System DietadHoc: A Fusion of Human-Centered Design and Agile Development for the Explainability of AI Techniques Based on Clinical and Nutritional Data

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Abstract: In recent years, the scientific community's interest in the exploratory analysis of biomedical data has increased exponentially. Considering the field of research of nutritional biologists, the curative process, based on the analysis of clinical data, is a very delicate operation due to the fact that there are multiple solutions for the management of pathologies in the food sector (for example can recall intolerances and allergies, management of cholesterol metabolism, diabetic pathologies, arterial hypertension, up to obesity and breathing and sleep problems). In this regard, in this research work a system was created capable of evaluating various dietary regimes for the aforementioned specific patient pathologies. The system is based on a mathematical-numerical model and is tailored for the real working needs of experts in human nutrition, endocrinologists and cardiologists, using the Human-Centered Design (HCD - ISO 9241 210). DietAdhoc is a decision support system to the aforementioned specialists for patients of both sexes (from 18 years of age) developed with an innovative agile methodology. The software consists in drawing up the biomedical and clinical profile of the specific patient by applying two implementation approaches on nutritional data.

1 INTRODUCTION

Food science is currently an area of particular scientist interest, both for software developers, and for the clinical specialists involved (nutritional biologist, cardiologists, diabetologists and endocrinologists). "Do it yourself" diet software, advertised on internet, television and in newspapers, are often followed by people with various types of nutritional problems. In this research work the direct interaction with a dietician - nutritional biologist made it possible to highlight that the problem with such lies in the fact that, once tested, they generate approximate and incomplete results, often causing situations of malnutrition. Basing on the HCD approach, in the user – research phase (Mastrangelo et al., 2015), and under the supervision of the nutritional biologist involved in the creation of the DietAdhoc system, twelve commercial software tools (DietUp[1], Easy Diet[2],

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[1] dietup.it
[2] easydiet.it

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Evolution Fit[3], Fatsecret[4], Melarossa[5], MetaDieta[6], Myfitnesspal[7], Nutribook[8], Nutrium[9], Nutriverso[10], SifaDieta[11], Winfood[12]) have been evaluated in all their functionality. It was found that the aforementioned software tools, available through various subscription formulas, present generic and redundant functions and therefore are incomplete for all the clinical. Practically such systems don't adequately support end user (specialists in human nutrition, cardiologists, diabetologists and endocrinologists) for their lack of explainability and reliability. During this assessment, it has been possible to highlight the absence of an exploratory analysis of a patient's clinical and nutritional data and a poor attention to the relevant aspects, specifically in the following areas:

- allergies and intolerances (shellfish, dried fruit, mushrooms, gluten, lactose, yeasts, nickel and other);
- analysis of the pathological history with possible familiarity (anemia, autoimmune pathologies, endocrine pathologies, oncological pathologies and cardiovascular risk);
- functional anamnesis analysis (abdominal pain, bowel movements, asthenia, menstrual cycle, dermatitis, dyspepsia, eczema, hiatal hernia, stools, smoking, gastritis, abdominal swelling, loss of appetite and myalgia);
- analysis of sports activity (type of discipline and daily frequency);
- complete evaluation of total blood chemistry tests (azotemia, blood urea nitrogen, blood glucose, creatinine, direct bilirubin, indirect bilirubin, total bilirubin, total cholesterol, cardiovascular risk index, chemical test of urine, cholesterol HDL, cholesterol LDL, creatinine, eGFR, mGFR, complete blood count, ferritin, glycolysed hemoglobin (HbA1c), Homa Index IR, Homa – β, insulinemia, homocysteine, hormonal dosages, iron level in blood, triglyceridemia, transaminases GOT, transaminanes GPT);
- any therapies in progress, or taken in the last few months (name of the drug with relative dosage);
- section in which the nutritional biologist can insert complementary clinical notes;
- dynamic configurators for determining the macronutrients to be consumed daily (carbohydrates, proteins and fats) for evaluating the kilocalories and micronutrients (cholesterol, fibers, potassium, sodium, etc.) to be consumed in the various meals of the day;
- ORAC values (antioxidant power of foods) to counteract cellular aging (Haytowitz D.B. et al.,2010);
- PRAL values (renal acid load potential) to calculate the chemical balance of the acidifying and alcalinisant molecules of a food (Remer et al., 1995);
- BIA data, (obtained from the bioelectric impedance analysis) – (Mehra et al., 2024);
- glycemic index of a food (Scazzina F. et al., 2016);
- glycemic load, calculated based on the quantity of carbohydrates in the food portion in grams for the specific glycemic index (Scazzina F. et.al., 2016);
- absence of the glycemic curve of the meal;
- absence of the weight history (current weight, desirable weight, ideal weight).

