The Tangible Reminder

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Abstract

Today's computer systems rely on standard input and output hardware which often complicates the tasks of interacting and mapping. The Tangible Reminder introduced in this paper presents an highly usable, self explanatory, real life interface. It's task is to keep track of appointments, giving an overview over their current states and reminding the user of upcoming events. For that purpose it integrates calm ambient display technology with tangible interfaces to give a non interruptive overview. While it supports peripheral perception it nonetheless grasps the user's attention whenever necessary.

1 Introduction

The tremendous advances in computer technologies over the past twenty years made the personal computer an affordable and powerful tool. The PC made its way into our daily life, especially into our daily work, and is nowadays an integral part in many areas. We use one single PC to fulfill a vast number of different set tasks as well as to communicate and to organize our working day and keep track of appointments.

We use one standard PC today where before many different tools were necessary: The computer has truly become a universal tool. But this universal tool provides us with the same standardized interface for all the different tasks. It introduces the need of metaphors and learning of new patterns for every task. Often expert knowledge is needed even for plain interaction with the device not only for the set task [13]. This takes practice, cognitive abilities and consumes time.

Nevertheless the computer provides us with many useful functions and can support us in our daily life. But for a lot of people these benefits are not a viable option because they cannot bridge the gap introduced by the machine and its interface. The cause can be a variety of reasons. For some people the complexity of interaction or task can be crucial, some cannot deal with the virtualization, some are stopped by the unfamiliar interface or situation and with some people it is just the aversion against technical machinery [3]. Unfortunately these groups of people are often those who could profit the most of these supportive techniques in their daily life.

The crucial role of a good interface is addressed in various publications dealing with possible future directions for the computer development. Mark Weiser for one describes in his visionary article in 1991 the future computer as a machine that is not seen as a computer but is literally disappearing. A disappearing computer is no more recognized as a machine but is not perceived at all: It rather is one with the task it is made for, leaving the user with nothing but the task itself. [16]

Seizing this idea we work on systems in general and especially on interfaces that make the computer disappear. Our idea is to make the computer easy to use, at best without any training at all. Instead we try to find self-explanatory tools for special purposes.

The Tangible Reminder is such a solution we built. It is designed for the purpose of keeping track of your appointments. Other than a computer calendar with various views for different periods of time showing many kinds of appointments we chose a different approach. The idea is that with most appointments one does not want to know when they are but one does not want to miss them. So the absolute date is not important but the appointment relative to the current date.

Furthermore the Tangible Reminder is a system that fits into the surrounding. It displays appointments by associating them with real life objects. These objects can be put into the reminder's trays and the trays show the urgency of the associated appointment on an ambient display. Thus we bring the abstract data into the real world setting it into context with the meaning of the real life objects the data is associated with as envisioned by Ishii and Ullmer [4].

This way we firstly aim on making the benefit of active systems applicable for people not often using computers and secondly to improve the ease of use. We studied the Tangible Reminder to evaluate our solution and appraise its mappings. Hence we set up a user survey with the here described system which is currently in use at our department.

2 Scenario

With today's computer supported calendar solutions people are missing a fast and easy way of managing and keeping track of their appointments.

2.1 Calendar Solutions

Calendars usually use various views for different time spans. Every single view is adequate for a specific period of time and suits appointments in this period quite well. It

