A Dietary Consultation System using Semantic Rules and Reasoning Based Approach

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ABSTRACT

Ontologies play an important role in knowledge-intensive contexts such as nutrition, personalised dietary, diet-sensitive disease conditions management and sport activities. Ontologies offer a shared data model for concept integration making possible to actuate automatic data analysis processes such as inference reasoning and allow interoperable communication among heterogeneous systems. In this paper, we propose Food Data Manager, a dietary consultation system which aims to improve the life quality of both healthy people and individuals affected by chronic diet-related diseases. Food Data Manager is an ontology-based system whereby we can automatically reason with food and its properties through inference engines in order to better assist users in making the correct choices for their particular health status, age, lifestyle, preferences, etc. In particular, we developed a set of semantic rules to transfer human dietary and nutrition expertise into machine understandable knowledge.

CCS CONCEPTS

• **Information systems → Data management systems**; **Semantic web description languages**; *Document representation*; Web applications;

KEYWORDS

health informatics, semantic web technologies, dietary, ontology-based data representation

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1 INTRODUCTION

Nowadays, there is a growing demand for well being services to help people improve their health habits [9]. The intrinsic potential of the available online food data and Internet of Things (IoT) physical activity datasets can be exploited using sophisticated data analysis techniques such as automatic reasoning to find patterns and extract information and knowledge in order to enhance decision-making and deliver better healthcare to the population. Moreover, personal health information sharing and analysis in conjunction with non-traditional health data sources (e.g., social media, web contents, and smart environmental devices) can provide an important component to facilitate the development of the next generation health services, in particular, services for research purposes [11] and public health surveillance [10]. However, due to the high heterogeneity of data representation and serialisation formats, and a lack of common accepted standards, the well being landscape is characterised by an ubiquitous presence of data silos which prevents domain experts from obtaining a consistent representation of the whole knowledge. Without a shared data model for such concepts integration, it is impossible to actuate automatic data analysis processes like inference reasoning, especially within inter-domain contexts.

Semantic Web (SW) technologies are a promising solution for the integration and exploitation of data about food, health, nutrition and physical activity. SW describes a new way to make resources content more meaningful to machines, whereas the meaning of data is provided by the use of ontologies. Ontologies, as a source of formally defined terms, play an important role within knowledge-intensive domains overcoming the problem of interpreting homonyms and synonyms in different sources [2, 5, 6]. Ontologies can also be reused, shared, and integrated across applications. They provide a common agreed understanding of the domain by specifying a formal representation of the entities and relationships involved in concepts and the associated background knowledge [1, 3, 4]. When automated reasoning is required, the Web Ontology Language (OWL) is the output format adopted [8]; in fact, it is oriented to knowledge representation and its description logic level permits to use reasoning over the knowledge base.

In this paper, we propose Food Data Manager, a dietary consultation system which aims to improve the life quality of both healthy people and individuals affected by chronic diet-related diseases. Food Data Manager is an ontology-based system whereby we can automatically reason about the food products and their characteristics (i.e., quantities, ingredients and composition) through inference engines in order to better assist users in making the correct diet choices for their particular health condition such as age, lifestyle and culinary preferences. The main ontological component employed in this study makes use of open data, published ontologies, domain knowledge and sensors data to construct a domain ontology consisting of common constructs, concepts, and instances. In addition, we developed semantic rules to transfer human expertise into

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machine understandable knowledge using the Semantic Web Rule Language (SWRL) [7] commonly adopted for building inference mechanisms in healthcare OWL-based knowledge systems [12].

2 FOOD DATA MANAGER ARCHITECTURE

The main components of the proposed system architecture are the *Input Layer* and the *Knowledge Layer*.

2.1 The Input Layer

The Input Layer is responsible for receiving data from users or IoT sensors. This layer includes the possibility of getting input data both from users using computer based solutions (e.g., web applications) and through automatic data transfer by connecting the platform directly to wearable devices. We want to reduce as much as possible the time consuming activities on the user side, for example, the insertion of all consumed foods during a week. The developed system allows users to insert the ingredient of a specific consumed dish or the walking distance and calories burned during a training session along with the location of where the activity took place. In all these cases, we reduce the time required for the user to enter the data because the system partially retrieves the basic components from domain ontologies. Each user can also customise the system by inserting his own dishes and recipes in order to be able to use them whenever necessary, simply by selecting them through the graphical interface.

2.2 The Knowledge Layer

The Knowledge Layer includes both the management of domain ontologies and the choice of rules to be set. The *Personal Profile Ontology* included in our project models basic input parameters (i.e., gender, age, weight, height and physical lifestyle) and information about the input data (e.g., BMI, ideal weight, number of calories and nutrients for each meal type). The *Food Ontology* describes classes which represent specific concepts from the food products domain such as Food Categories, Recipes, Nutrients and Ingredients, and properties such as energy per 100 grams and carbohydrates per 100 grams. Instances of the Food concept describe food for which nutrients (i.e.,carbohydrates, lipids, proteins, sugar, vitamins, etc.) are available, while instances of the Recipe class describe the composition of dishes (e.g., Pizza) as a list of food. The *Activity Ontology* (a re-adaptation of the IFO ontology [12]) is built around the notion of *Episode*. An episode represents the set of the all possible events that can be measured by the IoT fitness devices and wellness appliances. For example, an episode could be the heart rate measured during a running training session by a wearable wrist worn heart rate monitor or the person's body weight measured by a smart scale. To each episode is associated a time reference and a numeric measurement value with the related unit of measurement. Along the IFO hierarchy two main categories of episodes can be distinguished: (1) the physical activities and (2) the body measurements. Physical activities comprehend any kind of activity involving body movement such as walking, running, swimming or steps taken. Body measurements, on the other hand, are relative to the physiological parameters of a person such as the body weight or body height or the person's vital signs such as the heart rate or the blood pressure. Other minor categories of episodes that the Activity Ontology defines, concern the sleep and the meditation. Furthermore, the system interacts with external Linked Open Data portals (LODs), such as DBPedia, to get information related to diseases that may be significant for the definition of the diet, for instance in the presence of endocrinology and gastroenterology problems.

3 CONCLUSION

The contribution presented in this paper focuses on the design and implementation of a personalised dietary consultation system, namely Food Data Manager. The system is able to assist users in making the correct choices for their personal diet. The system receives input data from both users and IoT sensors. Time consuming activities on the user side, such as data insertion, are reduced as much as possible thanks to system customisation. Food Data Manager can be used to obtain suggestions about healthy eating habits or about nutrition exploiting data available on the web and to set a personalised diet taking into consideration the user's daily physical activities and health status. The system is also able to take into consideration the contribution of the single nutrients present in food or in a recipe, offering wider useful features. We described how the use of several knowledge bases in a knowledge-intensive context has been integrated to provide a structured and precise representation of heterogeneous information.

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