Context Tags – Exploiting User-given Contextual Cues for Disambiguation

Matthias Böhmer
DFKI GmbH
Stuhlsatzenhausweg 3
66123 Saarbrücken, Germany
matthias.boehmer@dfki.de

Gernot Bauer
Fachhochschule Münster
Stegerwaldstr. 39
48565 Steinfurt, Germany
gernot.bauer@fh-muenster.de

Antonio Krüger
DFKI GmbH
Stuhlsatzenhausweg 3
66123 Saarbrücken, Germany
antonio.krueger@dfki.de

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Abstract
Most context-aware systems rely on physical sensors. To some extent, these systems are able to reason about a user's situation by means of the measured data. However, their overall uncertainty in modeling human behavior leads to ambiguity. A language for the mediation of context information between the user and the system is required to enable the user to adjust the machine's interpretation of his context. We describe how keywords that are attributed to activities by users themselves can act as such a mediator. We present results of a study that investigates the nature of this context attributes. The results demonstrate that different users use similar keywords to describe similar situations and different keywords to describe different situations. Therefore, algorithms developed to evaluate the semantic relatedness of tags and resources within folksonomies can be applied to exploit knowledge about the users' contexts from the keywords they have assigned. We discuss a prototype that recommends mobile services by enhancing its model with the described keywords.

Keywords
Context, disambiguation, tagging, folksonomies.

ACM Classification Keywords
H5.2. User Interfaces: Input devices and strategies.

General Terms
Human Factors, Measurement.

Introduction

Ubiquitous computing envisions a future where computational services will be interwoven into our environment. Due to perpetual changes in people's activity and their environment not every function of a service will be of the same constant relevance for a user. In addition due to cognitive limitations and restrictions of user interfaces, e.g. limited screen size of mobile devices, a user is not aware of all available services at one time. The problem of information overload arises [1]. The research field of context awareness addresses this issue by exploiting the user's context in order to provide only relevant services to the user [2]. In this paper we investigate how users can bias the system's interpretation of their contexts by providing additional information.

An intuitive definition of context can be given by somebody's answer to the question: What are you currently doing? Dey [2] gives a more formalized definition: context summarizes basically all pieces of information that are relevant for HCI. Zimmermann et al. [3] break down this information into five categories: individuality, location, time, relations, and activity. We refer to activity as our notion of context since this is what the introduced question asks for. Most approaches try to reason on context by interpreting sensor data. Due to the uncertainty in modeling human behavior and peoples' changing interests [4] sensor-based approaches bear an a-priori-failure that leads to ambiguity [5]. The best sensor would be the human himself, since only he has a holistic knowledge about his context. A language for the mediation of this knowledge is required since it cannot be read implicitly.

In this paper, we present an approach for explicit context information based on user-given situational keywords, which we call context tags. By adopting algorithms originally developed to analyze the semantic relatedness of keywords within folksonomies in the Web 2.0, we can make such user-given context descriptions measureable and comparable. Our research question is: If people annotate their contexts with keywords, will we be able to estimate the similarity of their contexts?

Torre et al. [6] give an overview on strong and weak semantic techniques for adaptive systems and argue, that the potential of the latter is currently underestimated. Carmagnola et al. [7] investigate the value of collaborative tagging systems for user modeling. Szomszor et al. [8] exploit folksonomies from different web sites to understand a user's interests; this is related to modeling a user's needs in a context. Shih and Tseng [9] describe an approach for retrieving location-aware learning content based on a folksonomy; they enrich context information with tags extracted from other content. Halpin et al. [10] give a formal definition of folksonomies and describe how the process of users tagging different resources can be modeled. However, hitherto mostly web objects (e.g. bookmarks or pictures) have been investigated as tagged resources. In this paper, we examine the user's own context as the resource. A similar approach taken by Heckmann et al. [11] differs since it relies on a fixed ontology.

Tag	# (%)
Cafeteria	28 (76%)
Waiting	16 (43%)
Lecture	12 (32%)
Hunger	12 (32%)
Food	12 (32%)
Queue	10 (27%)

Table 1. Distribution of the six context tags mentioned most often at the cafeteria.

The contribution of this paper is the proposed concept of context tags as a new source of information on context. We present a first study that investigates the nature of keywords that users provide for their actual contexts. It gives preliminary evidence for our approach and sketches its feasibility. Our results informed the redesign of a context-aware client for mobile services. The prototype is presented later in the paper.