These gaps obviously cause an approximation of the patient's clinical profile. As will be explained in detail in the following chapters, the objective of this research word consists in creating a virtuous integration between the consolidated clinical experience of a specialist in human nutrition and its supporting technical equipment to create a software that improve patient well-being and help prevent diseases **(Figure 1).**

Figure 1: DietAdhoc's virtuos integration.

[3] evolutionfit.it
[4] fatsecret.it
[5] melarossa.it
[6] metadieta.it
[7] myfitnesspal.com
[8] nutribook.app
[9] nutrium.com
[10] nutriverso.cloud
[11] sifadieta.com
[12] winfood.it

2 DIETADHOC DESIGN

During the user research phase of HCD approach, the designer of the DietAdhoc system takes into account various clinical checks and visits carried out by the nutritional biologist (ethnographic research). Following this process, the system designer develops a series of unstructured interviews and specific questionnaires to define:

- the complete profile of the characteristics of the nutritional biologist and of the designer – system administrator who will use the system [age, gender, type of interaction with the system (primary or secondary), frequency of use of the system (daily, in the specific case), level of computer experience (inexperienced, sufficient, good, expert), system usage time and technical support equipment];
- task analysis (both for the nutritional biologist, and for the designer - system administrator);
- usage scenarios (both for the nutritional biologist, and for the designer – system administrator);
- future stakeholders (cardiologists, diabetologists and endocrinologists), interested in scientific collaborations to share clinical information for the creation of a multidisciplinary team).

In the initial phase, the two figures in charge of the software will be the nutritional biologist (domain expert) and the system designer who will also act as system administrator. The nutritional biologist, is 32 years old and has basic computer skills. He represents the primary user of the system because he uses it daily and deals with the insertion and update of all the patient's clinical data (including reports from other specialists), of a new food portions relating to certain diets into the database, and for the generation of clinical reports to be sent via e-mail to patients). The designer – system administrator, is 42 years old, and has a high level of computer skills. He represents the secondary user of the system because he is contacted on the base of the needs of the nutritional biologist. The system designer remotely checks for any malfunctions in the workflow and in the interfacing with the technical instrumentation.

Subsequently the nutritional biologist has contacted other medical specialists (cardiologists, diabetologists and endocrinologists) for the creation of a scientific multidisciplinary team to support the DietAdhoc® system. The current technical instrumentation supporting the human nutrition specialist consists of: SECA 799 digital column scale, the SECA mBCA 525 digital bioimpedance meter and the GIMA digital caliper. At the moment the system administrator is in contact with the commercial and technical managers of the aforementioned medical devices to evaluate the possibility of inserting the DietAdhoc system into them. Finally, based on the data obtained from unstructured interviews and questionnaires, also addressed to the aforementioned clinical specialists, the designer created usage scenarios, i.e. descriptions in natural language, of how the application (with all the tasks identified) will be used by current and potential users in order to verify all the needs expressed.

2.1 Requirements

It was found that a software to support a professional in the field of nutrition, compared to classic data processing applications coded in a procedural manner, had to manipulate a knowledge of a clinical nature with an inferential approach and had to allow an analysis of the patient with three levels of detail:

- descriptive – analyze the data of the various patients to decipher the latent details that escape medical procedures;
- predictive – creation of analytical and complete models from the aforementioned latent data with the aim of predicting valid results from the scientific community in the nutritional field;
- prescriptive - suggest corrective clinical actions for a given patient, using all the information that the system has generated.

