



Architectural Framework for Context Awareness and Health Conscious Applications on Mobile Devices

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Abstract. In recent years context-aware applications have emerged on smart devices and have become a new development trend. Context-aware applications allow for users to adapt to an ever-changing environment and also enhance interaction between users and their mobile devices. In the field of health care, along with the vigorous development of science and technology and especially the Internet, wireless mobile devices have changed the delivery of health care services from “brick & mortar medical facilities” to an “anywhere, anytime” service model.

This paper proposes a framework for the application of contextual healthcare on mobile devices with the idea of providing health care “anywhere – anytime”. The aim is to improve health care service by enabling them to become easily accessible with the result being a higher quality of life for all users up to and including the saving of lives.

Keywords: Context aware health care · Mobile device · Support system

1 Introduction

The rapid development of the mobile industry has resulted in smartphones becoming center stage in the digital arena. Recently, manufacturers are focusing on developing smartphone tracking in healthcare applications. Most notably with wearable tech to monitor heart rate, blood pressure, body temperature, etc. which will provide vital information to the user. However, these devices are not secure and such information could be accessed by other parties making security a concern.

The context-aware health care application model that we propose will collect user information and build a “health profile” for each individual. Each user will have their unique profile specific to his or her own condition. It will be based on user information recorded in a medical context (via a measuring device) and placed in a medical database. The application will provide users with useful updated health information coupled with medical advice directly related to the user’s needs. And at the same time it will caution a person about symptoms which may lead to health complications or send immediate signals to relatives or doctors in an emergency.

The rest of paper is organized as follows. Section 2 shows an overview of related research. In Sect. 3, modeling context aware sensibility for mobile systems and theoretical basis for model building are introduced. In Sect. 4, we propose a framework for context-aware healthcare applications for the mobile platform. Finally, Sect. 5 draws conclusions and comments on further research work.

2 Related Research

2.1 Contextual and Context Aware

Dey [2] defines context as “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the applications and the users themselves”.

Schmidt et al. [1] defines C context space with a definition of a combination of context parameters, ontology domain elements, and service descriptions. $C = \{U, P, L, T, D\}$, where U is the set of user & role factors, P is action & process, L is location, T is time, D is device, I is the information object available, S is the service available or described. A specific context is a point in the context space.

Dey and Abowd [3] define context awareness as “A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task”. This definition tells us how to determine whether an application is context-aware or not. According to Dey, context is an attribute of a system that uses context to provide information or services related to the user, in which the relevance depends on the user’s task.

2.2 Contextual Aware Applications in Health Care

The application of context aware technology in the field of health care has a lot of scientists interested in the research as follows:

In [4], the authors used context aware mobile agents to aid critical decision making in emergency medical applications.

In [7], the paper presents research in the design and implementation of a framework for cost cutting electronic healthcare delivery services for rural and suburban communities. This is achieved through the development of a semantic web services framework that would be deployed providing wireless mobile healthcare delivery services and health management services for rural African communities.

In [10], the study focuses on the design of the framework that supports an active repository in developing a component. To test the proposed Component-Based Development (CBD) intelligent framework, the healthcare monitoring system has been presented.

In [9], the system is based on context-awareness and case-based logic. It collects patients’ newest context and provides a particular patient’s details to the nurse 24 h call system allowing the nurses to provide urgent care.

In [5], the author has proposed a system for using mobile phones to track patients remotely, using the advantages of serial ports available in mobile phones to make a common interface with patient monitors.

In [6], a intelligent, context-aware monitoring home health care system was developed. In this system, sensors are used to collect data from a patient and then sent to a center for monitoring, analysis and to identify crucial patient details while the patient remains at home. The identification of an abnormal patient situation can activate a local device or commence an interaction directly with the person or issue an emergency message.

In [8], it is a proposed and subsequently implemented policy based architecture that will allow autonomous and continuous monitoring of patient thereby providing continuous necessary medical information to hospital personnel by utilizing software agents and wireless sensing technologies.

