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Optimization Methods and its Application in Nutritional Diet

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Abstract

To maintain health, increase life expectancy and to decrease the frequency of cardiovascular diseases one has to improve its dietary habits. Proper diet from the very early stages of life helps in proper growth, development and it also reduces the risk of diseases. Construction of diet plan in hospitals, schools, nursing homes etc.is very important as it helps to plan well administrated menus that can be adapted to user's need, satisfies given constraints and resources and also maintains bodily fitness. From simple and efficient linear programming optimization to various Artificial intelligence based heuristics and metaheuristics optimization algorithm are used for construction of proper diet satisfying certain objectives and performing transformation with lesser inconsistencies. The present review paper summarizes some of the popular mathematical based optimization algorithm which not only educate the user but also helps to plan optimized menus which can be transformed according to the user's need and requirements.

Index Terms: *Optimization, Linear programming, Heuristic search, Genetic programming, Particle Swarm, Differential Evolutionary Algorithm.*

I. INTRODUCTION

The word "diet" means right amount and type of food and liquid one should consume every day. Unhealthy eating habits may lead to various health and food related diseases. The health survey conducted in 2006 disclose that the prevalence of diabetes rates is higher among the Indian, Malaysian and the Chinese people[7]. To maintain a healthy life and prevent various diseases one should follow a strict diet plan involving variety of foods with right amount of calories and other required nutrient which is a complex task if performed manually .Recommended Diet plan should be always complete, balanced i.e. should incorporate all the essential nutrients, and should be properly adapted to user's medical problems. To plan menu different menu planning systems are available which makes decision by using different tools and techniques. One such technique is 'Case base Reasoning' generally used in medical applications to solve new problems by remembering solutions of previously stored similar cases. Abdus Salam Khan, Achim Hoffmann in their research paper[2] described fully automated and CBR based adaptable menu construction using an incremental knowledge acquisition system (MIKAS)which is fully tailored to the client's needs and requirements. Another popular method is an expert system based on fuzzy ontology[3,4] which not only handles the imprecise and vague data but also tailored toIndividual nutritional needs. The main focus of all these methods is diet recommendation and not optimization. Mathematical based approaches and AI methodologies can provide high-level mechanisms for implementing optimized numerical models and solutions. The present review paper summarizes different optimizing techniques for analyzing construction and transformation of diet. In this review paper various optimization methods such as linear programming, AI based mathematical

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diet recommendation models their techniques ,issues and scopes are described. Our discussion will mainly focus on diet optimization techniques, such as Linear programming, heuristic search, particle swarm, Genetic Programming and differential Evolutionary Algorithm.

II. LINEAR PROGRAMMING OPTIMIZATION

Finding an adequate diet at minimum cost or which satisfies any given objectives is an best and classical example of Linear Programming [5]. Many optimization techniques using linear programming have been used for diet optimization. Author MaryTom [6] described the use of linear programming for nutritionally balanced diet by creating a optimized pareto solution set. The model DIligenS comprises of knowledge base, InferenceEngine, Database, Dataextraction and conversion Module. To overcome incomplete and uncertainties and imprecision effectively Fuzzy programming was used which provides device acceptable solutions. For effectively modeling imprecision Wisram[1] suggested to use linguistic terms derived from trapezoidal fuzzy numbers. The nutrition intake can be appropriately evaluated and described by employing fuzzy sets and fuzzy arithmetic. Wisram evaluated the nutritional intake by comparing it with the recommended intake, while doing this assessment other nutrients where assumed to be constant . Figure 1 shows the degree of health obtained by varying the intake of one nutrient and keeping others constant at an optimal level .Optimization was performed using fuzzy arithmetic considering values in optimal range.

