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Food Track & Trace ontology for helping the food traceability control

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ABSTRACT

This paper describes a food ontology developed for traceability purposes. The Food Track&Trace Ontology (FTTO) is part of a general framework devoted to managing food traceability and it has been developed with the aim of being connected with a Global Track&Trace Information System. The main goal of the proposed FTTO Ontology is to include the most representative food concepts involved in a SC all together in a single ordered hierarchy, able to integrate and connect the main features of the food traceability domain. FTTO is formed by four modules food, service products, processes and actors involved in the supply chain. This paper describes the main features of the FTTO ontology and some examples of application.

1. Introduction

Today the food traceability issue is attracting the attention of public authorities and private companies due to its important impact in society and its relevance in case of food outbreak diseases. The increasing interest in food traceability directly interfaces with customer demands on food quality and security (Trienekens and Zuurbier, 2008). Nowadays, customers are more and more exigent and require the governmental control of the whole food system. In addition, traceability plays an important role in the food industry and it is directly connected with food quality and safety. Safety, in fact, can only be guaranteed by following food products along the entire supply chain, from "farm to fork". Currently, different types of traceability systems are emerging as a result of regulatory interventions at an industry-wide level and as a consequence of competitive strategies adopted at the level of individual supply chain.

The regulatory framework for food traceability is wide and heterogeneous. If the regulatory perspective is considered, companies around the world (UE, Japan, USA, etc.) deal with different implementations of responsibility and liability regulation of products (Mirabelli et al., 2012a). In Europe, the EC Directive 178/2002 (European Commission, 2002) of the European Parliament and of the Council, lays down the general principles and requirements of food law, establishing the European Food Safety. This Directive defines food chain traceability as "the ability to follow a food component intended to be, or expected to be into a food product through all stages of food supply chain" (European Commission, 2002).

The ability of monitoring the whole Supply Chain (SC) is obtained assuring the observation of two primary functions: tracking and tracing. Tracking is the process by which a product is followed by upstream to downstream in the SC. Tracing is the reverse process of tracking by which the history of a product is reconstructed through the information recorded in each step of the SC, identifying the source of a food or group of ingredients and consequently the real origin of a product.

Recently, the need of food quality and security lead to the development of several traceability systems and to their implementation at the industry level. Nevertheless, current traceability systems are characterized by the inability to link food chains records, inaccuracy and errors in records and delays in obtaining essential data, which are fundamental in case of food outbreak disease, and represent the key issues frustrating the job of food safety agents. These deficiencies have been mainly highlighted by the recent food outbreak diseases, which have pointed out the importance of a global traceability system in a global market and have suggested the need of more information to be recorded. In addition to systematically storing information that must be made available for inspection from authorities on demand, a traceability system should take also food safety and quality improvement into account. To take into consideration the current regulated requirements on food quality for health care, additional data that is not strictly

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necessary for traceability must be stored. For instance, for a cooking activity, oven temperature and humidity can be considered important parameters in case of hazard. For a cultivation activity, operations on the parcel are fundamental to identify the possible cause of a contamination due to the use of particular plant protection products or fertilizers.

The information registration is therefore limited by the lack of common standards for information encoding and management (De Cindio et al., 2011a) that represents the main problem related to the development of an efficient traceability system. Standards are consequently required for recording and exchanging information. It is essential to assure a way through any company can connect to a global information system for exchanging information in the SC and, for that it is required to solve the important issues about information system integration and standardization. In order to ensure the system interoperability and communication between the different actors, the use of standards is required for encoding information for all reference operators (De Cindio et al., 2011b).

In order to facilitate the identification of a product responsible for a food borne outbreak disease, information, and the way that it is organized, must be standardized and conceptualized. Under this context, the objective of the presented work is to present a method for facilitating the identification of food borne outbreak disease in a short time window. This research work is part of a doctoral thesis, which aim is to develop a general framework for the traceability of food products able to support quality and safety control (Pizzuti, 2012). A traceability system prototype is proposed as part of the general framework developed to assist the process of information extraction and unification in compliance with legal and quality requirements. In such a context, the development of the Food Track & Trace Ontology (FTTO) ontology has played a relevant because the ontology supports the management of a unique body of knowledge based on natural language and its corresponding synonymous, through the integration of different concepts and terms coming from heterogeneous sources of information and users involved in the SC.

