ISSN 2278-3091
Volume 9, No.4, July – August 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse210942020.pdf
https://doi.org/10.30534/ijatcse/2020/210942020

Context modeling-based healthcare architecture in Pervasive Computing

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ABSTRACT

Ubiquitous computing seamlessly integrates computers into everyday life in response to information provided by sensors in the environment. This information is generally exploited by several domains namely the healthcare domain. Representing knowledge through building an ontology for healthcare system is important to achieve semantic interoperability among health information, predict the patient real-time context and to better execute decision actions. In this paper, we propose a healthcare system which integrates context ontology in order to provide smart services to the patients.

Key words: Sensing data, healthcare domain; ontology; context.

1. INTRODUCTION

Ubiquitous context-aware systems attempt to provide services that are invisible and responsive to the needs of patients in order to improve their quality of life, intelligently manage their environment and provide them with comfort and assistance according to their health needs.

Context knowledge is a key element in creating smart applications. The contextual data collected is usually raw information from different distributed sources, which must be interpreted. From ontologies, it is possible to build semantic models that will be fed by this raw data and thus not only increase their level of semantic representation but above all to be able to use them to make automatic decisions to adapt applications according to the context at runtime.

To achieve a healthcare context-aware, these systems must be able to understand the patient context and be sensitive to the dynamic and unpredictable changes of the context. Implementing this adaptation is far from easy. Several research questions need to be resolved starting with context definition, context representation and modeling, and contextual reasoning.

The objectives of our work include:

- To model a smart system that enables predicting the patient's real-time context
- A real-time data modeling and knowledge representation through ontology.
- A mechanism for collecting raw data from different sources.
- A case study of the proposed system's implementation.

This paper is organized as follows. In Section II we discuss some related work and used concepts, section III and IV present in detail our approach, section VI introduces the implementation of a case study of our proposition, and, the final section concludes the paper and discusses future work.

2. RELATED WORK

Over the past decade, interest in well-being has increased among the population. Several approaches have been proposed to improve healthcare systems.

In mobile systems, equipment is not able to obtain information about the context in which it is found in a transparent and flexible manner. The idea of ubiquitous computing is that of a world that integrates the context in a transparent and useful way (which is the core of the system.) The very concept of context is very difficult to define. field of research. The definition of the context does not only contain the objects and the changes that can reach them. It can also translate into the locations and identities of people around [1]. Another definition is given by [2].

A system is characterized by context awareness when it is based on different contextual information detected or deduced from the environment, processes and evaluates this information and eventually decide on the best service to be provided to the user. In other words, context sensitivity characterizes the adaptation of the functioning of a system to its environment. Solanas A. et al. [3] provided an overview of the main fields of knowledge that are involved in the process of building this new concept.

Context-aware computing allows the system to interact with users through context-aware devices. Its main objective is to maximize the efficiency the use of services [4], [5], [6]. A

system is considered context sensitive when it (i) is based on the different contextual information detected or deduced from the environment, (ii) processes, (iii) evaluates this information and (iv) eventually decides on the best service to provide to the user.

Venkatesh J. et al. [3] proposed an approach which integrates smart health applications with the connectivity of the Internet of Things (IoT), facilitating the use of machine learning and improving the complexity of context-aware designs.

The proposed approach makes it possible to design more complex health applications with limited resources, using sensors both on the user and in the surrounding spaces.

In their work [4] Zamanifar A. et al. Introduces a new scalable hierarchical network scheme, DSHMP-IOT, for managing the mobility of IP sensors, which benefit from predicting the direction of movement of mobile nodes in healthcare applications to reduce the hand-off cost. Venkatraman S. et al. [5] developed user ontology for a Smart Health Information Portal (SHIP) to provide collaborative health terms in holistic medicine. The proposed approach integrates conventional medical terms related to cardiac conditions along with Homeopathy and Ayurvedic terms towards providing meaningful complementary heart health information within an existing SHIP.

In [6] Azimi I. et al. began by studying advanced IoT-based approaches to monitoring older people to examine their benefits and shortcomings from a different perspective, with a focus on the needs of older people. Thus, they presented a modernized classification and proposed a hierarchical model for elderly-centered monitoring to investigate the current approaches, objectives and challenges in a top-down fashion.

Guarino then reviews Gruber's definitions by defining an ontology as "the common and shared understanding of a subject matter that can be communicated between people and systems". The ontology must be understood by many people but also understood by software. Charlet reminds us that the representation of an ontology is a set of object classes. He defines ontology as a "standard specification representing classes of objects recognized as existing in a domain". Constructing an ontology also means deciding how to be and exist objects.in that domain" [9]. Bachimont reminds us that an ontology refers to logic. He defines an ontology as a "rigorous and structured description of the vocabulary, in the logical sense, of a specialized field" [10].

Kim J. et al. presented in [11] an ontology-driven interactive healthcare (OdIH_WS) to apply real-time information acquired from wearable sensors to services.