Preliminary Study

We used contextual inquiries to elaborate i) whether people are able to tag their contexts, ii) what these tags look like, and iii) if meaningful tags appear repeatedly. We collected responses from participants in two different situations in <anonymized city>: we interviewed people in the morning at the weekly farmer's market and during lunchtime at a university cafeteria. As we introduced our definition of context, we asked the participants what their current activity was. After they got a clear notion of their actual context, we asked them to break it down into keywords.

Results

Our results are based on 71 participants (34 at market, 37 at cafeteria). Their average age was 23.1 years. We interviewed 31 women and 40 men who were chosen randomly on-site. All of them were native <nationality>, habitants or students of <city>, so the keywords were in <language>. As interviewers we were able to qualitatively judge their answers with regard to the activity we determined as ground truth.

People were able to announce their context. All participants were able to spontaneously give a brief description of their actual activity. However, there were differences. Some people gave very short answers (e.g. "I am shopping", "I am hungry") and others were more detailed (e.g. "I am buying flowers at the market", "I am at the cafeteria and I am waiting for lunch"). Further, some also forecasted a future activity (e.g. "I am going to have a coffee"). 55% of the participants also mentioned the place (e.g. "I am having breakfast at the market", "I am waiting in the queue at the cafeteria"). When it came to tags, people used 3.4 keywords on average (min 2, max 6) to describe their context (e.g. using 'breakfast', 'market', 'work', 'flowers', 'cheese', 'waiting', or 'lunch').

For similar contexts similar tags were chosen. Among individual participants there was a redundancy with respect to the announced context tags. In total, we collected 240 tags (market: 104, cafeteria: 135). For the market situation 56 distinct keywords were used, for the cafeteria situation only 27. Especially the participants at the cafeteria made clear, that people use similar or even the same tags to describe their context. We only asked people standing in the queue at the food counter and we took care that the participants did not bias each other (they were not able to hear each others' answers). Table 1 shows the tags mentioned most often at the cafeteria and the number of their appearances. The most specific tags were repeated pair wise, e.g. 'cafeteria / waiting' was mentioned 12 times (44% of answers), 'cafeteria / queue' 9 times (33% of answers), 'waiting / queue' 5 times (19% of answers).

For different contexts different tags appeared. At the market our result is different and the context tags are more heterogeneous. During the interviews we – being able to interpret the given answers – found out, that we did not catch all participants in the context that we expected them to be in at the market. Besides people who were buying food and goods, we found e.g. people

Tag	# (%)
Market	17 (50%)
Coffee	8 (24%)
Breakfast	5 (15%)
Work	4 (12%)
By foot	3 (9%)
Weather	3 (9%)
Morning	3 (9%)
Cheese	3 (9%)
Sausage	2 (6%)

Table 2. Distribution of the nine most mentioned context tags at the market.

who had breakfast, who had an appointment or who just passed the area. This can be deduced from a qualitative analysis of the given tags, but also by statistical means. People within our expected market context provided tags mentioning things they want to buy, e.g. 'cheese', 'fruits', or 'vegetables'. Other people mentioned tags like 'breakfast', 'coffee', or 'work'. One conspicuous outlier, a 15-year-old boy who was ditching school, mentioned the tags 'vocabulary test', 'candy' and 'boredom'. However, also at the market we found conspicuous tag-pairs, but due to the higher heterogeneity at the market they did not show up as repeatedly as at the cafeteria.

Discussion

Our study suggests, that the semantic similarity of contexts is measureable based on context tags. Algorithms that are used for analyzing folksonomies correlate tags based on their co-occurrence [12]. We observed that the most specific context tags were repeated pair wise. This results from the semantic relatedness that is established by the very user himself, e.g. induced by his activity, place or needs. Therefore we may assume that this effect also appears in the same context at different locations (e.g. another cafeteria or market). We expect, that within a larger sample some specific tag-pairs we found will disappear, while others will remain in force and furthermore other pairs will appear. However, since the pair wise repetition as a structural feature of folksonomies [12] exists beyond context tags, we may assume that algorithms based on co-occurrence originally designed for folksonomies will also work for estimating similarities between context tags and contexts.

The physical sensor data of our participants at the market or even patterns within this data would not have been significantly different among the people, although they were in different contexts, e.g. buying goods, having breakfast, or just passing by. Obviously geo-position, time and temperature were the same, and also for speed and acceleration we determined, that not everybody who is walking across the market has the same activity and goal. However, contexts become distinguishable by context tags because of the fact that different tags were mentioned for different contexts, e.g. 'market / cheese / sausage' vs. 'breakfast / coffee' vs. 'by foot / weather'. This suggests that our approach can decrease the ambiguity of solely sensor-based systems.

