2020 International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS) 978-1-7281-3126-9/20/$31.00 ©2020 IEEE 10.1109/ICMCECS47690.2020.246978

African Buffalo Optimization Algorithm for Personalized Diet Optimization

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Abstract - Food provides our body energy, vitamins, and other essential nutrients needed by the body to sustain us for our day-to-day activities and to function properly. Malnutrition is a state of under-nutrition or over-nutrition that can lead to one or more Diet Related Diseases (DRDs). Therefore, a personalized diet optimization and recommendation is a vital area to be investigated when attempting to prevent DRDs and meet nutritional necessities is the objective of this study. African Buffalo Optimization (ABO) algorithm was compared with Particle Swarm Optimization (PSO) based on ease of convergence. ABO was applied to diet optimization because it produces very competitive result and it is also one of the recently developed metaheuristic. Its result was compared with Particle Swarm Optimization (PSO) because PSO is one of the commonly used metaheuristic. ABO was seen to achieve convergence in lesser time.

Keywords – ***African Buffalo Optimization, Particle Swarm Optimization, Diet optimization, Metaheuristics***

I. INTRODUCTION

Food is an element with life supporting substances needed by all living creatures for sustenance. Medical Studies have revealed that consumption of healthy foods help the body to fight against diseases [10]. A healthy diet is a combination of foods ingested in the human body to enhance physical and mental development. Food choice selection has immense effect on health as hale diets help provides energy, vitamins, and other essential nutrients needed by the body to sustain balanced body weight, body beauty, enhanced growth, and boost immune system thereby promoting good mental function for daily activities [11].

A hale and hearty population is one of a country's most priceless resources since healthy populaces assist to add value and contribute the society and the economy [6]. It has been generally accepted that dietary habit is strictly related to a person's health; therefore, cultivating the practice of improving dietary habits of people is an exceptionally huge duty. Eating disorder habits is a serious problem in the entire life course [7]. The involvement of double income and the evolution of eating-out occasions as a result of changes in the environment has been known to be one of the reasons for the changeable dietary habit and explosion of lifestyle-related diseases, and the number of troubled people for dietary habit has been expected to be still increasing yearly [8].

Modern society increasingly characterized by an eruption of several lifestyle-related diseases such as Diet Related Diseases. According to a study by JAMA in 2018, DRDs are the most prominent grounds for high mortality in the United States. These diseases include obesity, cardiovascular diseases, diabetes, and so on [12].

Optimization is a procedure of searching for the optimal solutions to a specific problem of concern, where this search procedure is done out by means of numerous agents which fundamentally form a system of evolving agents [4]. Several algorithms have been developed to effectively solve optimization problems. Those algorithms include Genetic Algorithm, Particle Swarm Optimization, Simulated Annealing, Great Delude Algorithm, Harmony Search, Hill Climbing algorithm, African Buffalo Optimization, Moth flame optimization algorithm, etc. several factors are considered when the effectiveness and efficiency of an algorithm is tested in the optimization of a problem. One of the factors is the ease of convergence, which is considered in this study.

Meal planning problem involves evaluating food compositions by calculating nutrient components in food items. The traditional method of meal planning entails manual calculation or trial and error through food exchange list which a professional nutritionist can to an extent manually manage to plan menu within the confines of regular

menu planning. The process of meal planning usually involves a number of various objectives such as taste, costs, method and time of preparation, and quality. Optimizing any of these objectives with respect to diet help the practice of decision making in menu planning.

II. RELATED WORKS

For several eras, there have been numerous efforts to solve the diet optimization problem. In 1945, George Stigler [1], a renowned economist, attempted to solve the diet optimization by proposing the cheapest foods to nourish a moderately active man in a year while putting nutritional needs into consideration. In 1959 [2], Smith designed a diet optimization model that chooses food quantities based on nutritional needs and least cost of food items using Linear Programming. However, Linear Programming gives result that are complex and complicated in reality [5].

