Computers in Biology and Medicine 70 (2016) 67–79

Contents lists available at ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/cbm

The Latin American laws of correct nutrition: Review, unified interpretation, model and tools

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ARTICLE INFO

Article history:
Received 25 September 2015
Accepted 22 December 2015

Keywords:
Laws of Nutrition
Domain model
Diet planning
Menu planning
Unified Modeling Language (UML)
Object Constraint Language (OCL)
Software
Model validation

ABSTRACT

Background: The "Laws of Correct Nutrition": the Law of Quantity, the Law of Quality, the Law of Harmony and the Law of Adequacy, provide the basis of a proper diet, i.e. one that provides the body with the energy required and nutrients it needs for daily activities and maintenance of vital functions. For several decades, these Laws have been the basis of nourishing menus designed in Latin America; however, they are stated in a colloquial language, which leads to differences in interpretation and ambiguities for non-experts and even experts in the field.

Methods: We present a review of the different interpretations of the Laws and describe a consensus. We represent concepts related to nourishing menu design employing the Unified Modeling Language (UML). We formalize the Laws using the Object Constraint Language (OCL). We design a nourishing menu for a particular user through enforcement of the Laws.

Results: We designed a domain model with the essential elements to plan a nourishing menu and we expressed the necessary constraints to make the model's behavior conform to the four Laws. We made a formal verification and validation of the model via USE (UML-based Specification Environment) and we developed a software prototype for menu design under the Laws.

Conclusion: Diet planning is considered as an art but consideration should be given to the need for a set of strict rules to design adequate menus. Thus, we model the "Laws of Nutrition" as a formal basis and standard framework for this task.

1. Introduction

For a long time society has recognized the relationship between diet and health. But today's common concepts of 'balanced diet' or 'good nutrition' have emerged since 1935 when Dr. Pedro Escudero, considered the "father of nutrition" in Latin America [1,2], proposed four Laws of Correct Nutrition, now considered one of his fundamental contributions to the discipline [3]. Also known as "Laws of Feeding"[1] [4], these Laws are:

- Law of Quantity, which states that the amount of energy the body demands should be the amount consumed.
- Law of Quality, which states foods from all the food groups should be consumed.
- Law of Harmony, which highlights the need to keep a proper relation between the distributions of ingested nutrients.
- Law of Adequacy, which insists on adapting diet to the nutritional, social and psychological needs of individuals.

On the one hand, the importance of the Laws of Correct Nutrition is that they are the basis of nutrition theory [5] as they serve as a rule to correctly calculate nutritious menus and to classify them. However, since their introduction these Laws have been stated in natural language, which has the disadvantage of allowing different interpretations depending on the personal point of view, knowledge and experience of the reader. In fact, discrepancies in interpretation can be found in the literature, especially on informal Web sites as well, as different interpretations in different countries.

On the other hand, the general-purpose diagram-based Unified Modeling Language (UML) is currently the standard modeling language for the analysis and design of information systems. However, this is not the only field in which this language can be used as its applicability to cases that need to be modeled has been proved with multiple examples [6]. In medical systems, for example, there are models for stroke rehabilitation processes [7], models for the molecular biology domain [8], and UML forms the basis of the caCORE Software Development Kit [9].

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[1] For sake of simplicity, we will call them "Laws of Nutrition", as no official translation is available.

http://dx.doi.org/10.1016/j.compbiomed.2015.12.019

Nevertheless, UML itself lacks of sufficient expressiveness to specify detailed restrictions of classes and data types. To support such expressiveness a new standard has emerged: Object Constraint Language (OCL) that is a formal notation created to describe constraints and restrictions on UML objects models [10]. OCL allows the expression of arbitrarily complex constraints that must be always true (called invariants) which may be global properties or may be associated with methods of a class [11].

The main advantage of OCL is that it allows specifying restrictions on a notation free of ambiguities and without side effects, so it is used to complement UML diagrams. Although other languages that can be used to the same purpose, OCL is the only one that is standardized [12].

OCL has been used to model different kind of problems, for example, in the validation of the security properties of the San Francisco Subway train system [13], to specify the API of the Java Card smart card [14], or to specify business rules of financial messaging [15]. In medical systems, there is GELLO, an object-oriented query and expression language based on OCL. It is used for clinical decision support by facilitating the retrieving of data models from HL7 Reference Information Model compliant databases and is designed to provide a rich expression language for decision logic in guideline formalisms [16]. These works show it is possible to verify and validate UML conceptual schemas with arbitrary constraints formalized in OCL [17].

Due to its expressiveness and its potential to model real world problems, OCL was chosen for modeling the Laws of Nutrition, thus allowing the creation of a common language, where both researchers in Computer Science and in Health Science can interpret the specifications without misunderstanding.

