Finding Keys for People with Mild Dementia – Not Just a Matter of Beeping and Flashing

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Abstract. Searching for everyday objects are a frequent activity for most people. Misplaced keys, mobiles and other devices are a source of annoyance, and even more so, if people are affected by memory problems. Searching for objects is a frustrating activity, especially if this is a frequently recurring phenomenon. There are several existing techniques for retrieving objects, but many of them do not use the available technology to the full extent, providing solutions that are almost "good-enough" but not necessarily useable practice.

In this paper we present a solution that is intense to be more than good-enough, and simultaneously argue that there is a need for solutions that don't only facilitate a good life for people with impairments, but that also does so with the user's emotional experience (UEX?) in focus.

1 Introduction

People often lose or misplace things, permanently or temporarily. This is a matter of fact for most people, but becomes a real nuisance with people who have even minor memory problems, such as an onsetting dementia. Misplacing things is a more or less daily "activity" and recovering the objects might not always be a simple matter.[1] When you have more severe memory problems, you might even forget what you are looking for in the process. This kind of memory difficulties tend to persist, or more often worsen over time, although many times so slowly that the change is difficult to follow by the individual. This dysfunction is also invisible, since it is not possible to see that someone has a bad memory. However, it quickly becomes visible, as soon as people start noticing that the person is asking for help remembering more and more. Asking for help is thus the first step of *stigmatization* (see below).

As long as there has been wireless communication methods (e.g., sound-based, infrared, ultrasound) there has been a market for so called *key finders*. The earliest versions in the 70s reacted to sharp sounds such as whistles or hand claps. When infrared and ultrasound communications become affordable, the initiation was carried out through button presses, and the key finder emitted some small sound signals, beeps. It was pretty obvious that the item was lost, when it started to beep under a table or in the sofa. When this happens often there is a large risk of stigmatising the user of the device. There are other obvious

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drawbacks to this standard method, and in this paper we suggest a different method for the tracking of misplaced objects.

It but should be needless to say, but a well designed object locator does of course not only benefit people with chronic bad memory, but also most people in a stressed out society. In stressed situation, the memory also deteriorates (temporarily) and makes people forget where they put the car keys, their wallet or the handbag. Also in these situations there are great benefits for a locator of objects that can help people find the missing items.

2 Mild Dementia/Alzheimer's Disease

With growing age many people experience a declination of the memory functions, especially involving the short term and episodic memories.[1] In the initial stages the person is also very aware of the process, since the general cognitive functions are not affected by the memory problems. Forgetting things becomes a both frightening and stressing situation for the person, and every time he or she forgets something it becomes a confirmation of the ongoing dementia.

Critical issues with this condition are not only forgetting where an item is located, but also the common misplacing of more or less important items, where the object is later to be found also in uncommon places. Even when the item is finally found, it usually takes longer to locate the item than it would usually do, much to the frustration of the person. [1]

In very early stages of Dementia, and especially when Alzheimer's disease is concerned, there is a great tendency to put common objects in uncommon places, where they are difficult to find for all people involved. This misplacement is a slightly different variation of the more normal misplacing of objects, but of course just as frustrating as just forgetting where the thing is.

One other aspect of the dementia is that the ultra-short term memory might be affected at an early stage. This can result in the person forgetting what he or she was about to do (sometimes triggered by other distracting events). So, when the person has started to search for an item, it might be that they forget what they are looking for during the search. This can be supported by providing a suitable memory support (see below).

3 Disabling Design

An *impairment* results when the physical or cognitive property of the person derives him or her of some abilities. *Disability* is when an impairment results in an inability to perform a certain activity. This means that an impairment does not have to be disabling in itself. The matter of social disabling is an additional factor. When someone is excluded from an activity for other than proper physical reasons, we talk about social exclusion, an exclusion which comes primarily from

[1] This is also a common effect of other types of brain damages, such as after a stroke or severe cases of stress related exhaustion syndromes.

being "different". When the design will increase the difference, then the design itself will be disabling. One such example is the design of lifts for staircases, where the person is placed in a grey steel box that slowly rises to the platform, while all others can go quickly up the stairs.

In some models of disability and impairment, the design of the surroundings is what causes the disability, not the impairment itself.[2] By designing environments and tools in such a way that they make things possible in much the same way for everybody, everybody can be included. This is also the goal of non-excluding design.