In this regard, the operational knowledge was codified in the system by the designer and the following high fidelity prototypes were created (Conceptual design - second phase of HCD process):

- a section concerning four food categories (main food, vegetables, fruit and drinks) so that the nutritional biologist can insert, update and delete food portions with the relative contribution in kilocalories (kcal), macronutrients (carbohydrates, proteins and fats) and other nutritional parameters (cholesterol, ORAC, PRAL, and salts);
- a section for all patient data (name, surname, age, birth of date, gender, identity document, tax id code, telephone reference, e-mail, working activity, eventual Vat number);
- a section for entering medical reports of other professionals;
- a dynamic menu for evaluating the patient's medical history, blood chemistry tests and

current therapies;

- an accurate generator of anthropometric parameters based on seven basic measures from which all the others are derived;
- two menus for evaluating bioelectric impedance vector analysis (BIVA) and the analysis with digital caliper;
- two automatic food regime configurators;
- three heuristic algorithms based on clinical and nutritional data.

In the third phase of HCD process (Evaluation), the nutrition biologist carries out a thinking aloud usability test, designed by the system administrator, to evaluate the prototypes created in the conceptual design. All the functions can be viewed in the demonstration session of the system present at this link:

https://drive.google.com/file/d/1tnHvpCYAw444Oc28-mighNLX9SmV_Of-/view?usp=sharing

From the aforementioned demo, it has been found that the HCD design process is the conceptually correct model for the creation of decision support systems for human health professionals; the product is seen, even partially, from the beginning of the process and is perfected in subsequent increments. In this way, the nutritional biologist, continuously interfacing with the system administrator, can continually experiment with each implementation choice, immediately discarding the wrong ones **(Figure 2).**

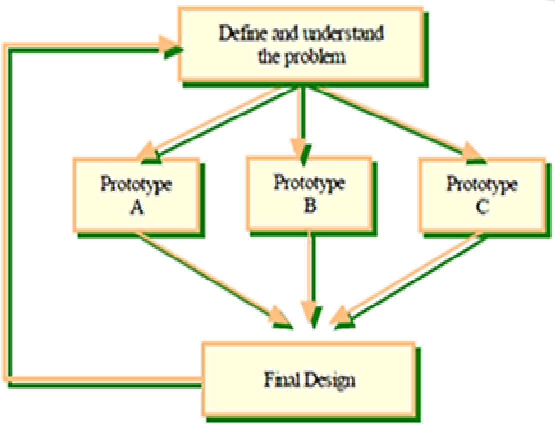

Figure 2: Iterative HCD Design Process adopted for DietAdhoc System.

Each prototypes of the DietAdhoc® system have been developed in Java language with an agile methodology **(Figure 3)** until the beta version of the DietAdhoc system is created.

Figure 3: Agile development adopted for DietAdhoc system.

The iterative design, the user involvement, the continuous prototyping and testing unite HCD Design process and Agile Development.

3 MATHEMATICAL MODEL

Unlike commercial software in the biomedical-nutritional field, mentioned in the section 1, the DietAdhoc system is founded on a mathematical model which provides scientific evidence and empirical evidence to this research work. The model determines an optimal requirement of daily kilocalories (in kcal), according to certain constraints on the requirement of macronutrients (carbohydrates, proteins and fats in grams), micronutrients (cholesterol, fibers, potassium, sodium, etc.) and other nutritional parameters (ORAC, PRAL, glycemic loads, and salts) basing on patient's clinical situation.