Mamat et al., [7], addressed a balanced menu planning system using fuzzy linear programming approach. They described the use of fuzzy linear programming approach with the triangular membership function on the variety of foods consumed by users and discussed optimizing human diet problem with price using fuzzy linear programming. In their work, fuzzy theory approach was employed, where the prices of foods were assumed as fuzzy numbers. The study identified by minimizing cost, humans can still fulfil their nutrient requirement every day. The Fuzzy Linear Programming approach was used to calculate the amount of nutrient in food taken and it is considered to estimate nutritional requirements for human body in daily routine, but, the quantity of daily calories that people should consume is unknown, therefore, the system was not personalized.

In Van der Merwe et al., [13], an expert system was created for the purpose of solving multiple facets of the diet problem, by creating a rule-based inference engine consisting of goal programming- and multi-objective linear programming models. The program was successfully applied to cases specific to South African teenage girls, which were obtained through system development. The resulting system compiled an eating-plan for a girl that conformed to the nutritional requirements of a healthy diet, included the personal food preferences of the girl, and consists of food items that result in the lowest total cost.

The structure of the paper is as follows. Section II discusses related works on diet optimization. Section III presents the methodology; Section IV shows the result of the experiment. Next is the conclusion followed by acknowledgement and the references.

III. METHODOLOGY

African Buffalo Optimization (ABO) algorithm, inspired by the dexterity of quality decision making, organizational and managerial skills of herds of African buffalos in their search for food in the forest [3]. In the herd of African buffalos, two calls or signals – waa and maa. Waa calls are made in the herd to signal to African buffalos to flee and move ahead as danger looms around. Maa calls on the other hand is used to signal to the herd of African buffalos to stay in that region because there is guarantee that the region was safe for grazing. ABO algorithm uses waa for exploration and maa for exploitation [14]. The buffalo's exploitation is updated using equation one.

$$m'_k = m_k + lp_1(bg_. - w_k) + lp_2(bp_k - w_k) \quad (1)$$

where m_k denotes exploitation moves, w_k denotes exploration moves, bg and bp shows the best fitness in the herd and the location of the best buffalo respectively; lp1 and lp2 represents the learning factor.

For diet optimization, three food nutrients were considered, namely, carbohydrate, protein and fat. The food items were grouped based on the most dominant food nutrient that they possess, and also based on what food they can be combined with since a meal usually contain different combinations of food items. Each of the food items also contains measurement and price per serving. The objective is to minimize the difference between the recommended calorie intake and the expected calorie intake as shown in equation 2.

$$\text{Min } |\sum_{i=1}^{n} x_i - Kcal| \quad (2)$$

where n is the total number of food items considered, Kcal is the amount of calories the individual is supposed to take based on the sex, age, height, weight and physical activity level.

IV. RESULT

In this study, the number of search agents and the number of iterations for a user is presented. The user's profile is as follows: age = 25; sex = female; height = 1.57m; weight = 57. Table 1 shows the expected food nutrient of user 1 and the recommended result [10].

Table 1. Expected and recommended nutrient values

Constraint	Expected Constraint Value	Recommended Values
Carb	≤ 220	234
Protein	≤ 150	132
Fat	≤ 30	16
Total	≤ 400	382
Budget	≤ ₦200	₦150

In order to investigate the best configuration of the population size and amount of iterations, the values of both of them were varied. Several runs were made and the ease of convergence of African Buffalo Optimization algorithm and Particle Swarm Optimization was compared.

