Exploring Ambient Visualizations of Context Information

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***Abstract*— In this paper we investigate how ambient displays can be used to share context information. Currently, many personal devices provide context information, such as location or activity, and at the same time the number of ambient displays is increasing. We developed two prototypes for visualizing contextual information and initially explored the suitability of these in an online study. Additionally, we investigated which parameters are important for users when sharing personal context. Based on our findings we discuss guidelines for the design of ambient displays for context sharing.**

Keywords- Context-aware computing, ambient visualization

I. INTRODUCTION

When living together with another person in an apartment, we obviously share a lot of information by being in the same context. In such a collocated setting we observe the other person, which inevitably influences our interactions with this person and creates bonds when sharing the context over a longer term (e.g. being in the same room for the whole day over several weeks). In the current society many people live and work in settings requiring them to live in long distance relationships – however many pervasive computing technologies are available which facilitate communication.

In this paper we investigate how sharing context, potentially between times in which we already share physical spaces or when we have synchronous communication, can be facilitated, how supportive devices can be designed, and what the values and concerns of users in this domain are.

Our research is motivated by the following facts:

(1) Many mobile phones, social networks, and communication applications can acquire context information.
(2) A variety of off-the-shelf ambient display devices is available that can be easily networked.
(3) People's need for being in contact and longing for connectedness is apparent.
(4) An overload of traditional (synchronous as well as asynchronous) personal communication presents a problem for many people.

The main contribution of this paper is our investigation in how ambient displays can be used to share contextual information. To understand this, we experimented with different designs and conducted an online survey to find out which context information, when and how has value for users and which representations are considered to be useful.

II. RELATED WORK

Several projects tried to exploit the advantage of displaying information in an ambient way, see e.g. the work by Intelle [6]. Pousman and Stasko [12] provide a list of definitions from various authors and distinguish *ambient*, *peripheral*, and *notification systems*. We also refer to them for a comprehensive overview of ambient systems, including 19 research projects and 3 consumer devices. They compare them according to the design dimensions *information capacity*, *notification level*, *representational fidelity*, and *aesthetic emphasis*. These ideas are taken further by Sukthankar [1] which shows how to display information dynamically within an environment. Such concepts could for example be implemented using steerable projectors as suggested by Pinhanez [14]. Metaxas et al. [10] present a service-oriented framework supporting the implementation of ambient awareness systems based on the Awareness Mark-up Language (AML).

Only few researchers looked into the evaluation of ambient displays in general. One notable example is Matthews et al. [9] who provide a set of generic evaluation criteria. In contrast to studies that evaluate a concrete tool like the carenet display by Consolvo et al. [4], this enables evaluating a concept abstracted from an actual implementation.

In the study presented in this paper, we were more interested in personal context. In fact, most projects presenting ambient systems use simple information sources such as weather forecasts (Skog et al. [13]) or bus arrival times (Mankoff et al. [8]). Hence, they cover mostly public rather than personal information. Even projects that consider a shared (working) environment displaying content created by other people, e.g. Cadiz et al. [3], do not consider context information of those people themselves.

With our research, we try to close the gap between the large amount of context information available and the opportunities of presenting them in an ambient way.

III. CONTEXT ACQUISITION

The acquisition of various types of context has become easily possible and is being widely used. However, the presentation of such information is typically done in a very direct and concrete way. In contrast to this, we explore the space and the advantages of ambient visualizations of such data.

A. Currently Available Methods

With pervasive computing technologies it is easily possible to collect the following types of context data:

Location: the current position of a user can be inferred with sensors such as GPS scanners for outdoor or based on WiFi or Bluetooth for indoor use. There exist commercial products (e.g. Google Latitude) and a multitude of research projects using location-based services. Often, location is used in different levels of detail; see Ashbrook and Starner [1] who abstract location into more meaningful places.

Activity: various ways exist to infer what a user is currently doing. Fábián et al. [5] provide an overview of current research on activity recognition on phones. Combined with location and information such as the user's calendar, nearby people, or Twitter streams can achieve high confidence. Current uses, e.g., in social community platforms such as Facebook use an explicit way of presenting such information and abstractions are rarely used.

Mood: currently, there is no way to reliably detect the present mood of persons. There are several research approaches that try to recognize emotions, e.g. by face recognition or by analyzing communication streams. Otherwise, this has to be specified manually and is often done in an abstract way (we follow this manual approach in our project).

Nearby people: by using location information or detection of short-range signals (such as Bluetooth or WiFi) collocation can be sensed or inferred. This is often used by friend finder applications such as Nokia's Mara project (http://research.nokia.com/research/projects/mara/).