The specific dietary regime is automated by the system DietAdhoc which supports the professional in reaching the final diagnosis through a process of successive steps with the intervention of the doctor (as supervision). This model is based on a problem of continue optimization, therefore the decisional variables (the kilocalories of each portion of food belonging to four food categories) are defined on $\mathbf{R^n}$ (continue values). The scope of the study consists to maximize a quantity (the daily kilocalories for the specific diet, given by the sum of each combination of four portions of food, or of n portions chosen through the next two algorithms) through a function f: $\mathbf{R^n} \rightarrow \mathbf{R}$ with $\mathbf{S \subseteq R^n}$ according to the notation $\mathbf{max\{f(x): x \in S\}}$. The function $\mathbf{f(x)}$ is a function of n real values $\mathbf{f(x_1,x_2,\ldots,x_n)}$, called objective function, and the set S, the admissible set, i.e. the set of possible solutions to the problem. The set S is a subset of $\mathbb{R}^n$, so $\mathbf{x} = \mathbf{(x_1,x_2,\ldots,\ x_n)^T}$ is an n-dimensional vector variable. Every $\mathbf{x \in S}$ is an admissible solution. The admissible set **S** is described by a finite set of inequalities, or equations, of the type $\mathbf{g(x) \geq b}$, $\mathbf{g(x) = b}$, $\mathbf{g(x) \leq b}$ where g being a real-valued function defined on $\mathbb{R}^n$, while $\mathbf{b} \in \mathbb{R}$. More formally, assigned m functions $\mathbf{g_i}$**:** $\mathbb{R}^n \rightarrow \mathbb{R}$**,** $\mathbf{i = 1,2\ldots, m}$. and m real scalars b_i, we have that S is expressed in the form: $\mathbf{S = \{x \in \mathbb{R}^n \mid g_i(x) \geq b_i,\ i = 1,2,\ldots m\}}$. All of that inequalities $\mathbf{g_i(x) \geq b_i}$ represents a constraint, (the daily grams of nutrients to be consumed for the specific diet) and the admissible set is therefore formed by all those points x which are solutions of the system of inequalities. More specifically the objective function **f(x)** and all the functions that define the constraints $\mathbf{g_i(x)}$, $\mathbf{i = 1,2\ldots,m}$. are linear, that is expressible in the form $\mathbf{c_1x_1+c_2x_2+\ldots+c_nx_n}$ **(Figure 4)** where we may take the costs ci to be equal to unity **(c=1)** since in a clinical treatment it is not important to consider the economic side of food portion.

Formally, by introducing $c \in \mathbb{R}^n$ (cost vector), defined as $\mathbf{c = (c_1,\ldots, c_n)^T}$, $\mathbf{x \in \mathbb{R}^n}$, and $\mathbf{x = (x_1,\ldots,x_n)^T}$, the objective function can be written in vector notation as:

$$f(x) = c^T x = \sum_{j=1}^{n} c_j x_j = c_1 x_1 + c_2 x_2 + \ldots + c_n x_n.$$

Figure 4: Objective function.

The decision problem consists in determining the portions (in kcal) of each portions of food, $\mathbf{x_j}$**,** $\mathbf{j = 1,2\ldots,n}$, for the particular diet to be followed, so that the quantity of the j-th nutrient, present in a portion of food, is greater than, or equal to, the recommended value bi, daily requirement (in grams) of the j-th nutrient.

4 SYSTEM DESCRIPTION

In the specific clinical case, after entering of all the patient's clinical data and with the automatic generation phase of anthropometric values (phases that can be viewed in the demonstration session of software in section 2.1), the nutritionist biologist will evaluate a first dietary regime for the particular diet. The nutritionist biologist can set the dynamic configurator that determines the kilocalories of the diet (1413 – the objective function distributed for four meals of the day) and the quantity in kilocalories, and in grams, of macronutrients to be consumed.

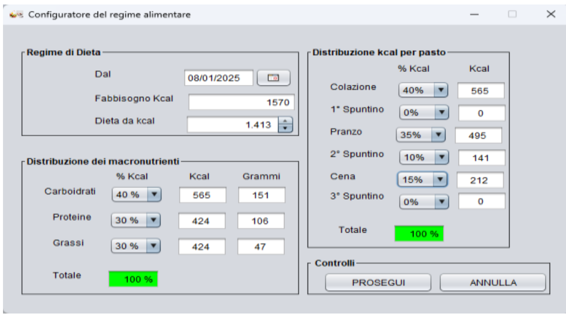

Figure 5: Diet configurator.

Two computational approaches have been applied to process the clinical and nutritional data generated by the system. The first approach, based on the enumerative - heuristic algorithm with constraints, has been designed according to three levels of abstraction:

- planning of the specific meal which corresponds to the choice of a combination made up of four portions of foods belonging to the categories (main food, vegetables, fruit and drinks), to be taken within the specific meal (breakfast, morning snack, lunch, afternoon snack , dinner and third snack);
- planning of the day which corresponds to the choice of combinations made up of four portions of foods to be eaten over the course of a day (breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack);
- planning of the week which corresponds to the choice of the daily combinations made up of portions of four foods to be consumed over the course of a week.

