Exploring the role of Prospective Memory in Location-Based Reminders

Yao Wang
Center for HCI
Department of Computer Science
Virginia Tech
2202 Kraft Drive,
Blacksburg, VA24060, USA
yxw5167@vt.edu

Manuel A. Pérez-Quiñones
Center for HCI
Department of Computer Science
Virginia Tech
perez@cs.vt.edu

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Abstract
Ubiquitous technology has prompted the use of location-based reminders (LBRs) to help people remember to do things while being away from their desks. However LBRs are still not an effective tool for mobile users. Our work explores how to make LBRs better by using theories of memory, in particular prospective memory, and treating the system that captures the LBRs as an external memory aid. With the knowledge from these two pre-existing literature (prospective memory and external memory aids), we set out to explore how to influence the design and the use of LBRs. In this paper, we propose a framework that uses knowledge and principles from cognitive psychology and present how we might be able to improve LBRs. Our ultimate goal is to facilitate human memory recall for prospective tasks.

Introduction
Ubiquitous technology today allows people to record many life moments and use these recorded experiences. Back to 1945, Vannevar Bush proposed the concept of a personal device, Memex [3]. It involved a mechanized private file library with the purpose to support human memory. Inspired by his idea, Gemmell et al. [14] developed a technique to record people life experiences passively and easily. The recorded information could then be used to help people with memory recall and with gaining insights of personal life. Czerwinski et al. [6] mentioned that the

existence of ubiquitous technology aims to support people's ability to recall and retrieve information more effectively. They suggested that the recorded information might be able to be marked for remembering future events.

Different kinds of tools have been developed to support human remembering and to better manage the recorded information. People have to remember many things to do at work, at home or even on the way, such as remembering to buy milk on the way back home when near the grocery store. Tools that particularly help people remember future to-do things are widely known as reminders. Typical use of reminders in people's daily life include setting calendar alerts, making to-do lists, writing notes, sending emails to self and so on. With the advent of smart phones and advanced communication technology, reminders can also be triggered based on people's physical locations. The reminders can be triggered when people are entering (or exiting) the "geofence" around a specified location. This type of reminder has been considered as location-based reminders (LBRs) [23].

With the increase in information overload, people rely heavily on reminders. Remembering to perform an intended task in the future involves human prospective memory [11]. Schacter pointed out that memory is fallible [30], and often, forgetting to-do things can get people in trouble. Several researchers have been studying prospective memory theory and developed tools to aid human memory or remedy daily memory problems [7,21,28,35]. As a result, people rely heavily on external reminders to assist them recall to-do things at the right time.

However, LBRs sometimes fail to delivery the reminder message accurately. People get frustrated when they are not reminded at the right moment. One of the research challenges in studying LBRs is how to set up a delivery point to effectively remind people to do the task. Some research has contributed to address this challenge [20,22,23,31,33,36], but because of the complex changing environment, it is still considered as a research problem.

Our work aims to extend the LBRs to be a new form of external memory aid. We propose a framework that explicitly applies memory theories into the technical design of LBRs. The goal is to help people recall to-do tasks in a context-driven way. By applying basic research findings from psychological research on prospective memory, we would like to restructure the LBRs encoding process, so the use of LBRs can better facilitate human memory recall.

Related Work

Human memory

Human memory is a vast research field. Researchers typically differentiate short-term memory from long-term memory, and describe working memory as an active-inactive memory phenomenon. Another memory classification refers to the difference between retrospective and prospective memory. These two distinguish between recalling a past event (retrospective) and remembering a future to-do task (prospective). Our work will focus on the use of prospective memory for LBRs.

Prospective memory

Prospective memory is defined as a distinct form of memory concerned with remembering events that will occur in the future [11]. Prospective memory (PM) is not a new type of memory, but instead it is a multidimensional procedure that involves different cognitive components [10]. A typical PM task follows a four-stage procedure, which was proposed by Ellis [13]. The four steps can be generalized as: (a) Intention formation, which requires human attention resources to process and encode the task; (b) Intention retention, which accounts for the interval from remembering the task until performing it; (c) Intention retrieval, which involves human prospective memory to recall and trigger the task; and finally (d) Intention execution, which means to execute the task.

There are a wide variety of PM tasks in people's daily activities. The most common distinction within PM tasks is between the time-based tasks and the event-based tasks. Time-based tasks are those to be performed at a specific future time, while event-based tasks are to be performed when a particular situation or event occurs. The inherent difference between these two types of PM tasks is in the cognitive retrieval process [12, 25]. Event-based tasks rely on external cues (such as a person, an object, a location or a particular situation) to trigger the intended task, but time-based tasks don't have these external cues. Instead, time-based tasks rely on an internal trigger that is based on time. Because of this difference, these two types of tasks make use of different retrieval processes. Event-based tasks are retrieved through a spontaneous process when people noticing an external cue associated with the intended task. Time-based tasks rely on self-initiated retrieval process.

