Information Access for Context-Aware Appliances

Abstract

The emergence of networked context-aware mobile computing appliances potentially offers opportunities for remote access to huge online information resources. Information access in context-aware information appliances can utilize existing techniques developed for effective information retrieval and information filtering; however, practical physical and operational features of these devices and the availability of context information itself suggest that, the document selection process should make use of this contextual data.

1 Introduction

There is currently increasing interest in the development of *mobile computing* applications. Until recently the role of mobile devices was generally confined to the provision of a range of applications to users while they were away from their normal office environment. For example, *PDAs (Personal Digital Assistants)* typically provide a diary, address book and basic word processing. However, the establishment of the *Wireless Application Protocol (WAP)* [1] means that PDAs and other devices can easily be connected to the Internet. WAP is currently appearing on mobile phones, but looks set to be added to any number of information appliances in the near future. The mobile delivery of online information has many potential benefits in enabling users to have immediate timely access to information or to call up information to assist them in their current situation.

An important feature of many networked mobile computing devices, and networked information appliances[1] in general, is that they have some sense of their *context*, e.g. their current location, the current time, their current operator, the ambient temperature. Context-awareness can potentially combine a large number of context parameters, but in

[1]In this discussion an information appliance is taken to be any independent computing device; this includes devices such as electronic sensors for temperature or location.

this discussion we generally limit the discussion to the simpler case of a single context variable. Utilizing context information in the provision of online information in these environments gives rise to the concept of *context-aware information access (CAIA)*.

In this paper we explore the relationship between established *information retrieval (IR)* and *information filtering (IF)* techniques and CAIA, highlighting the novel features of this retrieval environment, and describe our current work which is aimed at beginning to address these issues. We suggest that the characteristics of context-aware appliances (CAAs) mean that CAIA should not be implemented as either standard IR or IF, but that the novel features associated with being *context-aware* introduce new challenges and opportunities.

2 Background to the development of CAIA

In this section we explore the background to CAIA outlining relevant existing work, give definitions for standard IR and IF as used in this discussion, and explore the relevant details of the physical characteristics and operational environment of CAAs.

2.1 Existing Research in CAIA

Existing research in the development of CAIA applications has been restricted to small scale pilot studies, e.g. [2]. In these applications matching between user interests and available documents has been restricted to simple Boolean matching of fields. This technology has sufficed for small scale homogeneous data sets. However we believe that the realization of CAIA in large scale heterogeneous environments, such as those offered in WAP enabled applications, will require more sophisticated best-match retrieval strategies.

2.2 Information Retrieval and Information Filtering

Before examining the application of best-match retrieval in CAIA we first outline the key features IR and IF as used in this discussion. IR is generally viewed as the interactive retrieval, in response to a user search request, of potentially relevant documents from largely static document collections. The output of an IR system is usually a ranked list of documents with a brief summary indicating the contents of each document. The user then chooses from among these potentially relevant documents largely based on the summary information. By contrast, IF is based on the use of profiles (long-term requests) indicating long standing topics of user interest to select potentially relevant documents from among a stream of new documents. Users are thus presented with individual documents which the IF system "believes" may be of interest to the user. A detailed comparison of IR and IF is contained in [3].

2.3 Context-Aware Appliances (CAAs)

CAAs are typically small and highly portable. This has significant implications for interaction in information access. For example, the display of WAP enabled mobile phones is a *microbrowser* enabling users to view around 6 short lines of text and simple graphics. This small browser means that, by comparison to standard desktop computer based IR systems, it is difficult for users to browse among a long list of retrieved documents and potentially frustrating to examine more than a few documents for relevant information. This physical limitation suggests that CAIA applications should aim for high precision in order to reduce the need for browsing. While the user may often, in principle, be happy to accept any resulting reduction in overall recall such a strategy might lead to, experience with existing search engines suggests that often the user's search request will not be sufficiently detailed to yield such high precision[2].