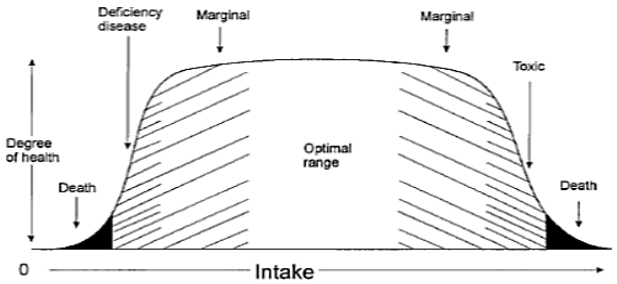

Fig. 1.Degree of health for one nutrient

Author Hamzah, AdibahShuib, et al. described a 2 stage Linear programming model (My_diet_Plan)used to determine healthy meals at low cost specially for Malaysian Peoples[7].As each group of members belong to different age, gender and nutrient requirements, stage-I determines minimum cost diet plans for the respective age-gender groups with 11 constraints in this case excluding children below 4 years and pregnant women's.Stage-II deals with total cost optimization. This study includes only seven nutrients and also to avoid complexity some of the age-gender groups were restricted from this process[7].Above 2 models viz.DIligens and 2 stage LP model provides cost-effective diets but lacks flexibility in accommodating a client's food preferences . Moreover these models generally suffer from limited scope and enhancement complexities.

III. HEURISTIC SEARCH

A well known idea suggested by Jean-Christophe Buisson and AlexandreGare is a nutrition software application Nutri-Edu[8]. Software balances and optimized it using heuristic algorithm. Fuzziness of food quantities and their imprecision are represented and computed by Fuzzy sets and Fuzzy arithmetic[8].The obtained result is then compared with the prescribed norms for retrieving the values in optimal range [9].These values are then integrated with heuristic search algorithms which modifies the meals and make it well balanced. Evaluation function is used as a guiding parameter in the whole search process .Its main task is to compute the term f= g + h by changing weight of the food items,Where g refers the minimum cost of transformation from the Starting meal to the current generated meal and h is the estimated cost use for transformation. This software provides a good model for the nutritional problems but sometimes the burden of fuzzy computation grows heavier in order to improve the meals.

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IV. GENETIC PROGRAMMING

The fastest and more efficient than the traditional methods, follows the law of jungle i.e survival of the fittest was developed by John Holland his colleagues and his students at the University of Michigan. GA Programming is a Heuristic search inspired by evolution generally viewed as function optimizers.[10]. A set of population/solution is put in a competitive environment producing new children undergoing crossover and mutation .Based on the objective function, fitness value is assigned to each chromosome/individual. The fittest candidates get maximum chance to mate and yield fitter individual. This process is repeated until objective is reached.

Author Petri Heinonen1 Esko K. Juuso2 in their research paper [11] presented a nutria flow software integrated with Fuzzy expert system to provide easy to follow nutritional guidance.Uncertainity,imprecision and mapping is handled by the FES system which contains licensed nutritionists' knowledge in a rule base . The output of FES is used to form a search space for GA.A randomly generated initial population in a search space represents foodstuff along with recommended intake .The GA algorithm runs and reruns several times with new population and the best of all is used to form dietary guidance.[11] .Following figure shows GA optimization process.

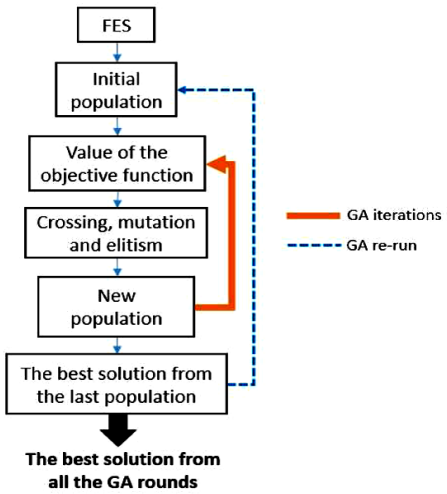

Fig. 2.GA optimization process

For data analyzing purpose the authors had recorded the performance of GA.For some cases GA doesn't work efficiently due to less number of variation in population or reduced population size whereas more population size will certainly increase the overall computational time of the process.The feasible result and a short computation time are essentials to make the Nutri-Flow® software usable[12].

