Cerebrum algorithm for automatic diet preparation

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***Abstract*—We have created a program that deals with the issue of dietetics and is strongly related to artificial intelligence. It aims to create an optimal nutritional plan. This is an innovative solution because our application is not only a basic calculator of calories, but thanks to a combination of advanced algorithms we can match the diet to each person individually unlimited number of times. There is a very large need on the market to develop such programmes because of the absence of dietary education in society and a large number of myths and incorrect and often misleading thesis.**

The idea behind the application was to help people who do not have knowledge about healthy diets. Thanks to the application, meals can be balanced and tasty. The user chooses how many meals wants to eat so the process of losing weight does not have to necessarily result in constant hunger. Neither building the muscles will not lead to eating too much. Our program is based on the kNN algorithm and soft sets. The soft sets choose allowed products. The kNN determines a product from allowed products that is closest to the point we need. This allows sufficiently good results to be obtained. The program is easy to use and requires only basic data from the user. Additionally, users can freely adjust one's meals with the food modes as intermittent fasting, no food after 18 or a regular meals every 3 hours.

I. Introduction

One of the problems of the modern world is the inappropriate consumption of meals.

Many people who want to lose weight look for help among 'wonderful' supplements, effectively slimming only wallets. Others spend hundreds of hours exercising or working out at the gym, but not getting the desired effects in a short time. There are also people who weigh too little and want to gain some weight.It concerns gym enthusiasts or underweight people who reach for different kinds of supplements in the form of powders or tablets that are very expensive.

An effective solution for them would be the help of a dietitian - a specialist who will effectively help to control body weight and choose a diet plan to match our individual preferences. However, the problem arises when we cannot determine the competence of the person to whom we entrust our goal.

A dietitian is a profession from which we require the knowledge about the issues of nutrition, help with choosing a balanced diet or time to explain us what a healthy lifestyle is.

Unfortunately, not long time ago, in Poland to become a dietitian there was no need to graduate from university. According to the law a short course was sufficient to have the status of a nutritionist. As a result our health might still be exposed to a risk due to insufficient knowledge of the so called "dietitians" and loose money for nothing. On the other hand, once we find a person with sufficient qualifications, we have to be aware that we will have to spend hundreds of zlotys on his or her service. So what should people who want to take control of their weight and achieve their goals without feeling of being on a diet and paying a huge amount of money do?

We recommend to use our diet app which thanks to advanced algorithms, accumulated knowledge and hours of work will help you with the perfect selection of macroelements. Our program is based on a combination of dietary and IT knowledge.

It will help to reduce weight, count calories, and prepare a plan of sample products for a single day. All you have to do is provide us with basic information about yourself and the program will suggest food products. Our application will select the right ingredients for your individual needs and preferences.

Our goal is to constantly improve the application, upgrade the algorithms and care about user's satisfaction. Soon there will be solutions to inform the user what GMOs are and whether to be afraid of them or not and other similar nutritional topics. There will also be section about how to distinguish reliable nutritional information from dangerous fake news.

We will also strive to improve our program so it can be compatible with social apps such as Facebook and Instagram.

Applications like ours are essential not only to lose weight, but also to gain proper dietary knowledge.

By using our application you will avoid dietary fake news and you will start to live in a healthy and balanced way.

A. Related works

From the point of view of modeling algorithms in order to select certain specific elements from the set due to the set of specific rules, various techniques of artificial intelligence can be used [1]. Neural networks or fuzzy logic are a popular tool. Especially the spiking neural network [2] – mathematical representation of mechanisms occurring in the human brain is an interesting subject, which is constantly being developed and analyzed in order to increase its accuracy and reduce the number of calculations. In [3]–[5], the authors proposed

the idea of using recursive approach to the classification of working groups or in the medical purposes. Again in [6], the idea of using and implementing convolutional neural network on mobile phones was described. Important issue is the creation of hybrid solutions like fuzzy logic with Markov chains [7] or neuro-fuzzy controler [8]. In this paper, we proposed a hybrid solution based on soft sets and k-nearest neighbors.

