Structured Knowledge: A Basic Aspect for Efficient User Applications

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Abstract. Designing a user ICT application in the Ambient Intelligence (AmI) Information Society requires an accurate study of the knowledge relevant to all the domains of interest for the application, in order to favour a holistic approach to the well-being of all users in their living environment instead of accessibility to the available interfaces. In the framework of a new approach for the design of user applications in the Information Society, a number of examples are provided, which highlight basic elements of the knowledge relevant and its structure.

Keywords: knowledge, ontology, expert system.

1 Introduction

The design of an ICT user application frequently starts from the selection and implementation of a technological infrastructure (for example a platform as Android and other hardware and software building blocks) and the identification of the general layout of its human-system interface. The contents of the application are often considered in a subsequent phase, when the system providing the service is supplied with information that, after appropriate processing, is presented to the user as a response to his/her request. In this paper, a methodology for setting up efficient applications, with special reference to the field of eInclusion, is described, showing that it requires a previous analysis of the information content of the application and of its structure. To make the explanation more effective, a specific application field was selected in order to present and to discuss relevant examples. Food, with its many related activities that affect the user, was considered an appropriate reference.

This paper starts with the introduction of new living environments as they emerge in the Information Society. It then introduces a new approach for the design and implementation of user applications relevant for eInclusion, in comparison with the traditional one. Next, for the specific kitchen environment (a food-related environment), it presents the relevance of a correct structuring and use of knowledge as a starting point of implementation of any application. Finally, several examples are introduced, and certain unusual characteristic are pointed out.

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2 Application Environments

The field of application of Information and Communication Technologies (ICT) has rapidly expanded from single devices, such as smart phones, to the entire environment in which people spend all their time. So far, the vast majority of analyses and implementations of ICT have been concerned with a few specific environments. First, the office, because activities carried out in this environment are often related to the management, delivery and reception of information in electronic format. Another environment where ICT plays an important role is the classroom, due to the possibilities offered by these technologies in the learning and educational processes. A third environment, which is no less important than the previous ones, is the hospital, both due to the importance of health in human life and to the possibility of a structured organization of information offered by ICT.

However, the house is recently receiving a particular attention. At home, each person carries out a number of activities, which assume a fundamental role for the quality of his/her life. A primary function can be related to each room, such as sleeping to the bedroom, even if additional activities are also related to it. Special importance is attributed to the kitchen, with special reference to all activities related to food and eating. The list of activities contains several aspects, from planning meals to their cooking, up to the social level, in which people, who are perhaps seated around a table and eating good food, can improve their social relationships. ICT shows its importance in the kitchen, in simplifying several tasks and thus improving people's quality of life. This positive impact is increased if the different elements of the kitchen are networked and connected to Internet, in order to have access to external services and applications.

An intelligent kitchen is under development in the context of the FOOD project [1] part of the Ambient Assisted Living Joint Programme (AAL).The project is setting up a set of services and applications to improve the quality of life of elderly people. Some of these applications are specifically related to feeding, addressing, for example, menu definitions based on nutritional needs or health conditions. Others also address more general aspects such as safety or communication related socializing activities, connected to feeding.

3 A Structured and Knowledge-Based Approach to the Design of User Applications

According to this vision of interconnected and intelligent environments, the concept of applications is changing as well. Until now, the analysis of the behaviour of a person in the environment, especially in e-Inclusion, started from an analysis of barriers or limitations of activities that users might experience. A specific answer to such limitations was pursued in order to attain a complete inclusion of people in the environment, namely one that is also supported by technology. For example, in the office the main questions were related to the access of people to computers and the use of applications for interpersonal communications, such as social networks. Safety, security and the control of the health status are other domains of main concern. The related applications normally start with the acquisition of data by sensors. These data have different sources: a few data are about environmental status, such as temperature or gas presence, but they can also be about user conditions, such as health-care parameters (blood pressure, or insulin value). This information can be processed at local level or can be sent to a control centre for continuous monitoring.

Even if this approach has demonstrated its validity over the past twenty years, recently the objective of ICT applications has been moving form accessibility, inclusion and, consequently, independent living, towards a more general concept, i.e. well-being. This implies that a service or application is no longer limited to address a solution for a specific user activity, but is aimed at helping people to reach a higher level of quality of life. For example, for a user affected by diabetes, an application is supposed not be limited to measuring and recording glycaemia values and giving alarms, but also to suggest the most appropriate food in each moment of the day, according to the patient's diet, even when s/he is shopping. A new concept of application is introduced, which is not limited to a specific activity, but follows the dovetailed daily activities of the user.

In order to design an application according to the previous approach, the knowledge to be used in the implementation and the general structure of the resulting application are essential. The structure describes all the hardware and software building blocks, at a level abstraction allowing the selection of available commercial products. The knowledge includes data relevant for the application (e.g. data about food) and the user's data including his/her physical, sensory and cognitive changes in real time. In addition, a clear description and measurement of the above knowledge as related to the context is necessary.

