Genetic Algorithm for Scheduling Diet Case: Liver Patient

M. F. Syahputra[1], R. F. Rahmat[1], Dian Aria Ningsih[1], U. Andayani[1]
[1]Department of Information Technology, Universitas Sumatera Utara , Jl. Alumni no.3, Medan, Indonesia

Keywords: genetic algorithm, diet schedule, liver patient.

Abstract: The main function of liver is to process the absorbed nutrients from food consumed. Several factors that affect its functions are alcohol, infection, drugs or herbal medicine, cancer, autoimmune disease, etc. Balanced and healthy diet can help the liver patients to heal the disease by considering the calorie needs. In this research, we schedule diet for liver patients by using genetic algorithm, which starts from calculating patient's calorie needs and then initializing the population, calculating fitness score, performing crossover and mutation. Next, 7 individuals with the lowest score will be selected as a diet schedule in a week (7 days). From the 8 times of testing results, we get 0.5 lowest fitness score with 20 initial population and 100 generations. It shows that the greater the created generation, the more the opportunities to obtain best individual with fitness score approaching 0 (zero) or equal to 0 (zero).

1 INTRODUCTION

The liver is the largest glandular organ that serves to process the absorbed nutrients from food consumed and also to keep the body pure of toxins and harmful substances (Dixit, 2014). Several factors that affect its functions are alcohol, infection, drugs or herbal medicine, cancer, autoimmune disease, etc. The most common diseases that causes of chronic liver failure include hepatitis, cirrhosis, hemochromatosis, etc.

One of the treatment able to help the liver patients to cure the disease is balanced and healthy diet, by considering the calorie needs. It aims to prevent the fatal liver failure, to repair the damaged liver tissue, to reduce its workload, to meet nutrition of patients and to prevent the complication of liver failure (Kargulewicz, 2014). Food consumed by liver patient needs specific nutrient levels, such as protein, energy and fat in a certain amount. Therefore, diet scheduling system is required for liver patients to help them meet the nutrient level and cure the disease more rapidly, and also to inform them various food menu able to be consumed so that it can increase the appetite of patients.

Several method had been proposed for dietary recommender system. The latest research was done by Norouzi, et al. in 2016 who narratively reviewed food recommender system for a diabetic patients (Norouzi, 2016). They recognized three common methods for food recommender system, namely Collaborative Filtering Recommender System (CFRS), knowledge based recommender system (KBRS), and content aware recommender system (CARS). Artificial intelligence method and semantic web techniques are also often used in food recommender systems.

In (El-Dosuky, 2012) used ontology and heuristics for building food recommender system. They concluded that their proposed algorithm could give better result of F-measure, recall, precision and accuracy than the other existing semantic recommenders (El-Dosuky, 2012). But, due to the complexity of the ontology construction, many researchers prefer to use artificial intelligence techniques. In the next year, Chen, et al. constructed a diet recommendation system using fuzzy rules and knapsack method. They designed a diet recommendation system which has the expert knowledge of three high chronic diseases, namely diabetes, hypertension and cholesterol. The system recommended suitable diet based on six parameters, namely height, weight, activity levels, kidney function, hypertension and hyperlipidaemia. They also stated that their system had been evaluated by the nutritionist to prove that it is effective (Chen, 2013).

Recently, genetic algorithm (GA) is often used for solving optimization problems, such as shortest path

Syahputra, M., Rahmat, R., Ningsih, D. and Andayani, U.
Genetic Algorithm for Scheduling Diet Case: Liver Patient.
DOI: 10.5220/0010091919051909
In *Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR 2018) - Research in Industry 4.0*, pages 1905-1909
ISBN: 978-989-758-449-7

and also scheduling system (Kumar, 2010). In 2013, Skinner, et al. presented genetic algorithm based optimization approach to improve container handling operations at a container terminal in Australia. The experimental result of their research showed that GA can reduce the overall time for container transfers and improve the overall performance (Skinner, 2013). Another related research in 2014, Filho, et al. solved scheduling problems on flexible manufacturing systems (FMS) using genetic algorithm (Filho, 2014). Next research, Xu, et al. also used GA for task scheduling on heterogeneous computing systems using multiple priority queues. They concluded that GA can cover a larger search space than the deterministic scheduling approaches and do not lead to high computational cost (Xu, 2014).

In this research, we propose genetic algorithm to schedule diet for liver patients. The rest of the paper will be organized as follows: Section II describes the proposed method. Results and discussions are presented in Section III. Section IV provides summary and suggestions for future research.

2 CONCEPT DEVELOPMENT

Here are the steps in implementing the GA to calculate the calorie needs:

2.1 Data Collection

This data of the calorie needs consist of two parameter, i.e., liver patient and food nutrition. The liver patient parameters, i.e., age, sex, weight, height, allergy, ability of oral intake and edema. The food nutrition parameters are food name, type of food (staple food, side dishes, vegetables, fruits, and complement), energy (kcal), protein (gr), fat (gr) and carbohydrate (gr) and the ingredients data in 100 grams obtained from Nutri Survey Indonesia in 2007.