To improve convergence speed,population diversity and global optimization ability a new improved version of GA called Improved Quantum genetic algorithm was proposed by Author youboLv, Dong Li. [13,14]. In QGA the superposition mechanism of qbits improves the population diversity and higher computing parallelism still it suffers from low convergence moreover with rising problem complexity this method converge prematurely .The authors had put forward some improvements. They changed the process of chromosome initialization, elitist strategy and Introduced partial population disaster strategy, by which an improved IQGA is evolved having robustness, usability and higher searching capability.

V. SWARM PARTICLE OPTIMIZATION

A population based Swarm Optimization is an Artificial Intelligence approach proposed by Kennedy and Elbe hart [15]. It is used in GA and for training ANN.Based on simple mathematical operators this evolutionary programming is having several advantages based on their simple design ,less calculation and best solution.

Author YouboLv[16] had developed an assembled effective multiobjective method which complex nutritional diet decision making problem. This effective method is based on quantum particle swarm optimization (QPSO) algorithm along with Bayes net. Solution is represented by a particle having a random position which is updated iteratively and moves in a state space for finding the better solution while moving in a state space this particle holds several essential information like

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position,velocity,personal best, local best and global best.

Particle i is denoted as Y*i* = [y*i*1,y*i*2 ,_, y*iD*]

Velocity Vi denoted by Vi=[vi1,vi2,….,vid] in d dimensional phase.

Velocity ,position of the particle iand dimension *d* at iterationsare dynamically updated.

Quantum particle swarm optimization [16] is based on quantum bit called qubit as an basic information unit.In addition to the values 0 and 1 these qbits also represents a superposition of the two at the same time, to represent an exponential sets with less number of qbits.Optimization problem is solved using discrete binary version of PSO algorithm. Bayesian networks are used to represent complex multiobjective decision related with diet[16].Suggested Combined approach helps in computing nutritious and valid food for patients thus helping in decision making correspond to their actual needs.

VI. DIFFERENTIAL EVOLUTION

To achieve global optimization in search space and to improve the convergence performance Storn and Price had proposed a differentialevolutionary algorithm in 1995[10].Unlike GA and PSO, DE generates a new solution represented by a D dimensional vector by combining various generated solutions with the candidate solution.Like GA and PSO de evaluates fitness value from randomly generated population called vectors.For each target vector DE generates trial vector by applying mutation and crossover methods,calculates the fitness value of trial vector and after comparing it with target vector updates the global best vector.This survived vector goes to the next round and the process is repeated[10].

Author João Gabriel Rocha Silva et.al in their research paper proposed a calorie restricted diet planning using a multi objective DE algorithm. The main objective of this paper is to increase the protein count in a diet while minimizing the calorie count. This work is an extension of their previous work of generating a mathematical model for calorie restricted diet problem [17] using single or mono objective DE algorithm. By comparing both the methods with same database they had found that multiobjective DE is more effective in producing hipocaloric diet with a high amount of protein.

VII. CONCLUSION

Optimization plays a vital role in our life as we have limited resources and time and we want to make most of it.

This paper gives a systematic review of the various optimizing algorithm and its application in diet.The multi objective linear programmingoptimization algorithm allows cost effective and balanced diet by performing simple mathematical computations while creating a pareto optimal solution set but its efficiency decreases for large data set and increase number of food items. A state space and efficient Artificial intelligence optimization algorithm called A* also provides optimal and balanced solution catering users need but usually get stuck in local search. A population based and bio-inspired intelligent algorithms such as GA,PSO and DE algorithm addresses highly complex optimization problem and provides best and balanced diet through iterations by performing mutations and crossover.

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