AmbiX: Designing Ambient Light Information Displays

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ABSTRACT

In today's information society a vast amount of information is competing for our attention. The increase of incoming messages and continuous information updates often distracts us from our primary tasks and makes it challenging to stay focussed. A solution to this is to provide an overview of information updates in an unobtrusive manner, which does not require an immediate attention shift, but rather creates a continuous and overall awareness. One approach to provide such an awareness are ambient light displays, which address humans' perception abilities to gain cues from our periphery. In this paper we present six examples, which investigate the use of ambient lights in different contexts and situations, such as household and office settings as well as mobile and social networking tasks. We describe our experiences from these examples and the conducted user studies. We further derive challenges and questions for future research.

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H5.2 Information interfaces and presentation: User Interfaces

INTRODUCTION
Digital information helps us to perform many of our daily tasks more easily and efficiently. We use it in many different contexts, such as at work, at home or when traveling for private as well as for business. However, the amount of digital information is increasing continuously. Status updates, emails, messages from social networks or news feeds, suddenly incoming alarms for reminders draw steadily on our attention, leading in fact to a lower performance and frustration as we have to switch our focus back and forth. In addition to the need to switch tasks that results in an increasing cognitive load, the perceptual load is increased as well as most of our tasks are performed using the most effective visual sense.

A solution to these problems is to lower the amount of messages to the user by providing overviews first with an reduced information content, according to Shneiderman's visualization mantra [10], and to display this overview in a more unobtrusive, ambient manner. In our approach we, instead of attracting the user's visual focus, make use of the peripheral vision capabilities. Humans can gain cues about their surroundings from information that lies in the periphery [6]. Ambient light displays information in the user's periphery. It's strength is that it "`can move from the periphery to the focus of attention and back again"' [9]. Thus, ambient light provides a means of conveying information to the user with minimum interference to a primary task. Instead of addressing focused vision, information is displayed in the periphery and may be observed at a glance.

Light is rich in parameters and the design space for ambient light information displays therefore offers a number of degrees of freedom. Colour, brightness, saturation as well as duration and frequency of changes in parameters can be varied to encode information [7]. Another factor is the location of the light source with respect to the observer. Ambient light displays can be integrated into daily life's settings as they can be aesthetically pleasing and unobtrusive. Ambient light display's size can vary from a single LED to large architectural installations. There are two tpyes of information encoding: Explicit encoding requires the user to know the meaning of an encoding [5]. This can facilitate private information, even in public or semi-public spaces. Implicit encoding on the other side relies on intuitive understanding by the users of given cues [4,11].

DESIGNING AMBIENT LIGHT INFORMATION DISPLAYS
In the following we present six examples addressing household and office settings as well as mobile and social networking tasks. Five examples utilize ambient light, emitted by various sources, four of which rely on LED-technology, one is using an ambient wallpaper on a mobile phone.

AmbiPower
Energy consumption is increasing worldwide. Private households in Germany, for example, consumed about 29% of the total electrical power in 2009 [2]. An approach to reduce the power consumption is to raise the awareness by communicating the current consumption to the inhabitants [3]. We aimed at raising awareness in an unobtrusive but omnipresent way and to persuade users to lower their consumption. In an iterative process we developed the ambient light display AmbiPower. In the final design, AmbiPower displays the current power consumption using

(a) AmbiPower: Visualizing household power consumption

(b) AmbiTweet: Mobile phone wallpaper to display social network activity

(c) Ambient Anchorman: Managing discussion contributions

Figure 1: Examples for household (a), social networks (b) and talk moderation (c) situations

a pulsing Philips LivingColors. The faster it pulses the higher the power consumption. The household's remaining power quota, determined using the average daily consumption, is displayed using the LivingColor's colour. The lamp is green in the morning and fades to red over the day depending on the amount of used power.

During development we tested different visualization designs in a lab study with five participants. The final design has been tested in a diary study conducted in one household over a week. The results from the lab study suggest that changing the brightness might not be sufficient to communicate information mainly because the perception of the brightness depends on the surrounding light (see figure 1a). The results also suggest the pulsing might be perceived precisely but could be annoying. Varying the colour seems to be an appropriate compromise to communicate information without being obtrusive. The diary study suggests that taking the average power consumption as a baseline for the display proved to be not effective, as certain appliances consume far more power than average. There is nothing the user can do to reduce the appliance's consumption, thus there is potential for frustration.