allows for a good overview of the given period and represents periodic repeats very well. Nevertheless the user has to keep track of every single view to be aware of every appointment. Imagine a weekly view which is the most common standard view. For example to keep track of the appointment next week in general and next monday in particular, the user has to switch the view: She has to move to the next week's representation or switch to the month's view. The reason for this problem is very simple: It is introduced by the exact transfer of the real life paper based calendar to the computer application. While this helps comprehension it introduces all the problems of this solution as well. Even in the real world the appointments are distributed amongst different appropriate views. And here the computer even amplifies the problem as it tries to merge all these views, resulting sometimes in overcrowded views with every appointment in the current period represented in the view.
So the calendar metaphor is easy to use because it is well known and provides the user with a good absolute overview over a given discrete period of time. On the other hand these rigid views are less effective when it comes to showing upcoming events. There is the risk of missing an appointment just because of the inflexible rigid time period.
This is a known issue for such applications and there are several attempts to meet this problem. To name just a few some applications provide the user with another relative view: This does not show a calender any more but rather provides a summary listing of all upcoming events. Or other ways of communication are used to notify the user in advance. Calendar applications making alarm sounds or popping up messages or showing animations are examples thereof.
These steps illustrate interesting trends: The rigid calendar views are becoming less important. They are rather used for overview and data entry. But the calendar applications nowadays can be supportive data management and reminding tools. The strengths of the computer can make the calendar system your personal secretary.

2.2 Appointments

Besides the need of good metaphors and views in general to get to an easy to use, comprehensible display we have to take a closer look at appointments. While every appointment can be modeled to have absolute dates for beginning and ending, this is not how appointments are conceived. We could distinguish three different kinds of events:

- **events with a certain specific deadline:** This class contains most cases of appointments. It comprises every appointment that has a specific beginning and/or end date. Typical examples would be a meeting or the beginning of a vacation trip.

- **events with a relative deadline:** Every appointment that is defined relatively to the current time goes in this set. Typically this class holds events with a short deadline. Examples thereof would be a timespan in which students have to pass a test (3 hours from now) or a very short period until your tea is brewed (lets say 2-3 minutes).

- **event with repetitions or more than one deadline:** Appointments can occur regularly and we remember them not as absolute dates but as repetition. An example would be sports every tuesday evening or the lab meeting every wednesday morning. And the aggregation of dates can also contain different events with different but repeating dates. This aggregation of dates is often closely linked to objects. A standard example would be somebody who has to take medication at different but specific times during the day.

We distinguished these classes because they have all special qualities the computer system can help us with. For all three we want to be reminded of the appointment, maybe even a little while in advance. Note that how long in advance is dependent on the appointment and the circumstances.

2.3 Users

For a lot of people the usage of current systems is too complicated. It can simply be because starting up a calendar application for measuring the time inserting an appointment just to get a reminder on when tea is ready to drink would be too much of an effort. But think of when the teacup simply could create the appointment for you.
Or imagine elderly people who have to take their medication regularly: They could be reminded automatically by the package when to take it. Maybe this information could even be added by the pharmacist during the purchase or the doctor while prescribing. This could be a solution to help the elderly to stay longer at their loved home instead of living under supervision in a retirement center.

3 Our Solution

To tackle the challenges described above we devised a tool which integrates itself into everyday life, the Tangible Reminder. It is easy to use by persons without experience with computers and especially the elderly.

3.1 Walkthrough

The Tangible Reminder consists of two pieces of hardware: Firstly the Reminder itself as an ambient display and secondly the input subsystem with its small plate to place objects on connected to an input device as shown in figure 1.
A typical use case is a user who has an appointment, e.g. for bringing her car to the repair shop. First of all a good metaphor needs to be chosen, in this case this might be a miniature car or perhaps a small tire if the tires need to be changed. The user is completely free in the choice, the only constraint being, that the object representing the appointment fits into a tray of the Tangible Reminder.
Next, the appointment has to be associated with the object. This is done by placing it on a plate which is connected to an input device. We use a small notebook in our prototype which employs pen input to facilitate a natural interaction.

Figure 1: The Tangible Reminder system. The display subsystem on the left is showing different appointments, on the right hand a new appointment is being entered using the input subsystem.

After placing the object on the plate a dialog screen will be shown by the notebook, enabling the user to enter an appointment, possibly delete an older existing one or modify one if necessary. All of this takes little time and after entering the appointment, the user will place it in one of the Tangible Reminder's trays. Upon insertion it, the display behind the object will turn on and show a color depending on how close the appointment is. Typically it will be green at first, signifying to the user that no immediate action is required. Once the appointment draws close the display will start blinking, thus spurring the user to act. As soon as the user takes care of the appointment, she will remove the object from the tray and place it somewhere else until a similar appointment needs the object for remembering.