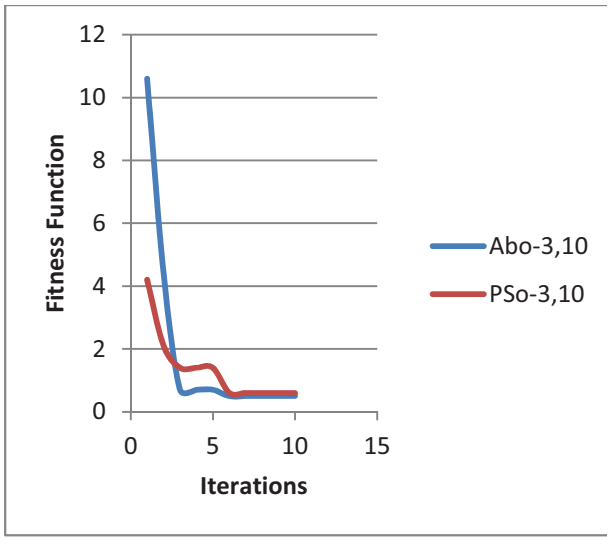

Fig. 1. Population size of three with ten iterations

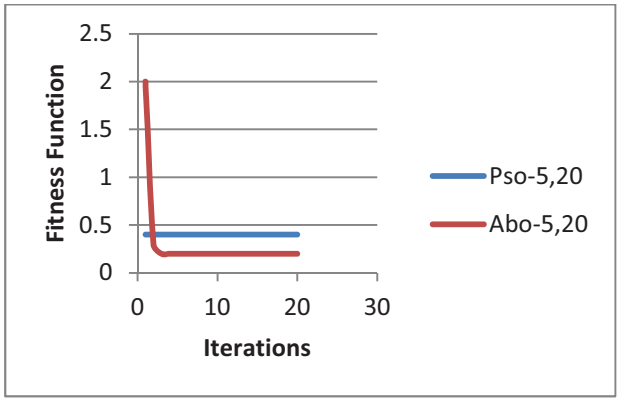

Fig. 2. Population size of 5 with twenty iterations

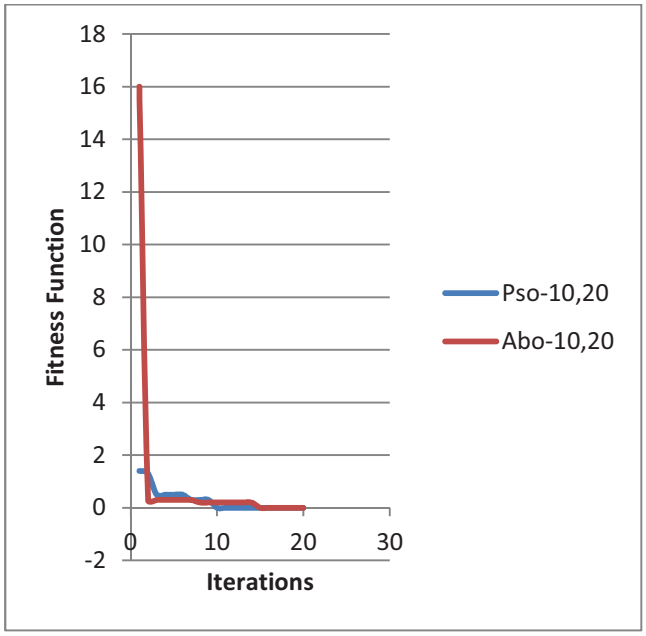

Fig. 3. Population size of ten with twenty iterations

The figures above show that ABO has a good balance between exploration and exploitation when the diet problem is considered. Also, increasing population size and number of iterations increases the fitness function. In addition, ABO converged faster than PSO in all the runs.

V. CONCLUSION

In this study, generating a meal with balanced and appropriate food nutrients from a user profile was presented. A personalized diet optimization is an important area when endeavouring to prevent DRDs and meet nutritional necessities in order to reduce mortality rate. African Buffalo Optimization (ABO) algorithm was applied to diet optimization problem because it produces very competitive

result and it is also one of the recently- developed metaheuristic. Its result was compared with Particle Swarm Optimization (PSO) because PSO is one of the commonly used metaheuristic. Some of the factors of a good algorithm are its ability to have a good balance between exploitation and exploration and its ease to converge. These factors were showcased in ABO as it converged in lesser time than PSO; therefore, this study concludes that ABO performs better in solving diet optimization problem than PSO.

ACKNOWLEDGEMENT

The authors appreciate the support of the Department of Mathematical Sciences, Faculty of Science and Science Education, Anchor University, Lagos

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