AmbiTweet

For many people, exchanging messages via social networks, such as Facebook or Twitter, has become an important means for staying connected and an integral part of their life. Thus, more and more often we see people checking their smartphones frequently in order to see if new messages have arrived. With AmbiTweet we aimed at overcoming this need by pushing the status of a social network to the user in an ambient way. We use a live-wallpaper for Android phones simulating beautiful blue water. The wallpaper can be connected with a Twitter account and visualizes the level of activity in an ambient way (see figure 1b). The more messages are posted within an hour on the users timeline, the brighter and the busier the water becomes.

The application was published on the Android Market and was downloaded 4850 times between Dec 2010 and Feb 2012. It has yet to be shown that the AmbiTweet will be

able to generate a peripheral, ambient awareness of social network activity. Therefore, a number of assumptions have to be investigated. First, we need to ensure that the brightness and busyness of the water interface can be perceived when the phone is not lying in the focus of the user. Second, we need to show that AmbiTweet allows concentrating on a primary task while remaining aware of the level of activity on a social network account. Third, and finally, we will need to show that the awareness created by the ambient display allows users to calm down and feel a lesser need to check their smartphone regularly.

Ambient Anchorman

Meetings are an important part of most office workers' daily schedule. Keeping track of participants' contributions to a meeting is sometimes difficult. One participant might use a lot of the available time for his contributions others may fall silent, thus valuable insights will be lost for the group. A moderator would see to an even distribution of contributions but is not always part of a group meeting. An ambient display may help a discussion group to mediate contribution times of speakers by showing the distribution of contributions [8]. We created a portable design called Ambient Anchorman which uses a network of iPhones or iPads to keep track of participants' contributions and visualizing them on the screen of the devices.

A design study revealed that participants preferred an encoding of contribution times via color change. Ambient Anchorman uses the displays of the involved devices to show the contribution of each speaker to the discussion (see figure 1c). The system enables users to share one device or use a network where every participant holds her own device. A study consisting of a series of sessions with two groups with six participants each showed that participants noticed the changes in the ambient display as the meeting progressed but were not distracted by it from the on-going discussion.

AmbiGlasses

In the era of mobile phones and ubiquitous computing the demand to access information whenever and wherever increased significantly. Traditional devices, like a smart phone, fail in providing the information in an unobtrusive

(a) AmbiGlasses: Providing unobtrusive visual navigation cues

(b) Ambient Timer: Supporting transition between tasks in the office

(c) Ambient Reminder: Activity reminder for elderly persons' households

Figure 2: Examples for mobile navigation (a), office task switching (b) and household activity (c) situations

and ambient way. Rather, these devices often interfere with the user's primary tasks such as walking or driving. Pulling out the phone to, e.g., check navigation instructions requires active and absolute user attention. On the move this results into annoying, fragmented interaction and can cause dangerous traffic situations.

Our aim was to provide users with a mobile ambient display for tasks like navigation. We designed a mobile device called AmbiGlasses, which is a pair of glasses with 12 LEDs that illuminate the periphery of the user's field of view (see figure 2a). We assume that this ambient display can be perceived accurately by a user and is able to convey, e.g., directional information. We conducted a user study with 9 participants which shows that users are able to locate the correct LED with 71\,\% accuracy and estimate the rough position (i.e., top, left, right, bottom) with 92% accuracy. In a participatory design process we identified mostly consistent visualization configurations for four directional information (i.e., front, left, right, behind). The results suggest that the AmbiGlasses can be used to convey ambient, unobtrusive and intuitive navigation instructions.

Ambient Timer
Keeping track of daily appointments while maintaining a creative workflow in the task at hand is difficult in today's office work. Reminding oneself of the next meeting by means of an alarm may cause an abrupt interruption of the primary task [1], thus leaving work unfinished and thoughts cut off in a frustrating way. Checking the clock regularly to maintain awareness of the progress of time may hinder a creative and focused workflow in the primary task. An ambient light display that unobtrusively informs the user of an upcoming task helps to avoid unfinished thoughts and frustration through interruptions.