If activities that are important for the user's quality of life must be pointed out in order to design applications aimed to favour their performance, their survey cannot be limited to results of tests with a small number of users. Since the main goal is to consider the variety of users, it is important to utilize international classifications that are produced and approved by a wide range of stakeholders. The document that best fits these requirements is the International Classification of Functioning and Disabilities, produced by the World Health Organization (WHO) in 2001[2]. In its main sections, it presents a classification of Body Functions, Body Structures, Activities and Participation, and Environmental Factors. These classifications can also be expanded, and a few modifications have already been approved by the WHO[3]. With reference to a specific example such as diabetes, not only the health aspects are considered, but also the more general aspects related to well-being [4][5]. Fourteen categories of the "Activity and Participation" components are considered influential from the patient's perspective. Among many, Acquisition of goods and services (d620), Preparing meals (d630), Doing housework (d640), Caring for household objects (d650), Complex interpersonal interactions (d720), and Informal social relationships (d750) can be cited. These few examples are sufficient to show how health conditions and activities in various environments are closely connected. These are the relationships to be taken into consideration in setting up a user application.

In any case, in order to obtain a collection and formalization of the knowledge required, the adoption of an ontology is appropriate. This is because it describes both the structure and the relationship between all the elements relevant for the problem. A comparison of the different knowledge available allows an analysis of the approaches adopted by other researchers.

As a preliminary summary, it is clear that in a complex environment as the kitchen, where many networked appliances are present and complex activities are carried out, it is not possible to use the approach used so far in eInclusion, where single difficulties are addressed and specific solutions for them are looked for. It is necessary to look for holistic approaches, where a set of tasks, for example connected to feeding as in the FOOD project, are addressed concurrently and coherently. Moreover, when application is designed it is not convenient to start from scratch. A lot of knowledge is available and most of it is structured and formalized in ontologies. Finally, some of these applications, as the one aimed to suggest diets for people with diabetes are so complex, that it is necessary to be able to reason about the individual situations (experts systems have been already used).

From the above considerations, it is clear that the concern about interaction, i.e. about accessibility, so far predominant in eInclusion, becomes only one of the aspects to be considered. Moreover, it is clear that, as far as possible, the interaction, and therefore the human-system interface, must be suggested by the type and quantity of information to be transferred and adapted to the functionalities that the service or application is able to offer to the users.

4 Examples of Structured Knowledge

As already mentioned before, in many cases applications are designed without taking into account that in many application environments a lot of information is available and formalized (for example in the form of an ontology) to be easily incorporated in reasoning systems (as expert systems). This is the case with food in general and with diets for different medical information (for example diabetes),

In the following, a summary of the knowledge available to be used in the implementation of applications in the feeding sector is made available. Only when this information is integrated in the structure of the application, the identification of suitable interaction becomes again the main concern, with the main constraint that interaction should be designed to be suitable for the different users and not resulting from the adaptation of an interface designed for the average user.

Example 1: An example of food ontology for diabetes control is presented in [6] within the domain of nutritional and health care. This ontology has been produced in the context of the PIPS (Personalized Information Platform for Health and Life Services) international project[7], to manage heterogeneous knowledge coming from different sources. In an application, which collects information from different sources, brings together different stakeholders and includes structured, semi-structured and unstructured data, an ontological solution has been identified as the best approach *for achieving a common understanding of the domains in which the system works*.

Fig. 1. PIPS project logo

The starting point is the identification of existing classifications, by selecting a food coding system and integrating it with a database developed by a consortium partner for data management in healthcare applications. A process in seven steps is adopted, which leads to 177 classes, 53 properties and 632 instances. A specific step for considering the reuse of existing ontologies is included, among the seven steps of the complete process (from the identification of the domain and the scope of the ontology to the creation of instances).

Example 2: A second example of ontological knowledge is presented in [8]. This ontology makes no direct reference to diabetes or to health problems, but it refers to food in general. It covers four main areas: food, kitchen utensils, actions and recipes. The context is now related to a dialogue system, where an electronic agent answers to voice input allowing the control of home devices using only voice. It presents a first example of how it is possible to integrate structured information within a more complex system: in this case, a dialogue system. Among the many aspects, at least two add elements of interest to the present discussion: the separation between knowledge and the processing system, and the possibility of easily adding new domains to the system. This is important when the designed applications do not address a specific and defined problem, but a much more general condition of the user well-being. Also in this example, the starting point is represented by an acknowledgment as to what is available and what is not. In addition, among the modules of this ontology three auxiliary modules can also be found, related to units, measurements and equivalences. In a general system for diet advice, this aspect is important, because, according to most health guidelines, the daily or weekly food intake is indeed relevant. The calories contained in a meal or a dish are often not meaningful if they are not evaluated over the space of a day.

