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Granular best match algorithm for context-aware computing systems

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Abstract

In order to be context-aware, a system or application should adapt its behaviour according to current context, acquired by various context provision mechanisms. After acquiring current context, this information should be matched against the previously defined context sets. In this paper, a granular best match algorithm dealing with the subjective, fuzzy, multi-granular and multi-dimensional characteristics of contextual information is introduced. The CAPRA – Context-Aware Personal Reminder Agent tool is used to show the applicability of the new context matching algorithm. The obtained outputs showed that proposed algorithm produces the results which are more sensitive to the user's intention, and more adaptive to the aforementioned characteristics of the contextual information than the traditional exact match method.

Keywords: Pervasive computing; Context-awareness; Context matching

1. Introduction

Context-aware computing research is a subset of ubiquitous computing. The aim of ubiquitous computing is to realize unconscious use of computing capabilities and continues availability of information resources (Weiser, 1991). Context-aware research plays a very critical role in this scenario.

Active Badge (Want et al., 1992) and ParcTab (Want et al., 1995) known as the first context-aware applications were emerged in early 1990s. After that research on this field both context-aware computing and ubiquitous computing have increased tremendously. When we consider the past decade, research and solutions were mostly application specific and technologically dependent (Mitchell, 1999).

Since it was a relatively new field of research, there are many rooms for development. Generally, the aim is to realize effective and efficient provision and usage of contextual information. There are some general research directions in this field. First of all, to develop context-aware computing applications, it is required to have tools that are based on clearly defined models of context and of system software architecture (Dey et al., 2001). Another essential need is the common formal and reusable context representation format and ontology (Henricksen et al., 2002). Moreover, sensor technology perceiving the most of the physical context data should be improved (Schmidt, 2002). Context fusion is one of areas in which most of the research effort is done.

Researches on this sub-field deals with the abstraction and classification of low level context information to the high level ones (Van Laerhoven and Cakmakci, 2000; Wu et al., 2002). Finally, sophisticated and configurable context matching mechanisms are required for the better coupling of provided and desired context information and thus more adaptive servicing.

While dealing with contextual information, its multi-dimensionality, multi-granularity, subjectivity, and fuzziness characteristics should be taken into account. This brings complexity to matching of contextual information. The exact match method has been widely used due to its simplicity so far. However, in order to deal with this complexity properly, we need more powerful matching

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mechanisms. In this study, we introduce a more elaborate matching mechanism to address these issues.

The rest of the paper is structured in the following way. In Section 2, context matching operation will be described and some of the special characteristics of contextual information will be discussed. Various approaches to the context matching problem will be introduced in Section 3. After giving the details of Granular Best Match Algorithm in Section 4, CAPRA – Context-Aware Personal Reminder Agent will be described in Section 5. Finally, in the last Section, conclusion and future work will be explained.

2. Context matchıng

Context matching is the matching process taking place in context-aware computing systems. It matches two context data: provided context and desired context. Provided context information is coming from the sensors, other applications, and generally from context providers. On the other hand, desired context information is the query of the context consumers in active or passive format. Context matching is needed when an explicit query is made by the user (active) or a previously recorded query waiting to be triggered (passive) (Brown and Jones, 2002).

Matching operation on context data highly depends on the used context model and representation, and apparently the needs of context-aware applications. Use and selection of matching methods are directly related with the representation and defined ontology for context. Since the context-aware computing is relatively a new field of research, there are no commonly accepted standard representations, models, and ontology for context information in these systems. Thus the proposed approaches become mostly application specific.

There are also some critical issues or requirements special for the context matching operation in context-aware computing systems due to the internal characteristics of these systems and characteristics of contextual information.

Firstly, notion and definition of context are not so clear. Meaning and usage of context differ from application to application, systems to systems. It is impossible to draw the borders of context at any point of time. Fuzziness exists for both each of the context elements value and the number of context elements to be included to the scope of current context. Although some applications may be satisfied with very limited dimensions of context information and with simple exact matching of context information, more advanced applications need larger set of context elements and more sophisticated context matching methods.

Secondly, context may include almost everything, so it is very difficult to categorize and model all context information. Although contextual information needed by the applications may differ very much, it is necessary to provide some generic infrastructure and model of context covering a reasonable set of context elements. However, determining a common set of context information is not so easy. Parallel to this, providing a generic matching mechanism for an unknown set of context elements is also quite tricky even is not possible.

Thirdly, most of the context information is obtained from the sensory mechanisms with different measurement types (meters, centimetres, centigrade, fahrenheit etc.), different precisions and different error rates and reliability. For even just one type of context element, there could be many providers with different profiles.

Fourthly, the characteristics and dynamics of context elements are very different. Time, location, temperature, activity are some of the context elements. Each of these elements has different validity times, precisions, usage types and specifications. Thus provision of generic mechanisms for modelling and matching of all context elements are quite difficult, but on the other hand specific methods for each type seems not so feasible.

Finally, for many of context elements there could be many abstraction levels. For example location element of a context record might be Turkey, Ankara, Çankaya, ODTU, MM-Building or room-410 or just outdoor/indoor. Similarly time could be January 2 14:50, first week of the January or just 2006. For the activity element of context, stationary, non stationary, meeting, working or talking is some of the possible abstractions.

In addition to these, a typical context record consists of many fields textual, numeric and symbolic. Although many methods available in IR literature for these, they are not applicable to most of the context elements. For example, how can we define a similarity metric between two activities such as studying and reading or walking and running? How can we define the spatial relations based on symbolic or textual representations?

In the next section, some of the approaches to these issues in the field will be discussed and then granular best match algorithm for context-aware computing systems will be introduced.

3. Related work

The most elaborative approaches to context matching in context-aware computing issue have been done so far by Brown and Jones (2002), Jones and Brown (2002). Brown claims that current search engines take no account of the individual user and their personal interests and their current context. The development of personal networked mobile computing devices and environmental sensors mean that personal and context information is potentially available for the retrieval process. He refers to this extension of established information retrieval as Context-Aware Retrieval or CAR. He has concentrated on the matching operation with best match with gradual and predictable context change (Brown and Jones, 2002).

Rhodes used fuzzy matching techniques in wearable remembrance agents (Rhodes, 1997). In this wearable Remembrance Agent (RA), a continuously running proactive memory aids using the physical context of a wearable computer to provide notes that might be relevant in that