This algorithmic approach is based on the first specialist's modus operandi and considers a decomposition of the original problem into simpler sub-problems to solve. It is an implicit enumerative procedure in several steps. Initially it generates all the possible solutions (combination of four portions of food in the research space), then in the next steps the specialist evaluates the heuristic **("MEDIA CHILOCALORIE")** and sets the bounds to choose the optimal food combination of four meals for the specific patient based on his specific eating disorder.

Naturally, for the specific nutritional problem, the operating logic of the step of choosing the optimal food combination is controlled by the nutritional biologist and is extended for the six meals of the day.

From a conceptual point of view, the technique implemented in the system for the first enumerative -

heuristic algorithm adopts the following steps:
1. Automatic generation of the n-ary tree of the all set of eligible solutions ***S*** (combination of four portions of food in the research space) based on the value of the objective function (kilocalories for the specific meal – i.e 565 kcal for breakfast) set by the nutritional biologist through the diet configurator **(Figure 5)**;
2. First summary evaluation by the nutritional biologist of the n admissible solutions (n child nodes of the n-ary tree) based on the objective function (565 kcal for breakfast) and average value (of all food combination) 312 kcal like heuristic, of all food combinations **(Figure 6)**;
3. The nutritional biologist sets lower and upper bounds (operation on the objective function) to avoid the evaluation of all food combinations of the four food portions (method not feasible from a computational point of view) **(Figure 7)**;
4. Evaluation of the optimal feasible solution, **f(x*)**, in the range of lower (i.e. 396 kcal) and upper (i.e. 442 kcal) bounds of the objective functions and completed by an integrated step based on a local search approach that explores a neighborhood ***N: S*** → ***N(S)*** subset of the feasible set **S**, and determined by the bounds and the heuristic, the average of food combinations included in the bounds (i.e. 415 kcal). In choosing the most suitable food combination for the specific meal of the day, the nutritional biologist will be able to take advantage of the clinical information (histogram of nutrients and glycemic curve of the combinations) present in the sections **“NOTE CLINICHE”** and **“STATISTICHE”** (to be viewed in the software demo session – section 2.1**)** to evaluate the constraints (cholesterol, fibers, potassium, sodium, etc.) of each combination of four portion of food **(Figure 7).**
5. The food combination chosen for breakfast by the nutritional biologist is the following: gran cereale (4 biscotti – 100 g) , fiocchi di avena (30 g), banana (25 g) and yoghurt greco liquido (150 g);
6. Iteration of the previous steps for all remaining meals of the day determined through the diet configurator (lunch, afternoon snack, and dinner – **Figure** 5);
7. Stop criterion (the nutritional biologist chose the daily food combination).

Note 1 - For the first computational approach, the **"SALTA PASTO"** option was programmed which allows not to consider a combination of food portions for each of the six programmed meals (breakfast, morning snack, lunch, afternoon snack, dinner, evening snack).

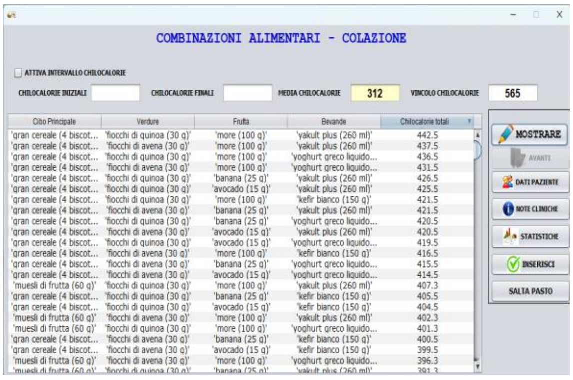

Figure 6: Running demo session of the steps 1 and 2 of the enumerative - heuristic algorithm with constraints.