In [12] Ko E. J. et al. presented a new approach to model the context reason on it in a context-aware architecture that is executed on an embedded wearable system in a U-Healthcare pervasive computing environment.

Ahmad N. H. et al. [13] proposed the knowledge representation for C overflow vulnerabilities (COV) ontological model which incorporate the connection among vulnerabilities and its properties. The researchers' work was based on different semantic technologies, such as; the software ontology (Protégé) to create and model the different classes of the ontology and SPARQL mechanism to excute queries on the proposed model.

The research work [14] revolves around proposing an ontological model in the idea of tithe/almsgiving (zakat) in the Pillars of Islam. The authors proposed an engineering methodology which is based on different phases (e.g. Define the classes and the class hierarchy, Define the properties of classes-slots, etc.) in order to create their ontology.

In [15], [16], [17], [18], [19], the authors proposed different architectures based on semantic web technologies to model the user context in different domains such as; multimedia documents adaptation, healthcare and tourism domains [20].

The next section introduces a detailed view our proposed approach.

3. PROPOSED SYSTEM

Adaptation and access to services in context-aware pervasive systems are directly related or even inferred from contextual information. That's why context is a fundamental notion in pervasive computing and the basis for effective adaptation. The figure 1 introduces our proposed system modules:

- **Semantic layer:** The semantic layer is divided into two components:
  - the contextual ontology which can be updated and filled through external data;
  - The context manager that allows inferring a set of rules and generate actions which will be executed by the service plane.
- **Sensors layer:** The system turns on objects health condition identified with human bodies, that sense dynamic information as indicated by the set of patients and collects dynamic setting data from objects.
- **Service Layer:** It contains the service manager that allows the communication between the different components of the proposed layers. The resource manager which interact with different sources and provide with the suitable data.

The next section introduces our proposed ontological model for healthcare context prediction.

4. HEALTHCARE CONTEXT ONTOLOGY

In this section we present an ontology for modeling healthcare context in pervasive computing environments. The general framework of our work is the field of pervasive computing. We are particularly interested in context awareness and prediction of the patient's real-time context. Our interest is in proposing new general context prediction ontology under a logical temporal formalism to support the development of healthcare context-aware systems.

As a consequence of evolving nature of contextual computing, completely formalizing all contextual data is likely to be an impossible task to overcome. However, we found that location, environment, device, health status, patient and activity are most fundamental context for capturing the information about the executing action. These contextual entities not only form the skeleton of context, but also act as indices into associated information. The objectives of our context model include modeling a set of levels, and providing flexible extensibility to add specific concepts in different application domains.