3.1 Stigmatization

Not all the designs are beneficial in themselves, some designs will have the effect that they will single out someone who uses it as being "*non-normal*". In Sweden, many of the supportive devises that are available for people with impairments are institutional to their design, which makes the people using them stand apart from everybody else. Such tools have a much higher acceptance barrier, and will often give the person using it a lowered self-esteem. The *self image* is degraded. The supportive tool itself will add to the stigmatisation of a person (who is already considered to be different).

The concept of *stigmatisation* is attributed to Erving Goffman, who discussed the term in social theory around 1960 [2]. The word has its origin in the old Greek word for "to prick" which is "stig". In order to be able to distinguish a slave, which was a valuable property, and have him or her returned, the slaves were tattooed with a pointed instrument. The resulting mark was a "stigma" [3]. This has been transferred into disability research as a term for the derogatory attitude displayed towards people with certain distinguishing features, such as impairments, or race. It has the effect of the singling out of certain people as being "different" or abhorrent from the normal. Being stigmatised is thus normally a very negative experience.

To people with visible disabilities, the stigmatization is an important issue, which adds to the social isolation that many disabled people experience in the society. Wheel chair lifts, that (very) slowly carries a person up and down a flight of stairs is a good example of a stigmatising (supportive) device. A person is put on display while using it, and the progress is so slow that the exposure time is very long (at least in the experience of the person).

Invisible disabilities do most of the time not explicitly promote stigmatization, since the disability is not evident to the surrounding bystanders. However, as soon as the person is forced to "reveal" the disability publicly, it also prompts a possibly stigmatising situation. Many assistive technologies may induce a stigmatization [4], and it is crucial to decrease this tendency as much as possible. A device might be perfectly designed from a functional usage point of view, but still remain unused, if the person feels that he or she is exposed when using them.

[2] Assuming that the environment itself is designed, of course.

In a Masters Thesis one of my students made a study of digital maps for visually impaired people [5], and in one of the interviews the informant described how she avoided to use the public tactile maps that are available in some places, such as malls or parks. When asked for the reason she said that even though the maps were often well designed, she felt too exposed when she approached the map. This is not a single observation, but is very telling. A device, which only exists to provide visually impaired people makes the intended user feel too exposed, to the extent that it is not used. When designing assistive technology this aspect is very important to consider, although it seems to have been a secondary issue for a long time. Design to avoid stigmatisation is an increasingly important issue in todays society.

4 Existing Key/Object Finders

In a survey made by Kiarii Ngua as part of his Master Thesis [6] there were essentially two different types of Object Finders that were available on the market. The first type is based on an active tag, which reacts to the user pressing a button on the accompanying remote control, exemplified by the *Doro MemoryPlus 335*, which can manage up to four different tags (i.e., four different items). However, the control does not provide any clues to which button is connected to which object, and the buttons are very anonymous. Moreover, the tags are relatively large, and not something you would want dangling from your glasses, or bulging in the wallet. This bulkiness defeats the purpose of the tracker, namely to to keep track of all kinds of large or small items. The small object are essentially excluded from this application.

The second type is represented by the *Now You Can Find It Locator*. This device relies on the use of passive RFID tags that are responding to the radio waves from the handheld control. The control beeps when the item is within reach. However, it requires the person to walk around the place to find the item, since the the direction indicator is less accurate. However, for this type of device the detection range is within 6 to 8 meters.

Since these devices are on the consumer market, it is easy to see that they do not conform to the expectations of the users. Comments such as "It's as bad as the rest..." clearly conveys the idea that there is much to be said about the usefulness of these marketed products.

There are also other usability problems that appear on these specific products, namely that the user will have to remember which out of four or eight buttons that activates which tag. For a person with memory problem this rings a warning bell, since the problem is exactly to remember.[6] A person with memory problems will have greater difficulties recalling the right button, than recognising, for instance an image of the item he or she is searching for.

In the survey Ngua found that most object locators were based on the same two principles, and thus also had the same general usability problems:

– Difficulty for the person connecting an item to the right button on the controls.

- Tag sizes were to big for tagging certain types of objects, such as glasses or wallets.
- The battery lives were too limited, which is especially difficult when the battery resides in the tag (Doro)
- The locator introduces a new device that has to be added to the existing controls in the home.

For the active tagging systems, there is also additional problems:

- The tag emits sounds or lights, which might cause uneasiness in the user
- The person has to locate the sound (or light) which makes it unusable for deaf (or blind) people.