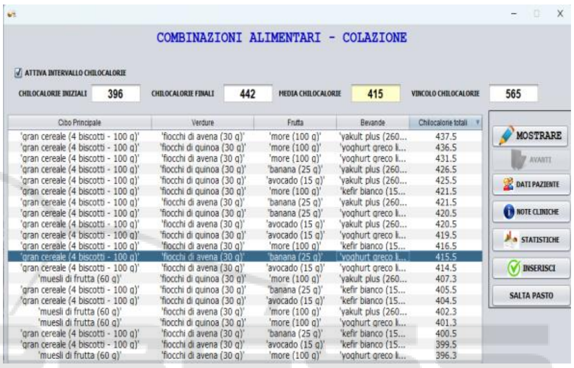

Figure 7: Running demo session of the steps 3 and 4 of the enumerative - heuristic algorithm with constraints.

The first heuristic algorithm has been implemented through a two-dimensional array of real numbers, ***double[][] foodmatrix = new double [n][m]***; having as rows, n, the portions of the food for the specific meal to which the relevant kilocalories are associated, while as the m columns (m=5) the specific food category (main, food, vegetables, fruit and drinks) and like last columns the sum of the kilocalories of the selected food combination. The second solution approach, based on a combinatorial - heuristic algorithm with constraints, has been designed according to three levels of abstraction:

- specific meal planning - corresponds to the choice of **n** portions of foods, belonging to the categories (main food, vegetables, fruit and drinks), to be taken within a specific meal (breakfast, morning snack, lunch, afternoon snack, dinner, and third snack), calibrated for a single meal;
- planning of the day - corresponds to the choice of **n** portions of foods, belonging to the categories (main food, vegetables, fruit and drinks), to be taken within the six specific meals

(breakfast, morning snack, lunch, afternoon snack, dinner and third snack), calibrated for a day;

- planning of the week - corresponds to the choice of **n** portions of foods, belonging to the categories (main food, vegetables, fruit and drinks), to be taken within the six specific meals (breakfast, morning snack, lunch, afternoon snack, dinner and third snack), calibrated for a week.

The idea behind the second algorithmic approach is to adopt an expansion criterion based on the most "promising" decision in a given step of the problem to reach an optimal solution for the given meal of the day, **f(x*)**, compatibly with the constraints imposed on the nutrients to be respected for the specific diet. The expansion criterion is updated iteratively to take into account previously evaluated decisions. The combinatorial algorithm with constraints created allows the nutritional biologist to iteratively add, or not, the portions of food with relative kilocalories until arriving at a complete solution (expansion criterion for the specific meal of the day). At each iteration, the portions of food, with relative kilocalories, that produces the greatest improvement in the objective function for the specific meal of the day is added (automatically determined by the food regime configurator under the supervision of the nutritional biologist). This algorithmic approach is applicable if the solution (a combination of n food portions for all meals of the day) can be obtained as a subset of input data (all the possible combination of m food portions for all meals of the day) – **(Figure 8)**

Below is the formalization of the data of the second algorithmic approach:

S.P. = Specific problem (maximization of the objective function based on kilocalories of food portions for all meals of the day), established by the nutritional biologist and evaluated by the diet configurator with the relative constraints imposed on nutrients;

S = Set of eligible solutions (food portions for the specific daily meal: breakfast, morning snack, lunch, afternoon snack , dinner and evening snack);

$S_{optimal}$ = Subset of ***S***, consisting of optimal portions of food chosen by the nutritional biologist for the particular diet;

$S_{partial}$ = Partial solution for the specific meal of the day (breakfast, morning snack, lunch, afternoon snack, dinner, evening snack) chosen by the nutritional biologist for the particular diet;

Beyond the conceptual scheme of the second algorithmic approach is the following:

1. Initialize the problem instance ***S.P***.;
2. Evaluate the set of admissible solutions ***S***;
3. For each choice to be made, the nutritional biologist makes the optimal decisions respecting the nutritional constraints of the specific problem ***(S.P.)***;
4. The criterion for inserting the n portions is dynamically updated in order to take into account the choices made previously to determine the partial solution $S_{partial}$

There are two stopping criteria:
1. predetermined number of choices, made by the biologist nutritionist, for the specific daily meal;
2. obtaining final optimal solution consisting of most suitable portions of food chosen by the nutritional biologist for all daily meals.