Physiological information: retrieving information about the physiological state of a user is still difficult to achieve without dedicated sensors. Examples include sports sensors measuring the pulse or galvanic skin response sensors.

B. Research Questions

Although all these measurement methods exist, applications rarely make use of their full potential. In our study, we were aiming to answer the following research questions relevant for the design of corresponding ambient applications.

Do people associate value with sharing information about their own context (R1)? Context is important information within social networks and sharing it nowadays is common through various types of communication (conversations, Twitter, Facebook, etc.). Bentley and Metcalf [2] for instance showed that more than 70% of the phone calls recorded during a study revealed one caller's current location or activity.

What types of context are important to users (R2)? As illustrated above, various types of context exist. It is important to assess which of those are of interest and which not.

What influences the value and readiness to share context information and how should this influence the design of sharing applications (R3)? It is interesting to see whether there are particular circumstances when sharing is especially valuable or the need for information is especially high.

Are there temporal patterns in the users' interest in contextual information (R4)? Currently, the time of sharing or receiving information is controlled by the sender (by pushing information) and the receiver (by actively looking at, e.g., web pages). If more information was available, this could be exploited for the design of such systems.

IV. Exploration of Ambient Context Devices

Ambient devices can be used as a convenient means for presenting information in a non-intrusive, abstract, and hence privacy preserving way. In an online study we found out that 73% of the participants considered presenting detailed information to affect their privacy. However, only 40% considered the same to be true for an ambient visualization.

A. Ambient Devices

Currently, several ambient devices are commercially available. They mainly differ in the amount of information they are able to convey. For our research we opted to use the Nabaztag (see Figure 1) who has been subject to several research projects (e.g., [11]). It provides two movable ears and means for audio/speech output. The second device we used is a digital picture frame, which is equally suitable for the visualization of ambient information.

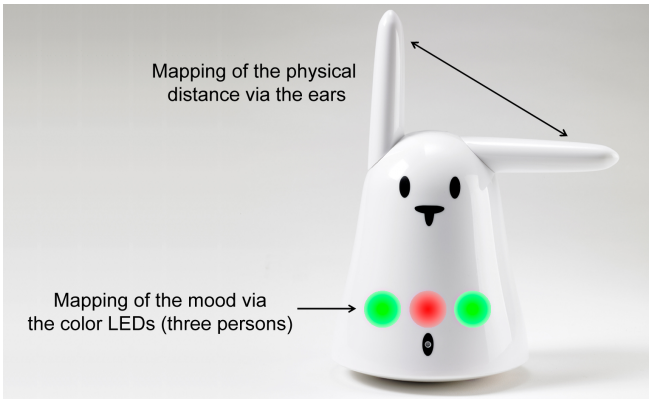

Figure 1. Visualization of distance and mood on the Nabaztag.

B. Prototype System

To explore different design options, we implemented a prototype system capable of distributing context information of persons in one's social network in an ambient way. For collecting input data, we use the IYOUIT platform and its mobile client since this already covers a large part of the envisioned data (http://www.iyouit.eu). It provides information about location, mood, activity, weather, and places.

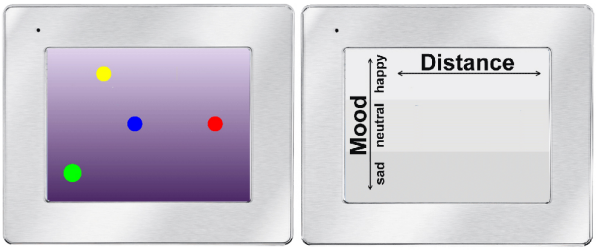

Figure 2. Visualization / Mapping on a digital picture frame. Example: the person represented by the yellow circle (topmost) is physically very close to the "blue" (centre) person and is in a happy mood.

On the output side, we use separate, exchangeable software modules to enable representations for different devices. In the current implementation, visualizations are available

for the Nabaztag ambient device and an abstract, geometrical representation on a digital picture frame (see Figure 2).

For the Nabaztag, we decided to map location information to the ears' position while the LEDs represent the mood of different persons. Figure 1 illustrates one possible state.

The picture frame uses, as is depicted in Figure 2, colored circles to represent each person and context data is mapped based on x and y coordinates. Hence we can, for example, use the horizontal position of the circles to encode the location, the vertical position to encode the mood.

V. Study Setup and Results

In summer 2009, we conducted an online study over a period of 4 weeks consisting of two parts: in the first part, we gathered informative data regarding the use and value of context information of people in one's social network as well as the potential design of ambient devices. In the second part, we evaluated the design of a prototype implementation to gain further insight into potential issues and challenges. The study consisted of 26 questions most of which used a 5-Point Likert scale but we also included open questions. Participants were recruited from mailing lists, and via Facebook. The completion took roughly 15 minutes.