The locator needs good hearing in order to 1) notice, and 2) find the direction of the sound. People who are deaf may not be supported by these devices. Also, with coming of age, the hearing often gets more or less impaired, which means that the signals from the locator might get unnoticed by the user. [7]

That the locator becomes a new device, added to the exiting technology is also a disadvantage in terms of dementia, since one of the major symptoms is the inability to operate new or complex equipment.[8] Eftring used the term "useworthy" to describe exactly this problem. New technology has to defend its position with the people using it, since it will not be used id it "is not worth it" [9].

In the approach suggested in this article, the user should only need to have a smart phone (which can be used for other tasks, such as reminders for medication) and the active tracking should instead be based on a central placed in the users home. This relieves the user from carrying additional devices, and also allows for a much more active device, as we shall describe below. The back side of this approach is that there is a need for a permanent installation, since it relies on a computer and triangulation sensors. Thus, the technology might be most suitable in old peoples homes, or as permanent installations in homes, at least to start with.

5 Technology Foundations

The tools for this application are in many cases well known and already used in other application areas. In a survey made in 2010, Koyuncu and Yang compare a number of different techniques that can be used for both indoor and outdoor tracking [10]. Most of these were utilising active tags, i.e. tags that emitted sounds or lights when called upon through an activation device, such as a remote control.

5.1 GPS Tracking

GPS (Global positioning systems) is a technique used by most navigation systems (for cars) today. However, the technology is mostly available for outdoor

usage. The devices are also using active technology, which is dependent on battery life. However, GPS technology could be useful for larger items, and for personal tracking in outside locations (albeit this is connected with integrity problems). The GPS is therefore primarily regarded as a supportive addition to a tracking device.

5.2 RFID Technology

RFID (Radio Frequency Identification Documents) Technology has been around since the mid-seventies. It is a well developed area of tracking devices, which is in common use for item tracking (including theft preventions systems). There are essentially two types of RFID systems, one that is based on passive technology, where the tags do not require external power sources, and active tags, which have a longer reach, but require battery powering. In this perspective the passive version of this technology seems better adapted to the current approach. However, the power consumption of the active devices is so small, that they might be considered for keeping track of larger objects, such as wallets, canes, etc.

The passive RFID tags, on the other hand have the disadvantage of short reaches. Currently there are few types of tags that can reach more than a meter, which is of course too short. The advantage with RFID tagging is that each object can be identified by its tag. This means that the system can present the user with more details about the object than is available just by beeping. For instance, the tracking system can tell the user how long it has been in the current place (and, e.g., estimate whether the battery of the mobile phone has run empty).

RFID technology has even reached the stage where it can be developed in smaller scales, and the technology has also reached reasonable costs [11]. This means that it could be feasible for the approach discussed in this article.

5.3 Bluetooth and Wi-Fi

Bluetooth and wi-fi are of common use almost everywhere, today, and provide many different ways to identify and monitor objects in a home. However, both these techniques need powered devices. They are therefore not interesting for the tracking part of the system. However, in order to locate the user, Bluetooth technology and wi-fi networks can be excellent sources of communication. Homing in on wireless devices become more and more accurate by the day, and thus become important location devices for the user, as part of the guiding process, once the object is located.

6 Internet of Things

In the area of Internet of things, the general idea is to have a cloud intelligence that keeps the individual aware of the current status of his or her world. Much

of the Internet of Things deals with monitoring and censoring the status, using an open communication channel between the objects and the person. [12] In this sense the POTT is not directly a candidate for this approach, at least not on the surface. However, as part of the "calm technology" as suggested by the late Mark Weiser and John Seely Brown [13], the POTT technology could play an interesting part. The field of research into ubiquitous computing provides a framework from which the POTT architecture could be developed. [14]

In the context of the Internet of things, the underlying architecture of sensor networks would provide the framework into which the specific POTT locating sensors would plug in. This infrastructure is not yet available on any larger scale, but in the current project the suggested RFID triangulation technology provides a reasonable substitute for testing out the prototype.

7 POTT Architecture

The POTT system as outlined by Ngua [6] depends on the use of passive RFID tagging, with triangulation software that can detect the position of a misplaced object. The RFID tags are so small that they can be almost invisibly fitted to most objects. Even glasses can be equipped with this kind of tracking device. Even with the limited range that the passive tagging provides they are feasible in most indoor environments (depending on the base sensor density). To find an object in a two dimensional space (east-west) three sensors are enough to triangulate a position completely, and four is required for three-dimensional positioning. However, with more base sensors, the accuracy increases significantly. Also, the distance between object and sensors becomes less important, since the sensor network can be made in such a way that the room is covered.