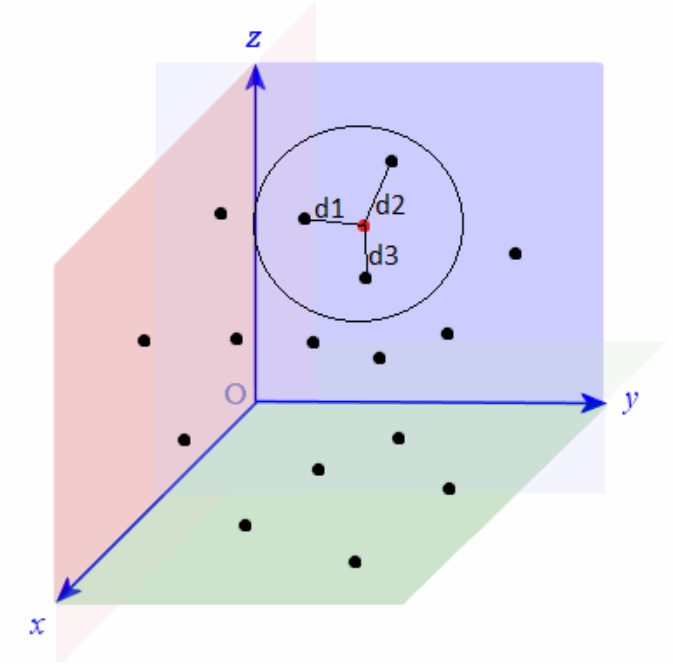

Figure 1: Traditional model of the kNN algorithm. The ideal point and 3 connections with points from the base are marked. The algorithm selects the point that is closest to the ideal point.

II. Proposed approach

Our original Cerebrum algorithm divides the dietary requirements according to the formula:

$$\alpha = \frac{Np}{\Delta m}, \beta = \frac{Nf}{\Delta m}, \gamma = \frac{Nc}{\Delta m} \tag{1}$$

where α, β, γ are the amount of proteins, fats and carbohydrates that a program assigns to a meal. Np, Nf, Nc are other requirements for proteins, fats and carbohydrates.
m is a difference between amount of meals declared by the user and the number of the current meal.

The products are analyzed by the algorithm based on soft sets. The list of allowed products is created by the following formula:

$$(\Omega \in (\zeta \in \alpha \wedge \zeta \in \beta \wedge \zeta \in \gamma)), \tag{2}$$

where Ω represents allowed products, ζ is the item in a set and α, β, γ are levels of required proteins, fats and carbohydrates

We use the K-Nearest Neighbors algorithm which is one of the non-parametric regression algorithms used in statistics to predict the value of a certain variable. It is based on following steps:
comparison of the values of explanatory variables for observations of C with values of these variables for each observation in the training set;
selection of k, which is a predetermined number, of the nearest to C observations from the set; average of the value of the explained variable for selected observations so as a result we get a forecast.

The mentioned kNN algorithm [9] determines the product that adapts best to the current daily requirement for macronutrients according to the formula:

$$\eta = 2 \cdot \Delta\alpha + \Delta\beta + \Delta\gamma \tag{3}$$

where η is the level of matching, $\Delta\alpha, \Delta\beta, \Delta\gamma$ are differences between needs for macronutrients and macronutrients of the product

The proteins have doubled value due to the high importance of this element and the rare occurrence in the products.

III. Description of the proposed system

At the beginning we use our own Cerebrum algorithm . It is used for dynamic distribution of nutritional values, depending on the products, their nutritional values and the user's daily demand. The dynamic division is based on checking the user's needs and then subtracting from them the sum of the values of the macroelements used in the list of products. Next, it's divided by the number of products declared by the user and decreased by the number of already used products.
Example: the user declared 10 products. The program found 3 products. Therefore, the division will be by 7, because: $10 - 3 = 7$.

The received request is sent to the Soft Set algorithm [10]. Then, from the list of available products soft sets select those products that do not exceed the daily requirement. It was planned for people who want to reduce body fat so they do not exceed the daily demand and can enjoy their dream figure sooner. Additionally, it provides correct results by the kNN algorithm, which will be explained in the next section.
The obtained products are analyzed by the kNN algorithm. This involves selecting the products that are closest to the requirements. If the macroelements of the products exceeded the daily demand, the distance would be negative, hence the protection in the Soft Set algorithm.
Finally, the best suited products are added to the list of products and the algorithm is executed until the number of products is reached.

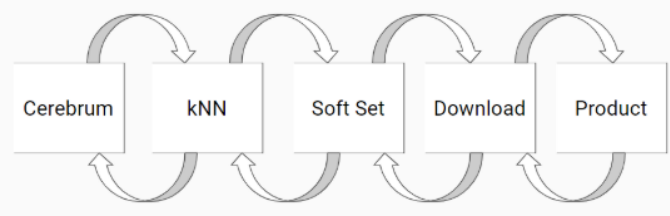

Figure 2: Visualization of the proposed method.

