger is energy intake more difficulties have the algorithm to find an acceptable solution, as it was expected from the nature of the problem.

4 Conclusions

In this paper we introduce an automatic diet generation using genetic algorithm, which satisfies the dietary guidelines established in WHO technical report #916 for population nutrient intake goals.

We take advantage of the combinatorial nature of the genetic algorithm in order to generate diets. Generally, due to that it generate a set of aliments and drinks to be consumed in a day it is possible to find an adequate way to do it, thus is, which ones in each meal time. However some of the aliments are not considered in their cooked forms, and some ways of cooking them and the additives used can vary their properties. So the inclusion of these cooked aliments in the database is desired and proposed as future work.

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