Our work is focused on location-based tasks, a typical type of event-based tasks. Van den Hoven and Eggen found out that one of the keys to successfully support remembering is the memory cue [34]. Researchers have concluded that some parameters of external cues, such as the distinctiveness and the associativity with the intended task, are inherently important to support task retrieval [25]. If external cues are salient, distinctive and highly relevant with the intended task, it will more effectively trigger the intended action. Sohn et al. [31] concluded that in LBR systems, location itself serves more like a reminder cue rather than just the place of task execution. However, there isn't much research of how to provide effective cues with the purpose of supporting location-based task remembering.

Location-based reminders

Researchers have developed several prototypes to prove the usefulness of LBRs. ComMotion [24], for example, was designed to provide just in time information delivery based on location. Cybreminder [8] made use of the rich context in the environment to more appropriately trigger the reminder. MemoClip [2] suggested that in many cases location is more appropriate to trigger the reminder rather than time.

A big research challenge in studying LBRs is how to deliver the message more accurately. When people are on the way, the environment and the context are complex and continuously changing. Several studies have tried to enhance context-awareness to set a more effective delivery point [8,20,31]. By making use of the rich context around them, like allowing users to set the relevant person and the particular time and location, the LBRs might be able to detect a better way to send the reminder. This technique is useful in some ways, but it also forces users to put more effort when setting up a reminder. Cakmak and Basoglu indicated that users don't like a long process for setting up a simple reminder [4]. Other researchers tried to explore the factors influencing the location-based reminder delivery [23, 33]. They concluded that the effective reminder delivery depends on the geographic layout of the space. Tu et al. [33] developed a LBR prototype based on the routes users are about to take instead of the "geofence" radius. But the research problem of when and where to send the reminder is still not fully resolved.

External memory aids

The purpose of external memory aids is to facilitate human memory. In the scope of our work, we situate external memory aids within prospective memory needs of LBRs. Some researchers have concluded that external memory aids function as cues in supporting task recall for encoding, recoding, reorganizing, rehearsing and retrieval [18,19]. Under experimental conditions, lab studies have shown that PM failure can be caused either because of the breakdown of encoding stage or due to the failure access of retrieval stage [5]. In a real life environment, cues sometimes fail to trigger the action for unexpected reasons [9].

Researchers have explored the effectiveness of external memory aids [16,18,27]. External memory aids have been classified into two types. One type is merely external storage of information, referred as passive reminders; and the other type acts as active cues to trigger the task, referred as active reminders. Harris concluded that active cues are more effective than passive cues [18]. External memory aids have also been studied based on the content of the reminder message. The most effective message in reminders provided both the external cues and the intended task [16, 27]. But the current design of LBRs only allows users to put effort on defining external cues (locations) in the encoding process.

Some mobile-based reminders have been particularly designed to aid human memory. Memojog [28] was an interactive memory aid for elders with normal cognition, aimed to help elders remedy everyday memory problems. Forget-me-not [21] was a conceptual prototype that exploited human episodic memory. It captured important data and context from personal life and later used these data to support human memory. Devaul and Corey [7] designed a memory glasses and concluded that providing subtle visual cues can be effective as a just in time memory retrieval aid, especially when overt cues are distractive and inappropriate.

To better support human memory and human behaviors, some researchers have also used PM knowledge into the design of existing reminders. Back in the early 90's, Payne provided a cognitive analysis between calendars and the task of prospective remembering [29]. As the electronic calendars became popular, researchers started to consider calendar use in the therapy of memory-impaired patients through the understanding of PM theory [26,32]. As sending emails became an everyday activity, Gwizdka [17] investigated the phenomenon of supporting prospective information in email, and contributed in the email design by applying human PM model. But none of these studies tried to apply PM knowledge to redefine the concept of LBRs.

Intons-Peterson and Newsome III indicated that memory may be affected by the encoding and recoding of materials that occur when external memory aids are prepared [19]. Vemuri and Bender considered this preparation process as a memory-encoding aid [35]. They suggested that the more details one encodes, the more associative paths there will be available in memory. Studying memory-encoding aid for LBRs is lacking in this research area, our work aims to address this gap by extending LBRs to a new form of memory encoding aid.

Framework

The task flow for PM activities discussed previously is mirrored in the task flow of LBRs. Figure 1 shows how we connect the PM task flow with the LBRs task flow. To successfully finish a PM task, LBRs play different roles in supporting human memory. By "supporting", we mean LBRs are considered as human external memory, which help people record, store, retrieve and maintain the information accordingly.

In the first stage, intention formation, LBRs serve as a memory-encoding aid. When people are forming an intention, they need to manually set up a to-do task on their LBRs. At the time people input the intended task, they need to perceive and process the task into their working memory. This process involves attention resources, so when this piece of to-do task pops up at a later time, people are aware of it and can reconstruct the context for the action. As this process becomes automatic (e.g., email programs automatically adding reminders in calendar programs), fewer details are provided to people when they are encoding. The result is that people have very fuzzy memories about the encoded task. The unintended result is that people rely more heavily on the external reminders rather than their own memory.

In the second stage, intention retention, LBRs serve as external memory storage, similar to what a to-do list does. It provides people a method to rehearse the to-do tasks by maintaining all the information externally. More than a to-do list, tasks can be organized on a map-based view, which exploits human spatial memory to support remembering for location-based to-do tasks.