A. Pseudocode of the proposed algorithm

```
Cerebrum:
get protein, fat and carbohydrates from user
get number of meals from user
for (number of meal)
      get product from kNN
      add product to list
return products

kNN:
get protein, fat and carbohydrates from
    cerebrum
get products from SoftSet
for each product in products
      calculate fitness score
      if (fitness score > previous the best
          fitness score)
best product = product
return best product

SoftSet:
get protein, fat and carbohydrates from kNN
get products from Download
for each product in products
      if (requirements == true)
Add(product) to List
return List

Download:
get products from database
return products
```

IV. Experiments

We carried out a series of several experiments. A few of examples below

1) Man weighing 100 kg, interested in building the muscles.
   Our program estimated following macronutrient needs: proteins 200 g, fats 100 g, carbohydrates 575 g

2) Man weighing 100 kg, interested in weight reduction.
   Our program estimated following macronutrient needs: proteins 200 g, fats 70 g, carbohydrates 292 g

3) Woman weighing 70 kg, interested in loosing weight.
   Our program estimated following macronutrient needs: proteins 140, fats 50, carbohydrates 185g

4) Woman weighing 50 kg interested in muscles building.
   Our program estimated following macronutrient needs: 100g proteins, 45g fats, 223g carbohydrates

Person	Proteins	Fats	Carbohydrates	Average
1	0.50%	18.00%	0.00%	6.17%
2	4.00%	0.00%	2.40%	2.13%
3	1.43%	12.00%	0.54%	4.66%
4	1.00%	15.56%	0.45%	5.67%
Average	1.73%	11.39%	0.85%	**4.66%**

Table I: Achieved results- Percentage of mismatch

We can see from the Table I and diagram below that the estimated results are close to the expected daily demand for macronutrients.
The lowest mismatch turned out to occur for carbohydrates. The protein level was also very satisfactory. The greatest mismatch level of the program was for the fats.
Interestingly, the perfect fit of the fats was noticed for the person 2 from the experiment who wanted to lose weight. Other results for fats led to a more than 10 percent mismatch in average.
The final average mismatch of the program is less than 5 percent. You can therefore acknowledge the results of the program as reliable.

V. Conclusions

Based on the results of the analyzed persons, it can be concluded that the program is very good at finding products with an adequate supply of protein and carbohydrates. The level of fats is almost 89%, which is a satisfactory level.

The average lapse of the program was 4.66%, which is a very good result.
Statistically, the higher level of mismatch connected with fats than level of mismatch connected with of proteins or carbohydrates may result from the initially lower daily demand for these macronutrients. As a result, over the whole division, fat is more than 4.5 times less common than carbohydrates, having the same search weight in the kNN algorithm.
However, an interesting case is person number 2. Proportionally, the amount of macronutrients is not much different from other cases. However, the missing amount of fat was 0 %. At the same time, this person has the lowest mismatch bias, which is only 2%.

The program allows to efficiently search for products that allow effective help in achieving goals. Most importantly, it does not use stereotypical divisions for the "healthy" and "unhealthy" food. Instead, each food product is treated objectively, according to its properties. It avoids subconscious thinking about food products as good or bad.
In our innovative application, everything depends on objective values. Therefore, a person who wants to reduce weight can