Most of the health care systems that have been proposed are for patients, although supervision and care are often limited to specific areas, such as in hospitals, nursing homes, etc. So we propose a healthcare model that will provide support for everyone, without the limitations of time and distance.

3 Modeling Context Aware Sensibility for Mobile Systems

The context aware application system can be described in the following expression:

F: $P \rightarrow Q$

With:

F: set of rules.

Q: set of recommendations or capabilities, for example: in healthcare applications Q is a set of the user's health states; in the decision support application, Q is a set of user actions.

$P = L \times T \times E \times U \times V$: context space of the system.

L: spatial context variables include: location, related objects (people, widgets nearby).

T: time context variable.

E: environmental context variables such as temperature, humidity, weather, etc.

U: user context variables include: profile information related to the user.

V: application context variables also calls the context variable or target context variable containing context information that has a major impact on the application. For e.g. in health care applications, V is information about the health of the user, including: body temperature, blood pressure, heart rate, etc. With the decision support application, V is the user behavior.

The process of arguments in the application is to identify a mapping from the set P to the set Q. Let p be a context in P ($p \in P$), q be a possibility in Q ($q \in Q$), then:

$$p \mapsto Q$$

It means that for a value $p \in P$ we will have the corresponding value $q \in Q$.

So to solve the problem we have to determine the set Q and the relation holds P and Q .

To determine the set P we must define the context variables $L, T, E, U, \& V$. These variables are collected through sensors and user information. Sensor sources and context information are often not uniform, so there needs to be a context retrieval department (Fig. 1). Another problem is in the presentation of contextual knowledge within the system and in applications where we use formal logic, descriptive logic, ontology or a combination of forms.

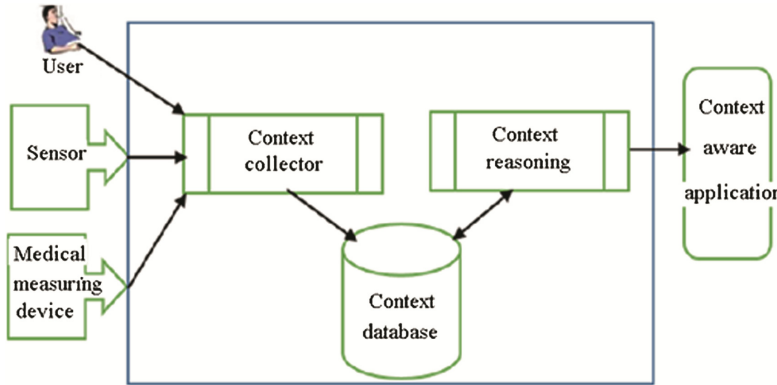


Fig. 1. Context - aware application model

Determining correlations P and Q use reason based on inference rules and RDF, OWL, SWRL or build a hybrid language based on these languages.

3.1 Logical Description Knowledge Base

Descriptive logic (DL) is designed as an extension of the semantic frame and semantic network and these types were not provided semantic based on formal logic. The complex concepts in the description logic are constructed using the Attribute Language (AL) or the extended languages of AL, called the “descriptive language” which will help us to formulate new concepts.

e.g.: Suppose we have elementary concepts such as “person” and “Male”:

Man ‘ $Person \cap male$.

Woman ‘ $Person \cap \neg male$.

Father ‘ $Man \cap \exists hasChild.Person$.

With: $C \cap D$ is intersection of concept C and D

$\neg D$ is negative of concept D .

The knowledge based system represented by the descriptive logic contains two main components (Fig. 2):

- TBox (Terminological Box) presents the terminology of an application domain. TBox defines the concepts and it specifies concept hierarchies which portray how atomic concepts and atomic roles are interrelated.
- ABox (Assertion Box) is an assertion component that describes facts associated with concepts and roles inside the knowledge base. ABox contains assertions on named individuals in terms of vocabulary. ABox has extensional knowledge about the domain of interest called membership assertion.