Example 3: In this example [9], a still more complete system related to food, based on three main modules, is shown. It is based on an ontology for knowledge about food, an expert system for reasoning about diets, and a user interface for presentation, in order to set up a counselling system for food or menu planning in different contexts, such as a restaurant, a hospital, or at home. The presentation layer is also included, with different renderings within different contexts. This example show how more and more complex ontologies assume a growing importance in systems, especially when the system will be used in different contexts and with different interfaces. An additional element of interest is the review of existing Databases examined in order to set up the system: USDA (the USDA National Nutrient Database for Standard Reference, is a database published by the United Stated Department of Agriculture[10]); AGROVOC [11](a multi-lingual thesaurus compiled by the Food and Agriculture Organization of the United Nations (FAO) that contains nearly 20,000 concepts and 3 types of relations: preferred term, related term and broader term).

Example 4: In this example [12], a specific system for food recommendations for people with diabetes is presented. It is a complete intelligent system and can provide a plan in accordance with a person's preferences and health conditions.

In this example, the user profile influences the results coming from the system, so that the general level and the personal level are interconnected to give the user an even more accurate result.

Example 5: The importance of this example is based on the context in which the work was carried out. It comes from the European project OASIS (Open architecture for Accessible Services Integration and Standardisation)[13]. A precise reference to the aforementioned PIPS project is made within the framework of a service platform for health and life, which includes domains such as nutrition or physical activity. A dimension of well-being is presented in the project. Concepts such as diet, menus or food are essential to the activities of the project. It uses an ontology based on standards in nutrition such as Eurocode 2[14]; however, an even more interesting element in this discussion is that the ontology related to food is integrated with the others coming from different fields. A structured knowledge of people activities and their integration for each context is presented and the user and her/his characteristics are shown within a unified perspective.

Fig. 2. OASIS logo

Example 6 [15] shows the importance of a well-defined structure of the information also with the introduction of new devices. In this example, another element enriches the discussion. So far, in all the presented examples, the starting points were identified by previous ontologies or codes. Here, the large numbers of existing applications on mobile phones is considered. It is a new way to consider work, ideas and activities carried out in this field of interest. Even if international codes or standards maintains their importance, the results coming from new communication ways are taken into account. This means that, together with standards, international codes and scientific outcomes, knowledge can come also from a sort of distributed intelligence, such as (in this case) applications on tablets and mobile phones that are normally referred to as apps. The methodology presented by this example is a survey of existing apps to lists of the most common terms referring to diabetes. The application is intended for the health context, but, as said before, contexts are no longer kept very separate.

Example 7: Before concluding, as a final example, LanguaL™ [16] is reported. LanguaL is an automated method for describing, capturing and retrieving data regarding food. It provides a standard language for describing food, and serves specifically for classifying food products with the purpose of information retrieval. LanguaL™ is based on the concept that any food (or food product) can be systematically described by using a combination of characteristics. These characteristics can be classified into viewpoints and coded for computer processing. The resulting viewpoint/characteristic codes can be used to retrieve data relative to food from external databases.

5 Collection of Elements

In order to set up applications in the context of e-Inclusion, the previous examples contain several useful aspects of the knowledge, which is involved in such applications. The first example shows how the starting point for the process can be an ontology for the specific problem. An ontology allows designers to adopt a conceptual structure rather than a data oriented approach, which result much more useful for an application, able to evolve with the changes of users requirements. The second reference introduces an example of a structured information in complex processing system, such as a dialogue system. In this case, the split between knowledge and processing becomes a design criterion. The split also suggests that for an open system addition of different domains becomes easier. This is a basic aspect in implementing well-being applications, in comparison with service devoted only to a specific problem. Another aspect to be taken into account for effective services is the introduction of the concept of measure, as a basic component. Warning messages are not sufficient to guarantee an efficient application, which must also be able to provide specific values for each user. Since the first two building blocks of the system have been identified as a knowledge component (e.g. an ontology) and an expert system, the third element to be considered is the interface. This means that applications for the new environments not only require data from different domains, for example health and leisure, but they must also address different final users, who interact with the system at different levels and with different interaction needs and abilities. For example, in a health application, the final user is not only the patient, but also the caregivers, the nutritionists and the shopkeepers have to be considered. The importance of the user profile is particularly stressed in the following example, together with the need of connection with the other information for applications that adapt themselves to modification of user needs and preferences. This aspect assumes a particular importance for elderly people, because they often experience change in their conditions, which require modifications in the application, in real time too.

If the previous mentioned aspects are the basis of a well-being application, at least two additional characteristics have been identified. The first, coming from the sixth example, is related with the importance of already existing data collections, which represent a common reference for different community to make easier their interconnections and the second to the importance of standard languages for the description of the elements in a domain.

6 Conclusions

In the Information Technology Society, the approach to applications capable of giving effective help in improving the quality of life must be discussed. An approach, which takes the role of knowledge in the entire process into much more consideration in comparison to other aspects, as for example the interface, must be considered. The importance of the availability and an efficient structure of information is discussed in the paper by means of several different examples related to food and to a heath condition such as diabetes. The examples show how an ontological approach has been recognized and adopted by several communities, even if with some differences. The ontology can represents a building block, which together with an appropriate expert system to reason about user problems and a user interface provide users with the appropriate application, even when the context changes and new domains, new requirements from the user or from the contexts of use intervene.

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