A. Demographics

The survey was completed by 73 participants (19 females) with an average age of 28.2 years. Most of the participants were employees (36) or students (31).

B. Informative Results (Part 1)

With regard to our research questions, we were especially interested in which types of context are interesting to the user, when users are interested in information, their desired update frequency, their preferred device type, how much information they would like to have displayed per device, and the setup location for such a device.

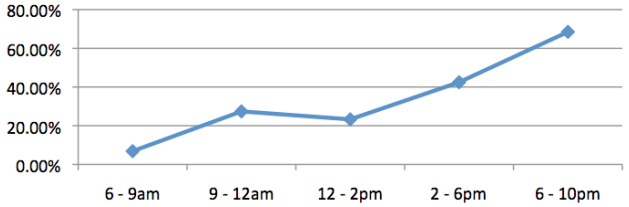

Figure 3. Time-based interest in ambient information. Information becomes more interesting towards the evening.

First, to assess the types of context that would bring most value to users, we asked them to rate what information about other persons was most interesting to them *(R1, R2)*. The following results are based on responses of 4 and 5 on the Likert scale. Most popular types of information are the current location (55%), activity (43%), mood (33%), and who is currently in the proximity (26%). Very personal context, such as the pulse (7%) seem to be interested to marginal groups only.

Second, we were interested in the different *times of day*, at which users were interested in ambient information *(R4)*. Figure 3 reveals that the interest of the participants increases over the day with a peak between 6pm and 10pm (69%). There is no significant increase during noontime.

Third, we were interested in the preferred information *granularity (R3)*. Hence, we asked the users which update frequency seemed reasonable for each type of information. Surprisingly there were no conclusive results but mostly uniform distributions across all information types except pulse (where people deemed high update rates to be necessary). It seems that the answers to this question are very much related to the users' individual preferences and the application area.

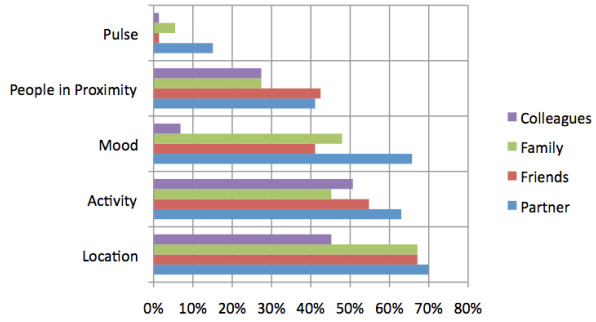

Figure 4. Close relationships between persons lead to an increasing interest in context information.

Fourth, we were interested in the *number of people* for which the participants would like to have context information be displayed *(R1)*. We discovered that this to a large extent depends on the device. Whereas for the Nabaztag the preferred amount of people was 1 or 2 (63%), most participants liked to have information on 4 or more people to be displayed on the digital picture frame (64%). We investigated the way users would like to have information on different people to be displayed. For both the Nabaztag and the picture frame, the most popular option was to display everything on one device at the same time.

Fifth we were interested in the *location users would setup such a device (R3)*. Most popular locations were the living room (51%) and the office (43%). Kitchen (25%) and bedroom (18%) were less popular (multiple answers possible).

Finally, we were interested which *types of other person's context* users considered to be interesting *(R2)*. The results, depicted in Figure 4, reveal that the closer the relationship between persons is, the more interesting ambient information is. The most important ones are location, activity, and mood.

C. Design evaluation (part 2)

In the second part of the study we evaluated the design of our prototype implementation with a focus on the mapping, the understandability, and the acceptance of the devices *(R3)*.

We showed the users sample visualizations from both the Nabaztag and the picture frame. We briefly explained how the mapping works. In order to test the understandability of the mapping, we then presented the users with four statements regarding the visualization for each device, two of which were correct and two were wrong. For the Nabaztag the questions were answered correctly on average by 66%, for the picture frame by 78% of the users. The visualization was considered to be understandable/very understandable by 52% of the users for both Nabaztag and picture frame.

Furthermore, we asked the users if they could imagine using either of the two devices. For the Nabaztag 25% could imagine using it as a device for ambient information visualization, for the digital picture frame the result was 33%.

VI. Discussion and Recommendations

In the following we summarize recommendations for application designers and developers.

No full penetration: the value people see in context information and the acceptance of particular devices, mappings, and visualizations vary a lot. Input and output must be configurable and adjustable based on users' needs.

Open architecture: as methods and tools for context sensing advance and the opportunities for ambient displays are extended, a framework offering context-aware ambient services must be reconfigurable and open to accept many types of input and output (e.g. audio output, see Kilander and Lönnqvist [7]).