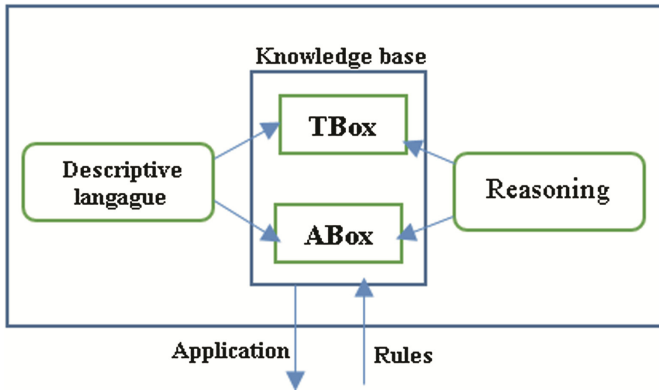


Fig. 2. General structure of the description logic system

Ex: Doctor(Peter), Patient(Alan), Careof(Peter, Alan), HasFever(Alan, high), Father(Jol, Alan), RelativeOf(Peter, Alan).

$$\text{Doctor(Peter)} \cap \text{Careof(Peter, Alan)} \rightarrow \text{DoctorOf(Peter, Alan)}$$

$$\text{Father(Jol, Alan)} \cap \text{Careof(Jol, Alan)} \cap \text{Patient(Alan)} \rightarrow \text{RelativeOf(Jol, Alan)}.$$

3.2 Ontology

In computer science and informational science, an ontology is a formal naming and definition of the types, properties, and interrelationships of the entities that really or fundamentally exist for a particular domain of discourse. Thus, it's a practical application of philosophical ontology, with a taxonomy.

An ontology compartmentalizes the variables needed for some set of computations and establishes the relationships between them.

Common components of ontologies include:

Individuals: Instances or objects (the basic or “ground level” objects).

Classes: Sets, collections, concepts, classes in programming, types of objects, or such kinds of things.

Attributes: Aspects, properties, features, characteristics, or parameters that objects (and classes) can have.

Relationships: Ways in which classes and individuals can be related to one another.

For example: The Ontology medical knowledge base has:

Individuals: doctors, patients, relatives, etc.

Concept: sick, symptom, situation, treatment.

Attributes: gender, body temperature, heart rate.

Relationship: Identified by, symptomatic, treatment.

3.3 Multi-agent System

Agent is a complete computational system or program placed in a certain environment that is capable of operating autonomously and with flexibility in that particular environment to achieve its intended purpose.

A multi-agent is a set of agents that work together in a system; each of which can have different purposes but the entire agent system is oriented toward the same goal through various interactions.

When used in multi-agent systems, ontology is a semantic structure that is referenced in the communication process between agents, which enables agents with different knowledge domains to understand each other in the exchange process. By understanding the messages it receives.

4 Framework for Context-Aware Healthcare Applications on Mobile System

4.1 Architecture Framework

The main component of the context-aware healthcare support system is its portability, which integrates the following devices (Fig. 3):

- **User interface:** Allows entering user context related information. Exporting information and giving supportive health care for users when necessary or when the user requests it.
- **Environmental sensor:** Provides contextual information about environment such as temperature, pressure and weather information.
- **Medical measuring devices:** provides medical measurements of the user such as heart rate, blood pressure, blood glucose, etc.
- **Locater:** Used to locate the user to provide timely help in cases of emergency.