The aim of this research was to characterize the validity of a nourishing menu. Then we propose model the basic elements needed to create menus using the UML, make a review of the Laws of Correct Nutrition, and formalize these Laws in a unified format, using the OCL, while verifying and validating the correct specification of constraints and restrictions using the open source licensed modeling tool USE: A UML based Specification Environment [18]. As far as we know, there are no previous proposals modeling this set of postulates.

2. Methodological approach

A domain model captures the most important types of objects in the context of some area of interest; it represents the starting point in an Object Oriented Programming software development methodology [19]. Firstly, we design a UML class diagram representing the domain model. Each class in the domain consists of attributes, i.e. basic data, and methods, i.e. operations over the data. Secondly, we specified the invariants for the Laws of Nutrition. The code conventions and programming styles used are the ones proposed and used by Google in its Java software projects [20].

2.1. Problem domain

The scope of the Laws corresponds to the planning of nourishing menus. Each menu item is generally quantified in rations, grams or milliliters, which leads to an overall quantification of calories and nutrients [21].

Fig. 1 shows the proposed domain model, which considers the basic elements in the process of planning nourishing menus. The elements are enumerations, classes, one abstract class and one association class describing the relationship amongst them. Enumerations in the model are data types consisting of predefined list of values used to define valid constant values. Variables declared as having an enumerated type must be equal to one of the predefined values of that type. Enumerations shown in Fig. 1 are:

- *Gender*: a set with two values identified as female or male.
- *PhysicalActivity*: set with four types of physical activity: repose, light activity, moderate activity and intense activity [22]. See Table 1 for details.
- *MealTime*: a set that specifies the occasions in a day when food is eaten. Traditional occasions are breakfast, lunch, and dinner, but morning snack, evening snack, and night snack are also considered [23].
- *FoodGroup*: food sets with similar properties. The classifications are taken from Mexican food composition tables [24]: Cereal grains and its products, legumes, oleaginous and nut seeds, vegetables, starchy roots, fruits, meat and viscera, marine resources, native food, dairy products, poultry eggs, oils and fats, sweets and honey, processed and ready to eat foods and beverages.
- *HealthyPlateGroup*: the food classification according to the ideal dish proposed in the 'Healthy Eating Plate' [25]: vegetables, fruits, whole grains, healthy protein and healthy oils. To consider other foods not listed in these healthy groups, the addition of an 'others' group was necessary.
- *UnitOfMeasurement*: typical units of measurement to quantify food. Valid units are slice, gram, kilogram, milliliter, liter, ounce, pound, cup, centimeter, inch, teaspoon and tablespoon [26]. We also add the very common household units can and pinch.

An abstract class represents an element that cannot be instantiated directly, thus it is useful in case of inheritance. The abstract class shown in Fig. 1 is:

- *Recipe*: represents a set of one or more basic foodstuffs. This class models both dishes and drinks, because both have the same characteristics and operations.

Classes in the model are abstract representations of the objects involved in the menu planning process. Classes shown in Fig. 1 are:

- *User*: an individual with particular characteristics that requires a menu.
- *BasicFoodstuff100gr*: a distinct ingestible substance that belongs to any of the food groups, in 100 g portions. The attribute values are taken from Mexican food composition tables [24]. Examples include lemon, condensed milk or honey.
- *Dish*: a solid or semisolid stew that can be ingested during a meal. A dish may be as simple as one *taco* or as sophisticated as a serving of "Rice and beans", which is Haiti's national dish and a traditional dish in throughout Latin America, consisting of 50 g of rice, 30 g of black beans, and half a cup of chopped onion, 1 tablespoon of vegetable oil and 1 teaspoon of salt. This class inherits attributes and methods from *Recipe*.
- *Drink*: a liquid that can be ingested during a meal. For example, a drink as simple as 1 L of orange juice or as sophisticated as 1 cup of "Spiced coffee", a common aromatic coffee made with dark roasted coffee, brown sugar, cinnamon, cloves and orange peel. This class inherits attributes and methods from *Recipe*.
- *Meal*: a set of dishes, drinks and basic foodstuffs by themselves ingested at a certain time of the day. For example a typical breakfast consisting of 200 ml of orange juice, ½ piece of bread roll and 2 scrambled eggs.
- *Menu*: a particular set of meals that a user should eat during one day to fulfill his or her nutritional requirements.
  An association class is the result of a logical connection between classes, the association classes found on Fig. 1 are:
- *RecipeIngredient*: the class resulting from the relation between Recipe and BasicFoodstuff100gr. Each ingredient from a recipe is