The third stage is the time to perform the intended task, and the LBRs serve as an external retrieval cue. A salient cue that exists in the physical environment could work well in triggering the intended task as long as it catches people's attention. A reminder sent by LBRs works like a salient cue. If the reminder is effective enough, it would interrupt people's ongoing activity and get people's attention to switch to the intended to-do task. Current LBR research prototypes mostly focus on improving this retrieval stage, trying to find a more effective location point to delivery the reminder.

Rather than having LBRs use one cue (one target location serving as one external cue), our work aims to provide more external cues in the encoding stage. These cues would come from the real life environment at the moment of retrieving stage. For example, if the LBR system has an address or name of a location, like a supermarket, the LBR can display such landmarks or a route street view at the time of encoding. We believe that this will increase the saliency of the cue at the retrieval stage and thus improve the role of the memory aid for PM tasks.

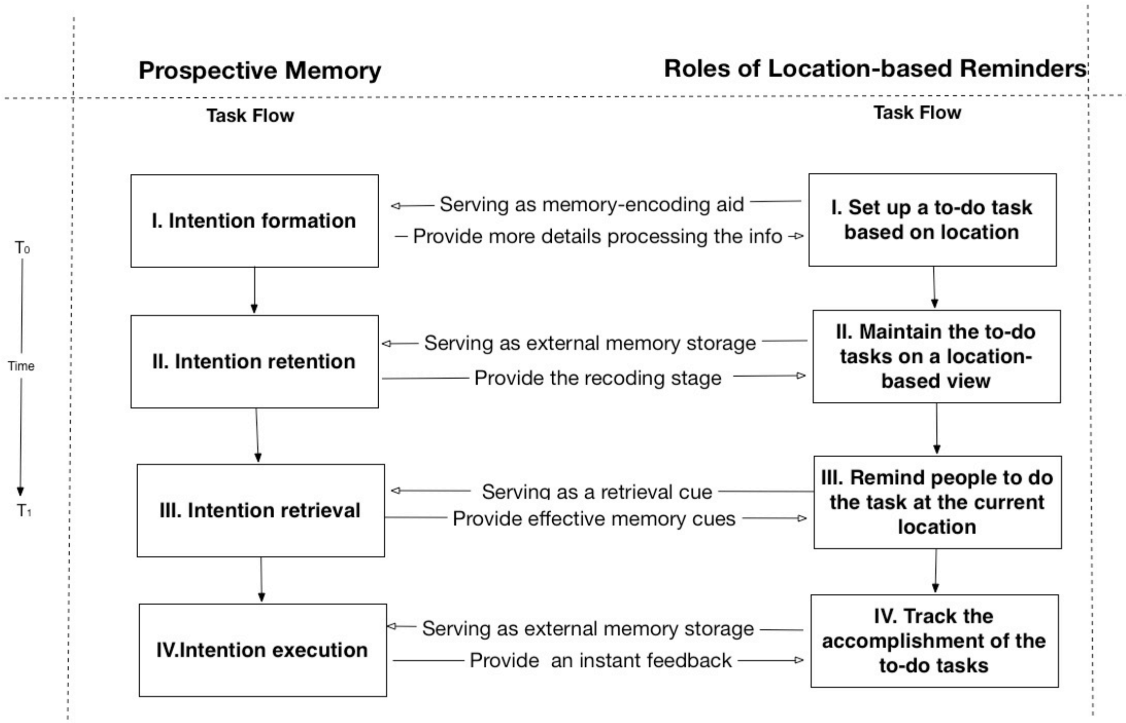

Figure 1. Prospective memory connected with location-based reminders

Finally, people need to execute the intended to-do task, and LBRs again serve as external memory storage by tracking the completed tasks. In addition, at the time of execution, people are often reminded of tasks to be done without the context of where the task was created. We will explore how we can reconstitute the context of the task at execution time by using ideas from another one of our research projects [1].

Conclusions

In our work, we are interested in how to improve the prospective remembering of daily activities. We focus our research on how external memory cues in the natural physical environment can improve the recollection of to-do tasks. Information captured in human memory sometimes cannot be used effectively because the information has not reached the awareness level. The stored information just needs an appropriate trigger to activate the memory, so it can be brought into the awareness level and catch people's attention.

We have presented a framework that applies theories of PM into the task flow supported by LBRs. Research in cognitive psychology has created a deep understanding of PM. We are exploring how some theories can enhance the human memory recall for PM uses. In particular, we are studying the effectiveness of memory cues in this context during the task encoding process.

Our work takes advantage of existing ubiquitous infrastructure to present memory cues from the environment around us. To extend LBRs to a memory-encoding aid, the LBRs could automatically provide relevant contextual cues at the encoding stage. It shouldn't require more human effort to input the information, as we feel that this can be done automatically using information available in today's ubiquitous environment. Furthermore, we feel that the extra cues in the encoding stage would require less human attention to process the provided cues at retrieval stage with the hypothesized result that these cues will further facilitate the task recall.

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