The most claimed weakness of folksonomies is their vague formalization and heterogeneity. In addition to methods arising from folksonomies themselves, it further seems promising to relate the occurrence of a tag to a sensor data stamp to solve the issue of homonyms and synonyms (e.g. the meaning of 'party' as an organization to gain political power or a group of people gathered together for pleasure). We further argue that people would not get along with fixed categories for describing their context. It would be easier to reason based on a fixed context ontology or predefined attributes, but it would constrain the human ability to express their activity [13]. Furthermore, a list with the granularity we experienced in our study would be too long or incomplete, e.g. the boy who ditched school used nearly unforeseeable tags.

However, we do not propose context tags as a standalone solution. Instead, they can be used to enhance sensor-based approaches. Both concepts increase each other's degree of separation. Thus, ambiguity and error probability decrease. Context tags, as

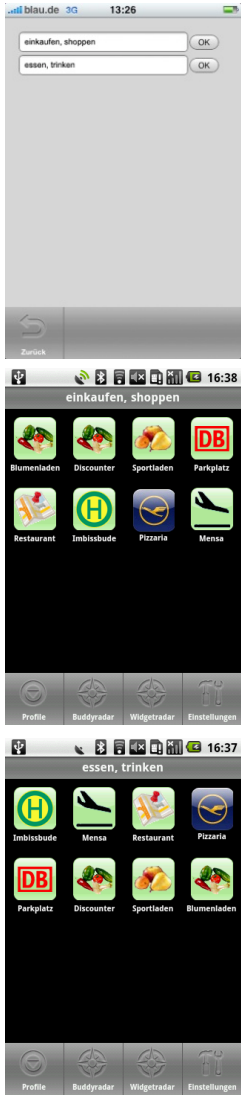

Figure 1. Input of context tags (top) and context-aware menus (dummy icons).

additional explicit context information, can serve as a mediator between an existing reasoning engine of a context-aware system and the user.

Prototype: A Mobile App Using Context Tags

The results of our study informed the redesign of a context-aware client for mobile services. We introduced context tags to extend its previous location-aware approach. Figure 1 shows the mobile client from the user's perspective. On the first screen, the user is able to define his context tags. We decided to not only allow users to input ephemeral context tags, but also to maintain and recall them as persistent sets. For each set the client provides an adaptive menu. The user can easily insert new context tags to adjust the system or swap through the context adapted menus to recall some previous context tags. The corresponding tags are shown in the title of the menu.

The reasoning engine of our prototype is very rudimental. An author of a new service can place his service on a map [14]. The system then uses the geographic distance between the user and the service to recommend only the nearest services to the user. Now context tags tailor this location-based filtering to the user's context.

The semantic relatedness of tags within our system is based on their co-occurrence [11]. Our prototype makes use of this measure in two ways. Firstly, if a service itself has a description in form of tags, we can use these to match them against the user's context tags. Thereby, the relevance of a service is given by the similarity between the tags of the service and the tags of the context. Secondly, we can estimate the similarity of the user's different contexts based on their corresponding context tags. Our system logs the service usage and thereby learns about the relevance of a service within a context. This relevance is related to the specific tags a user provides for his context. Following a context-collaborative approach [15] the system recommends those services to a user that have been used in similar contexts before.

Currently, our system does not contain enough data to estimate the semantic relatedness of tags. It will stabilize after a context has been tagged several times (e.g. 100 times for folksonomies on the Internet [16]). Therefore Delicious, a social bookmarking platform, acts as a makeshift. Of course, the nature of those tags is different from our ones. However, our current system enables the enrichment of the user's location with the context tags to get a higher semantic description of his context. First tests with our prototype system suggest that the tailoring of the recommended services can become more precise with context tags and that context tags can abolish ambiguity.

Conclusion

In this paper, we proposed the concept of context tags. Our contribution is an approach that allows a system to gain context information where the knowledge about it is most clearly available – i.e. at the very user. We argued that user-given contextual keywords are suitable as an explicit source of context information and can serve as mediator between the user and a context-aware system. We conducted a study that gave first evidence for our approach. It offered that in similar contexts specific pairs of tags appear repeatedly, and in different contexts the sets of tags are disjunctive. This structural property enables us to apply algorithms that estimate the semantic similarity of tags and contexts.

The study informed the described redesign of a context-aware client for mobile services that has been enhanced with context tags.

Future work is on different measures to correlate the tags beyond co-occurrence, e.g. by measuring the time span between occurrences. We plan to gain a larger sample to further substantiate our findings. For the system it also seems promising, to proactively ask the user to insert new tags or to verify the former ones when it assumes that the user's context has changed or that the failure rate has increased.

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