Tailoring Activity Recognition to Provide Cues that Trigger Autobiographical Memory of Elderly People

Lorena Arcega, Jaime Font, and Carlos Cetina(✉)

School of Computer Science, San Jorge University, Zaragoza, Spain
{larcega,jfont,ccetina}@usj.es

Abstract. About a 19 % of elderly population is associated with poor performance in assessments of memory; the phenomenon is known as Age-related Memory Impairment (AMI). Lifelogging technologies can contribute to compensate for memories deficits. However, no matter how functional technology is, older people will not use it if they perceive it as intrusive or embarrassing. This paper shows our work to tailor current activity recognition techniques (based on Emerging Patterns) to provide value for AMI people from RFID reading and GPS positioning. Evaluation shows (1) increases in the recall of autobiographical memories, (2) recognition issues, which require the supervision of the e-Memory Diary, and (3) evidences that this approach didn't suffer from the usual rejection showed to this technology by elderlies.

Keywords: RFID · Activity recognition · Age-related memory impairment

1 Introduction

About a 19 % of elderly population is associated with this decline in various memory abilities; the phenomenon is known as Age-related Memory Impairment (AMI) [8]. The use of external memory aids to help people to compensate for their memories deficits. The vision of lifelogging technologies [10] can significantly contribute to realize these external memory aids. Lifelogging technologies record multiple kinds of data as complete and automatically as possible for storing collections of heterogeneous digital objects that users generate or encounter. However, recent works have found that users with collections of thousands of digital photos never access the majority of them [11].

Furthermore, the particular domain of adoption of technology by elders is strictly dependent on a delicate acceptance process: no matter how functional

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technology is, older people will not use it, if they perceive it as intrusive, complex or embarrassing [7]. We believe that recent research efforts on activity recognition can play a key role to trigger autobiographical memory about past events. In order to be really accepted by elderlies, these techniques have to be shaped to meet the findings of recent literature about designing technology for elderlies [7].

This paper shows our efforts to tailor current activity recognition techniques to provide value for AMI persons. In particular, we tackle RFID reading and GPS positioning issues taking into account the 'look and feel' needs of elderlies. Then we apply Emerging Patterns as the activity recognition technique. To present the history of activities, we design an *e-Memory Diary*. Finally, to evaluate the improvement of autobiographical memory, we use a method similar to the one presented in [1]. The results of the evaluation show that our approach helps in improving the autobiographical recall. Furthermore, the behaviour of the participants suggests that this approach didn't suffer from the usual rejection showed to this technology by elderlies.

2 Related Work

Dobbins et al. [3] presents DigMem, a system for creating human digital memories (HDMs). The system creates HDMs that are composed of a variety of information. Various intelligent devices are used to gather data, whilst linked data is used to bring this information together. Their resulting set of interrelated data is presented, to the user, as a memory box of a temporal event. Lee and Dey [6] describe the design of a lifelogging system that captures photos, ambient audio, and location information. The system presents the selected cues for review in a way that maximizes the opportunities for the person with Episodic Memory Impairment to think deeply about these cues to trigger memory recollection on his own. The wearable devices and user interfaces of the above approaches do not address the acceptance process of elders adopting technology at home. On the other hand, our work provides evidences about the use of current activity recognition techniques to trigger users' memories and takes into account previous research efforts to achieve the acceptance of elderly adopting technology.

3 Our Sensing Platform: e-Memory Diary

To decide the sensing dimensions included in our approach we have taken into account the increasing popularity of smartphones and its capabilities. Modern smartphones incorporate many sensors that can be used to capture information and they can be also extended by wearable devices using connection capabilities.

For capture RFID tagged things that are touched by the users, we capture the digital object identifier and each one corresponds with a human-readable name. Despite the availability of RDIF-capable mobile devices, the identification process they provide disrupts the natural interaction between users and objects. Therefore, our sensing platform uses a RFID reader attached to a Bluetooth capable wrist-worn. In this way, users can just interact with an object in the

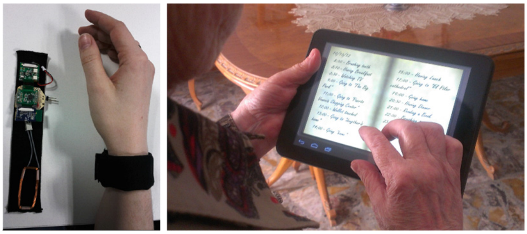

Fig. 1. Final prototype of our sensing platform (left). One of the users consulting de e-Memory Diary (right).

normal way. Therefore, the user feeds the approach whenever he touches a tagged thing, consciously or not. Finally we decide to encapsulate it as a watch because beyond the bare minimum of hardware and software the issue of look and feel needs to be addressed. The device should be perceived as cool not dorky or handicappy [5]. Figure 1 left shows the final watch.