Support many types of context: 70% were interested in at least one of the proposed types of context.

Concentrate on spare time: context information seems to be more interesting after work when people start making plans about social activity.

Variable update frequency: it seems that the update interval is fully dependent on the person, situation, and information need and should be configurable.

Space rather than time multiplexing: people preferred having all information visible at once and not have the display cycle through various types of context.

Optimum information density: for many ambient devices and visualizations, there seems to be an optimal number of people for which context information is displayed at once. This number can be found out by using mockup displays.

Location of the display: people tend to put general purpose displays in the living room or office and have specific room types such as a kitchen reserved for special purpose objects.

Relation defines value: the relationship between people is a strong indicator about what information is interesting and what will be shared. A more fine-grained categorization than found in most platforms is needed.

VII. Conclusion and Future Work

Though several researchers created heuristics to evaluate ambient displays in general and specific devices in particular, less focus has been on the actual content. In this paper, we advocate using context information as content for ambient visualization and extracted a set of nine requirements.

The results of our survey encouraged us to explore long-term effects of providing contextual information to people in a real world deployment. They also show that especially among people in close relationships (good friends, partners) the ambient visualization of information offers a convenient and unobtrusive way to convey feelings and emotions.

Currently we are setting up a longitudinal study over the course of several weeks with subjects being close friends and people in long-distance relationships. In the study, a Facebook application will be used which allows each person to set their current mood and location. We use the visualization on the Nabaztag presented in this paper to ambiently convey this information to (the) other person(s). With the study we want to (a) find out how information on the other person *impacts the way people communicate with each other* (i.e. does knowledge about the current emotional state of the other person foster communication via other channels, e.g., phone calls, SMS, etc.?), (b) gather qualitative feedback on the *acceptance and potential (privacy) concerns* of the users (i.e. is it ok for other people to know where I am and what I am doing / are there situations in which it is not?) and (c) verify *how and in which situations such a system is used* (are there certain situations in which it is important for people to know about their partners' whereabouts / emotional state, e.g., business trip, etc.?).

References

[1] D. Ashbrook and T. Starner, "Learning significant locations and predicting user movement with GPS," In ISWC'02, pp. 101-108.

[2] F.R. Bentley and C.J. Metcalf, "Location and activity sharing in everyday mobile communication," In CHI'08 EA, pp 2453-2462.

[3] J.J. Cadiz, S.R. Fussell, R.E. Kraut, F.J. Lerch, and W.L. Scherlis, "The awareness monitor: A coordination tool for asynchronous, distributed work teams," Unpublished manuscript, 1998.

[4] Consolvo, P. Roessler, and B.E. Shelton, "The care-net display: Lessons learned from an in home evaluation of an ambient display," In UbiComp'04. pp. 1-17.

[5] Á. Fábián, N. Györbíró, and G. Hományi, "Activity recognition system for mobile phones using the motion-band device," Mobile Networks and Applications 14(1), 2009, pp.82-91.

[6] S.S. Intille, "Change Blind Information Display for Ubiquitous Computing Environments," In UbiComp'02, p. 91.

[7] F. Kilander and P. Lönnqvist, "A whisper in the woods–an ambient soundscape for peripheral awareness of remote processes," In ICAD'02.

[8] J. Mankoff, A.K. Dey, G. Hsieh, J. Kientz, S. Lederer, and M. Ames, "Heuristic evaluation of ambient displays," In CHI'03, pp. 169-176.

[9] T. Matthews, T. Rattenbury, and S. Carter, "Defining, designing, and evaluating peripheral displays: An analysis using activity theory," Human-Computer Interaction (22), 2007, pp. 221-261.

[10] G. Metaxas, P. Markopoulos, and E. Aarts, "Amelie: a recombinant computing framework for ambient awareness". In AMI'09, pp. 88-100

[11] T. Mirlacher, R. Buchner, F. Förster, A. Weiss, and M. Tscheligi: "Ambient Rabbits Likeability of Embodied Ambient Displays," In AMI'09, pp.164-173.

[12] Z. Pousman and J. Stasko, "A taxonomy of ambient information systems: Four patterns of design," In AVI'06, pp. 67-74.

[13] T. Skog, S. Ljungblad, and L.E. Holmquist, "Bringing computer graphics to everyday environments with informative art," In SIGGRAPH'02 Abstracts and Applications, p.153.

[14] C.S. Pinhanez, "The Everywhere Displays Projector: a device to create ubiquitous graphical interfaces," In UbiComp'01, p. 331.

[15] R. Sukthankar, "Towards ambient projection for intelligent environments," In CV4IIE'05, p. 172.