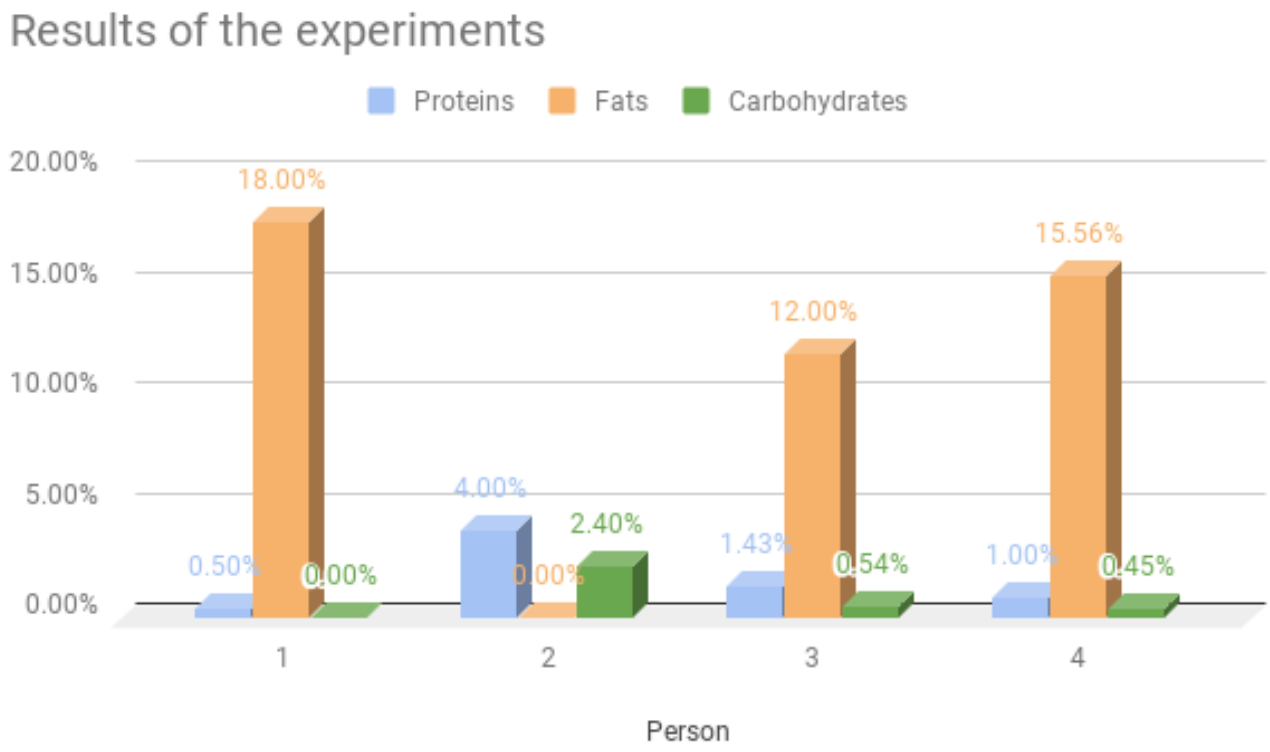

Figure 3: Diagram presenting results of the experiments- the level of mismatch

eat a cheeseburger and a pizza while losing weight.
An important attribute of the application is also the control of the amount of dishes. Thanks to this the user can freely choose whether one wants to eat pizza or a large amount of vegetables or other products.

References

[1] F. Beritelli, G. Capizzi, G. Lo Sciuto, C. Napoli, and F. Scaglione, "Automatic heart activity diagnosis based on gram polynomials and probabilistic neural networks," *Biomedical engineering letters*, vol. 8, no. 1, pp. 77–85, 2018.

[2] S. Brusca, G. Capizzi, G. Lo Sciuto, and G. Susi, "A new design methodology to predict wind farm energy production by means of a spiking neural network–based system," *International Journal of Numerical Modelling: Electronic Networks, Devices and Fields*, vol. 32, no. 4, p. e2267, 2019.

[3] C. Napoli, G. Pappalardo, E. Tramontana, R. K. Nowicki, J. T. Starczewski, and M. Woźniak, "Toward work groups classification based on probabilistic neural network approach," in *International Conference on Artificial Intelligence and Soft Computing*. Springer, 2015, pp. 79–89.

[4] M. Woźniak, D. Połap, G. Capizzi, G. L. Sciuto, L. Kośmider, and K. Frankiewicz, "Small lung nodules detection based on local variance analysis and probabilistic neural network," *Computer methods and programs in biomedicine*, vol. 161, pp. 173–180, 2018.

[5] M. Wozniak, D. Polap, L. Kosmider, C. Napoli, and E. Tramontana, "A novel approach toward x-ray images classifier," in *2015 IEEE Symposium Series on Computational Intelligence*. IEEE, 2015, pp. 1635–1641.

[6] X. Zhang, X. Zhou, M. Lin, and J. Sun, "Shufflenet: An extremely efficient convolutional neural network for mobile devices," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2018, pp. 6848–6856.

[7] H. Xie, G. Tian, G. Du, Y. Huang, H. Chen, X. Zheng, and T. H. Luan, "A hybrid method combining markov prediction and fuzzy classification for driving condition recognition," *IEEE Transactions on Vehicular Technology*, vol. 67, no. 11, pp. 10 411–10 424, 2018.

[8] S. Parvathavardhini and S. Manju, "Cancer gene detection using neuro fuzzy classification algorithm," *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, vol. 3, no. 3, pp. 1223–1229, 2018.

[9] N. S. Altman, "An introduction to kernel and nearest-neighbor nonparametric regression," *The American Statistician*, vol. 46, no. 3, pp. 175–185, 1992.

[10] P. K. Maji, R. Biswas, and A. Roy, "Soft set theory," *Computers & Mathematics with Applications*, vol. 45, no. 4-5, pp. 555–562, 2003.

[11] B. Ahmad and A. Kharal, "On fuzzy soft sets," *Advances in fuzzy systems*, vol. 2009, 2009.

[12] B. Shaw and T. Jebara, "Structure preserving embedding," in *Proceedings of the 26th Annual International Conference on Machine Learning*. ACM, 2009, pp. 937–944.

[13] V. Kuznetsov, A. Y. Andreev, O. Kuznetsov, L. Nikolaeva, T. Zotova, and N. Gudkova, "Heavily doped si layers grown by molecular beam epitaxy in vacuum," *physica status solidi (a)*, vol. 127, no. 2, pp. 371–376, 1991.