Beyond the conceptual scheme, it is possible to formalize the combinatorial- algorithm with constraints in pseudocode:

INPUT ***S.P.*** (Instance of the specific problem)
$S \leftarrow S_{partial}$ (Initializing partial solution for S.P.)
WHILE ***S*** can be extended DO
Find the $S_{optimal}$ extension of S: $S \leftarrow S_{optimal}$
END WHILE
OUTPUT ***S***

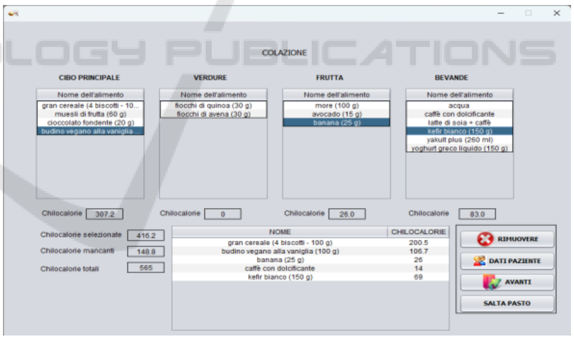

Figure 8: Running demo session of the combinatorial – heuristic algorithm with constraints.

In the specific case:

S.P. = maximization of the kilocalorie value established by the diet configurator for the specific meal (565 kcal for breakfast)

S = totality of the specific clinical choices of the nutritional biologist based on the food portions foreseen for the specific meal (breakfast);

$S_{optimal}$ = choice by the nutritional biologist of all the food portions, among the various available , most suitable for the specific daily meal and for the particular diet;

***S**partial* = gran cereale (4 biscotti – 100 g), budino vegano alla vaniglia (100 g), banana (25 g) and caffè con dolcificante e kefir bianco (150 g).

The algorithm was implemented through a circular queue. In this way the nutritional biologist can eventually delete ***[dequeue operation – Dequeue()]*** the choice of food portions belonging to four categories (main food, vegetables, fruit and drinks). Seeing the demonstration session present in paragraph 2.1, the nutritional biologist has a real time evaluation of the update, or modification of the objective function (kilocalories associated with food portions for the specific meal) – **(Figure 8).**

5 DEDUCTIVE DATABASE

In the previous chapters, two heuristic algorithms were shown that allow the nutritional biologist to examine various food combinations and determine the most suitable ones for the specific patient. At the same time, the DietAdhoc system can have a symbolic approach. If Prolog programs are constrained to use only atoms, integers, and reals, and do not allow recursive rules, you get a powerful subset of SQL. Under these assumptions, Prolog and SQL share a core: every query expressible in a subset of Prolog can in turn be expressed in a subset of SQL, that means these subsets are logically equivalent (Warren D.S., 1999).

For this research work, it has been studied the possibility of interfacing SWI - Prolog with the DBMS at the basis of the DietAdhoc system through the ODBC driver **(Figure 9)**, transforming the relational database underlying the system into a deductive database. Prolog rules has been created which allow the connection with the relational database of the DietAdhoc system, access its tables, carry out queries (even nested), generate all the anthropometric parameters of the patient and evaluate the enumerative - heuristic algorithm **(Figure 10).**

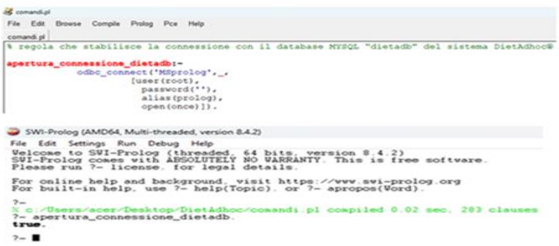

Figure 9: Connection with the deductive database.

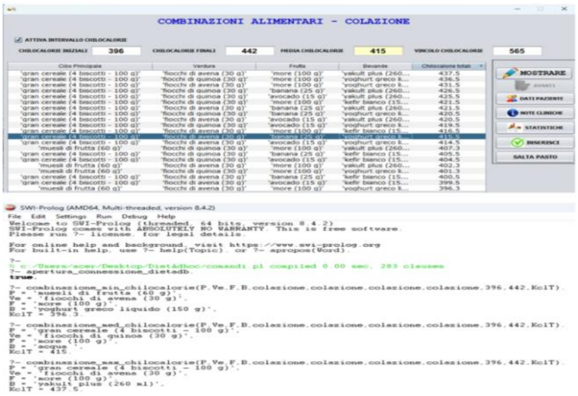

Figure 10: Enumerative - heuristic algorithm in the form of Prolog rules of a deductive database (corresponding to the specific Java interface).