3.2 Mapping Appointments

The Tangible Reminder is a tool that reminds users of appointed times. To keep track of different appointments an object is associated with each appointment as explained above. This facilitates an easy mapping of appointments to objects which can be intuitively grasped by users. By choosing good mappings for the events by themselves, the users are less vulnerable to misremember. A glimpse toward the ambient display is then enough to recognize the states and events represented in the ambient display. Our inspiration to let the user choose the mapping herself is based on the observations of Don Norman who mentioned the positive effect of good mappings on intuition already in 1988 [12].
The Tangible Reminder is quite different from a customary calendar by showing how much time remains until an appointment and relieving the user of calculating the urgency of taking action for each appointment which has to be done with a normal calendar. It allows the user to select the timespan for each object herself. At the beginning the user will be reminded calmly of the proximity of the appointment. If the appointment is very close and action should be taken by the user, the notification will get more interruptive.
There are three kinds of appointments, mapping one object to one appointment, to a relative appointment or to many appointments.

3.2.1 Events with a specific Deadline

The first mapping is of one object to one appointment with a specific deadline. This is illustrated above in the example of making an appointment for bringing the car to the garage.

3.2.2 Events with a relative Deadline

The second kind of appointment is a relative one. In this case an object is mapped to the template for an appointment which gets instantiated the moment the object is placed in a tray of the Tangible Reminder. This kind is also a one to one mapping but the behavior is different from the first type.

3.2.3 Events with Repetitions or more than one Deadline

The third kind is mapping many appointments to one object. Appointments can occur regularly which is the same as having many appointments of the same type at varying times. It is also possible to aggregate different kinds of appointments in the mapping to one object. This may sound like a bad idea at first, but if the appointments are all very similar it can be plausible. Consider the following example: An elderly person needs to take different kinds of medication for her ailments. To do so she uses a pillbox with a number of compartments but she still has to check the watch all the time to see which to take next. By placing the box in a tray of the Tangible Reminder, she could easily notice when to take medication and be freed from checking the time every now and then.

3.3 Input to the Reminder

The Tangible Reminder can use a variety of input mechanisms. The usual way of inputting appointments of the first type is to use a notebook and a plate with an RFID reader as input device to set appointments (cf. figure 2). The user places an object on the plate and a dialog is shown on the notebook's screen. Using a stylus or the keyboard the user can then delete, modify or arrange new appointments. Figure 3 shows the more natural way of inputing an appointment using the stylus.
In the case of relative appointments the input has to be performed only once, since the deadline will be instantiated by placing the object in a tray as often as desired afterward. A good example is a teacup for which the relative deadline is set at three minutes. As soon as the cup is placed in the Reminder, the date is instantiated and three minutes from placing it there, the user will be notified that tea is ready. In this case the user would not have to set an extra alarm clock or check the watch repeatedly.

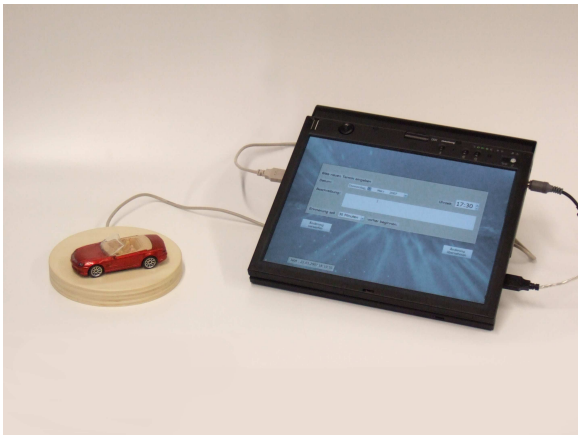

Figure 2: The prototype of the Tangible Reminder graphical user interface and interaction platform. The original idea was to combine the platform with a touchscreen for input and detailed information display.