This technique is used with the GPS navigation systems that are currently on the market, but with satellites being the "passive" objects, sending out time signals, and the GPS monitor calculating the current position (see fig 1). When the distance of the reference point is calculated from the three fixed points (sensor bases or satellites), there is only one point that matches the combined point (the star in the crossing of the circles). In most cases this is enough to locate an object within a room. However, the more bases we could add to an environment the more precise the positioning will be. If the positioning can be made within 30 - 50 cm in a room this would be enough to find most objects.

7.1 POTT Framework

In the POTT architecture, the object to be searched for is the passive component, responding to the signal from the sensor(s), and replying with its identity signal. The sensors then measure the distance from the object in the room, and the central computer unit calculates the input from all the sensors into the two- or three-dimensional position of the detected object. The system then detects the user's position and even orientation through the sensors in the phone. The phone application displays the object that is being searched for, and gives the user the directions on how to go to the right place.

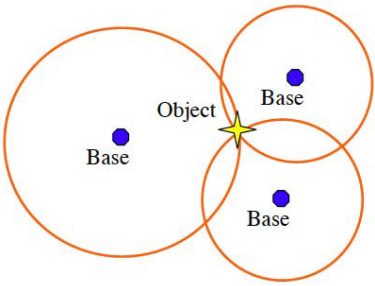

Fig. 1. RFID Triangulation principles. (Image Source Hightower, et al. [15])

In order to increase the precision of the object location, more than three (four) sensors need to be used in each separate location. In the development stages we have looked at the use of RFID tags to secure shop items in stores from theft. Here the RFID tags are detected by special antennas, normally located around the store exits. By extending this technology to the triangulation scenario it might be possible to locate the approximate whereabouts of the object, while it is being moved.

7.2 POTT Smartphone Application

The smartphone application and the sensor network are the active components, and the tagged object the passive. It follows that the missing object will not emit any sounds or guiding signals. The rationale is to minimise the stigmatisation by removing any non-controllable visual or auditive signals from the object. Beeping sounds and blinking lights will attract the attention from other people, and may thus cause the person with memory problems to feel intimidated by the object finder.

The smartphone application is intended to be more *intelligent* than the existing devices, in that it keeps track of the different kinds of tracked objects. Whenever a tag is applied, a picture can be taken of the object. It is also named and described briefly, so that when it is searched for, the application can show he picture of the object together with the instructions to find it. Contrary to the existing devices, the smartphone app has to keep track on the objects position, the user's position and the direction of search, in order to display the right information and instructions to the user.

The instructions can be either iconic (arrows) or textual (such as in GPS navigation) or a combination of both. Optionally, for people with bad visual perception, the device can use speech input (such as the iOS Siri application, see [16] for details) for initialising the search and speech output for the guiding. One advantage with using the user's smartphone is that any adjustments in the interface can be adapted by the POTT app. A visually impaired person might have special settings for the speech output, and the app can then adapt to the system already installed and used on the phone.

In an extended version, the system could combine the user and the object tracking, in order to ensure that the user doesn't leave the house without keys or wallet. A user tracking system based on wi-fi and/or Bluetooth discovers that the user i approaching the door out, and that he or she has not brought the keys or the wallet. This type of functionality would be very useful in the cases of more advanced stages of dementia or other memory problems.

8 Summary

In this paper we have presented the basic ideas around a tracking system for small personal items, such as glasses, keys, wallets, etc. belonging to people with mild memory problems, e.g., in the case of early stages of dementia, after strokes or exhaustion syndromes. The system is based on the use of fixed installation of a triangulation framework that keeps track of the object, and a smartphone app that is used to guide the user to right spot, where the object is located. The basic design strategy for this object locating system has been to minimise stigmatization from the location device, while making the system robust, and not sensitive to battery life or other power provision.

The smartphone app is designed to support the user's memory, not only by locating the missing object. It also provides memory support during the search by actively showing the item searched for. In this way it provides a more supportive role than the existing devices.

There are still some issues that need to be solved. The practical range for locating the object is still on the short side with the current RFID technology. However, this can be compensated by a larger number of sensors in the location area, but with the development of the RFID technology the range problems will most likely be solved.

From the user perspective, the approach is concerned with the Emotional Experience of the User. Much of assistive technology does have a large emotional component [4] and in order to be used (not usable) the device has to take the emotional component of usage into account. If there is any risk of stigmatisation of the user, this will have a large negative impact on the attitude towards the device from the user.

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