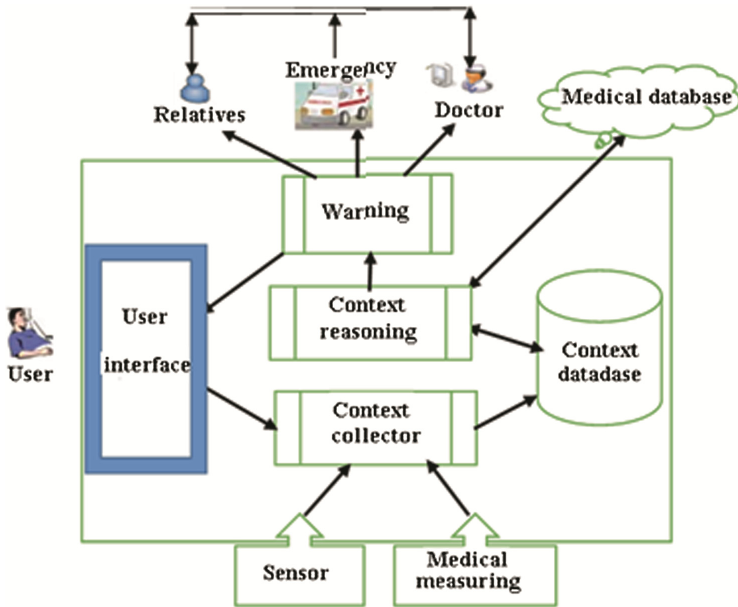


Fig. 3. Context-aware health care system on mobile devices

Components of portability:

- **Context collecting:** collecting context and identifying user context information.
- **Context databases:** organizing and storing user context databases.
- **Medical database:** Organizing and storing medical databases in the form of laws.
- **Contextual Argument:** Based on the contextual database and the health database, the argument provides user health information for warning.
- **Warnings:** Health information for when users request it or support for users health when needed. In case of emergency sends information and emergency signals to doctors, relatives, or for the emergency switchboard for timely critically needed solutions.

Participants in the system include:

- **User:** A person who needs health care support.
- **Relatives:** Those who support health care for users when necessary.
- **Doctor:** He directly supports the care, treatment and health advice for users when necessary.
- **Emergency call center personnel:** The medical facility where the emergency services are registered by the user, will provide emergency medical assistance in case of emergency.

4.2 Mechanism of Operation

(a) Service registration: A user who subscribes to a healthcare service will be provided with a wearable device (users can use a compatible mobile device) and a code that allows an installation program and connects to the system.

When the device is activated, the user logs into the system by the code provided, then enters their relevant information and connects with the support services:

Information provided includes: personal information and health claims.

Registration for support services includes: consultations, emergency services and relative’s phone numbers.

The context collector accumulates environmental and health contexts, including health metrics. On this basis the system will compile a health profile for each user.

(b) Operating system: After a t cycle, if there is a change in the environmental information from the sensor and the measurement from the medical measuring device, the context collector will update the context database.

Based on contextual database information, contextual history and medical databases, the contextual argument will infer and then provide the user’s health result for warning.

Based on the results obtained from the set the alert will send information according to each case as follows (Fig. 4):

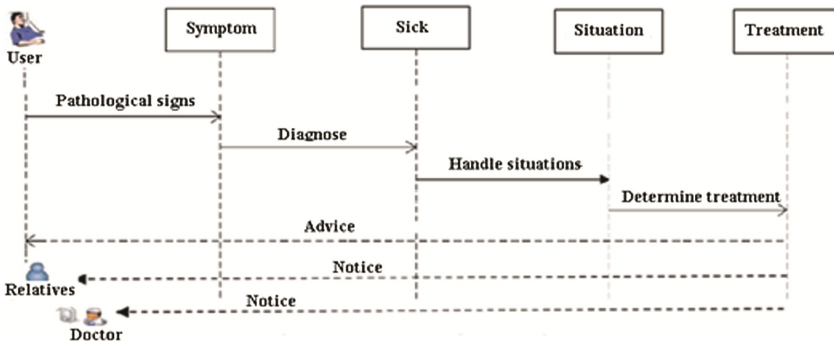


Fig. 4. Process reasoning in the system

Normal: Displays user health information, advice on health care for users such as exercise, sleep, diet and more.

Problem: Display health information to the user and send information to the doctor and family to follow up treatment support and prompt the user to comply with treatment schedules and advise on medical issues to support treatment.

Emergency: Send information to emergency services, doctors and relatives for timely assistance.

5 Conclusion

Through the study of the context sensibility in mobile platforms we have proposed a model of context aware support for mobile users and a theoretical basis for modeling. This model will be the basis for the production of health care support devices in the future contributing to improving the quality of life for people in any area and in real time.

In further development research we will finalize the detailed components throughout the model. Specifically, research develops solutions for context collectors and context filters and studies the theoretical basis for storing contextual databases and building language arguments on the context database. Research also studies the organization of medical databases supporting the arguments on the system.

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