If the user wishes to employ appointments with repetitions or map many appointments to one object, this is also possible with the provided device, although it's reasonable to assume that the mode of employment for a mass produced device could be quite different. Considering the pillbox example an apothecary would input the recurring dates unless not already provided by the manufacturer, so the user would not have to do this herself.

Figure 3: Interaction with the Tangible Reminder: Inputing a new appointment.

3.3.1 Choosing Mappings

To associate an object with an appointment the user is required to choose an object that represents a task or is in some way a good metaphor for the appointment. This is in a way similar to mnemonic link systems, like the loci system[1], but uses concrete objects. By allowing the users to choose the objects themselves, they can lessen the cognitive load of remembering different appointments [14].

Since the size of the Reminder's trays impose a limit, only small everyday objects, which can be manipulated easily, are eligible. By using small everyday objects, the Tangible Reminder adheres to the tangible approach.

3.3.2 The Ambient Display

Figure 4: The ambient display subsystem of the Tangible Reminder, with an object in each tray, showing the different colors for different states.

An object with an associated appointment can be placed in one of the Reminder's trays as seen in figure 4. Each tray is connected to an ambient display which then shows the remaining time till the appointment by changing its color. We set different colors according to prevalent cultural constraints. A green color signifies much time left until the deadline of the appointment, yellow means the appointment is getting close and red is of course associated with the appointment being due.

By using set colors and an ambient display the dates are not intruding on the user. It's possible to consciously check on them from time to time or to be aware of them since they appear peripherally [6].

Thus the level of interruption is being kept as small as possible to be in accordance with calm technology and to enable users to stay in their primary tasks [2]. Our system utilizes a simple heuristic of specified periods of time until an appointment to change its behavior to a more active mode. If an appointment is due or overdue the display will start blinking in red color. A blinking red color signifies urgency and the blinking captures the user's attention. Since the user is required to act on both occasions, this state is not further differentiated.

[1] In the loci system a user memorizes things by associating them with places in her imagination.

4 Implementation

The Tangible Reminder consists of two subsystems for its input and display. While the display subsystem consists mainly of a real world wooden case, the input subsystem's integral part is the software application. The system implemented in C# runs on a standard PC platform. The only needed requirement is a running database where appointments can be stored and retrieved.

4.1 The Input Subsystem

The purpose of the input system is the creation of new appointments, linking these to real world objects and displaying detailed information of an appointment.
To create an appointment the user places an object on the plate of the input system. This plate contains an RFID reader whose state is monitored by the software of the Tangible Reminder input subsystem. The software reads the ID attached to the object and decides whether to display the details of an existing appointment or to create a new one: This information can be retrieved by simply looking up the ID in the database.
If no matching entry is present in the database the input screen is displayed. The user specifies an appointment by filling in the form. In our prototype we use a standard Tablet PC. This way we are able to provide the user with pen input thus offering a more natural way of input (see figure 3). Once the user submits the information a new appointment is created and stored in the database.
If an object is placed on the reader plate with a matching entry in the database, the appointment is displayed. This suites two purposes: Firstly a detailed view for an existing appointment is provided and secondly the appointment can be edited. This provides the user with full control over the appointments and enables rechecking the data linked to an object.
In addition to setting an appointment the user can specify how much in advance the notification should begin. A simple heuristic is then used to determine the color of the ambient display. If there is still a lot of time until the deadline the display will be green. As soon as the notification should start the display will toggle to yellow and switch to red at half the remaining time from notification to deadline. Once the deadline is crossed it will start blinking red.

4.2 The Display Subsystem

The display subsystem visualizes the states of appointments. For this purpose we constructed a wooden case with trays to contain objects with an ambient display behind each tray as shown in figure 4. The arrangement of the trays allows to take in all the states in a glance and be easily reminded.
An RFID reader is mounted beneath each tray. Upon placing an object in a tray the subsystem reads its RFID tag and looks up if its ID is associated with an appointment in the database in which case the remaining time till the deadline is computed and the color on the tray's display set according to the heuristic described above. A microcontroller mounted in the case activates the LEDs behind acrylic frosted glass. Each display is made up of three red and three green LEDs. Since there are only red and green LEDs in the display, the yellow color is mixed. In determining the colors we followed cultural constraints as described above.