We designed Ambient Timer an ambient information system to unobtrusively inform users of an upcoming event. User attention is smoothly drawn to the next appointment. This gives them the opportunity to finish their current work in a sensible way. We use DMX-driven RGB-LED to build this prototype (see figure 2b). For our initial experimental setup, we place a frame with LEDs behind a monitor and will convey information via the reflection of the wall or a

reflective medium. We plan to conduct a lab experiment to verify our assumptions in a controlled environment as well as a longitudinal study in the field as ambient displays are never really ambient in a lab setting [4].

Ambient Reminder
With increasing age, elderly people are often confronted with an increasing forgetfulness, which can lead to serious issues influencing their lives, such as people forgetting meetings with friends, appointments with the doctor, or even taking life-sustaining medicine. At the same time, electronic tools to remind people of appointments are often tailored towards technically affine people, which can lead to usability issues for elderly people. We addressed this problem by designing an "Ambient Reminder" [5], an electronic tool that can be unobtrusively integrated into household settings, which uses an LED-based Ambient Light (Philips LivingColors) to help users remember their schedules activities (see figure 2c).

We conducted several experiments with users from our target group, comparing various forms of encoding appointments in light, such as an increase in color intensity or change from one color to another to show the type of activity and the remaining lead time. We could reveal different findings, including the fact that a) users typically fail to perceive slow changes in parameter values, e.g. color saturation; b) the effect of ambient light depends heavily on the surrounding light conditions; but also that c) ambient light was found a very unobtrusive and convenient modality as it didn't distract users from their primary tasks.

CONCLUSIONS AND CHALLENGES
We have presented six examples for ambient light displays, addressing various daily life situations. User studies reveal insights into ambient light displays as well as challenges and questions to be in future work:

Unobtrusiveness vs. Effectivity

Ambient displays provide users with information in the periphery. Our studies revealed a high acceptance rate of information presentation in the periphery. Users were aware of the information but did not feel distracted by it.

One challenge we identified is how to keep an ambient display ambient and still effective? At which point does an ambient display change from the inattentional level to divided or even focused attention? What are the mechanisms we can use, to enable smooth and abrupt transitions for the intended level of attention?

Environmental influences
Ambient light displays are obviously not "build once - use everywhere". Our studies showed that ambient light displays depend on the surrounding light conditions to function in the intended way.

Further research has to be conducted towards the effectivity of ambient light in various and changing lighting situations. How do we have to adjust the design, to ensure that the ambient display can be perceived in the intended way? What are the limitations to this approach? We will further try and find out which kind of ambient display fits which setting of daily life.

Information encoding
We have gained some insights in effective and efficient encoding of information through the user-centered design process. However, a more systematic approach to information encoding for ambient light displays seems necessary.

Our findings lead us to conducting further research on the amount of information that can be encoded using ambient light. Our studies suggest that different situations of daily life require different encodings of information. We will further try and determine which encodings suit the various applications and situations.

Privacy issues
Regarding situation appropriate information encoding, privacy issues play an important role. Unless other modalities like e.g. vibration or sound, which can be presented totally private, ambient light though it is subtle and silent, it is semi-public, because people around the user can percept it, too.

In some situations a user may not be comfortable with knowing that people near-by are aware of the presented information. For example, when using AmbiGlasses for navigation, a user might find it unpleasant to know a person following him could easily know where he wants to go before he actually does. This leads us to the question: In which contexts can the semi-publicity of ambient light be critical and in which contexts can we take advantage of this feature?

User groups
Ambient displays can be used for various applications and different users. One of our spotlights is on supporting elderly people by using ambient assisted living (AAL) technologies. We have conducted a series of studies with this user group and will further continue work towards AAL for elderly people as well as for persons with mild cognitive impairments (MCI). Because of the special needs and characteristics of these users, it is necessary to investigate if this user group requires a different set of information encoding and presentation.

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