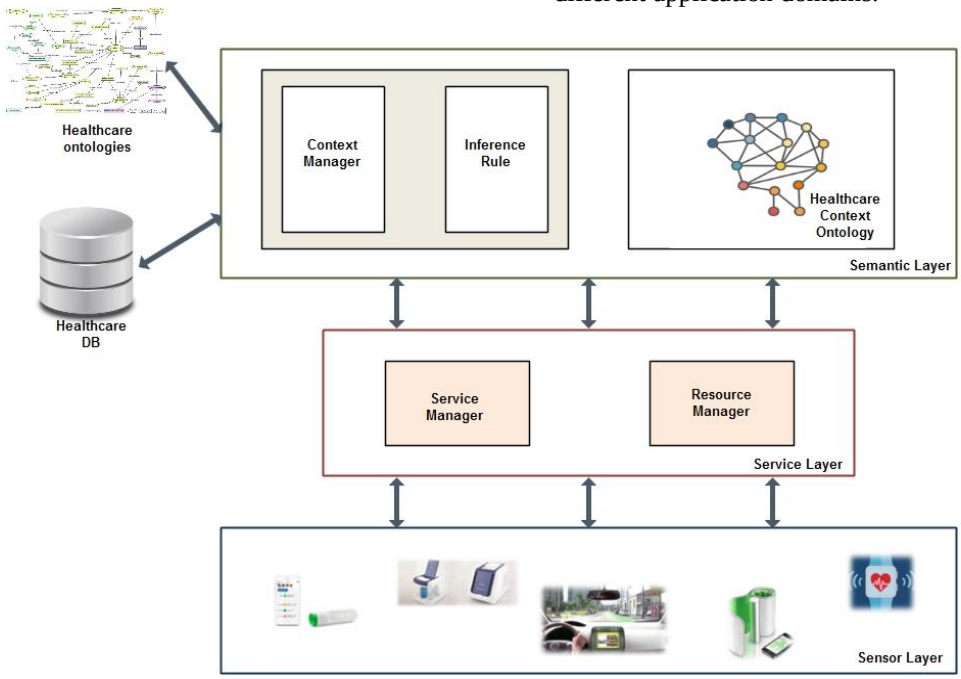

Figure 1: Proposed System

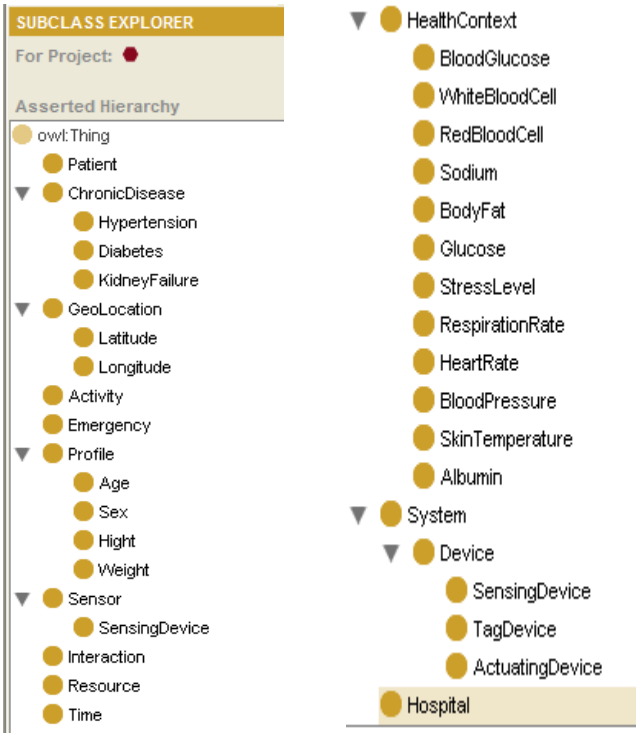

Figure 2: Healthcare context ontology

Figure 2 illustrates a snapshot of our proposed healthcare context ontology. In the healthcare context ontology, relevant context items include patient health context (i.e. heart and respiration rate values, etc.), the patient's geolocation and activity, etc.

In the next section, we will introduce the implementation of a case study of our proposed system.

5. IMPLEMENTATION

For the purpose of implementing our approach, we propose a case study of context-based reasoning and analysis.

Algorithm : *MultimediaAdaptation*	
Inputs	IR: Inference rules owl: ontology
Output	Act: Adaptive action
1.	r=null;

2.	**if** !identified() **then**
	//To check if the user is already identified
	identificationService();

3.	**else**
4.	r=analyse(IR,owl); //The result of analyzing process
5.	Act=AdaptationService;
6.	**end if**

Figure 3: Proposed algorithm

To better understand our approach, consider the following scenario: Marc who has a sight disability wants to display on his mobile phone a multimedia document containing a text sent by Steve, the mobile application captures his current context (e.g. physical disability) and sends the request and the captured contextual information to the service manager.

The algorithm (see Figure 3) begins by testing if the user is already logged into the system using **identified()** method. If the user is not identified yet, an identification service will be called using the method **identificationService().** The analysing process is done by **analyse()** which receives as parameters the inference rules and the context ontology (described in the previous section). Thus, depending on the analysis result, an adaptation service will be called through the method **adaptationService()**.

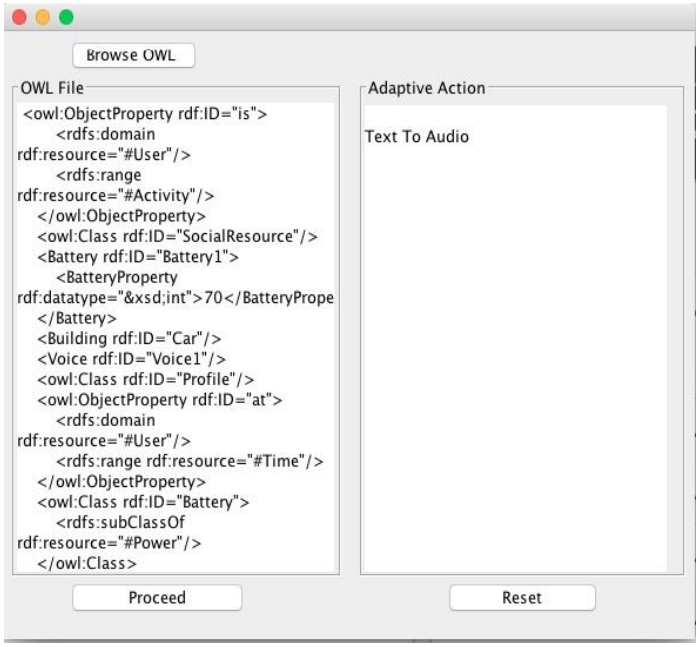

Figure 4: Implementation screenshot

The application allows uploading OWL file, thus, proceeding the inference based on the data represented in our proposed ontology. Once the inference process is finished, the result is generated in the adaptive side as shown in the last figure.

6. CONCLUSION

In this paper, we proposed a healthcare system which integrates a knowledge representation through an ontology for patient's context prediction. Our system allows the prediction of the patient real-time context, analyzing and processing their health conditions to better execute decision notification.

As discussed above, there remains more work to be carried out for covering all the aspects of healthcare context-awareness and for deepening the specification of services providing.

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