4.3 System Integration

Usually the input subsystem is used as a writer adding data to the tags and the display subsystem serves as a reader. The database serves as the central information storage through which the information is exchanged.
However our solution introduces a new kind of interaction which intermingles the division of these two components. The act of placing a specially annotated object in a tray triggers writing to the database. In this case interacting with the reader subsystem results in writing a new appointment to the database.
This kind of interaction pattern especially fits relative appointments because only the current time is necessary to create the appointment. Just placing an object is sufficient to create a new relative appointment.

5 Heuristic Evaluation

After constructing the first prototype we conducted a heuristic evaluation to rule out coarse errors. A heuristic evaluation differs from a usual evaluation by checking a system according to a set of rules with a relatively small group of participants. Eleven test subjects with background knowledge of tangible user interfaces and ambient displays ranging from novice to expert took part.
Since the Tangible Reminder consists of an ambient display combined with a graphical user interface, we base our survey on two sets of rules. The first one being based on the work of Molich and Nielsen[10, 11], who developed the original rules for graphical user interfaces and the second set for ambient displays, developed by Mankoff et al. [7].
By combining the rules for graphical user interfaces and tangible user interfaces we created a form containing questions about different aspects of the system in which errors should be detected. The subjects testing the Tangible Reminder were shown a description containing general information on the system beforehand. They were free to read and experiment with the system and were under no time constraints. One session took 50 minutes on average. They created various appointments and mapped them to objects as they experimented with the system. They reported their findings in the prepared form by rating aspects of the system based on the Likert scale (1: very good .. 5: very bad) and were given the opportunity to comment.
Remarkably, our system was rated above average in all categories. The most important findings are summarized below:

- **Visibility of system status:** The users rated the visibility of system status with a score of 1.36 very high.

They felt supported and well informed by having access to feedback about the system's activity at all times.

- **Easy transition to more in-depth information:** This category was rated 1.43, illustrating the ease of accessing detailed information by simple interaction with augmented objects.
- **Consistency and standards:** The input subsystem conforms to standards common to graphical user interfaces and therefore achieved a rating of 1.60.
- **Consistent and intuitive mapping:** The display subsystem reduces the cognitive load to a minimum as the rating of 1.45 indicates. This is achieved by the user's freedom of choosing suitable personal objects keeping the cognitive load for memorizing appointments low and preserving consistency by following cultural constraints in the use of colors.
- **Peripherality of display:** The users appreciated the ambient display as calm technology evident by a rating of 1.36. This indicates that the Tangible Reminder's display subsystem meets the requirements. The system remains in the periphery of the user's perception until the full attention is needed.

As is evident from above, the Tangible Reminder supports the user in managing appointments in an effortless way without interfering with the user's primary task. This is facilitated by employing mappings, cultural constraints and calm technology.

6 Related Work

Since our system brings together tangible user interfaces, personal objects and ambient displays there is a number of prior research to be considered.

McCrickard and Chewar raise the issue of systems not being adapted to the users' attentional state. In their article [9] they propose a framework to describe systems' goals in terms of interruption, reaction and comprehension. They conducted empirical studies with two systems using their framework resulting in implications for attentive notification systems: An attentive user interface should adapt to the user's attentional state, provide exactly the necessary information when it is due and ease interface learnability. They especially recommend the ability to adapt to change in user goals for attentive user interfaces.

Is spite of the Tangible Reminder not being an attentive user interface the findings of McCrickard and Chewar apply to our work as well. Being an ambient display it is nevertheless important to provide an interface easy to learn and use. In particular providing the necessary information at the right time is the main function of the Tangible Reminder.

Peripheral displays enable a user to continue to pursue the primary task while providing supplementary information. Matthews et al. present a toolkit for peripheral display in [8]. They designed a distributed architecture and implemented a library for common display components. For this purpose they analyzed a number of peripheral displays and extracted three characteristic features: Abstraction, notification levels and transitions.