For localization we use the GPS of the smartphone, we are aware of the limitations of GPS. We expect this issue to fade as sensors improve, but it is a significant concern for any deployment on currently available smartphone hardware. To improve location sensing, we can attach location information to those tags that we know will be static. RFID tags allow us to save additional information on it. So, we recorded static labels with their location. When our approach is used outside a familiar environment we obtain the geocoding with the Google API to find out the place and address where the user is. Google API enables us to get the points of interest (POIs) that the user has visited. This allows us to not only show geometric coordinates or an address, but show the name of the POI. Although we cannot overcome the sensor limitations entirely, we are designing the system to be as robust as possible to sensor errors.

In order to recognizing human activities from sensor readings we use Emerging Patterns (EP). An emerging pattern (EP) is a feature vector of each activity that describes significant changes between two classes of data [4]. Consider a dataset D that consists of several instances, each having a set of attributes and their corresponding values. To find these attributes *support* and *GrowthRate* are computed for every attribute. The support of an itemset X, is $count_D(X)/|D|$, where $count_D(X)$ is the number of instances in D containing X. The *Growth Rate* of an itemset X from D_1 to D_2 is 0 $if\ supp_1(X) = 0\ and\ supp_2(X) = 0$, $\infty\ if\ supp_1(X) = 0\ and\ supp_2(X) > 0$, and $\frac{supp_2(X)}{supp_1(X)}\ othrerwise$. EPs are itemsets with large growth rates from D_1 to D_2.

We have applied EPs in a similar way than in [4]. Each observation performed with our sensor platform contains an RFID tag, a timestamp, a human-readable location, accelerometer and gyro data. In order to apply EPs we have two different phases, the training phase and the activity recognition phase. In order to "train" the system, we need to select the activities set that we want to recognize and use them as raw data for the training phase. We have selected the activities

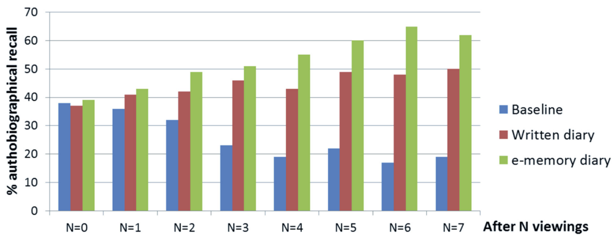

Fig. 2. Average recall of autobiographical events

described in the literature as commonly performed by elderlies [9]. We are aware that the technique applied for extracting the EP's and recognizing the activities can be improved, but we don't focus on this area and therefore we don't have any claim on this.

Finally, we design an interface that shows the information previously gathered while avoiding the rejection showed by elderly people to this kind of technology [7]. We have took into account the associative thinking of the human mind suggested in Memory Extender (Memex) [2]. In addition to that, in [10], Sellen et al. suggest moving away from an obsession with "capturing everything" to a more precise specification. Therefore, we focus on giving cues about past events of the user. We believe that these cues can trigger the associate thinking in order to enable user's recall autobiographical memories of the events performed.

Furthermore, the interface needs to map intuitively. Having that in mind we have designed our interface, the *e-Memory Diary*, to look like a traditional written diary, so elder people can feel comfortable as it looks like something that they already know. Figure 1 right shows an example of the use of the *e-Memory Diary*. It is structured like a written diary, the date is at the top followed by all the diary entries for that day. Each of the entries starts with the hour, and then the cue itself. We have three different kind of entries, activities, positions in readable format and the tagged objects touched that isn't part of any activity.

4 Case Study

The objective of the case study is to determine if the use of our approach, improves autobiographical memory recall in people that suffers from AMI. We have run the same experimentation with two different husbands and wives, following the same procedure than in [1]. The two couples were above 70 years old and one of the members of the couple has Age-related Memory Impairments (we will refer this member as AMI, and non-AMI for the other member).

As in [1], we evaluate three different conditions, an *e-Memory Diary* condition, a written diary condition (control) and a baseline condition (without using anything that might help her to remember). Figure 2 shows the results of the recall trials performed during the case study. It shows the average percentage result of the trials for both users, for all the three conditions evaluated. Figure 2 indicates that, as the number of *e-Memory Diary* and written diary viewings increased, there was an increase in the recall of autobiographical memories. By contrast the trend for the baseline condition is the opposite. It turns out that the improvement of the *e-Memory Diary* is greater than the written diary improvement.

In addition, the case study participants were concern about the customization possibilities of the *e-Memory Diary*. They argued that they wanted to add more details or even rewrite some of the entries in order to create a more personal diary. In fact, participants stated that they would prefer using the *e-Memory Diary* as a starting point rather than facing the challenge of writing out from the scratch the traditional diary every day. This behaviour suggests that the presented approach didn't suffer from the usual rejection showed to this technology by elderly people.

5 Conclusions

There are open topics regarding implications about privacy, security and the right of people to forget. However, we hope that our evaluation results and insights encourage researches to reach a trade-off between sensors bother and activity complexity that enables to bring more activity recognition techniques to the domain of memory aid technology for AMI population.

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