In particular, the main goal of the proposed FTTO Ontology is to include the most representative food concepts involved in a SC all together in a single ordered hierarchy, able to integrate and connect the main features of the food traceability domain. In addition, FTTO have been particularly designed in order to be connected with the Global Traceability Information System proposed by Pizzuti et al. (2012)and obtained through the modeling of a general food SC and data shared among different actors. The sources of information used in the knowledge acquisition phase, consist mainly of thesaurus and food databases, books and the Internet. The food classification tree built in the conceptualization phase refers to the Codex Alimentarius Classification of Food and Animal Feeds (Joint FAO/WHO Food Standards Program CODEX ALIMENTARIUS COMMISSION, 1993).

The knowledge model has been formalized using Protégé (Stanford Center for Biomedical Informatics Research, 2013), which was also used to automatically generate the ontology code. The resulting ontology comprehends four main modules covering the key concepts of the tracking domain: Actor, Food Product, Process, and Service Product.

This paper is structured as follows: Section 2 introduces a brief state of the art of current works carried-out in the development of ontologies in the food domain; Section 3 provides a description of the FTTO ontology, introducing a brief overview of the building process and detailing information for each developed module; Section 4 describes the Global Food Traceability Framework, which is the base of the FTTO Ontology; Section 5 demonstrate the scope and feasibility of the proposed framework and the remaining section address future work and conclusions.

2. State of the art

The increasing need to guarantee the quality and safety required for the food in a global market lead, in recent years, to the introduction of several mechanisms for food traceability. At the same time, important technologies, such as the Internet and the new generation of communication infrastructure, have been developed for supporting new traceability application. The first traceability schemes were based on working papers used to record information on incoming and outgoing products, while more recent systems are based on the use of the new information technologies. New research activities are currently investigating how ontology can be used to set up a traceability semantic model in order to reuse the information resources in the process of tracing and to promote the accuracy and efficiency of the information management. Furthermore, information shared in a general SC is heterogeneous and it is recorded into different data collection. In such a context, ontologies can be used for integrating heterogeneous databases and enabling inter-operability among different systems, since consistent vocabulary is needed for unambiguous querying and unifying information from multiple sources (Jagadish, 1990). The aim of an ontology is to capture knowledge in related field, provide shared understanding to conceptual knowledge, definite common vocabulary in this field and give clear definition to the mutual relationship between these jargons and words from different levels of formal model (Heijst et al., 1995). Ontologies, defined as explicit formal specifications of terms in the domain and relations among them (Kim et al., 1995), have become common in the World-Wide Web.

The need for ontologies has increased in computer science recently due to the need of a common core for heterogeneous agents for communicating and expressing knowledge. This section illustrates the relevant literature on food ontologies and the semantics of food traceability and introduces the main features that should be included in a new ontology for representing the whole knowledge related to the domain of food traceability.

A systematic literature review approach has been used for identifying the current food supply chain ontological models. The general idea was to classify the scientific literature focusing on the specific domain area of the works published in order to reuse the main concepts for the definition of the FTTO ontology. Three main subsections have been identified. The first subsection describes the current ontological models developed for describing the food world from a top level point of view. Moreover, these ontologies mainly refer to the nutrition, diet and health domain. In the second subsection, a deep analysis has been conducted focusing on the main works carried out for the definition of ontologies devoted at describing the knowledge related to specific food products. The last subsection includes some concepts related to the traceability domain and some works carried out in this area are analyzed. Finally some considerations are provided, highlighting the main features to include in a new ontology for food traceability purpose.

Table 1 presents the main work carried out with a short description on the main topic and the specification of the domain area (Bansal and Malik, 2011; Batista et al., 2006; Cantais et al., 2005; Chifi et al., 2007; Drummond et al., 2007; Easwaran and Thottupuram, 2011; Graça et al., 2005; Heflin, 2000; Kim, 2012; Noy and McGuinness, 2001; Snae and Bruckner, 2008; Yue et al., 2006).

2.1. Food ontologies for the domain of health care, diet and nutrition

The definition of a complete taxonomy for food is fundamental for modeling the domain of food traceability. There are various types of information about food, such as name, ingredients, stuff,