2.2 Calculation of Calorie Needs

The calorie needs can be calculated using Harris-Benedict equation which estimates resting energy expenditure (REE). The total calorie needs for liver patients is called by basal calorie that used to create a chromosome that consists of food menu.

Here, the following steps to calculate the calorie needs (basal calorie).

Step 1 : Calculating the ideal body weight (kg) based on the formula rule that showing in Table 1.

Table 1: Rule of Ideal Body Weight Calculation

Sex	Height	Formula
Male	< 160 cm	(Height-100) x 1 kg
Female	< 150 cm	
Male	≥ 160 cm	((Height-100) x 1 kg) x 90%
Female	≥ 150 cm	

Step 2 : Calculating Basal Calorie (kcal) based on rule in Table 2.

Table 2: Rule of Basal Calorie Calculation

Sex	Formula
Male	Ideal Body Weight x 30 kcal
Female	Ideal Body Weight x 25 kcal

2.3 Gen and Chromosome Structure

In genetic algorithm, an individual consists of gen and chromosome. In this subsection, we will discuss about the structure of gen and chromosome.

2.3.1 Gen

It consists of food types that will be initialized to create initial population in genetic algorithm. In this research, there are 5 genes (kind of food), namely staple food (st), side dishes (sd), vegetables (v), fruits (f) and complement (c). Each of them has two values, namely calorie and food weight. The value in each of gene is called by allele. Fig. 1 shows the structure of gen.

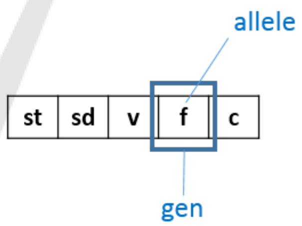

Figure 1: Gen structure

2.3.2 Chromosome

In this research, there are three chromosomes in each of individual, namely breakfast, lunch and dinner. Each of chromosome has 5 genes, so there are 15 genes in an individual. It also has two values, namely fitness score and the total of calorie. The total of calorie is the calorie of food menu in a chromosome for scheduling diet in a day. The fitness score is used to evaluate the generated food menu based on the patient calorie needs. Fig. 2 shows the structure of chromosome.

Breakfast					Lunch					Dinner				
st	sd	v	f	c	st	sd	v	f	c	st	sd	v	f	c

Figure 2: Chromosome structure

2.4 Initialization of Population

In this research, population is the data of food menu. The greater the size of population, the more the generated diet variation. Several steps below are done to initialize the population.

Step 1 : Normalize food menu which aims to adjust the generated diet

2.4.1 Divide the Total of Calorie Needs

Total of calorie needs is divided into 3 chromosomes, namely breakfast, lunch and dinner. It aims to make the diet schedule consider the balance of total calorie for breakfast, lunch and dinner. It is done as formulated in equation (1)

$$Total\ calorie\ per\ chrom = \frac{Total\ of\ calorie\ needs}{3} \quad (1)$$

2.4.2 Calculate Total Calorie for Every Kind of Food

Each of chromosome consists of 5 genes of food type, namely staple food, side dishes, vegetables, fruits, and complement, which respectively has a weight of 0.45, 0.2, 0.15, 0.15, and 0.2. It can be calculated using equation (2) until equation (6).

$$staple\ food = 0.45\ x\ total\ calorie\ per\ chrom \quad (2)$$
$$side\ dishes = 0.2\ x\ total\ calorie\ per\ chrom \quad (3)$$
$$vegetables = 0.15\ x\ total\ calorie\ per\ chrom \quad (4)$$
$$fruits = 0.15\ x\ total\ calorie\ per\ chrom \quad (5)$$
$$complement = 0.2\ x\ total\ calorie\ per\ chrom \quad (6)$$

2.4.3 Calculate Each Food Weight in 100 Gram

Each of food in database is expressed in units of 100 grams. In the database, there are a few of menu that has calorie more than needed calorie for the food. To generate the number of calories and weight that corresponds to the total calorie needs of DM patient, we do the calculation as formulated in equation (7)

$$Food\ weight\ (gr) = \frac{Calorie\ needs}{Food\ calorie} x100 \quad (7)$$

Step 2 : Random and generate 15 food menu based on its type as an initial population.

Step 3 : Input the calorie of food into chromosome. The generated food menu from previous step will be divided into 3 chromosomes, namely breakfast, lunch and dinner, so each of chromosome has 5 genes which contain the calorie of staple food, side dishes, vegetables, fruits, and complement. The number of generated population is based on the number of initial individual and generation.

2.5 Calculation of Fitness Score

Fitness score is used to evaluate the generated solution and compare among the individuals to determine the better or the worse one. In this research, the fitness score for each individual is based on the total of patient calorie needs and the total of food calorie in a day. An optimal solution for an individual is if the difference between the total of patient calorie needs and the total of food calorie in a day equal or approach to 0 (zero). Therefore, the less the generated fitness score, the more optimal the individual. Fitness score can be calculated using equation (8), while the average of fitness score for each generation can be calculated using equation (9).

$$Fitness\ score = |total\ calorie - total\ food\ calorie| \quad (8)$$

$$fitness\ average = \frac{\sum_{k=1}^{7}(a_k)}{7} \quad (9)$$

Where:

a_k = fitness score for each individual

k = individual in a week (1-7)

2.6 Selection

In this research, we use Rank-Based fitness so that the selection of individual is based on the lowest fitness score. It aims to select the individual which becomes a parent for the next phase, crossover. The number of selected individual depends on the probability of crossover.