2.4 Operation Environment Issues for CAIA

IF may appear better suited to CAIA than IR since detailed profiles are often available enabling high precision to be achieved. However, in addition to the loss of interactivity, we may encounter another practical problem. IF applications will often require high recall; in order to achieve this precision is likely to suffer. While operating in an IF mode a CAA is likely to be of secondary interest to the user while they are engaged engaged in some other activity. Experience suggests that they are likely to become frustrated very rapidly if their attention is repeatedly drawn to an CAA often providing non-relevant information [4] in order to achieve high recall.

Our current research is exploring the augmentation of standard IR and IF in CAAs to take their *current context* into account in the process of information delivery. The following section introduces the methods we are exploring and describes a simple example illustrating one approach that we are currently developing.

[2] CAAs typically include various features such as dictionary-based word completion or speech recognition to assist the user in the entry of query words.

3 Techniques for CAIA

The current context can be used in various ways in the information access process. It can be used as a simple Boolean filter on documents to be delivered, e.g. if the time associated with a document and a query matches. Matching scores are calculated for documents that pass an initial Boolean filter test, these documents can then passed on to the user in ranked order.

A more sophisticated strategy may be adopted to take context into account as part of the calculation of the matching score between a document and a query. For example, assuming that search term i in each document j has a *combined weight (cw(i,j)* incorporating standard concepts of collection frequency, term frequency and document length compensation [5]. The standard matching score $ms(j)$ between a search query and a document j is given by,

$$ms(j) = \sum_i cw(i,j).$$

For CAIA we can introduce a context matching function between the document j and the current context c . Thus for location we could introduce a function $f(c,j) = K * \exp^{-d}$ where d is a measure of the distance between the current location and the location associated with document j and K is a suitable empirical constant[3]. This context matching function decreases as the distance between the current context and that of the document increases. Incorporating the $f(c,j)$, the matching score becomes,

$$ms(c,j) = f(c,j) \sum_i cw(i,j).$$

Of course depending on the application alternative context functions can be used to take into account features such as rate or direction of context change.

These techniques assume that the current context is correlated to document relevance. It is hoped that the incorporation of contextual information in this way will enhance precision with respect to the current context. By incorporating context directly into the matching function precision may be improved without precluding the retrieval of documents with high query-document matching scores for which there is a mismatch in context. In practice, users can be offered the opportunity to enter a given context manually to simulate retrieval for a context other than the current one.

[3] For IF this could be implemented by applying the context function between the assigned context of an individual profile and a document associated with the current context.

3.1 Context-Aware Documents

In order to make CAIA systems work, documents must have a notion of context associated with them, e.g. a location or time with which they are most closely associated. This context might be assigned manually, e.g. in the case of map, or automatically assigned by a process of shallow information extraction, e.g. extracting proper nouns such as place names. The physical proximity of locations might then be found from a map.

This need for context information requires more "intelligence" in the matching process that is usually adopted for IR and IF. For applications able to support browsing of large document sets CAIA may not be appropriate, but for CAAs we believe that context-awareness can be an important feature in efficient information access.

3.2 Elaborations

Relevance Feedback While CAAs may have very limited scope for browsing, the application of basic relevance feedback is fairly straightforward. Users are merely offered the opportunity to mark documents as relevant. This information can be used in a standard way to modify term weights and expand the search query. Additionally this information may be used to modify the parameters of a context weighting function $f(c)$.

Prediction of Future Context An important practical aspect of context is that it usually changes gradually; hence it is often possible to predict what the next context will be [6]. This prediction information can be used as part of the matching process. The weighting of a document associated with a likely next context can be increased, whereas that of a context which is becoming more remote can be decreased.

4 Conclusions and Current Work

The work described in this paper is part of an ongoing study into CAIA. Current work is concentrated on further exploration of the CAIA paradigm and development of suitable matching models. An important aspect of this work which we are keen to develop is the establishment of an evaluation framework and test set to explore CAIA applications. It is hoped that the final paper will be able report initial results from trials with a small experimental data set.

References

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