For the Tangible Reminder these aspects identified by Matthews et al. are a primary concern. We make use of abstraction by reducing the complexity of a common calendar to discrete levels of urgency. There are four levels of urgency in our system. The transition for the first three levels is a simple change of color whereas the last transition introduces blinking. The change from a steady display to blinking also implies a higher lever of notification raising the users attention.

Another project using similar criteria is the AuraOrb presented by Altosaar et al. in [1]. They use an ambient display for notification employing two levels of abstraction. The appliance consists of a sphere and an eye gaze sensor. The sphere allows for two different output modes. The sphere glows in a specific color silently indicating a notification for the user whenever an event occurred. Upon perceiving the change in the orb the user is prone to look straight at it in which case the orb changes to the second level of abstraction by becoming translucent and displaying text inside.

Interesting similarities to our system are the non intrusiveness of the ambient display notification by change in color thus staying true to the concept of calm technology as well as introducing different levels of display. The Tangible Reminder also notifies users by changing the color of the displays but in addition it starts blinking, attracting the user's attention whenever necessary. We also provide a detailed view which our system shows on demand if the user interacts with a tangible object and places it on the input plate. In this point our system differs from the AuraOrb because it is based on interaction with tangible objects.

One of the first papers describing the interconnection of real world objects with virtual information was published in 1999 by Want et al. [15]. Their primary goal was to enable users to interact with real world objects and at the same time affecting the virtual world. They present a solution to link digital and virtual objects by employing RFID tags. Their relatively small size allows for a invisible augmentation even of very small real world objects making a seamless interaction of real and virtual world possible.

The writers express their hope of an "invisible interface" in the future. Our work clearly runs along the same lines since we use the proposed augmentation of real world object to implement an invisible interface to a large extent.

Van den Hoven and Eggen state in [14] the importance of personal objects to recollect memories in everyday life. In their study on personal souvenirs they were able to prove the value of personal artifacts as external memory aids. They propose the use of personal objects to tap the full potential of tangible user interfaces. We follow this idea with the Tangible Reminder as we enable the user to freely choose which object is suited best for being associated with an appointment.

A project employing personal objects are the Digitally Augmented Collectibles proposed by Lampe et al. in [5]. In their project they bring together collectible glass figurines

with video and audio data matching the figurines' characteristics. When placed on a platform the RFID attached to the figurine's socket is read and corresponding multimedia files are extracted and shown on a framed display.
Our system relies on the same technology to link real world objects to data. We also use a display to show the detailed information but in addition our ambient display provides a more abstract view of the data. In this way we make use of the tangible user interface approach which in combination with an ambient display allows new kinds of interaction.

7 Conclusion and Future Work

We presented the Tangible Reminder – an ambient system to keep track of appointments which's main purpose is to show the current acuteness of an appointment in a peripheral fashion and to remind you if an appointment is due. It uses colors from green to red to indicate the current state remaining calm. Though if an appointment is due it starts blinking and grasps the users attention.
The Tangible Reminder was designed to be an ambient display with a tangible interface. It fits nicely in the users surrounding and it even leaves the choice of mapping between real life objects and appointments to the user. Objects working with the Tangible Reminder are equipped with an RDIF chip. Using an RFID reader the user can display and edit appointments via a small computer system. In the current system we use a pen based input device with handwriting recognition to relinquish the keyboard.
In the future we want to improve the input subsystem further as it is still quite computer related right now. Steps into this direction are already taken by automatically inserting appointments when certain objects are put in the Tangible Reminder's trays like our enhanced tea cup. Maybe the whole programming can be achieved via real life object interaction. This clearly needs more investigation.
The relation between objects could be interesting for the ambient display as well delivering new aspects if they are linked to each other. Functional aspects could be given to special objects representing abstract conditions thus making up an appointment in combination.
Clearly the Tangible Reminder would benefit from these investigations making the future computers disappear by combining ambient technology with tangible inputs to enrich our future world.

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