2.7 Crossover

The used method of crossover in this research is one-point crossover which generates the offspring from every 2 parents. These following steps are done in the process of crossover.

Step 1 : Calculate the number of individual which becomes a parent for crossover by using equation (10)

$$N_{co} = N_i\ x\ 0.1 \quad (10)$$

Where N_{co} is the number of individual for crossover and N_i is the number of individual.

Step 2 : Determine the cut point of gen by generating a random number from 1 until the number of chromosome for each parent. The crossover will start from the gen with the position after the random number.

Step 3 : Performing crossover. Genes in parent 1 will be copied to the offspring before the cut point, while genes in parent 2 will be copied to the offspring after the cut point. This process will generate one new offspring.

2.8 Mutation

Random mutation will be conducted after the crossover by randomizing the position of chromosome and gen to be mutated. These following steps will clearly explain the process of random mutation.

Step 1 : Calculate the number of gen to be mutated. It depends on the Probability of mutation (P_m) and the number of genes from all chromosomes. In this research, we set 0.2 as probability value, while the total of gen depends on the number of initial population and generation. The calculation can be done using equation (11).

$$N_G = P_m \; x \; total \; of \; individual \; x \; 15 \qquad (11)$$

Step 2 : Determine the position of individual and gen to be mutated randomly.

Step 3 : Performing mutation. The gen will be mutated if the gen in the next chromosome has the same type. For example, if generated gen is gen with type of staple food in breakfast, then the gen will be exchanged with the gen with the type of staple food in lunch. And then the gen with the same type will be exchange to chromosome of breakfast. It aims to keep the calorie of every type of food as needed.

3 SYSTEM DESIGN

Figure 3 shows the general architecture of our proposed method.

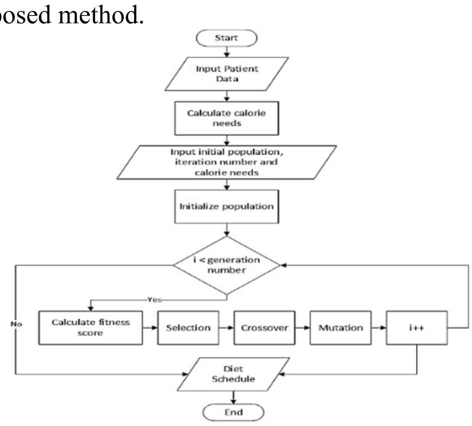

Figure 3: General architecture

From the figure above, the iteration numbers of initial inputs to calculate the calorie needs from the patients by implementing the Genetic Algorithm (GA) by generating the number of selecting the 7 (seven) best individuals (solutions) with the lowest fitness score, performing one-point crossover to the individuals with the lowest score, and performing random mutation to the chromosome. The output of this system is a schedule menu in a week for liver patients.

4 SYSTEM TESTING

The testing is conducted 8 times with different number of initial individual and generation. 10 initial individual is tested with the number of generation respectively 60, 80, and 100. It is also conducted with 20 initial individual in the next testing. Then, 30 initial individual is tested with 60 and 80 generations. The result of this research is schedule of diet for liver patients.

Table 3: Testing Result with 10 Initial Individual

Number of Generation	Minimum fitness score
60	74.5
80	13.5
100	11.5

Table 4: Testing Result with 20 Initial Individual

Number of Generation	Minimum fitness score
60	74.5
80	13.5
100	11.5

Table 5: Testing Result with 30 Initial Individual

Number of Generation	Minimum fitness score
60	16.5
80	4.1

5 RESULT AND EVALUATION

From all the testing results, it can be concluded that the greater the number of generation, the greater the evolution of individual that causes the more possibility of fitness score approaches or equals to 0 (zero). It means that the calorie total of the generated food menu will correspond to the total of patient's daily calorie needs.

6 CONCLUSIONS

Based on all testing result of diet scheduling system for liver patients, there are several obtained conclusions. First, the greater the number of population, the more the possibility of fitness score changes into approaching best fitness score. The greater the number of generation, the greater the evolution of individual that causes the more possibility of fitness score approaches or equals to 0 (zero). Best individual has the smallest fitness score. The last solution of scheduling diet can change every time running the system. It is caused by the initial population generated randomly, so that the generated fitness score in the solution of scheduling diet becoming more varied.

For further research, adding the generated food menu can be done to make it more varied and increase the appetite of liver patients, but still limit the food that contains meat. Another optimization algorithm can be used to improve the effectiveness of the obtained results.

ACKNOWLEDGEMENTS

This research was supported by Universitas Sumatera Utara. All the faculty, staff members and laboratory technicians of Information Technology Department.

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