6 EXPERIMENTAL RESULTS

For the first and the second algorithmic approaches, once the nutritional biologist chooses the food combinations for the particular diet, the system generates a final daily report in which it is possible to view all the data obtained with flexible and customizable user interfaces for the purposes of the various clinical assessments **(Figure 11).**

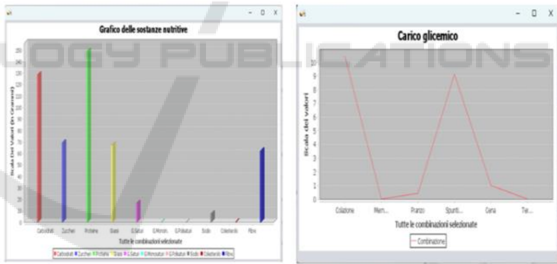

Figure 11: Decision support through various graphical components.

The nutritional biologist will be able to view the composition of the macronutrients and micronutrients of the chosen food combinations via a special histogram **(Figure 11).** In the case of the glycemic curve (Carico glicemico) for the diagnosis of diabetes, through a time series the Y phenomenon was modeled through five observations at time t, corresponding to the six daily meals, with integer t varying from 1 to t. **(Figure 11)**.

The vector bioelectrical impedance analysis (BIVA) is a methodology developed in the second half of the 1990s, which uses vector models and is based on the electrical properties of tissues without the use of constants, equations and body weight. These characteristics, together with the low cost and speed of execution, make BIVA the type of bioimpedance analysis most used for all those patients who present alterations in renal and/or cardiac function, or who find themselves in conditions of extreme malnutrition, as well as for cancer and neurodeprived patients, who may have difficulty interacting correctly or enduring exams that take too long (Campa F. et al., 2023). The report includes a graphical representation (vectors) of the body resistance and reactance values **(Figure 12)**. This therefore allows an evaluation of the subject's hydration and nutrition status independently and without a mathematical calculation of the data based on the resistance/reactance detected.

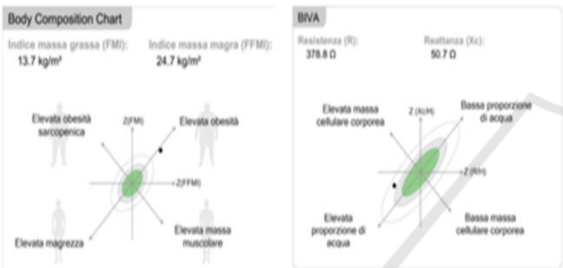

Figure 12: BIVA data.

7 COPYRIGHT

The algorithms implemented and the source code of the DietAdhoc system are protected by copyright law (Legislative Decree 518/1192, E.C. Directive 250/91, Law 747/1994, L.633/1941 Articles 20 and 24). Anyone who violates the aforementioned regulations faces civil and criminal sanctions relating to the legal protection **of** the DietAdhoc software (Law 248/2000).

8 CONCLUSIONS

Basing on the initial clinical objectives agreed with the domain expert, it has been demonstrated that two computational approaches, enhanced by the complete explanation of the decisions generated, can configure diets supported by the scientific community providing an aid to the diagnosis of various eating disorder with the generation of a complete prediction model.

Some system upgrades are currently in development:

- Import and integration of biomedical data of a semi-structured nature (json and xml), and in csv format into the system DietAdhoc;
- Distributed evolution of software for the creation of a collaboration network between experts in the nutrition sector and other specialists;
- Human – Centred AI (HCAI) techniques which allow to have a complete vision of all the data generated by the system for the purpose of clinical choices;
- Insertion of predictive machine learning algorithms for the exploratory analysis of clinical and nutritional data;
- Symbiotic Artificial Intelligence (SAI) techniques for support, without replacing them, other specialists in human nutrition, and professionals in the medical field interested in a scientific collaboration;
- Visual Data Mining techniques to discover regularities and patterns in patients with similar ongoing therapies;

In subsequent papers, a framework will be proposed to accelerate the transfer of artificial intelligence to clinical contexts and to personalize the treatment of all nutritional pathologies

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